General Knowledge Today

Prelims Geography-1: Astronomy

Target 2016: Integrated IAS General Studies

Last Updated: April 3, 2016
Published by: GKTODAY.IN

Contents

Model Questions

Kindly Check the 20 Model Questions in the end of this module for Prelims Examinations.

Basic Facts about Universe

The universe is all of *space, time, matter, and energy* that exist. Universe is not just space, but space is just the framework or the scaffolding in which the universe exists. As Space and time are intimately connected in a four-dimensional fabric called space-time.

Age of Universe

The universe is *not infinitely old*. According to modern astronomical measurements, the universe began to exist about 13.7 billion years ago.

Size of Universe

It has not yet been scientifically determined exactly how large the universe is. It may indeed be infinitely large, but we have no way yet to confirm this possibility scientifically.

Cosmic Horizon

The *farthest limit to our viewing is called the cosmic horizon*, which is about 13.7 billion light-years away in every direction. Everything within that cosmic horizon is called the observable universe.

Structure of Universe

The structure of the universe—as opposed to the structure of matter in the universe— is determined by the shape of space. The shape of space is, surprisingly, curved.

On a very large scale—millions or even billions of light-years across—space has a three-dimensional "saddle shape" that mathematicians refer to as "negative curvature".

Big Bang Theory

According to the Big Bang theory, the universe began to exist as a single point of space-time, and it has been expanding ever since. As that expansion has occurred, the conditions in the universe have changed—from small to big, from hot to cold, and from young to old—resulting in the universe we observe today.

Big Bang theory developed as independent works on Einstein's General Theory of relativity by Willem de Sitter (1917), Alexander Friedmann (1922), Georges Lemaître (1927), Robertson, and Walker.

In 1929, Edwin Hubble analyzed and concluded that the galaxies are drifting apart. This became one of the cornerstone of the Big Bang theory.

Big Bang theory remains a theory as of now. The key evidences to Big Bang theory include *expansion of universe* and the *cosmic microwave background radiation*.

Expansion of the Universe

Universe is expanding but the scientists say that this expansion has not been at same rate all the times. Scientists say that for a very small fraction of second (Planck Time or 10 Scientists say that for a very small fraction of second (Planck Time or 10^{-43} seconds), universe underwent hyperinflationary expansion, which suddenly expanded the diameter of universe by at least a factor of ten billion billion. This is the so called Hyperinflationary model of expansion of universe.

Long after the hyperinflation ended, the expansion returned to an almost-constant rate, slowed down very slightly, and then billions of years ago started speeding up. Right now, the expansion rate of the universe is slowly but surely increasing. *We live in an accelerating universe.*

Cosmic Microwave Background

In the 1960s, astronomers at Bell Telephone Laboratories in USA were testing some of their instruments when the detected an ubiquitous microwave static that came from all directions in the sky. This discovery was later used as a proof to big bang theory.

Cosmic Microwave Background refers to the leftover energy from the hot, early universe that still fills space and permeates the cosmos in every direction.

Hubble Constant

The expansion rate of the universe is called the Hubble Constant in honor of Edwin Hubble (1889–1953). Currently the best measured value of the Hubble Constant is about 73 kilometers per second per megaparsec.

This implies that if a location in space is one million parsecs from another location, then in the absence of any other forces or effects the two locations will be moving apart from one another at the speed of 263,000 kilometers per hour!

Hubble measured the galaxies' Doppler effect—the shift in the observed color of objects moving toward or away from an observer—by mounting a machine called a spectrograph on a telescope. He split the light from distant galaxies into its component parts and measured how far the wavelengths of emitted light shifted toward longer wavelengths.

Doppler Effect Definition

Doppler Effect is named after Christian Johann Doppler (1803–1853). It occurs when a source of sound (or any other wave) is moving toward or away from a listener. If the source is moving toward the listener, the sound wave's wavelength decreases, and the frequency increases, making the sound higher-pitched.

Conversely, if the source is moving away from the listener, the sound wave's wavelength increases, and the frequency decreases, making the sound lower-pitched. The next time a car or train passes by you on the street, listen to the sound it is making as it approaches and then moves away.

Doppler effect for light: Blue shift and Red Shift

When an object emitting light—or any kind of electromagnetic radiation, for that matter— moves toward someone, the wavelength of its emitted light is decreased.

Conversely, when the object moves away, the wavelength of its emitted light is increased.

For visible light, the bluer part of the spectrum has shorter wavelengths, and the redder part of the spectrum has longer wavelengths. Thus, the Doppler effect for light is called a "blue shift" if the light source is coming toward an observer, and a "red shift" if it is moving away. The faster the object moves, the greater the blue shift or red shift.

Black Holes

Each object has its own gravity which depends on its size and mass. The objects which have *highest mass in smallest size* would exert most gravity. The ultimate combination of large mass and small size is called a black hole. A black hole exerts such massive gravitational force that its escape velocity is equal or more than speed of light. The idea came in 18th century that such objects were so small and massive that particles of light could not escape from them and this would be black. When the general theory of relativity was confirmed, scientists started to explore the implications of gravity as the curvature of space by matter. Scientists realized that there could be locations in the universe where space was so severely curved that it would actually be "ripped" or "pinched off." Anything that fell into that location would not be able to leave. This idea of an inescapable spot in space—a hole where not even light could leave—led physicists to coin the term "black hole."

How Black Holes are detected?

One way of finding black holes is to observe the matter moving around in a orbit at much higher speed than expected. By carefully mapping this motion, the third law of Kepler and Newton's law of gravitation can be applied without seeing the actual object at the centre of the orbit.

Another way of finding black holes is to look at them as sources of X-ray radiation. The tremendous gravitational field of the black hole can produce huge amount of light nearby and around itself even if it itself is black. Just as a meteorite or spacecraft gets hot as it enters Earth's atmosphere, the in falling matter gets hot from the frictional drag too, sometimes reaching temperatures of millions of degrees. That hot material glows brightly and emits far more X-ray radiation and radio waves than would normally be expected from such a small volume of space. The scientists search for such small spaces with abonormally high X-Ray radiation to look for black holes.

Types of Black Holes

There are two categories of black holes viz. *low mass* and *super massive* are known to exist, and a third kind (*primordial blank hole*) has been hypothesized but not yet detected.

Low mass / Stellar Black Hole

Stellar black hole or low-mass black hole is found wherever the core of a very massive star (usually 20 or more times the mass of the Sun) has collapsed.

Super massive Black Hole

Super massive black hole is found at the centres of galaxies and is millions or even billions of times more massive than the Sun. Our Galaxy also has a black hole at its centre.

Promordial Black Hole

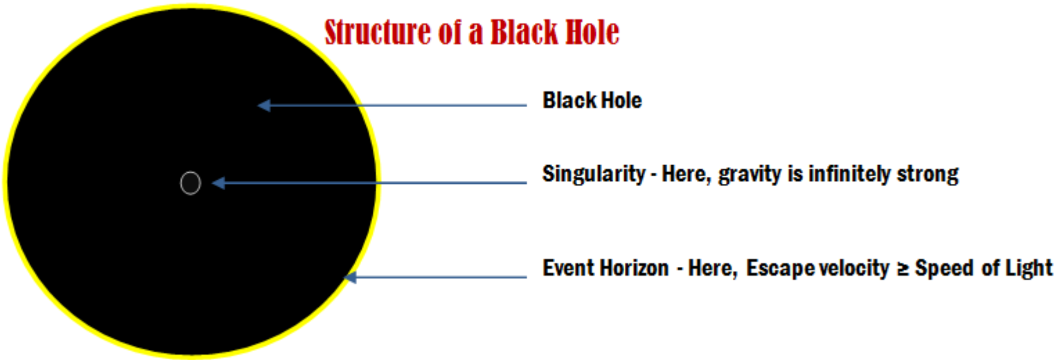
The third kind of black hole called a *primordial black hole* is found at random locations in space. It is hypothesized that these black holes were created at the beginning of cosmic expansion as little "imperfections" in the fabric of space-time. However, no such black hole has yet been confirmed to exist.

How many black holes are known today?

Today, thousands of black holes are known to exist, and the total population of black holes may number in the many billions.

Structure of a Black hole?

The centre of the black hole is called the **singularity**. It is a single point that has no volume but infinite density. The laws of physics as we understand them simply do not work at the singularity of a black hole the way they do in the rest of the universe. Surrounding the singularity is a boundary called the *event horizon.* This is the place of no return, where the escape velocity for the black hole is the speed of light. The more massive the black hole is, the farther the event horizon is from the singularity, and the larger the black hole is in size.



The singularity at the centre of any black hole has no volume. The size of the event horizon however, varies depending on the black hole's mass. The mathematical relationship between the mass of a black hole and the size of its event horizon was derived by the German astrophysicist Karl Schwarzschild (1873–1916), and in his honour, the radius of a black hole's event horizon is called **Schwarzschild radius**.

The Radius of a stellar black holes is few hundred miles while that of super massive black holes is few million to billion miles. Further, if Sun is squeezed small enough to become a black hole; its radius would be around three miles only. If earth is squeezed into a black hole, its radius would be about three-quarters of an inch.

Properties of Black holes

Black holes have huge densities and the key properties they have include mass (weight), rotation (spin) and electric charge.

Wormholes and Cosmic Strings

Wormholes and cosmic strings are theoretical imperfections in space-time. While a Black hole has one point of singularity, the wormhole may have two points – one where matter can only enter and another where matter can only exit. No worm hole has been detected so far, so they are only in theory and science fiction.

A cosmic string is a theoretical, vibrating stand that is like a black hole but instead of being a point or sphere, it is a long but very think crease left in otherwise smooth universe. Cosmic string is also theoretical and no such string has been detected so far.

Dark Matter and Dark Energy

In 1930s, astronomers noticed that in some galaxy clusters, some of the galaxies were moving extra fast than possible with available matter (and its gravitational force). The question was – Is there any matter which is not visible to us but exerts its gravitation responsible for keeping the galaxies put together? Again in 1970s researchers proposed that stars of Andromeda galaxy were moving so fast that there needs to be present some tremendous amount of matter which does not emit any electromagnetic radiation but exerts gravity. Since it does not emit any EM radiation, it's not visible to telescopes and thus is called dark matter. Later, the scientists confirmed that dark matter does exist and is an important constituents of the galaxies and clusters of galaxies and puts them together. Further, it is now estimated that 80% of the matter in universe is dark matter.

The direct observational evidence of the dark matter comes from careful observations of the rotation rate of the galaxies. To scientists, the galaxies appear to be surrounded by a *giant or galactic halo* containing matter capable of exerting gravitational influence but not emitting any observable radiation. Further, it was also indicated that majority of a galaxy's mass lays in this very large halo, which is around 10 times the diameter of the visible galaxy. For example, our own Milky Way galaxy contains about 100 billion stars and it is thought to have been surrounded by a dark matter halo that probably extends out to about 750,000 light-years. The mass of this dark matter halo appears to be about 10 times greater than the estimated mass of all the visible stars in our galaxy.

Dark Energy

Albert Einstein had introduced a mathematical term into his equations to keep a balance between cosmic expansion and gravitational attraction. This term became known as the "*cosmological constant*," and seemed to represent an unseen energy that emanated from space itself.
After Edwin Hubble and other astronomers showed that the universe was indeed expanding, the cosmological constant no longer appeared to be necessary, and so it was not seriously considered again for decades.
Then, starting in the 1990s, a series of discoveries suggested that the "dark energy" represented by the cosmological constant does indeed exist.
Current measurements indicate that the *density of this dark energy throughout the universe is much greater than the density of matter*—both luminous matter and dark matter combined.
Though astronomers have measured the presence of this dark energy, scientists still have no idea what causes this energy, nor they have a clue what this energy is made of.
The quest to understand the cosmological constant in general, and dark energy in particular, is one of the great unsolved questions in astronomy.

Composition of Dark Matter

But nobody has a real idea of what dark matter is and what these galactic halos are made of. However, there are some educated guess works divided into two schools of thoughts. One schools supports MACHOS or **Massive Compact Halo Objects** and another school advocates WIMPs or **Weekly Interacting Massive Particles.** However, no dark matter particle has ever been detected.

Implication of dark matter on shape of universe

- Dark matter in the universe exerts a gravitational pull in the expanding universe. The more dark matter there is in the universe, the more likely it would be that the universe would have a closed geometry, and that the universe would end in a Big Crunch.
- Continued expansion of the universe means that the total amount of dark energy keeps increasing.
- Since the total amount of mass in the universe is not increasing, that means that the expansive effect of dark energy will ultimately overcome the contractive effect of dark matter.
- The more dark energy there is, the more open the geometry of the universe will tend to be, and the faster the expansion rate of the universe will increase over time.

Galaxies

A galaxy is a vast collection of *stars, gas, dust, and dark matter* that forms a cohesive gravitational unit in the universe. In a way, galaxies are to the universe what cells are to the human body: each galaxy has its own identity, and it ages and evolves on its own, but it also interacts with other galaxies in the cosmos.

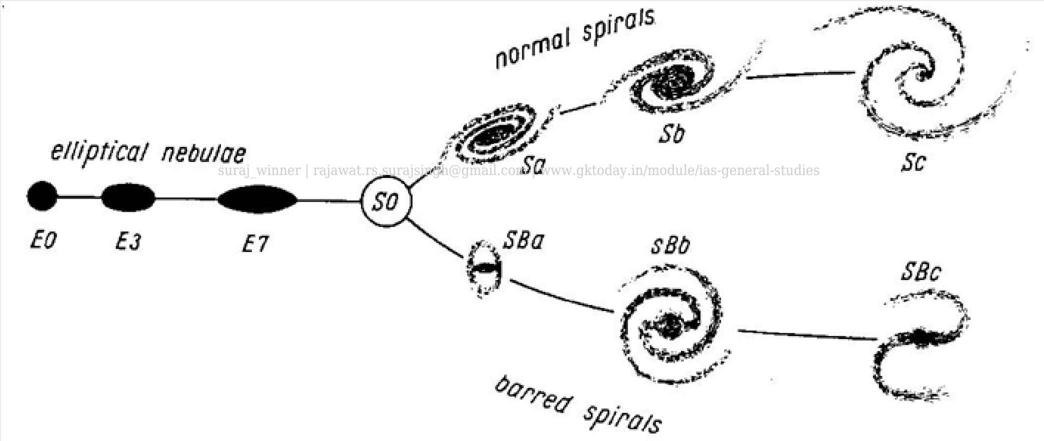
Within the observable universe alone, there exist an estimated 50 to 100 billion galaxies.

Types of Galaxies

Galaxies are of various kinds mainly divided into four types viz. elliptical, normal spirals, barred spirals and irregular.

Hubble Sequence and Tuning Fork Diagram

Hubble had proposed a way to classify galaxies based on their shapes. He proposed a "sequence" of galaxy types: from Eo (sphere-shaped elliptical galaxies) to E7 (cigar-shaped ellipticals), So (lenticular galaxies) to Sa and SBa (spiral galaxies with large bulges and bars), Sb and SBb (spirals with medium-sized bulges and bars), and Sc and SBc (spirals with small bulges and bars). The sequence is known as the Hubble sequence, and it is often shown visually as a Hubble "tuning fork diagram."



Further, an irregular galaxy is a galaxy that does not fit well into the standard categories of elliptical, spiral, or barred spiral galaxies. Two examples of irregular galaxies are the **Large Magellanic Cloud** and **Small Magellanic Cloud**, *which are visible from Earth's southern hemisphere.*

Size of Galaxies

Galaxies range greatly in size and mass. The smallest galaxies contain perhaps 10 to 100 million stars, whereas the largest galaxies contain trillions of stars. There are many more small galaxies than large ones. Our galaxy Milky Way has at least 100 billion stars and is a large galaxy. Its disk spreads around 100,000 light-years across.

Dwarf Galaxy

Dwarf galaxies have the least mass and fewest stars. The *Large Magellanic Cloud*, a *galaxy that orbits the Milky Way*, is considered a large dwarf galaxy; it contains, at most, about one billion stars.

Distribution of Galaxies

Galaxies are distributed unevenly throughout the universe. Majority of galaxies are collected along vast filamentary and sheet like structures many millions of light years long.

These filaments and sheets connect at dense nodes—clusters and super clusters— of galaxies, and the net result is a three-dimensional weblike distribution of matter in the universe. This is known as *Cosmic Web*.

Between the filaments and sheets are large pockets of space with relatively few galaxies; these sparse regions are called *voids.*

Group of Galaxies

Group of Galaxies contains two or more galaxies of bigger size and a dozen or more smaller galaxies. The *Milky Way and Andromeda galaxies are the two large galaxies in the* ***Local Group***. There are a few dozen smaller galaxies in the group, including the **Magellanic Clouds**, the dwarf elliptical **Messier 32,** the small spiral galaxy **Messier 33,** and many small dwarf galaxies. The Local Group of galaxies is a few million light-years across.

Cluster of Galaxies

A cluster of galaxies is a large collection of galaxies in a single gravitational field. Rich clusters of galaxies usually contain at least a dozen large galaxies as massive as the Milky Way, along with hundreds of smaller galaxies. At the center of large clusters of galaxies there is usually a group of elliptical galaxies called "cD" galaxies. Clusters of galaxies are usually about ten million light-years across. The Milky Way galaxy is *near, but not in*, the Virgo cluster, which itself is near the center of the Virgo supercluster.

Supercluster of Galaxies

Superclusters are the largest collections of massive structures. There are usually many clusters of galaxies in a supercluster, or a single very large cluster at its center, along with many other groups and collections of galaxies that are collected in the supercluster's central gravitational field. Superclusters contain many thousands—and sometimes millions—of galaxies. The Milky Way galaxy is located on the outskirts of the Virgo supercluster.

Milky Way Galaxy

The Milky Way is the galaxy we live in. It contains the Sun and 100 to 500 billion other stars. It is a barred spiral galaxy as grouped in the Hubble tuning fork diagram. It is located at the outskirts of the Virgo supercluster. The centre of the Virgo cluster is about 50 million light-years away from Milky Way.

Basic Features of Milkyway

Location of Earth in Milky Way

Earth orbits the Sun, which is situated in the Orion Arm, *one of the Milky Way's spiral arms*. Earth and the Sun are about 25,000 light-years away from the galactic center.

Size of Milky Way

The Stellar disk of the Milky Way is about 100,000 light-years across and 1,000 light-years thick. Based on current measurements, at least 90 percent of the mass in the Milky Way's gravitational field is made up of dark matter, so the luminous stars, gas, and dust of the galaxy are embedded at the center of a huge, roughly spherical dark matter halo more than a million light-years across.

Blackhole at centre of milky way

There is an object at the center of the Milky Way called Sag-A* (Sagittarius A-star) which emits much more X-rays and radio waves than expected for a star-sized body.

After mapping the motions of stars near Sag A* for more than a decade, astronomers concluded that Sag A* is an invisible object that is more than three million times the mass of the Sun. This is a super massive black hole.

Movement of Earth within the Milky Way Galaxy

Earth (and the solar system) is moving through the Milky Way's disk in a stable, *roughly circular orbit* around the galactic center. Our orbital velocity around the center of the Milky Way is about 200 kilometers per second. Even so, the Milky Way is so huge that one complete orbit takes about 250 million years.

Can we see the whole Milky Way?

Much of the galaxy is blocked from our view on Earth due to the barriers created by dusty gas clouds blocking much of the light. Using infrared, microwave, and radio astronomy techniques, it is possible to penetrate much of this dusty fog. However, that too allows us only detect only half of stars and gas.

Neighbours of Milky Way

Milky way galaxy is one of the 54 galaxies in the "Local Group" of galaxies. The Local group itself is a part of a larger group called *Virgo Supercluster*. Virgo super cluster itself is a part of *Laniakea Supercluster*.

Within the local group, three largest galaxies viz. Milky Way, Andromeda and Triangulum have their own system of satellite small galaxies and clouds. For example, the satellite galaxies of Milky way include Sagittarius Dwarf Galaxy, Large Magellanic Cloud, Small Magellanic Cloud, Canis Major Dwarf, Ursa Minor Dwarf etc. Some of those galaxies, such as the Sagittarius dwarf galaxy, are almost in physical contact with the Milky Way's outskirts.

The Andromeda Galaxy (aka. M31) is the closest large galaxy to the Milky Way. It can be seen from earth with naked eyes. This galaxy is considered to be slightly larger than Milky way and *largest galaxy of the local group*.

Important Facts About Andromeda

- In the local cluster, the Andromeda is largest galaxy but may not be most massive. It is thought that Milky way has indeed more dark matter which makes is more massive.
- Andromeda is nearest spiral galaxy from milky way. Both Andromeda and Milky way are approaching each other and it is thought that 4.5 billion years from this time, the Andromeda Galaxy and the Milky Way would collide and would form a giant elliptical galaxy.

Similarities between Andromeda and Milky Way

Both milkyway and Andromeda are *spiral galaxies*, both appear to be of *same age* and both have *similar objects including a massive blackhole at the center*. However, Andromeda is known to have a crowded double nucleus and its spiral arms are getting distorted by gravitational interactions with two satellite galaxies viz. M32 and M110.

Radio Galaxies

Radio galaxies are those ordinary-looking elliptical galaxies in which the radio wave emission far exceeds that of the galaxy's visible light emission.

Large / Small Magellanic Clouds

The Large Magellanic Cloud (LMC) and Small Magellanic Cloud (SMC) are two dwarf galaxies that are satellite galaxies of Milky way and orbit around Milkyway. Both of them are irregular galaxies. Both of them have forming stars at much faster rates than milkyway and so are important for the astronomers studying the formation and aging of stars and galaxies.

Interstellar medium

The interstellar medium is the matter that exists within, between and among the galaxies. Almost all of the interstellar medium is comprised of gas and microscopic dust particles.

Its density is very less, for example, interstellar medium in our region of the Milky Way galaxy has a density of about one atom of gas per cubic centimetre. By contrast, Earth's atmosphere at sea level contains about 1019 gas molecules per cubic centimeter.

Nebula

A nebula is a cloud or collection of interstellar medium in one location in space. Nebulae are produced in different ways. For instance, they can be gathered together by gravity, dispersed by stars, or lit up by a powerful radiation source nearby. Most of these beautiful nebulae contain only a few thousand atoms or molecules per cubic centimetre. This is many times sparser than even the best laboratory vacuum chambers on Earth can achieve.

Types of nebulae

There are different kinds of nebulae based on their appearance {such as dark nebulae, reflection nebulae and planetary nebulae} or the physical processes that create them {such as protostellar nebulae, protoplanetary nebulae, or supernova remnants}.

Dark nebulae

Dark nebulae look like black blobs in the sky. They are generally dark because they contain mainly cold, high-density, opaque gas, as well as enough dust to quench the light from stars behind them. One example of a dark nebula is the **Coal Sack Nebula**.

Reflection nebulae

Reflection nebula **is lit by bright, nearby light sources** because the dust particles in them act like

countless microscopic mirrors, which reflect light from stars or other energetic objects toward Earth. To the human eye, reflection nebulae usually look bluish. This is because blue light is more effectively reflected in this way than red light.

Emission nebulae

An emission nebula is a glowing gas cloud *with a strong source of radiation—usually a bright star*—within or behind it. If the source gives off enough high-energy ultraviolet radiation, some of the gas is ionized, which means the electrons and nuclei of the gas molecules become separated and fly freely through the cloud.

When the free electrons recombine with the free nuclei to become atoms again, the gas gives off light of specific colors. What colors they emit depends on the temperature, density, and composition of the gas. For example the Orion Nebula glows mostly green and red.

Quasar

Quasar refers to quasi-stellar radio source. They were thought to be stars earlier but they are not stars at all, but rather active galactic nuclei. Nowadays, the word "quasar" is often used to mean any Quasi-Stellar Object (QSO), whether or not it emits radio waves.

Stars

A star is a mass of incandescent *gas that produces energy at its core by nuclear fusion.* Most of the visible light in the universe is produced by stars. The Sun is also a star. Stars shine because nuclear fusion occurs in their core. Nuclear fusion changes lighter elements into heavier ones and can release tremendous amounts of energy in the process. Stars are mostly comprised plasma {gas that is electrically charged}. A person with good eyesight can see about 2,000 stars on any given night with naked eye.

Basic Facts About Stars

Asterism and Constellations

A group of stars that make some recognizable shape or pattern is called **Asterism**. Two famous asterism include the Big Dipper {used to locate north star} and Summer Triangle {three of the most prominent stars in the Northern Hemisphere's summer night sky}. A **constellation** is much more complicated asterism, containing more stars or larger areas of the sky. Constellations are mostly named after mythological gods, legendary heroes, creatures, or structures. The constellations encompass the entire celestial sphere and provide a visual reference frame.

Structure in Stars

All **stars** have layers like a **core, radiative zone, convective zone, photosphere, chromosphere,** and **corona**, but in different ratios of thickness depending on the star's temperature, mass, and age. Very hot, young stars can even be completely radiative and have no convective zone; very cool stars, on the other hand, can be completely convective and have no radiative zone.

The coronae around stars can also vary tremendously, depending on the strengths of the magnetic fields around the stars.

Closest stars to Earth

The Sun is the closest star to Earth. It is average 93 million miles / 149.6 million km away from Earth. The *closest star system* to Earth is Alpha Centauri. Nearest start in this system is Proxima Centauri, has been measured to be 4.3 light-years away from Earth. The main star in Alpha Centauri is about 4.4 lightyears away.

Proxima centaury is although closest star to Earth after sun, yet it is very faint. The brightest star as seen from Earth is Sirius or Dog Star, which is in a different constellation called Canis Major. It is 8.58 light years away from Earth.

North Star

The North Star is any star near the spot in the sky called the north celestial pole: the place that Earth's rotational axis is pointing toward.

Right now, and for the past several centuries, Polaris has been very close to the pole, and thus has served as a good north star. Earth's rotational axis changes its pointing location across the sky over the millennia.

Thousands of years ago, while ancient Egyptian culture thrived, the **North Star was a dimmer star called Thuban**. Between then and now, there have been stretches of many centuries when there was no useful North Star at all.

South Star

At present , there is no easily visible star near the south celestial pole. There are many asterisms and celestial objects relatively near the pole, so it is possible to triangulate between them and roughly find the location of the south celestial pole.

Stellar Evolution

Stellar evolution is a complicated process. All stars go through the continuous change and their life cycle is made of immature stage, mature stage and final changes towards end of their lives.

Stars pass through a definite evolutionary sequence, which can be broadly divided into three parts viz. Pre-main sequence, Main sequence and Post-main sequence stages. A star which is currently in its main mature period of its life cycle is called *Main Sequence Star*. Main sequence stars convert hydrogen into helium and are in an equilibrium state. The stars which are not yet in the main sequence are called *pre-main sequence or infant* stars. The stars which have already lived their main sequence life are called *post-main sequence or elderly* stars.

Pre-main sequence phases

Protostar

Birth of any star begins with the gravitational collapse of a giant molecular cloud (nebula) spread across hundreds of light years. When it collapses, the molecular cloud breaks into smaller fragments releasing gravitational potential energy as heat. Its temperature and pressure increases and one of the fragments condenses into a rotating sphere of superhot gas to be known as Protostar. A Protostar is a highly condensed cloud of gases, mainly hydrogen and helium. It continues to grow by accretion of gas and dust from the molecular cloud. However, its further development depends upon its mass. If it is of low mass, it would turn into a **brown dwarf**, while if it is high mass, it would further evolve into **main sequence star**.

Brown Dwarf

A brown dwarf develops from a low mass protostar in which absence of required temperature and pressure leads to no nuclear fusion chain reaction. However, they still have more mass than any of the planets in solar system. They are dim, emit very less visible light and can be found only by using infrared telecopy. Brown dwarfs have been identified lately only after development of infrared telecopy. Now it is assumed that there are so many brown dwarfs out there that they can outnumber all other different types of stars in galaxy. However, still, red dwarfs are considered to be te largest number of stars in galaxy.

Main sequence star

If the protostar is massive and its core temperature is worth starting a proton-proton chain reaction; it would onset its journey to become a main sequence star. Its mass decides which path it would further take. If it is of low mass, it would turn into a red dwarf; if it is intermediate mass, it would turn into a red giant. Both of them would burn for 6-12 trillion years and would end their life as post mains sequence **white dwarf.** However, if it is a higher mass, it would turn into a red giant or blue giant.

Red Dwarf

A red dwarf as discussed above, is a low-mass, main-sequence star, which is hot and massive than brown dwarfs and is capable to sustain proton-proton chain reaction; but is cool and less massive then other stars such as red giants, blue giants etc. The temperature of their photosphere is around 3,000°K. They are small and faint than other stars and have no radiative zone between their core and the convection zone. It is thought that red dwarf stars are in largest population in galaxy among all kinds of stars.

Red Giant

A red giant is also a main sequence star but has a higher mass than red dwarfs. The red dwarfs convert hydrogen into helium via nuclear fusion and over its life, the outward pressure of fusion is balanced against the inward pressure of gravity. However, once the hydrogen is finished off, the fusion would stop and gravity would take lead. This would upset the overall equilibrium of the star

and to re-adjust it. During this readjustment, the star's outer region expands while the core shrinks. Due to the large expansion of the outer shell, the star becomes very big, and its colour changes- to red. However, its core would compress and get tighter and smaller. This contraction increases the temperature at core and reaches at levels where Helium fuses with Carbon and turns into a white dwarf in post main sequence life.

We note that since energy in red giants is spread across large area, they have surface temperature cooler (around 2200-3200°C) and thus are little over half as hot as Sun. They shine in the red part of the spectrum and thus are called red giants.

Similarities and differences between Red Dwarfs and Red Giants

Similarities

- Both are main sequence stars
- Both end their lives as white dwarfs

Differences

- While red dwarf is of low mass, red giant is of intermediate mass
- While red dwarfs sustain hydrogen fusion, red giants go further and result in helium fusion reaction
- While red dwarf has little light emanating from it, red giants are little more radiative.

Yellow Dwarf

A yellow or G-dwarf star has a surface temperature of 5300-6000K and converts hydrogen to helium in its core by nuclear fusion. Sun, Alpha Centauri A etc. are some of the yellow dwarfs. The term yellow is a misnomer because yellow is white {for example Sun would appear white if there was no atmosphere}.

Sun's future as a red giant

Scientists believe that sun, currently a yellow / white dwarf, would deplete its hydrogen in next 5-6 billion years and once that happens – it will start to expand. At its largest size, its photosphere would engulf Venus, mercury and possibly earth. However, this is only a hypothesis. It is argued that when sun loses its hydrogen, it would cause earth and other planets to farther away due to lesser gravity.

Blue Giant

A blue giant big and blue. Such stars are usually **high-mass stars on the main sequence**. Blue giants live for only a million years or so, glowing a million times brighter than the Sun before they blow apart in titanic supernova explosions.

Post-main sequence stars

A giant star phase ends in white dwarfs, nova or super nova depending upon mass and some other factors. S. Chandrasekhar had proposed that only stars that have a certain mass limit would end their life as white dwarfs. He proposed that a star with mass above about 1.4 solar masses would collapse beyond the white dwarf stage and turn into something far denser and more compact. This upper mass limit is today called the Chandrasekhar limit.

Nova and Supernova

These are stars whose brightness increase suddenly by ten to twenty times or more due to a partial or outright explosion in the star. When brightness increases to 20 magnitudes or more, it is called a Supernova.

If the mass of the star is above Chandrasekhar limit, a tremendous explosion occurs at its core giving rise to a supernova. When that happens, it takes only a fraction of a second for the stellar core to collapse into a dense ball about ten miles across. The temperature and pressure becomes almost immeasurably hot and high.

There are two general types of supernovae.

- A Type I supernova is the result of an existing, older white dwarf that gains enough mass to exceed the Chandrasekhar limit, causing a runaway collapse.
- A Type II supernova is produced by a single highmass star whose gravity is so strong that its own weight causes the stellar core to reach a mass beyond the Chandrasekhar limit.

Neutron Star

A supernovae explosion in a star bigger than Sun but not more than twice as big, may leave behind an extremely dense, residual 'core of that star, reaching a density of 10^{14}gms/cm^3, known as Neutron Star. This serves as matter's last line of defense against gravity. In order to stay internally supported as an object and not be crushed into a singularity, the neutrons in the object press up against one another in a state known as *neutron degeneracy*. This state, which resembles the conditions within an atomic nucleus, is the densest known form of matter in the universe.

A neutron star is about as dense as a neutron itself. In other words, it has the density of an object more massive than the Sun, yet it is only about ten miles across. Its density is such that a single teaspoon of neutron star material would weigh about five billion tons!

Pulsar

When a neutron star spins incredibly fast, it forms magnetic field billions of times stronger than Earth's field. This magnetic field interacts with nearby electrically charged matter and can result in a great deal of energy being radiated into space, a process called *synchrotron radiation.*

The slightest unevenness or surface feature on the neutron star can cause a significant "blip" or "pulse" in the radiation being emitted. Each time the neutron star spins around once, a pulse of radiation comes out. Such an object is called a pulsar.

As of now, more than 1,000 pulsars have been found throughout our galaxy. Perhaps the best known one is the *Crab Nebula pulsar*. It is at the center of the Crab Nebula and is a remnant from a supernova that was first observed in 1054 AD.

It pulses once every 33 milliseconds, which shows that the body with the mass of the Sun is spinning more than 30 times per second!

X-Ray Star

An X-ray star emits a great deal of X-ray radiation. X-ray stars may emit thousands of times more X rays than visible light radiation. X-ray stars are almost always binary star systems or multiple star systems. The interaction between the two or more stars in the systems—one of which is usually a compact object like a white dwarf, neutron star, or black hole—is what causes the strong X-ray emission.

Binary Star

A binary star is a pair of stars that are so close together in the sky that they appear to be closely associated with one another.

Some binary stars, called apparent binaries, are merely close together because of our point of view from Earth; they have nothing to do with one another physically.

Black Holes

A black hole is an object With such strong gravitational field that even light cannot escape from its surface. Black holes are formed from neutron stars after the Supernova explosions of big stars.

Factors that influence, how stars will evolve

The most important factor that affects evolution of star is its **initial mass.** On this basis, the stars can be of very low mass (0.01 solar mass), low mass (0.1 solar mass),

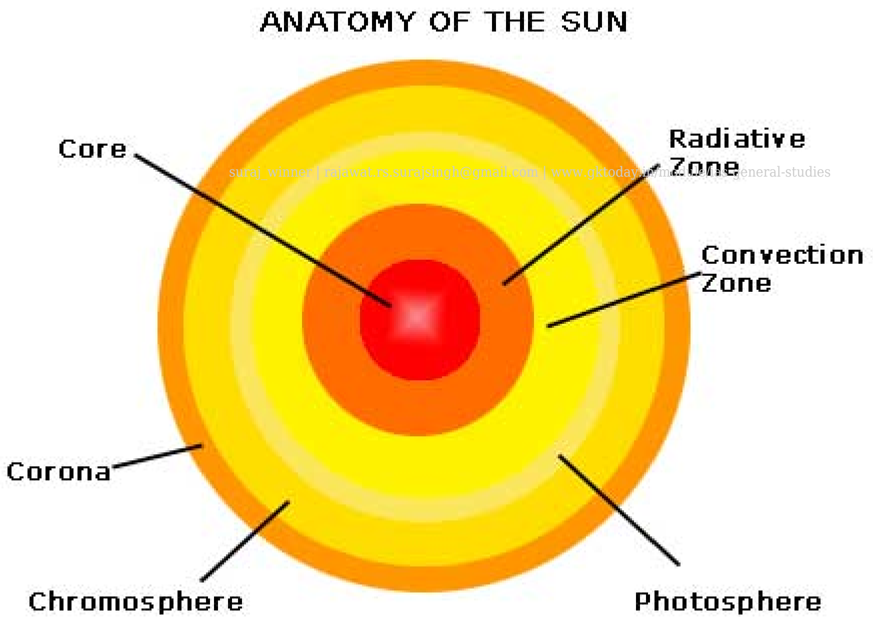
intermediate mass (about 1 solar mass), high mass (about 10 solar masses), and very high mass (up to about 100 solar masses). By this definition, Sun is intermediate mass star. *The more is the mass of the sun, more it spends time in its main sequence and* the hotter it is during its main sequence.

Sun & Solar System

Sun is a star with a diameter of 109 times of earth and a mass of 3.30 lakh times of Earth, roughly accounting for 99.9% of total mass of the Solar system. Sun is mostly made of Hydrogen and Helium and is a *main sequence yellow dwarf*. It was formed some 4.6 billion years ago and is expected to deplete its hydrogen in next 5-6 billion years to turn into a red giant at the end of its life.

Structure of Sun

The Sun has a core at its center; a radiative zone surrounding the core; a convective zone surrounding the radiative zone; a thin photosphere at its surface; and a chromosphere and corona that extends beyond the photospheric surface.



Each of these zones are briefly discussed here:

Core

Solar energy is produced at the core of the sun where temperatures reach 15 million °C by nuclear fusion. This enormous energy makes the sun shine.

Radiative Zone

Energy produced in core slowly rises in the radiative zone outside the core. It takes around one million years for energy to travel out of the radiative zone.

Convection Zone

Convection zone is just beneath the Sun's surface.

Photosphere

Photosphere is the visible surface of Sun where temperature is around 5500°C. This part gives us light, which takes around 8 minutes to reach from sun to earth.

Chromosphere

Chromosphere is a thin layer of gas above the photosphere. Along with Corona, it makes the atmosphere of Sun.

Corona

Corona is a thick layer of gas above chromosphere. It extends millions of kilometers around the sun. Corona and Chromosphere are visible during a total solar eclipse when the sun's surface is completely hidden behind moon.

We note here that Corona is much dimmer than the rest of the Sun, and can only be seen when the Sun is blocked from view—either by a scientific instrument called a coronagraph, or naturally during a solar eclipse. Even though it is thinner than the best laboratory vacuums on Earth and so far away from the Sun's core, the corona is very energetic and very hot, with its plasma reaching temperatures of millions of degrees. The scientists still have not been able to figure out how the corona gets so hot. Current research suggests that the strong electrical currents and magnetic fields in and around the Sun transfer tremendous amounts of energy to the corona, either generally or by special "hotspots" that form for short periods of time and then disappear again.

Composition of Sun

The Sun's mass is composed of 71 percent hydrogen, 27 percent helium, and 2 percent other elements.

In terms of the number of atoms in the Sun, 91 percent are hydrogen atoms, 9 percent are helium atoms, and less than 0.1 percent are atoms of other elements. Most of the stars in the universe have a similar chemical composition.

Mass of Sun

The Sun has a mass of 1.99 million trillion trillion kilograms. The most massive supergiant stars have about one hundred times more mass than the Sun. The least massive dwarf stars and brown dwarfs contain about one-hundredth the mass of the Sun.

Rotation of Sun

Sun rotates about its axis from *west to east*. Since the Sun is not a solid object but rather a big ball of electrically charged gas, it spins at different speeds depending on the latitude.

The Sun spins once around its axis near its equator in about 25 days, and in about 35 days near its north and south poles. This kind of spinning, in which different parts move at different speeds, is called **differential rotation**.

Implications of Sun's Spin

- Magnetic fields in the Sun, created by strong electric currents, are produced because of the Sun's spin.
- Since Sun has differential rotation, and its interior roils with tremendous heat and energy, the magnetic field lines in the Sun get bent, twisted, knotted, and even broken; sunspots, prominences, solar flares, and coronal mass ejections are the result.

Formation of Solar System

The solar system is thought to have developed by the so called nebular hypothesis {given by Simon de Laplace}. About 4.6 billion years ago, the Sun formed from a large cloud of gas and dust that collapsed upon itself because of gravitational instability. When the Sun was born, not the entire nebula of gas and dust that had been gravitationally gathered was incorporated into the Sun itself. Some of it settled into a disk of orbiting material. As this material orbited in a protoplanetary disk, numerous collisions between the tiny grains led to some of the grains sticking together, making larger bodies. After millions of years, the largest bodies—planetesimals—had sufficient mass (and hence gravity) to start attracting other objects in the disk to them.

Growing larger and larger, these planetesimals became protoplanets; the largest protoplanets grew larger still, until at last the planets were formed.

Although the solar wind has removed much of the remaining, unprocessed gas and dust, numerous smaller objects (and some of the gas and dust, as well) still remain today, providing the rich variety of objects and phenomena in a solar system more than four and a half billion years later.

Size of Solar System

Solar system reaches out to the orbit of the most distant planet, Neptune, or about five billion kilometers away from the Sun. Beyond Neptune is the Kuiper Belt, a thick, doughnut-shaped cloud of small icy bodies that extends to about eight billion miles (12 billion kilometers). Beyond Kuiper belt is the Oort Cloud, which is a huge, thick, spherical shell thought to contain trillions of comets and comet-like bodies. The Oort Cloud may extend as far as a light-year out from the Sun.

Thus, Solar system is generally divided into five major zones:

1. the inner (or terrestrial) planet zone,
2. the asteroid belt,
3. the outer (or gas giant) planet zone,
4. the Kuiper Belt, and the
5. Oort Cloud.

There is no exact boundary for these zones, however, and their sizes are not well determined; there is also overlap, in the sense that objects from one zone often appear in another zone.

Planets

A planet is an object which is not a star {i.e. no nuclear fusion takes place in it} and that orbits around a star and is mostly round because its own gravitational pull has shaped it into more or less a sphere. As per current scientific classification, the planets must satisfy three basic criteria as follows:

- A planet must be in *hydrostatic equilibrium* which implies a balance between the inward pull of gravity and the outward push of the supporting structure. Objects in this kind of equilibrium are almost always spherical or very close to it.
- A *planet's primary orbit must be around the Sun*. That means objects like the Moon, Titan, or Ganymede, are not planets, even though they are round due to hydrostatic equilibrium, because their primary orbit is around a planet.
- A planet *must have cleared out other, smaller objects in its orbital path*, and thus must be by far the largest object in its orbital neighbourhood. Due to this condition, Pluto is not considered a planet {but a dwarf planet}, even though it meets the other two criteria; there are thousands of Plutinos in the orbital path of Pluto, and it crosses the orbit of Neptune, which is a much larger and more massive object.

As per the current system, there are eight planets in the solar system—Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune—and a number of dwarf planets, including *Pluto, Charon, Ceres, Eris* etc.

Planetary Rings

A planetary ring is a system of huge numbers of small bodies—ranging in size from grains of sand to house-sized boulders—that orbit in a coherent ring-shaped pattern around a planet.

The most spectacular planetary rings in the solar system orbit around Saturn; they are more than 170,000 miles across, and are less than one mile thick.

Inner Planets/ Terrestrial Planets

The planets that are collectively thought of as belonging to the inner solar system are **Mercury, Venus, Earth, and Mars**. These four objects are called the terrestrial planets because they resemble one another (specifically, Earth) in their structure: a metallic core, surrounded by a rocky mantle and thin crust.

There are three moons in the terrestrial zone as well: Earth's moon, and the two moons of Mars: Phobos and Deimos.

Outer Planets / Gas Giants

Gas giant planets are so named because they are much larger than the terrestrial planets and they have atmospheres so thick that the gas is a dominant part of the planets' structure. Jupiter, Saturn, Uranus, and Neptune are all categorized as gas giants.

The gas giant zone is the part of the solar system roughly between the orbit of Jupiter and the orbit of Pluto. It contains the outer (gas giant) planets Jupiter, Saturn, Uranus, and Neptune. Each of the gas giant planets has a host of moons and rings or ringlets.

Important Facts About Planets

Mercury

At 58 million kilometers distance, Mercury is closest planet to Sun. Due this much proximity, mercury's orbit is very much stretched into a *long elliptical shape*. Other important facts about mercury are as follows:

- Mercury takes 88 Earth days to complete one revolution around sun, however, it takes 59 Earth days to complete one rotation.
- It's surface is covered with deep craters, separated by plains and huge banks of cliffs.
- Mercury's most notable surface feature is an ancient crater called the **Caloris Basin**, which is a huge pit for such a small planet.
- Mercury's very thin atmosphere is made primarily of *sodium, potassium, helium, and hydrogen.*
- On its day side (the side facing the Sun), temperatures reach 430°C ; on its night side, the heat escapes through the negligible atmosphere, and temperatures plunge to -170°C.

- Mercury is so close to the Sun, the glare of the Sun makes it difficult to observe Mercury from Earth. Mercury is therefore visible only periodically, when it is just above the horizon, for at most an hour or so before sunrise and after sunset.
- It also moves more quickly across the sky than the other planets. Even when Mercury is visible, the sky is often so bright that it is hard to distinguish it from the background sky. **TH**
- NASA's Mercury-orbiting probe, **Messenger,** has confirmed a vast amount of ice at the north pole on Mercury, the closest planet to the Sun. Mercury's north pole is always in shadows. The South pole is also believed to harbor ice but there is little data to support it.
- Messenger which was launched in 2004 orbits much closer to the north pole than the south.

Venus

Venus is similar to Earth in many ways and is closer in distance to Earth than any other planet, and it has a similar size and composition. Key facts about Venus are as follows:

- A Venus year is equal to 225 days while a Venus day is equal to 243 days. Thus, a day on Venus is longer than a year.
- Venus rotates on its polar axis backwards compared to Earth, so a Venus sunrise occurs in the west and sunset in the east.
- Venus is blanketed by a thick atmosphere nearly 100 times denser than Earth; it is made mostly of carbon dioxide, along with some nitrogen and trace amounts of water vapor, acids,

and heavy metals. No terrestrial life is possible on Venus.

- Venus's clouds are laced with poisonous sulphur dioxide, and its surface temperature is 500°C. *Interestingly, this is even hotter than Mercury, which is much closer to the Sun.* These hostile conditions are because of a runaway greenhouse effect on Venus.
- Since Venus is closer to the Sun than Earth, it is never up in the sky at midnight. Rather, Venus is visible in the sky either just after dark or just before sunrise, depending on the season, so it is called Morning or Evening Star.
- Further, due to highly reflective clouds on Venus, its albedo is much higher and it looks as third brightest object in the sky, after the Sun and the Moon.
- Through a small telescope, it is possible to see Venus undergo phases, just like the Moon. This occurs because, from our point of view on Earth, we see only the parts of Venus that are illuminated by sunlight at any given time. However, unlike the Moon, though, Venus is usually brighter to our view in its crescent phase than in its full phase.
- The magnetic field of Venus is *far* weaker than that of Earth because it is assumed that the core of Venus is less convective and may have already solidified.

Mars

Mars is known as the red planet because it looks red from Earth. The reddish color comes from the *high concentration of iron oxide compounds*—that is, rust—in the rocks of the Martian surface. Some key facts about Mars are as follows:

- Martian year is of 687 days and Martian day is 24h 37m.
- Martian atmosphere is very thin—only about 7000th the density of Earth's atmosphere. The atmosphere is mostly carbon dioxide, with tiny fractions of oxygen, nitrogen, and other gases.
- At the equator, during the warmest times of the Martian summer, the temperature can reach nearly –18°C at the poles, during the coldest times of the Martian winter, temperatures drop to -85°C and beyond.
- Mars is known for fascinating geologic features on its surface; it is covered with all sorts of mountains, craters, channels, canyons, highlands, lowlands, and **even polar ice caps.**
- Scientific evidence strongly suggests that once, billions of years ago, Mars was much warmer than it is now, and was an active, dynamic planet.

Polar Ice Caps on Mars

- Polar Ice Caps were first observed by Italian astronomer Gian Domenico Cassini, who is known for many important discoveries, including a gap in Saturn's rings (This is called Cassini division).
- He made detailed observations of Mars, and discovered light-colored patches at the Martian

north and south poles. These polar caps showed seasonal variations, spreading during the Martian winter and shrinking during the summer.

- Martian polar ice caps are made up mostly of frozen carbon dioxide {dry ice.}. Some frozen water, or just plain ice, may also be embedded within the polar caps.
- Due to the atmospheric conditions on the surface of Mars, however, neither the ice nor the dry ice would melt to make water or liquid carbon dioxide when the temperatures go up; rather, they would sublimate, or turn directly into gas. Thus, polar ice caps on Mars are not a source of liquid water.

Geological features of Mars

- Mars has a rich variety of geological features: huge craters, broad plains, tall mountains, deep canyons, and much more, all with colorful names.
- The tallest mountain in the solar system, the extinct volcano Olympus Mons, rises 24 kilometers above the Martian surface.
- A massive canyon called the ***Vallis Marineris*** (Mariner Valley) cuts across the northern hemisphere of Mars for more than 3,200 kilometers; it is three times deeper than the Grand Canyon, here on Earth.

- On the southern hemisphere of Mars is **Hellas,** an ancient canyon that was probably filled with lava long ago and is now a large, light area covered with dust.

Martian meteorite ALH84001

- ALH84001 was so named because it was found in the *Allan Hills region of Antarctica in 1984* . It is the most famous of a number of meteorites that are thought to have been pieces of the Martian surface millions of years ago.
- They were probably knocked loose by a powerful collision from a comet or asteroid, which sent pieces of rock into orbit around the Sun that later landed on Earth.
- Mars Exploration Rovers, *Spirit* and *Opportunity,* are geological robots that have explored several areas of Mars. Among the many discoveries made with them are minerals that form only in the long term presence of water; microscopic *mineral structures nicknamed "blueberries" that only form when moisture is present,* along with chemical and isotopic ratios in Martian rocks that would have formed only if liquid water were in the environment.
- The strong scientific conclusion is that Mars is currently dry on its surface, but that this was not always the case. It may even have been awash with liquid water billions of years ago.

Moons of Mars – Phobos and Deimos

Phobos and Deimos are irregularly shaped rocky objects. They look very much like asteroids. Phobos is about 10 miles across, and Deimos is about half that size.

Phobos and Deimos look like small asteroids. The proximity of Mars to the asteroid main belt, suggests that they were indeed once asteroids whose orbits took them close to Mars. The orbital conditions were just right for Mars to capture them with its gravity, causing them to enter into stable orbits around Mars.

Jupiter

Jupiter is the largest planet in solar system, twice as massive as all the other planets, moons and asteroids in solar system put together. More than 90 percent of Jupiter's mass consists of swirling gases, mostly hydrogen and helium; in this incredibly thick, dense atmosphere, *storms of incredible magnitude rage and swirl.* The largest of these storms is the **Great Red Spot**, which is often visible from Earth through even a small telescope.

Other notable facts about Jupiter are as follows:

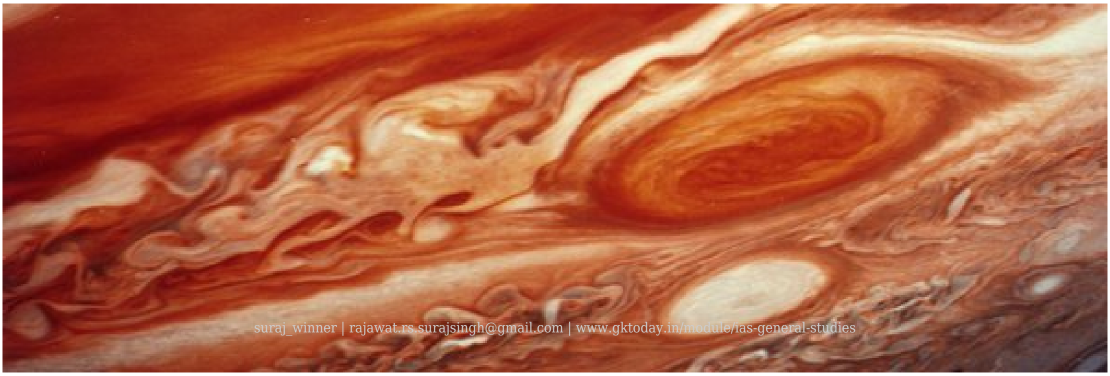
- A day on Jupiter is only 9 hours 56 minutes which makes it fastest rotating planet / body in solar system.
- Jupiter is 1,300 times Earth's volume and 320 times Earth's mass.
- Jupiter has a rocky core made of material thought to be similar to Earth's crust and mantle. Around this core, in these extreme conditions, it is likely that a thick layer of compressed hydrogen is present; the hydrogen in this layer probably acts like metal, and may be the cause of Jupiter's intense magnetic field, which is five times greater than even that of the Sun.
- As of now , there are 67 known moons of Jupiter; may of which are only a few miles across. However, four of them—*Io, Europa, Ganymede, and Callisto*—are about the size of Earth's Moon or larger.

Atmosphere of Jupiter

- Jupiter's upper atmosphere is composed of about 88–92% hydrogen and 8–12% helium by percent volume or fraction of gas molecules.
- There are also traces of carbon, ethane, hydrogen sulfide, neon, oxygen and sulphur. The outermost layer of the atmosphere contains crystals of frozen ammonia.

The Great Red Spot at Jupiter

The Great Red Spot on Jupiter is a huge windstorm more than 14,000 kilometers wide and 26,000 kilometers long. The storm that perpetuates the Spot is apparently powered by the upwelling of hot, energetic gases from deep inside Jupiter's atmosphere which produce winds that blow counter clockwise around the Spot at 400 kilometers per hour. Its red colour may be because of Sulphur or Phosphorus. Beneath it are three white, oval areas; each is a storm about the size of the planet Mars. There are thousands of huge and powerful storms on Jupiter, and many of them can last for a very long time.



Great Red Spot has been going on for at least 400 years, and which was first studied by Galileo Galilei, remains the biggest and most visible Jovian storm yet recorded.

Jupiter is the archetypal gas giant planet—so much so that gas giants are often called Jovian planets.

Rings of Jupiter

Jupiter has several very faint rings. They are nothing like Saturn's enormously developed and beautiful rings, but they can be detected through careful observations with instruments like the Hubble Space Telescope.

Possible Impacts of Jupiter on life on Earth?

Some astronomers believe that Jupiter helps Earth to remain habitable because it protects Earth from some comets, which in absence of Jupiter would have collided with Earth. The gravity of Jupiter slings these fast moving ice balls out of solar system before they can get closer to Earth. The scientists observed in 1994 a comet Shoemaker-Levy 9 breaking into several fragments and crashing on to Jupiter's atmosphere.

However, this theory has a negative side also. Sometimes, Jupiter can also divert a comet more towards earth. For example, in 18th century, a Comet Lexell had streaked past Earth at a distance of only one million miles. It had passed close to Jupiter which diverted it straight towards Earth, but somehow it missed earth.

Important Moons of Jupiter

Io – the most geologically active body in solar system

Io, the closest of the Galilean moons to Jupiter, is affected so strongly by the gravitational tides exerted on it by Jupiter and the other moons that it is the most geologically active body in our solar system. The *Voyager* spacecraft first detected huge volcanoes spewing lava and ash into space, and the surface is completely recoated with fresh lava every few decades.

Impact of Jupiter on its Io – Io Torus

- Jupiter's tremendous gravitational influence on its surroundings causes tidal activity on the Galilean moons.
- The tides alternately stretch and compress the cores of these moons.
- Another important influence exerted by Jupiter on its moons comes from the giant planet's magnetic field.
- Jupiter spins so fast, and contains so much mass, that the magnetic field generated by it engulfs the nearby moons and bathes them with ionization and charged particles.
- Meanwhile, powerful volcanoes that erupt on the surface of Io eject large amounts of small particles into space; many of them are swept up into Jupiter's magnetosphere, forming a doughnut-shaped torus of volcanic particles that form an ethereal envelope around the Jovian environment. This is called Io torus.

Europa

- Europa is the second closest to Jupiter of the four Galilean moons. Its surface is covered with frozen water ice.
- Studies by the *Galileo* spacecraft show that the ice has been moving and shifting much the same way that densely packed ice behaves on Earth's polar oceans.

Ganymede

Ganymede is the largest moon in the solar system, about one-and-a-half times as wide as Earth's Moon. It has a very thin atmosphere and its own magnetic field.

Calisto

Callisto, the furthest away from Jupiter of the four Galilean moons, is scarred and pitted by ancient craters. Its surface may be the oldest of all the solid bodies in the solar system.

Saturn

Saturn is similar to Jupiter, although about one-third the mass. A day on Saturn is only 10 hours and 39 minutes long; it spins so fast that its diameter at the equator is 10 percent larger than its diameter from pole to pole. However, its day is longer than that of Jupiter.

Saturn has a solid core likely made of rock and ice, which is thought to be many times the mass of Earth. Covering this core is a layer of liquid metallic hydrogen, and on top of that are layers of liquid hydrogen and helium. These layers conduct strong electric currents that, in turn, *generate Saturn's* *powerful magnetic field.*

Saturn's Moons

Saturn has 62 confirmed moons, and its largest moon is Titan, which is larger than Earth's own moon and has a thick, opaque atmosphere.

Saturn's Ring System

The most spectacular part of Saturn is its magnificent system of planetary rings, which stretch some 300,000 kilometers across. The ring system is divided into three main parts: the bright A and B rings and the dimmer C ring. There are many other fainter rings as well.

- The A and B rings are divided by a large gap called the Cassini Division, named after Gian Domenico Cassini.
- Within the A ring itself is another division, called the **Encke Gap** after Johann Encke, who first found it in 1837.
- Although these gaps appear to be completely empty, they are nonetheless filled with tiny particles, and, in the case of the Cassini Division, dozens of tiny ringlets.
- Although Saturn's rings measure more than 100,000 miles across, they are only about a mile or so (one or two kilometers) thick. That is why they sometimes seem to disappear from view on Earth. When the orbit of Saturn is such that we see the rings edge-on, the rings look like a thin line and can be nearly invisible.

One idea about formation of Rings is that the rings were once larger moons that were destroyed, either by collisions, or by tidal interactions with Saturn's gravity tearing them apart. The bits of moons then settled into orbit around Saturn.

Moons of Saturn

Saturn has 62 confirmed moons. Also like Jupiter, many of these are small moons that are likely to be asteroids captured in Saturn's gravitational field.

Mimas

- Mimas, the victim of a huge cratering collision long ago, looks almost exactly like the fictional "Death Star" space station from the movies.
- Mimas has a diameter of 396 kilometers. It is the smallest known body in the solar system that became round because of its own gravitation.

Enceladus

- Enceladus was recently (2005) detected as having geysers of water shooting out from its surface, suggesting the presence of liquid water deep in its core.
- Enceladus is one of only three outer Solar System bodies (along with Jupiter's moon Io and Neptune's moon Triton) where active eruptions have been observed.
- The craters of Enceladus have been named Alibaba and Alladin.

Titan

- Titan is largest moon of Saturn and perhaps the most complex moon in the entire solar system. This is the only moon in solar system with a dense atmosphere.

Uranus

Uranus is the seventh major planet in our solar system, and the third of four gas giant planets. It is 51,200 kilometers in diameter, just under four times the diameter of Earth.

- Like the other gas giant planets, Uranus consists mostly of gas. Its pale blue-green, cloudy atmosphere is made of 83 percent hydrogen, 15 percent helium, and small amounts of methane and other gases.
- *Uranus gets its color because the methane in the atmosphere absorbs reddish light and reflects bluish-greenish light*. Deep down below its atmosphere, a slushy mixture of ice, ammonia, and methane is thought to surround a rocky core.
- Although it orbits the Sun in a perfectly ordinary, near-circular ellipse every 84 Earth years, Uranus has an extremely odd rotation compared to the other major planets. It rotates on its side, almost like a bowling ball rolling down its lane, and its polar axis is parallel rather than perpendicular to its orbital plane.

This means that one end of Uranus faces the Sun for an entire half of its orbit, while the other end faces away during that time. So one "day" on Uranus is equal to 42 Earth years. Uranus is orbited by some 27 known moons and several thin rings.

Neptune

Neptune is the eighth major planet in our solar system, 17 times more massive than Earth and about four times its diameter.

- The most remote of the four gas giant planets in our solar system, Neptune takes 165 Earth years to orbit the Sun once.
- A "day" on Neptune, however, is only 16 Earth hours.
- Similar to Uranus, Neptune's cloud-top temperature is a frosty –210°C

Neptune is bluish-green in color, which might seem fitting for a planet named after the Roman god of the sea. However, the color does not come from water; it is due to the gases in Neptune's atmosphere reflecting sunlight back into space. Neptune's atmosphere consists mostly of hydrogen, helium, and methane. Below the atmosphere, scientists think there is a thick layer of ionized water, ammonia, and methane ice, and deeper yet is a rocky core many times the mass of Earth.

Kuiper Belt

Kuiper Belt or the **Kuiper-Edgeworth Belt** is a doughnut-shaped region that extends between about three to eight billion miles (5 to 12 billion kilometers) out from the Sun (its inner edge is about at the orbit of Neptune, while its outer edge is about twice that diameter).

Kuiper Belt Objects

Kuiper Belt Objects (KBOs) are objects that originate from or orbit in the Kuiper Belt.

Only one KBO was known for more than 60 years: Pluto.

Largest KBOs in solar system: (Diameter: km)

Eris	2300-2400
Pluto	2,306
Sedna	1,500
Quaoar	1,260
Charon	1,210
Orcus	940
Varuna	890
Ixion	820
Chaos	560
Huya	500

Many KBOs have been discovered since 1990s, however, and the current estimate is that there are millions of KBOs.

KBOs are basically comets without tails, i.e. icy dirtballs that have collected together over billions of years. If they get large enough—such as Pluto did—they evolve as other massive planet like bodies do, forming dense cores that have a different physical composition than the mantle or crust above it. Most short-period comets— those with relatively short orbital times of a few years to a few centuries—are thought to originate from the Kuiper Belt.

Plutinos

Plutinos are Kuiper Belt Objects that are smaller than Pluto, have many physical characteristics similar to Pluto, and orbit around the Sun in much the same way that Pluto does.

The discovery of Plutinos led to the recognition that the Kuiper Belt is heavily populated, and that Pluto itself is a Kuiper Belt Object.

Asteroids

Asteroids are relatively small, primarily rocky or metallic chunks of matter that orbit the Sun. They are like planets, but much smaller; the largest asteroid, Ceres, is only about 930 kilometers across, and only ten asteroids larger than 250 kilometers across are known to exist in the solar system. While most asteroids are made mostly of carbon-rich rock, some are made at least partially of iron and nickel.

Aside from the largest ones, asteroids tend to be irregular in shape, rotating and tumbling as they move through the solar system.

The four largest asteroids are the dwarf planet Ceres, Pallas, Vesta, and Hygiea. Other well-known asteroids include Eros, Gaspra, Ida, and Dactyl.

Asteroid belt

The asteroid belt (or the "main belt") is the region between the **orbit of Mars and the orbit of Jupiter**—about 240 to 800 million kilometers away from the Sun.

The vast majority of known asteroids orbit in this belt. The main belt itself is divided into thinner belts, separated by **object-free zones called Kirkwood Gaps**. The gaps are named after the American astronomer Daniel Kirkwood, who first discovered them.

Even though there are at least a million or more asteroids in the main belt, the typical distance between asteroids is huge—thousands or even millions of miles.

Asteroids located other than Asteroid Belt

There are many asteroids in other regions of the solar system. Chiron, for example, which was discovered in 1977, orbits between Saturn and Uranus.

Another example is the **Trojan asteroids** that follow the orbit of Jupiter near Lagrange points—one group preceding the planet, the other following it—and can thus orbit safely without crashing into Jupiter itself.

2010TK7 : Earth's Trojan Satellite

It was discovered in 2010 that Earth is not alone in its orbit around the Sun. There is a small 'Trojan' asteroid 2010TK7 that sits in front of earth and leads it. This is the 1st Trojan Asteroid of Earth discovered using the WISE Telescope. It has now become the First known Trojan Asteroid in Earth's Orbit.

A Trojan asteroid shares an orbit with a larger planet or moon, but does not collide. So a Trojan has a particular position in a stable spot – either in front of a planet or behind it called Lagrangian points. Because the asteroid and planet are constantly on the same orbit, they can never collide. Trojan asteroids were anticipated in earth's orbit but never discovered yet. Nasa discovered the asteroid, which lies 80 million km from Earth, using its Widefield Infrared Survey Explorer (WISE) telescope. Astronomers have long thought that Earth did have Trojans but their discovery has proved elusive because they can't be seen in daylight.

Origin of Asteroids

The origin of asteroids remains the subject of scientific study. Astronomers today think that most asteroids are planetesimals that never quite combined with other bodies to form planets.

Some asteroids, on the other hand, may be the shattered remains of planets or protoplanets that suffered huge collisions and broke into pieces.

Number of Asteroids

Many thousands of asteroids are being tracked regularly, and tens of thousands have been identified and catalogued. At least one million asteroids are estimated to exist; of those, astronomers estimate that about one in ten can be observed from Earth.

Comets

Comets are basically "**snowy dirtballs" or "dirty snowballs**"—collections of rocky material, dust, and frozen water, methane, and ammonia that move through the solar system in long, **highly elliptical orbits** around the Sun.

When they are far away from the Sun, comets are simple, solid bodies; but when they get closer to the Sun, they warm up, causing the ice in the comets' outer surface to vaporize. This creates a cloudy "coma" that forms around the solid part of the comet, called the "nucleus."

The loosened comet vapor forms long "tails" that can grow to millions of miles in length.

The English astronomer Edmund Halley (1656–1742) calculated the paths travelled by 24 comets recorded by astronomers over the years. Among these, he found that three—one visible in 1531, one in 1607, and one that Halley himself had observed in 1682—had nearly identical flight paths across the sky. This discovery led him to the conclusion that comets follow in an orbit around the sun, and thus can reappear periodically.

In 1695 Halley had predicted that a comet which has been seen thrice would return 76 years after its last sighting, in the year 1758. Unfortunately, Halley died before he could see that he was, indeed, correct. The comet was named in his honor, and to this day Halley 's Comet remains the best-known comet in the world. It last passed by Earth in 1986, and will return again in 2062.

Origin of Comets

Most of the comets that orbit the Sun originate in the *Kuiper Belt or the Oort Cloud*, two major zones in our solar system beyond the orbit of Neptune.

"Shortperiod comets" usually originate in the Kuiper Belt.

Some comets and comet-like objects, however, have even smaller orbits; they may have once come from the Kuiper Belt and Oort Cloud, but have had their orbital paths altered by gravitational interactions with Jupiter and the other planets.

Comet Shoemaker-Levy 9

The encounter between Comet Shoemaker-Levy 9 and the planet Jupiter was the first collision between solar system bodies ever directly observed by humans.

As the comet approached Jupiter in 1994, it broke up into a long chain of fragments. Astronomers observed with amazement in July 1994 as these fragments crashed, one by one, into the gas giant's thick atmosphere.

Meteorite and meteors

A meteorite is a large particle from outer space **that lands on Earth.** They range in size from a grain of sand on up. Around 30 thousand meteorites have been recovered in recorded history; about 600 of them are made primarily of metal, and the rest are made primarily of rock. A meteor is an object from outer space that enters Earth's atmosphere, **but does not land on Earth**. Instead, the particle burns up in the atmosphere, leaving a short-lived, glowing trail that traces part of its path through the sky. If a meteor is large enough to reach Earth, we call it a meteorite.

Sources of Meteors and Meteorites

Most meteors, especially those that fall during meteor showers, are *the tiny remnants of comets left in Earth's orbital path over many, many years*. Most meteorites, which are generally larger than meteors, *are pieces of asteroids and comets that somehow came apart from their parent bodies*—perhaps from a collision with another body—and orbited in the solar system until they collided with Earth.

Meteor Showers

Every Year the **Perseid meteor shower** happens in August, as Earth travels through the remnant tail of Comet 109P/Swift-Tuttle. In November, when earth moves through the remnants of Comet 55P/Tempel-Tuttle, it causes **Leonid meteor shower**.

Types of Meteorites

There are two main categories of meteorites: **stony and metallic**.

- Each category is further subdivided into more detailed groups with similar characteristics.
- **Vestoids**, for example, are all thought to have come from the asteroid Vesta, where, long ago, a powerful collision created shattered bits of Vesta that have been orbiting the solar system ever since.
- **Chondrites** are one kind of stony meteorite; they are often the oldest meteorites.
- Another category, the **pallasites**, have fascinating mixtures of stony and metallic material. Pallasites probably originated from boundary areas in larger asteroids, where rocky mantles were in physical contact with metallic cores.

Cosmic Rays

Cosmic rays are invisible, high-energy particles that constantly bombard Earth from all directions. Most cosmic rays are protons moving at extremely high speeds, but they can be atomic nuclei of any known element. They enter Earth's atmosphere at velocities of 90 percent the speed of light or more. The cosmic rays were discovered by Victor Franz Hess , who got interested in a mysterious radiation that scientists had found in the ground and in Earth's atmosphere. This radiation could change the electric charge on an electroscope even when placed in a sealed container. In 1912 Hess took a series of high-altitude, hot-air balloon flights with an electroscope aboard. He made ten trips at night, and one during a solar eclipse, just to be sure the Sun was not the source of the radiation. Hess found that the higher he went, the stronger the radiation became. This discovery led Hess to conclude that this radiation was coming from outer space. For his work on understanding cosmic rays, Hess received the Nobel Prize in physics in 1936.

Source of Cosmic Rays

A continuous stream of electrically charged particles flows from the Sun; this flow is called the solar wind. So, a fraction of cosmic rays originate **from** the Sun, but the Sun alone cannot account for the total flux of cosmic rays onto Earth's surface.

The source for the rest of these cosmic rays remains mysterious. Distant supernova explosions could account for some of them; another possibility is that many cosmic rays are charged particles that have been accelerated to enormous speeds by interstellar magnetic fields.

All of us are being struck by cosmic rays all the time, however, at Earth ordinarily, they have no deleterious effect on our health. If we go beyond Earth's magnetosphere, cosmic rays can cause potentially more damage to your body's cells and systems.

Model Question Answers for Prelims

Astronomy Model Questions for Prelims

1. Which among the following are the sources of Cosmic microwave background radiation?

1. Stars
2. Galaxies
3. Pulsars

Choose the correct option from the codes given below:

[A] Only 1 & 2

[B] Only 3

[C] Only 2 & 3

[D] None of the 1, 2 or 3

Answer: [D] None of the 1, 2 or 3

Just after the birth of the universe, the atmosphere was extremely dense and glowing white hot. Through the ages, the universe has been cooling — a process that is still going on. Light waves from a very distant part of the early universe reached the earth, making it possible to see the glow. However, since the universe is still expanding, the frequency of the waves of visible light changes to microwave frequency. This occurs due to the relative motion of either the source or receiver of the waves or both, with respect to each other. These waves, originating in the early stage of the cosmos, are cosmic microwaves. Cosmic microwave background radiation is not associated with any star, galaxy, or other object. This glow is strongest in the microwave region of the radio spectrum. The CMB's serendipitous discovery in 1964 by American radio astronomers Arno Penzias and Robert Wilson was the culmination of work initiated in the 1940s, and earned them the 1978 Nobel Prize.

2. With reference to the birth and death of stars, consider the following general observations:
1. The fate of a star after its nuclear fuel burns out, depends on the mass it was born with
2. When the star exhausts its nuclear fuel, gravity causes it to collapse & shrink
3. White dwarfs are one of the densest forms of matter in the universe, next only to black holes
Which among the above observations is / are correct?

[A] Only 1

[B] 1 & 2

[C] 1, 2 & 3

[D] 2 & 3

Answer: [C] 1, 2 & 3

The fate of a star after its nuclear fuel burns out depends on the mass it was born with. Stars with a

lot of mass become neutron stars or black holes. A low- or medium-mass star (less than about five times the solar mass, Ms) will become a white dwarf. When such sun-like medium-mass stars are generating energy by nuclear fusion of hydrogen in their cores, there is a delicate balance between gravity that pulls the star matter inward and the pressure of hot gas in the core that pushes outward. When the star exhausts its fuel, gravity wins and the star begins to collapse, resulting in a dense object called white dwarf, which is about as massive as the sun but only slightly bigger then the earth. Its density is about 200,000 times that of the earth. White dwarfs are one of the densest forms of matter in the universe, next only to black holes. (Frontline)

3. With reference to the recent developments in Astronomy, the Kepler Object of Interest (KOI) refers to ___:

[A] Earth Like Planets

[B] Dwarf Planets

[C] Stars located in Goldilocks Zones

[D] Potentially Hazardous Objects

Answer: [A] Earth Like Planets

4. With reference to the Milky way galaxy, which among the following statements is / are correct?
1.The Milky Way is a member of the Virgo super cluster

2.The two most massive members of the Virgo super cluster are the Milky Way and the Andromeda Galaxy

Choose the correct option from the codes given below:

[A] Only 1

[B] Only 2

[C] Both 1 & 2

[D] Neither 1 nor 2

Answer: [A] Only 1

A galaxy is a group of large number of stars in the sky which have generally the same origin of evolution, such as our Milky Way. A galaxy may contain billions of stars. A cluster of galaxies, which may have up to 10 or even more galaxies is called a local group. Clusters of galaxies are known as a super galaxy, or a super cluster. This may have up to 50 or even 1,000 galaxies. The Milky Way is a member of the Virgo super cluster. However, before that its is a part of smaller "Local group". Local Group is the group of galaxies that includes Earth's galaxy, the Milky Way. The group comprises more than 54 galaxies (including dwarf galaxies), with its gravitational center located somewhere between the Milky Way and the Andromeda Galaxy. The galaxies of the Local Group cover a 10 million light-year diameter and have a binary (dumbbell) shape. This group itself is part of the Virgo Supercluster. Thus second statement is not correct. Virgo Supercluster contains the Virgo Cluster in addition to the Local Group, which in turn contains the Milky Way and Andromeda galaxies. At least 100 galaxy groups and clusters are located within its diameter of 33 megaparsecs. It is one of millions of superclusters in the observable Universe.

5. Several reasons have been cited with reference to the inability of the Mars to sustain life. What is / are those reasons?

1.Mars has no magnetosphere

2.The atmosphere of Mars is very thin

3.Mars is well beyond habitable zone of solar system

4.Mars has no water, water ice and oxygen

Choose the correct option from the codes given below:

[A] Only 1 & 2

[B] Only 1, 2 & 3

[C] Only 2, 3 & 4

[D] Only 1 & 3

Answer: [A] Only 1 & 2

The first two statements are correct. The lack of a magnetosphere and extremely thin atmosphere of Mars are a challenge: the planet has little heat transfer across its surface, poor insulation against bombardment of the solar wind and insufficient atmospheric pressure to retain water in a liquid form (water instead sublimates to a gaseous state). Mars is also nearly, or perhaps totally, geologically dead; the end of volcanic activity has apparently stopped the recycling of chemicals and minerals between the surface and interior of the planet. The current understanding of planetary habitability—the ability of a world to develop and sustain life—favors planets that have liquid water on their surface. This most often requires that the orbit of a planet lie within the habitable zone, which for the Sun currently extends from just beyond Venus to about the semi-major axis of Mars. During perihelion Mars dips inside this region, but the planet's thin (low-pressure) atmosphere prevents liquid water from existing over large regions for extended periods. The past flow of liquid water demonstrates the planet's potential for habitability. Some recent evidence has suggested that any water on the Martian surface may have been too salty and acidic to support regular terrestrial life. The 4th statement is not correct because presence of water ice as well as traces of oxygen have been reported at Mars.

6. With reference to the Kuiper Belt, consider the following statements:

1. No planet of solar system is located in Kuiper Belt
2. In comparison to asteroid belt, the bodies found in Kuiper Belt are generally large
3. Haumea and Makemake are dwarf planets located in Kuiper Belt

Which among the above statements is / are correct?

[A] Only 1 & 2

[B] Only 2 & 3

[C] Only 1 & 3

[D] 1, 2 & 3

Answer: [C] Only 1 & 3

The Kuiper belt is a region of the solar system beyond the planets, extending from the orbit of Neptune. It is similar to the asteroid belt, although it is far larger — 20 times as wide and 200 times as massive. Like the asteroid belt, it consists mainly small bodies or remnants from the solar system's formation. The Kuiper belt objects are composed largely of frozen volatiles (termed 'ices'), such as methane, ammonia and water. It is home to at least three dwarf planets — Pluto, Haumea and Makemake. Pluto, discovered in 1930, is considered its largest member.

7. Which among the following is / are Jovian Planets?

1. Jupiter

2. Mars
3. Saturn
4. Venus

Choose the correct option from the codes given below:

[A] Only 1 & 3

[B] Only 1 & 2

[C] Only 1, 3 & 4

[D] 1, 2, 3 & 4

Answer: [A] Only 1 & 3

Jovian planets, also known as gas giants, is a collective term for Jupiter, Saturn, Uranus and Neptune. The term Jovian came from planet Jupiter, which describes the other gas giants in our solar system which are like Jupiter. These planets are surrounded by a number of moons and rings and their rotation is faster than terrestrial planets. Jovian planets have a dense core surrounded by a huge layer of gas which is made up of hydrogen and helium.

8. Pluto is considered to be a dwarf planet and not a planet. What could be the possible explanation to this?

[A] It is not in an orbit around the Sun

[B] It is not massive enough to be sphere by its own gravitation

[C] It makes a two system body with Neptune

[D] It has not cleared its neighbouring region of small bodies

Answer: [D] It has not cleared its neighbouring region of small bodies

According to current definitions, objects in orbit around the Sun are classed dynamically and physically into three categories: planets, dwarf planets and small Solar System bodies. A planet is any body in orbit around the Sun that has enough mass to form itself into a spherical shape and has cleared its immediate neighborhood of all smaller objects. By this definition, the Solar System has eight known planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Pluto does not fit this definition, as it has not cleared its orbit of surrounding Kuiper belt objects. A dwarf planet is a celestial body orbiting the Sun that is massive enough to be rounded by its own gravity but has not cleared its neighbouring region of planetesimals and is not a satellite. By this definition, the Solar System has five known dwarf planets: Ceres, Pluto, Haumea, Makemake, and Eris.Other objects may be classified in the future as dwarf planets, such as Sedna, Orcus, and Quaoar. Dwarf planets that orbit in the trans-Neptunian region are called “plutoids”.The remainder of the objects in orbit around the Sun are small Solar System bodies.

9. As per the current theory, whether a collapsing star would become a white dwarf or a black hole, is decided by __:

1.Mass of star

2.Temperature of star

3.Position of the star in a galaxy

Choose the correct option from the codes given below:

[A] Only 1

[B] 1 & 2

[C] 1 & 3

[D] 1, 2 & 3

Answer: [A] Only 1

The collapse of a star is a natural process that occurs when all stellar energy sources are exhausted. If the mass of the collapsing part of the star is below a certain critical value, the end product is a compact star, either a white dwarf or a neutron star. But if the collapsing star has a mass exceeding this limit, the collapse will continue forever and form a black hole and astronomers believe that any collapsing star with solar mass above 0.7 will form a black hole.

10. With reference to the Cosmic rays, which among the following statements is / are correct?

1.They are made up of only positively charged particles

2.The major source of Cosmic Rays in universe is Sun

3.They cause Ozone Depletion

Choose the correct option from the codes given below:

[A] Only 1 & 2

[B] Only 2 & 3

[C] Only 3

[D] 1, 2 & 3

Answer: [C] Only 3

The first statement is incorrect. Almost 90% of cosmic rays are protons, about 9% are helium nuclei (alpha particles) and nearly 1% are electrons. This means that Cosmic Rays are not made up of only positively charged particles. The second statement is also incorrect. Cosmic rays may broadly be divided into two categories: primary and secondary. The cosmic rays that originate from astrophysical sources are primary cosmic rays; these primary cosmic rays interact with interstellar matter creating secondary cosmic rays. Sun is not the major source but exactly is a minor source. The Sun also emits low energy cosmic rays associated with solar flares. The third statement is correct. The chain of reactions in the upper atmosphere due to the cosmic rays causes depletion of the ozone but this depletion is small in comparison to the depletion caused by CFCs.

11. With reference to the astronomical bodies, what is the difference between Blue Galaxies and Red Galaxies?

[A] Blue Galaxies are those which are moving towards earth, while Red Galaxies are those which are moving away from earth

[B] Blue Galaxies are those which are still actively making new stars, while Red Galaxies are those which have stopped making new stars

[C] Blue Galaxies are those which rotate clockwise as seen from earth, while Red Galaxies are those which rotate anti-clockwise as seen from earth

[D] Blue Galaxies are those which have a black hole at their center, while Red Galaxies are those which have no black hole at their centre

Answer: [B] Blue Galaxies are those which are still actively making new stars, while Red Galaxies are those which have stopped making new stars

12. Which among the following planets are called "Superior Planets"?

1. Venus
2. Mars
3. Jupiter
4. Saturn

Select the correct option from the codes given below:

[A] Only 1, 2 & 3

[B] Only 2, 3 & 4

[C] Only 2 & 3

[D] Only 3 & 4

Answer: [B] Only 2, 3 & 4

The planets closer to the sun than the earth, namely Mercury and Venus, are called the inferior planets. The planets located at a distance greater than the distance of the earth from the sun are called the superior planets. Mars, Jupiter, Saturn, Uranus and Neptune are superior planets.

13. With reference to the solar system, consider the following statements:

1. All planets except Venus revolve around the sun in the same direction i.e. from west to east
2. The direction of rotation of planets on their axis is also the same as the direction of their revolution around the sun

Which among the above is / are correct statements?

[A] Only 1

[B] Only 2

[C] Both 1 & 2

[D] Neither 1 nor 2

Answer: [D] Neither 1 nor 2

All of the planets move around the Sun in a direct (eastward) direction, but three of them (Venus, Uranus and Pluto) rotate in a retrograde (westward) direction, and are said to have a retrograde rotation. Do not confuse revolution, or motion around an orbit, with rotation, or turning about an axis.

14. The scientists use Red shift of distant galaxies as an evidence for which of the following?

1. Expansion of the universe
2. Existence of Black holes
3. Existence of Dark Energy

Select the correct option from the codes given below:

[A] Only 1

[B] Only 2 & 3

[C] Only 1 & 3

[D] 1, 2 & 3

Answer: [C] Only 1 & 3

Redshift occurs when light sources move away from the observer. If all the galaxies in the universe are moving away from us, that's evidence that the universe is expanding.
The evidence that black holes exist is their gravitational effects on visible objects near them, not redshift.
Redshift—specifically, increasing redshift, has been used as an evidence for **dark energy.**
On the other hand, anomalous rotation curves in galaxies, not redshift is linked to dark matter.

15. Stars pass through a definite evolutionary sequence. With this reference, which among the following is a correct order?

[A] Red giant, Nova, Supernova, White Dwarf

[B] White dwarf, Nova, Super Nova, Neutron Star

[C] Neutron star, Pulsar, Red Giant, White dwarf

[D] Nova, Supernova, White Dwarf, Red Giant

Answer: [A] Red giant, Nova, Supernova, White Dwarf

Stars pass through a definite evolutionary sequence.

Protostar

The first step in the formation of a star from gases is the Protostar. Protostar is formed by the gravitational contraction of gases present in the Galaxy. A Protostar is a highly condensed cloud of gases, mainly hydrogen and helium.

Red Giants

Second stage is Red Giants. The continued Nuclear fusion upset the overall equilibrium of the star and to readjust it star's outer region expands while the core shrinks. Due to the large expansion of the outer shell, the star becomes very big, and its colour changes- to red.

Third Novae and Supernovae

A giant star phase may end in a Novae/

Supernovae stage. These are stars whose brightness increase suddenly by ten to twenty magnitudes or more due to a partial or outright explosion in the star. When brightness increases to 20 magnitudes or more, it is called a Supernovae.

White dwarfs

A Novae/Supernovae explosion in a small star like our Sun (stars lighter than 1 .2 solar mass) may leave behind a very dense core of that state. A star of this size cools and contracts to become a White Dwarf.

Neutron star

A supernovae explosion in a star bigger than Sun but not more than twice as big, may leave behind an extremely dense, residual 'core of that star, reaching a density of 10^{14} gms/cm^3, known as Neutron Star.

Pulsar

A spinning neutron star emits radio waves and is called a Pulsar

Black Holes

A black hole is an object With such strong gravitational field that even light cannot escape from its surface. Black holes are formed from neutron stars after the Supernova explosions of big stars.

16. Consider the following:

1. Asteroid Belt
2. Kuiper Belt
3. Oort Cloud

Which among the following is the correct sequence of their increasing distance from Sun?

[A] 1, 2, 3

[B] 1, 3, 2

[C] 2, 1, 3

[D] 3, 1, 2

Answer: [A] 1, 2, 3

The Kuiper Belt is a doughnut-shaped ring, extending just beyond the orbit of Neptune from about 30 to 55 AU. The Oort Cloud is a spherical shell, occupying space at a distance between five thousand and 100 thousand AU. Thus, both of them are beyond the orbit of Neptune. The first mission to the Kuiper Belt is New Horizons of NASA. We note here that New Horizons is expected to reach Pluto in July 2015 before possibly heading farther into the Kuiper Belt.

17. Consider the following objects of the solar system:

1. Planets
2. Comets
3. Asteroids

Which among the above have elliptical orbits?

[A] Only 1

[B] Only 1 & 2

[C] Only 1 & 3

[D] 1, 2 & 3

Answer: [D] 1, 2 & 3

All planets, comets and asteroids in our solar system have elliptical orbits. Thus, they all have a closest and a farthest point from the Sun- a perihelion and an aphelion.

18. Which among the following decide decides whether a collapsing star would become a white dwarf or a black hole?

1. Mass
2. Temperature
3. Position in a galaxy

Select the correct option from the codes given below:

[A] Only 1

[B] 1 & 2

[C] 2 & 3

[D] 1, 2 & 3

Answer: [A] Only 1

The collapse of a star is a natural process that occurs when all stellar energy sources are exhausted.

If the mass of the collapsing part of the star is below a certain critical value, the end product is a compact star, either a white dwarf or a neutron star. But if the collapsing star has a mass exceeding this limit, the collapse will continue forever and form a black hole and astronomers believe that any collapsing star with solar mass above 0.7 will form a black hole.

19. Studying the ultraviolet images of galaxies is not possible from a telescope on earth. Why?

[A] Human eye cannot see ultraviolet waves

[B] Earth's atmosphere filters out most ultraviolet light

[C] A telescope on earth cannot see that far in space

[D] Cosmic background radiation interferes with ultraviolet signals on earth

Answer: [B] Earth's atmosphere filters out most ultraviolet light

Earth's atmosphere filters most ultraviolet light so NASA's Hubble Space Telescope is helping create the first ultraviolet image of the universe."

20. Kuiper Belt is:

[A] an asteroid belt located between Mars and Jupiter

[B] an elliptical plane located around the sun in the solar system

[C] a region filled with icy bodies located beyond the planet Neptune

[D] a collection of charged particles, gathered in place by Earth's magnetic field

Answer: [C] a region filled with icy bodies located beyond the planet Neptune

Third option is correct.