NICE IAS ACADEMY & UpRise

TNPSC Gr.II Mains – RUDRA 2.0 – Free Course Material

I. Role and impact of Science and Technology in the Development of India and Tamil Nadu

Nature of Universe – Part-I

1. ORIGIN & EVOLUTION OF SOLAR SYSTEM

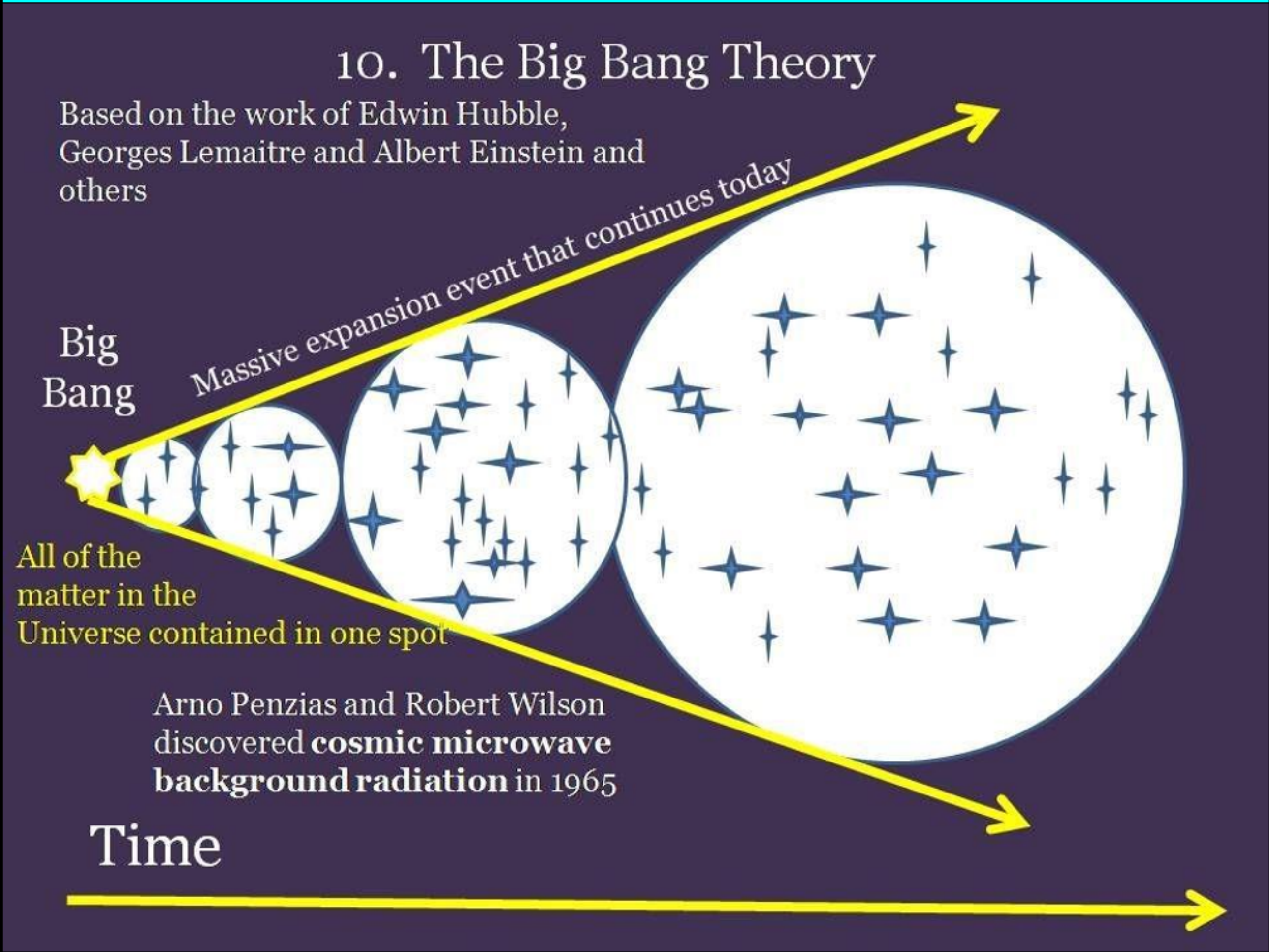
The Big bang theory

- ✓ The most popular argument regarding the origin of the universe is the Big Bang Theory.
- ✓ It is also called **expanding universe hypothesis.**
- ✓ **Edwin Hubble**, in 1920, provided evidence that the universe is expanding.
- ✓ As time passes, galaxies move further and further apart. Similarly, the distance between the galaxies is also found to be increasing and thereby, the universe is considered to be expanding. Scientists believe that though the space between the galaxies is increasing, observations do not support the expansion of galaxies.
- ✓ **The Big Bang Theory considers the following stages in the development of the universe.**

1. In the beginning, all matter forming the universe existed in one place in the form of a "tiny ball" (singular atom) with an unimaginably small volume, infinite temperature and infinite density.

2. At the Big Bang the "tiny ball" exploded violently. This led to a huge expansion. It is now generally accepted that the event of big bang took place 13.7 billion years before the present. The expansion continues even to the present day. As it grew, some energy was converted into matter. There was particularly rapid expansion within fractions of a second after the bang. Thereafter, the expansion has slowed down. Within first three minutes from the Big Bang event, the first atom began to form.

- ✓ Within 300,000 years from the Big Bang, temperature dropped to 4,500K (Kelvin) and gave rise to atomic matter. The universe became transparent.



- ✓ The expansion of universe means increase in space between the galaxies.
- ✓ An alternative to this was Hoyle's concept of steady state. It considered the universe to be roughly the same at any point of time.
- ✓ However, with greater evidence becoming available about the expanding universe, scientific community at present favours argument of expanding universe.

Formation of Galaxies and Stars

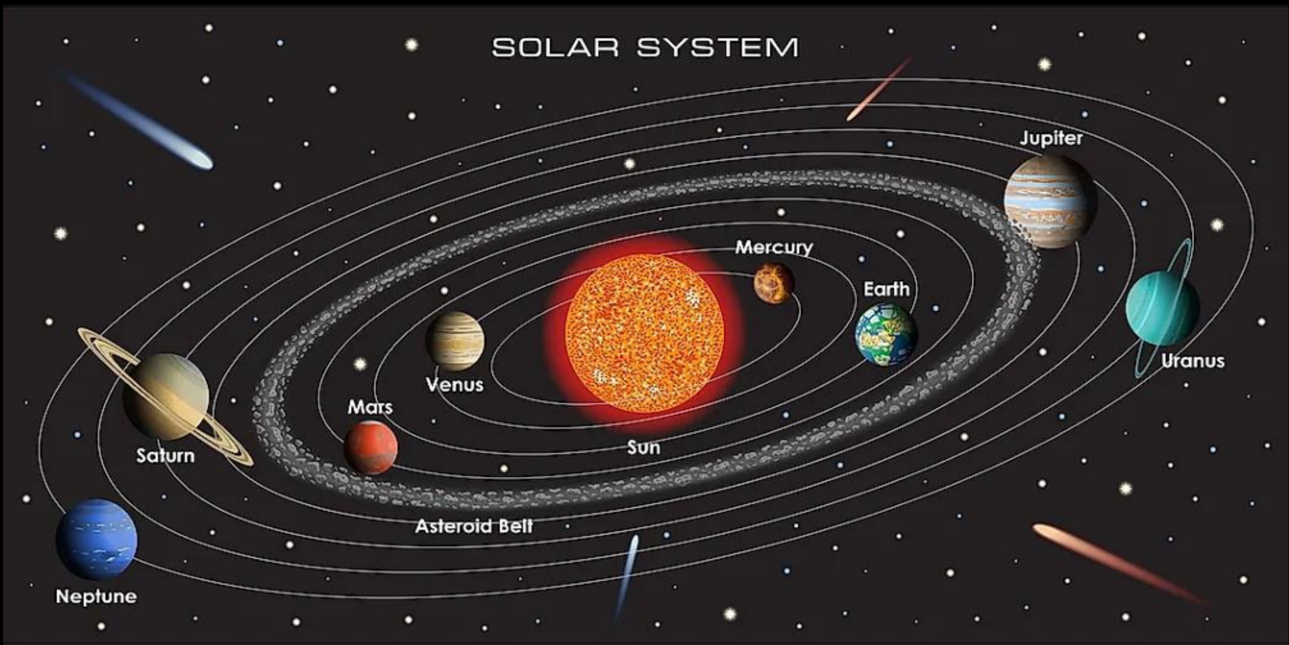
- ✓ The distribution of matter and energy was not even in the early universe.
- ✓ These initial density differences gave rise to differences in gravitational forces and it caused the matter to get drawn together.
- ✓ These formed the bases for development of galaxies.
- ✓ A galaxy contains a large number of stars.
- ✓ Galaxies spread over vast distances that are measured in thousands of light-years.
- ✓ The diameters of individual galaxies range from 80,000-150,000 light years.
- ✓ A galaxy starts to form by accumulation of hydrogen gas in the form of a very large cloud called nebula.

- ✓ Eventually, growing nebula develops localised clumps of gas.
- ✓ These clumps continue to grow into even denser gaseous bodies, giving rise to formation of stars.
- ✓ The formation of stars is believed to have taken place some 5-6 billion years ago.

Formation of Planets

- ✓ The following are considered to be the stages in the development of planets:
  - ➢ The stars are localised lumps of gas within a nebula. The gravitational force within the lumps leads to the formation of a core to the gas cloud and a huge rotating disc of gas and dust develops around the gas core.
  - ➢ In the next stage, the gas cloud starts getting condensed and the matter around the core develops into small rounded objects. These small-rounded objects by the process of cohesion develop into what is called planetesimals. Larger bodies start forming by collision, and gravitational attraction causes the material to stick together. Planetesimals are a large number of smaller bodies.
  - ➢ In the final stage, these large number of small planetesimals accrete to form a fewer large bodies in the form of planets.

Our Solar System



- ✓ Our Solar system consists of eight planets.

- ✓ The nebula from which our Solar system is supposed to have been formed, started its collapse and core formation some time 5-5.6 billion years ago and the planets were formed about 4.6 billion years ago.
- ✓ Our solar system consists of the sun (the star), 8 planets, 63 moons, millions of smaller bodies like asteroids and comets and huge quantity of dust-grains and gases.
- ✓ Out of the eight planets, mercury, venus, earth and mars are called as the inner planets as they lie between the sun and the belt of asteroids the other four planets are called the outer planets.
- ✓ Alternatively, the first four are called Terrestrial, meaning earth-like as they are made up of rock and metals, and have relatively high densities.
- ✓ The rest four are called Jovian or Gas Giant planets. Jovian means jupiter-like.
- ✓ Most of them are much larger than the terrestrial planets and have thick atmosphere, mostly of helium and hydrogen.
- ✓ The difference between terrestrial and jovian planets can be attributed to the following conditions:

  - ➢ The terrestrial planets were formed in the close vicinity of the parent star where it was too warm for gases to condense to solid particles. Jovian planets were formed at quite a distant location.
  - ➢ The solar wind was most intense nearer the sun; so, it blew off lots of gas and dust from the terrestrial planets. The solar winds were not all that intense to cause similar removal of gases from the Jovian planets.
  - ➢ The terrestrial planets are smaller and their lower gravity could not hold the escaping gases.

- ✓ All the planets were formed in the same period sometime about 4.6 billion years ago.
- ✓ Till recently (August 2006), Pluto was also considered a planet. However, in a meeting of the International Astronomical Union, a decision was taken that Pluto like other celestial objects (2003 UB313) discovered in recent past may be called 'dwarf planet'
- ✓ Let us briefly review the conditions on the other seven planets of the solar system.

  - ➢ **Mercury** is closest to the sun. It has a temperature range of 427ºC on its side facing the Sun and – 270ºC, on its dark side. It has no atmosphere.
  - ➢ **Venus** is the closest neighbour of the earth. It is about 40 mk away. It is an extremely hot planet with a temperature of 480ºC. Its atmosphere has 96% carbon dioxide and poisonous gases like sulphur dioxide and carbon monoxide.
  - ➢ **Earth** is the only planet known to sustain life.

- **Mars** is also close to earth. It is called the red planet. It has 95% carbon monoxide and reddish dust. It is relatively a very cold planet and as of now presence of life on it has not been conclusively established.
- **Jupiter** is the largest planet of the solar system. It is mainly a rapidly spinning ball of gas specially clouds of ammonia, and has no solid surface.
- **Saturn** consists mainly of hydrogen and helium. Its atmosphere has 90% nitrogen and a temperature of (-184ºC). It is also made up of hydrogen cyanide which is a highly poisonous gas. It is characterized by a ring that surrounds it.
- **Uranus** is also a very cold planet. Uranus is a distant planet of solar system and 7th in order from the sun. Uranus and Neptune are the outermost planets of the solar system. Uranus has a highly tilted rotational axis.
- **Neptune** is cold and dark with its surface coated with frozen methane.

The Moon

- ✓ The moon is the only natural satellite of the earth.
- ✓ Like the origin of the earth, there have been attempts to explain how the moon was formed.
- ✓ In 1838, Sir George Darwin suggested that initially, the earth and the moon formed a single rapidly rotating body.
- ✓ The whole mass became a dumb-bell-shaped body and eventually it broke.
- ✓ It was also suggested that the material forming the moon was separated from what we have at present the depression occupied by the Pacific Ocean.
- ✓ However, the present scientists do not accept either of the explanations.
- ✓ It is now generally believed that the formation of moon, as a satellite of the earth, is an outcome of '**giant impact**' or what is described as "**the big splat**".
- ✓ A body of the size of one to three times that of mars collided into the earth sometime shortly after the earth was formed.
- ✓ It blasted a large part of the earth into space.
- ✓ This portion of blasted material then continued to orbit the earth and eventually formed into the present moon about 4.44 billion years ago.

Origin of Earth

- ✓ The earth broke off about 4.5 billion years ago with an explosion.
- ✓ It was a burning hot white mass of gas and dust.
- ✓ Over a long period of time, dust and gas gradually condensed to form solid rock.

- ✓ Such condensation and shrinking made the earth heat up so much that the rock melted into a gluey liquid.
- ✓ After millions of years, the outer surface of the earth or the earth's crust cooled and formed hard rock again, just as melted chocolate or wax solidifies upon cooling.
- ✓ The interior of the earth is still very hot.
- ✓ The crust of the earth was formed from cooling and hardening of the molten matter and hot gases.
- ✓ With cooling of the earth the crust hardened and formed the land.
- ✓ Cooling of the earth also condensed water vapour into liquid water filling the depressions to form seas.

Evolution of Earth

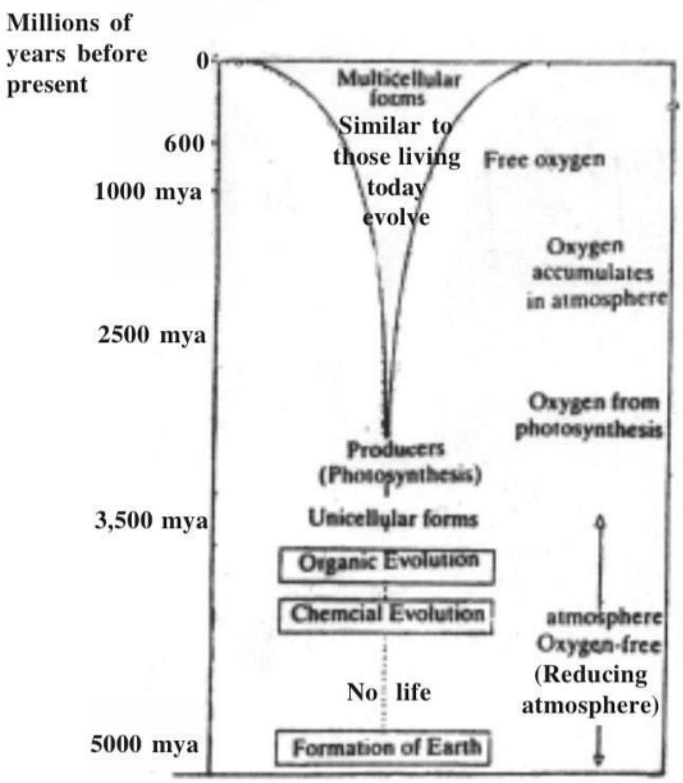


Fig. : Diagrammatic representation of major events of life on earth (mya = millions of years ago)

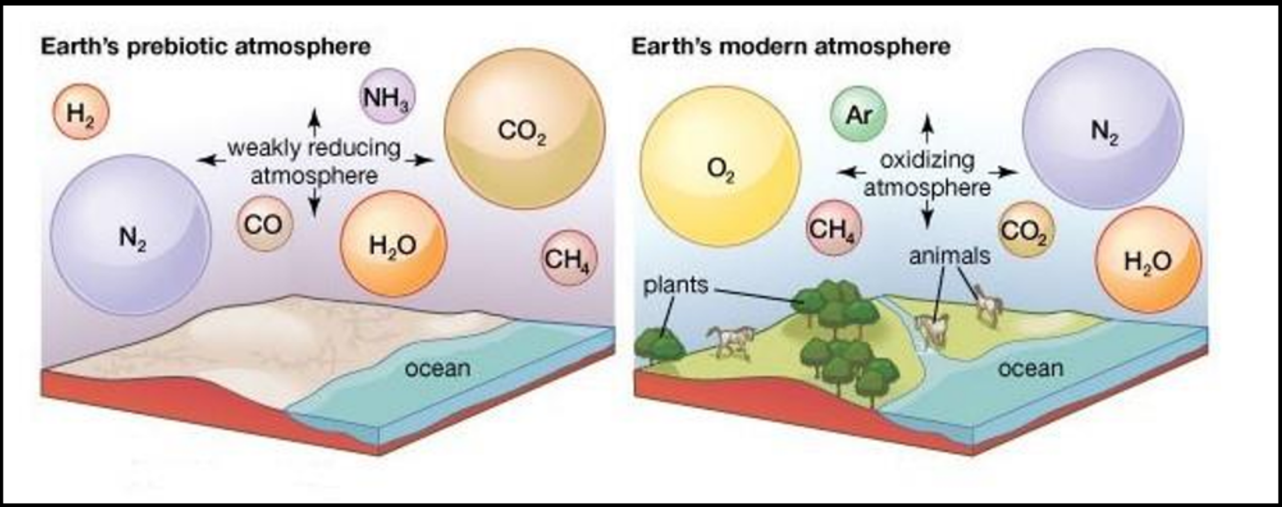
- ✓ The planet earth initially was a barren, rocky and hot object with a thin atmosphere of hydrogen and helium. This is far from the present day picture of the earth.
- ✓ Hence, there must have been some events– processes, which may have caused this change from rocky, barren and hot earth to a beautiful planet with ample amount of water and conducive atmosphere favouring the existence of life.

- ✓ The earth has a layered structure.
- ✓ From the outermost end of the atmosphere to the centre of the earth, the material that exists is not uniform.
- ✓ The atmospheric matter has the least density.
- ✓ From the surface to deeper depths, the earth's interior has different zones and each of these contains materials with different characteristics.

Evolution of Lithosphere

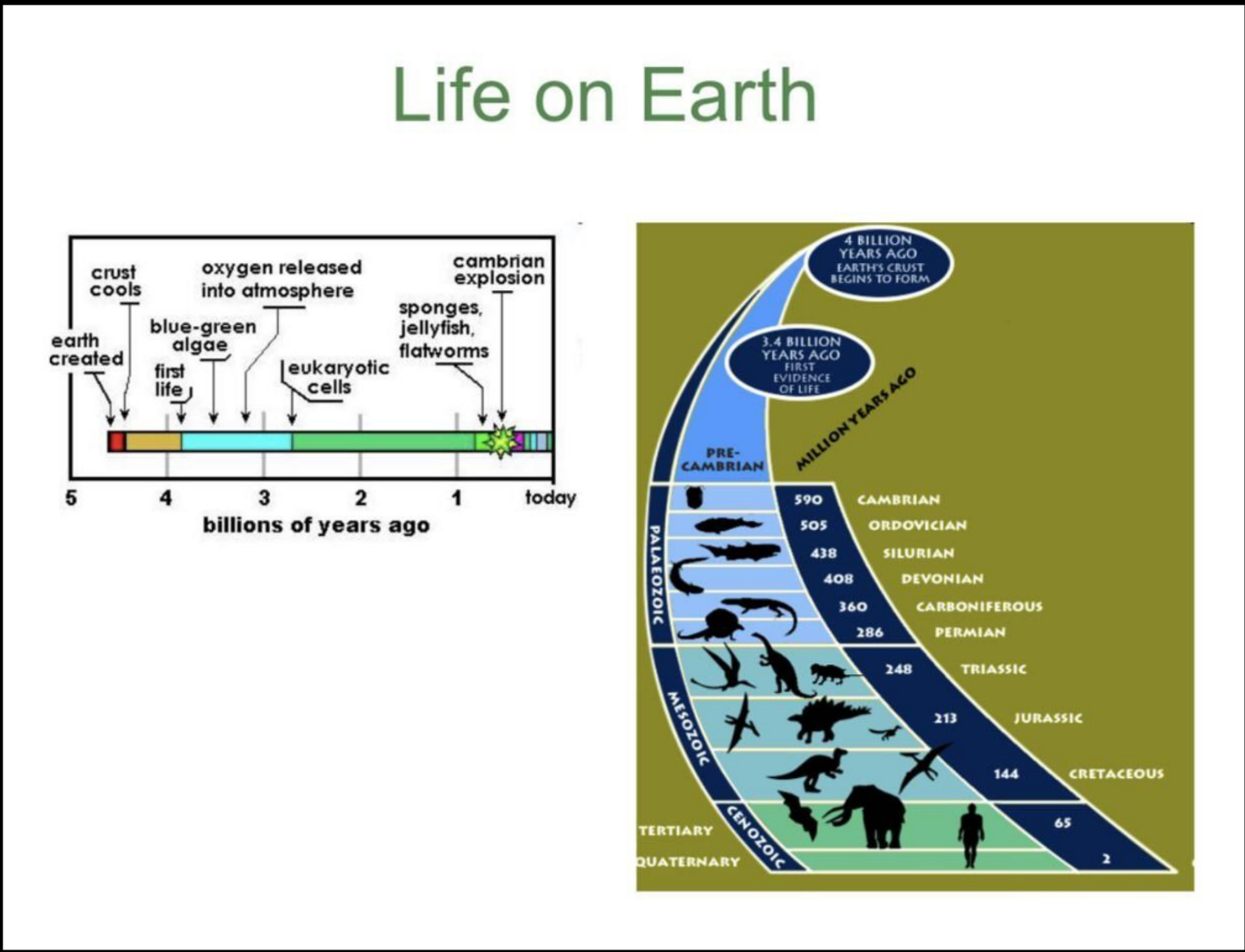
- ✓ The earth was mostly in a volatile state during its primordial stage.
- ✓ Due to gradual increase in density the temperature inside has increased.
- ✓ As a result the material inside started getting separated depending on their densities.
- ✓ This allowed heavier materials (like iron) to sink towards the centre of the earth and the lighter ones to move towards the surface.
- ✓ With passage of time it cooled further and solidified and condensed into a smaller size.
- ✓ This later led to the development of the outer surface in the form of a crust.
- ✓ During the formation of the moon, due to the giant impact, the earth was further heated up.
- ✓ It is through the process of differentiation that the earth forming material got separated into different layers.
- ✓ Starting from the surface to the central parts, we have layers like the crust, mantle, outer core and inner core.
- ✓ From the crust to the core, the density of the material increases.

Evolution of Atmosphere and Hydrosphere



- ✓ The present composition of earth's atmosphere is chiefly contributed by nitrogen and oxygen.
- ✓ There are three stages in the evolution of the present atmosphere.
- ✓ The **first stage** is marked by the loss of primordial atmosphere.
- ✓ In the **second stage**, the hot interior of the earth contributed to the evolution of the atmosphere.
- ✓ Finally, the composition of the atmosphere was modified by the living world through the process of photosynthesis.
- ✓ The **early atmosphere**, with hydrogen and helium, is supposed to have been stripped off as a result of the solar winds.
- ✓ This happened not only in case of the earth, but also in all the terrestrial planets, which were supposed to have lost their primordial atmosphere through the impact of solar winds.
- ✓ During the cooling of the earth, gases and water vapour were released from the interior solid earth.
- ✓ This started the evolution of the present atmosphere.
- ✓ The early atmosphere largely contained water vapour, nitrogen, carbon dioxide, methane, ammonia and very little of free oxygen.
- ✓ The process through which the gases were outpoured from the interior is called degassing.
- ✓ Continuous volcanic eruptions contributed water vapour and gases to the atmosphere.
- ✓ As the earth cooled, the water vapour released started getting condensed.
- ✓ The carbon dioxide in the atmosphere got dissolved in rainwater and the temperature further decreased causing more condensation and more rains.
- ✓ The rainwater falling onto the surface got collected in the depressions to give rise to oceans.
- ✓ The earth's oceans were formed within 500 million years from the formation of the earth. This tells us that the oceans are as old as 4,000 million years.
- ✓ Sometime around 3,800 million years ago, life began to evolve.
- ✓ However, around 2,500-3,000 million years before the present, the process of photosynthesis got evolved.
- ✓ Life was confined to the oceans for a long time.
- ✓ Oceans began to have the contribution of oxygen through the process of photosynthesis.
- ✓ Eventually, oceans were saturated with oxygen, and 2,000 million years ago, oxygen began to flood the atmosphere.

Origin and evolution of Life on Earth



- ✓ In **The Origin of Species, Charles Darwin** (1859) hypothesized that new species arise by the modification of existing ones—that the raw material of life is life. But somehow and somewhere, the tree of life had to take root from nonliving precursors. When, where, and in what form did life first appear? The origin of life is one of the most intriguing, difficult, and enduring questions in science.
- ✓ To begin with, conditions on earth were inhospitable for life.
- ✓ Gases of the primitive atmosphere were primarily methane, ammonia, carbon dioxide and hydrogen.
- ✓ Water vapour filled the atmosphere but there was no free oxygen.
- ✓ It was thus a reducing atmosphere on primitive earth and no life existed.
- ✓ **Biological evolution**– from the simple organisms to complex organisms

  - ➢ As earth cooled, water vapour condensed to form liquid water.
  - ➢ Rains poured to form water bodies on earth.
  - ➢ The molecules of life were formed in the water.

- From the molecules of the life evolved bacteria, the earliest and simplest organisms.
- The oldest fossils of bacteria which were the first living organisms on earth have been found in rocks that are 3-5 billion years old.
- For almost two billion years, different kinds of bacteria lived on earth.
- One of these evolved a green pigment called chlorophyll.
- These chlorophyll-containing bacteria used carbon dioxide and water and released oxygen through photosynthesis and started accumulating in the atmosphere.
- Continued photosynthesis by such bacteria progressively accumulated oxygen in the atmosphere.
- Thus the atmosphere gradually transformed from reducing to oxidizing.
- At one point of time oxygen content in the atmosphere become 21%.
- Such changes served as a big trigger for biological evolution to begin and progress and this led to the invasion of land by living organism.
- As time passed, protists evolved from bacteria.
- Both bacteria and protists are unicellular.
- Then came multicellular organisms, the fungi followed by plants and animals.
- Today the diversity of living organisms is comprised of five kingdoms of life. Monera, Protista, Fungi, Plantae and Animalia.

White Dwarf

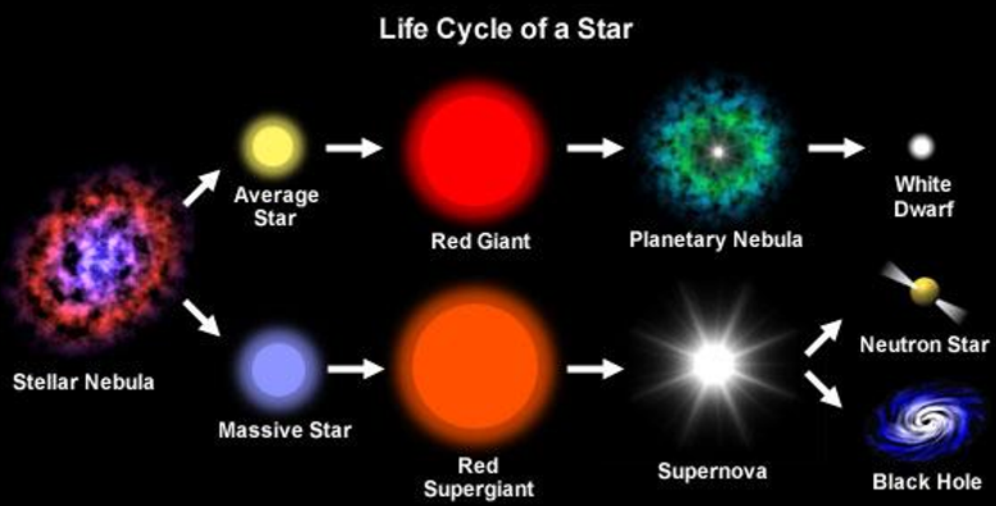
- ✓ Recently, an international team saw **a white dwarf losing its brightness in 30 minutes**, which usually takes a period of several days to months.
- ✓ This peculiarity in brightness of white dwarfs can be referred to as **switch on and off phenomena.**
- ✓ Using the **Hubble Space telescope** and **Transiting Exoplanet Survey Satellite (TESS)**, astronomers have identified several white dwarfs over the years.
- ✓ White dwarfs are **stars that have burned up all of the hydrogen** they once used as nuclear fuel. Such stars have very high density. A typical white dwarf is half the size of our Sun and a surface gravity 1,00,000 times that of Earth.
    - ✓ Stars like our **sun fuse hydrogen in their cores into helium** through **nuclear fusion reactions.**
    - ✓ **Fusion in a star's core produces heat and outward pressure** (they bloat up as enormous red giants), but this pressure is **kept in balance by the inward push of gravity** generated by a star's mass.
    - ✓ When the **hydrogen, used as fuel, vanishes and fusion slows**, gravity causes the **star to collapse in on itself into white dwarfs.**

Black Dwarf

- ✓ Eventually - **over tens or even hundreds of billions of years - a white dwarf cools** until it **becomes a black dwarf, which emits no energy.** Because the universe's oldest stars are only 10 billion to 20 billion years old there are **no known black dwarfs.**
- ✓ It must be noted that **not all white dwarfs cool** and transform into black dwarfs.

Chandrasekhar Limit:

- ✓ Those **white dwarfs which have enough mass reach a level** called the **Chandrasekhar Limit.**
- ✓ At this point the pressure at its center becomes so great that the star will detonate in a **thermonuclear supernova** (explosion).
- ✓ Chandrasekhar Limit is the maximum mass theoretically possible for a stable white dwarf star.
- ✓ A limit which mandates that no white dwarf (a collapsed, degenerate star) can be more massive than about 1.4 times the mass of the Sun.
- ✓ Any degenerate object more massive must inevitably collapse into a neutron star or black hole.
- ✓ The limit is **named after the Nobel laureate Subrahmanyan Chandrasekhar,** who first proposed the idea in 1931. He was awarded the Noble Prize in Physics in 1983.



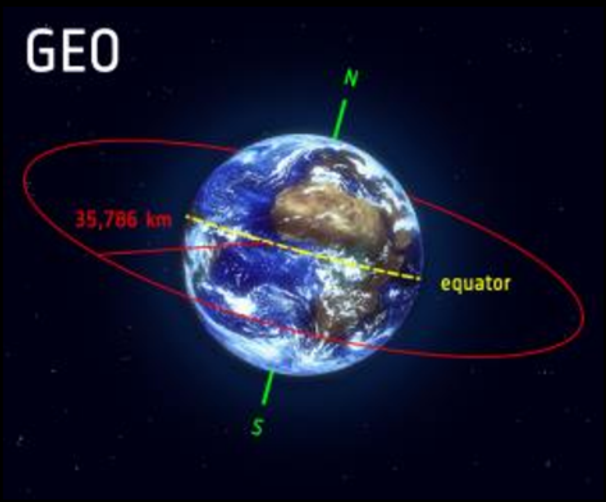
2. SPACE TECHNOLGOY

Types of Orbits

- ✓ An orbit is a regular, repeating path that one object in space takes around another one. An object in an orbit is called a satellite. A satellite can be natural, like Earth or the moon. Many planets have moons that orbit them. A satellite can also be man-made, like the International Space Station.
- ✓ Planets, comets, asteroids and other objects in the solar system orbit the sun. Most of the objects orbiting the sun move along or close to an imaginary flat surface. This imaginary surface is called the ecliptic plane.
- ✓ Upon launch, a satellite or spacecraft is most often placed in one of several particular orbits around Earth – or it might be sent on an interplanetary journey, meaning that it does not orbit Earth anymore, but instead orbits the Sun until its arrival at its final destination, like Mars or Jupiter.
- ✓ There are many factors that decide which orbit would be best for a satellite to use, depending on what the satellite is designed to achieve.

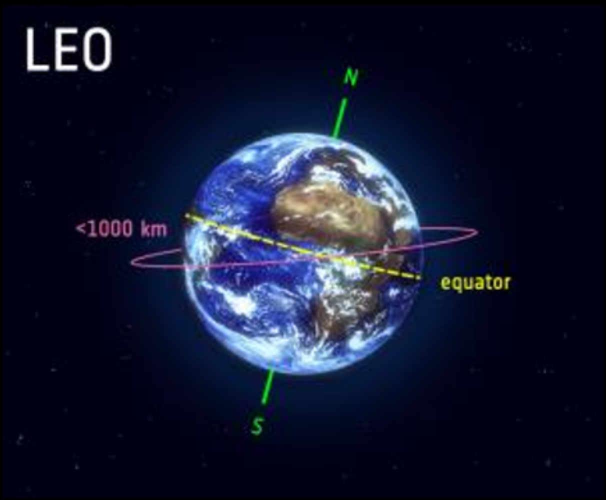
  - Geostationary orbit (GEO)
  - Low Earth orbit (LEO)
  - Medium Earth orbit (MEO)
  - Polar orbit and Sun-synchronous orbit (SSO)
  - Transfer orbits and geostationary transfer orbit (GTO)
  - Lagrange points (L-points)

Geostationary Orbit (GEO)



- ✓ Satellites in geostationary orbit (GEO) circle Earth above the equator from west to east following Earth's rotation – taking 23 hours 56 minutes and 4 seconds – by travelling at exactly the same rate as Earth. This makes satellites in GEO appear to be 'stationary' over a fixed position. In order to perfectly match Earth's rotation, the speed of GEO satellites should be about 3 km per second at an altitude of 35 786 km. This is much farther from Earth's surface compared to many satellites.
- ✓ GEO is used by satellites that need to stay constantly above one particular place over Earth, such as telecommunication satellites. This way, an antenna on Earth can be fixed to always stay pointed towards that satellite without moving. It can also be used by weather monitoring satellites, because they can continually observe specific areas to see how weather trends emerge there.
- ✓ Satellites in GEO cover a large range of Earth so as few as three equally-spaced satellites can provide near global coverage. This is because when a satellite is this far from Earth, it can cover large sections at once. This is akin to being able to see more of a map from a metre away compared with if you were a centimetre from it. So to see all of Earth at once from GEO far fewer satellites are needed than at a lower altitude.
- ✓ ESA's European Data Relay System (EDRS) programme has placed satellites in GEO, where they relay information to and from non-GEO satellites and other stations that are otherwise unable to permanently transmit or receive data. This means Europe can always stay connected and online.

Low Earth Orbit (LEO)



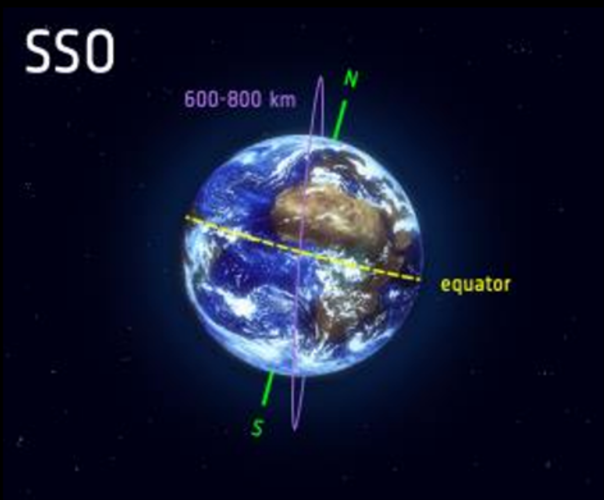
- ✓ A low Earth orbit (LEO) is, as the name suggests, an orbit that is relatively close to Earth's surface. It is normally at an altitude of less than 1000 km but could be as low as 160 km above Earth – which is low compared to other orbits, but still very far above Earth's surface.
- ✓ By comparison, most commercial aeroplanes do not fly at altitudes much greater than approximately 14 km, so even the lowest LEO is more than ten times higher than that.
- ✓ Unlike satellites in GEO that must always orbit along Earth's equator, LEO satellites do not always have to follow a particular path around Earth in the same way – their plane can be tilted. This means there are more available routes for satellites in LEO, which is one of the reasons why LEO is a very commonly used orbit.

- ✓ LEO's close proximity to Earth makes it useful for several reasons. It is the orbit most commonly used for satellite imaging, as being near the surface allows it to take images of higher resolution. It is also the orbit used for the International Space Station (ISS), as it is easier for astronauts to travel to and from it at a shorter distance. Satellites in this orbit travel at a speed of around 7.8 km per second; at this speed, a satellite takes approximately 90 minutes to circle Earth, meaning the ISS travels around Earth about 16 times a day. However, individual LEO satellites are less useful for tasks such as telecommunication, because they move so fast across the sky and therefore require a lot of effort to track from ground stations. Instead, communications satellites in LEO often work as part of a large combination or constellation of multiple satellites to give constant coverage. In order to increase coverage, sometimes constellations like this, consisting of several of the same or similar satellites, are launched together to create a 'net' around Earth. This lets them cover large areas of Earth simultaneously by working together.

Medium Earth Orbit

- ✓ Medium Earth orbit comprises a wide range of orbits anywhere between LEO and GEO. It is similar to LEO in that it also does not need to take specific paths around Earth, and it is used by a variety of satellites with many different applications.
- ✓ It is very commonly used by navigation satellites, like the European Galileo system (pictured). Galileo powers navigation communications across Europe, and is used for many types of navigation, from tracking large jumbo jets to getting directions to your smartphone. Galileo uses a constellation of multiple satellites to provide coverage across large parts of the world all at once.

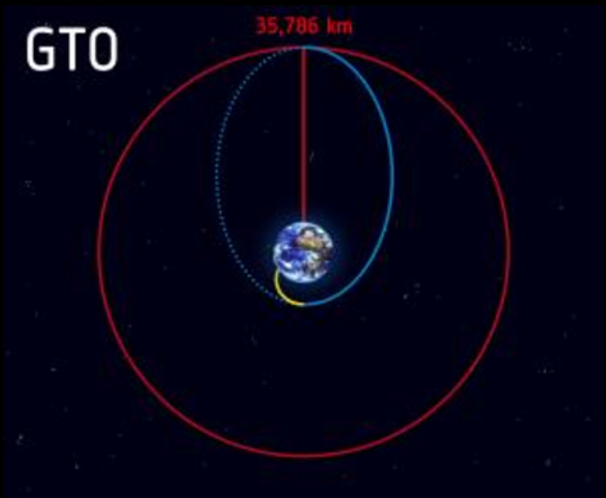
Polar Orbit and Sun-Synchronous Orbit (SSO)



- ✓ Satellites in polar orbits usually travel past Earth from north to south rather than from west to east, passing roughly over Earth's poles.
- ✓ Satellites in a polar orbit do not have to pass the North and South Pole precisely; even a deviation within 20 to 30 degrees is still classed as a polar orbit. Polar orbits are a type of low Earth orbit, as they are at low altitudes between 200 to 1000 km.

- ✓ Sun-synchronous orbit (SSO) is a particular kind of polar orbit. Satellites in SSO, travelling over the polar regions, are synchronous with the Sun. This means they are synchronized to always be in the same 'fixed' position relative to the Sun. This means that the satellite always visits the same spot at the same local time – for example, passing the city of Paris every day at noon exactly.
- ✓ This means that the satellite will always observe a point on the Earth as if constantly at the same time of the day, which serves a number of applications; for example, it means that scientists and those who use the satellite images can compare how somewhere changes over time.
- ✓ This is because, if you want to monitor an area by taking a series of images of a certain place across many days, weeks, months, or even years, then it would not be very helpful to compare somewhere at midnight and then at midday – you need to take each picture as similarly as the previous picture as possible. Therefore, scientists use image series like these to investigate how weather patterns emerge, to help predict weather or storms; when monitoring emergencies like forest fires or flooding; or to accumulate data on long-term problems like deforestation or rising sea levels.
- ✓ Often, satellites in SSO are synchronized so that they are in constant dawn or dusk – this is because by constantly riding a sunset or sunrise, they will never have the Sun at an angle where the Earth shadows them. A satellite in a Sun-synchronous orbit would usually be at an altitude of between 600 to 800 km. At 800 km, it will be travelling at a speed of approximately 7.5 km per second.

Transfer Orbits and Geostationary Transfer Orbits (GTO)



- ✓ Transfer orbits are a special kind of orbit used to get from one orbit to another. When satellites are launched from Earth and carried to space with launch vehicles such as Ariane 5, the satellites are not always placed directly on their final orbit. Often, the satellites are instead placed on a transfer orbit: an orbit where, by using relatively little energy from built-in motors, the satellite or spacecraft can move from one orbit to another.
- ✓ This allows a satellite to reach, for example, a high-altitude orbit like GEO without actually needing the launch vehicle to go all the way to this altitude, which would require more effort – this is like taking a shortcut. Reaching GEO in this way is an example of one of the most common transfer orbits, called the geostationary transfer orbit (GTO).

Types of Satellites

A satellite is a body that orbits around another body in space. There are two different types of satellites – natural and man-made. Examples of natural satellites are the Earth and Moon. The Earth rotates around the Sun and the Moon rotates around the Earth. A man-made satellite is a machine that is launched into space and orbits around a body in space. Examples of man-made satellites include the Hubble Space Telescope and the International Space Station.

1.**Astronomical**: Deployed for observation of distant planets, stars, galaxies, and objects in-universe. It is a space Telescope hanging in space to photograph objects in space.

2.**Biosatellite** : Places animals or plants in space to conduct research on the effects of space on these living objects.

3.**Communication**:These satellites support telecommunication. Telecasting, Phone calls, Internet connectivity, Radio, and much remote connectivity are typical applications. Communication Satellites provide services to telecommunications, television broadcasting, satellite newsgathering, societal applications, weather forecasting, disaster warning and Search and Rescue operations. The Indian National Satellite (INSAT) series of satellites in Geostationary Orbit (INSAT-3A, 3C, 4A, 4B, 4CR) are used for communication purposes. GSAT series also joins the constellation of INSAT system in providing communication services.

4.**Earth Observation**: Deployed to study environment, monitor climatic changes and mapping the earth for non-military purposes.

- Earth Observation Satellites are used for several applications covering agriculture, water resources, urban planning, rural development, mineral prospecting, environment, forestry, ocean resources and disaster management. Indian Remote Sensing (IRS) series of satellites in Sun-synchronous polar orbit are Earth observation satellites.
- Satellites in - Sun-synchronous orbit – RESOURCESAT-1, 2, 2A CARTOSAT-1, 2, 2A, 2B, RISAT-1 and 2, OCEANSAT-2, Megha-Tropiques, SARAL and SCATSAT-1
- Satellites in Geostationary orbit - INSAT-3D, Kalpana & INSAT 3A, INSAT -3DR

5.**Navigation**: Facilitates to trace the exact location of any objects on the Earth. This leads to the development of new applications, technology, and business cases.

- Navigation Satellites are used to meet the emerging demand of positioning, navigation and timing and also civil aviation requirements. GAGAN and IRNSS (NAVIC) are navigation satellite system in use. GPS Aided GEO Augmented Navigation (GAGAN), is implemented jointly by ISRO and Airport Authority of India (AAI). The main objectives of GAGAN are to provide Satellite-based Navigation services with accuracy and integrity required for civil aviation applications and to provide better Air Traffic Management over Indian Airspace. The GAGAN Signal-In-Space (SIS) is available through GSAT-8 and GSAT-10. Indian Regional Navigation Satellite System (IRNSS), NavIC is an independent regional navigation satellite system to provide accurate position information service.

6.**Killer (Military)** : Deployed to attack enemy satellites and space objects during the war period.

7.**Space Stations :** Designed for human beings to live and conduct research on objects on planets, stars, and galaxies.

8.**Reconnaissance**: Deployed for spying, surveying and scouting enemy territory during the war period.

9.**Crewed Spacecraft:** These satellites ferry astronauts to space and bring them back to earth. It has good grounding facilities and helps astronauts in accessing space stations.

10.**Recovery**: Recovery satellites are mainly used to recover bio, reconnaissance and other satellites back to earth.

11.**Solar Power : Space-based** satellites gather energy from the Sun and transmit it to earth for consumption.

12.**Miniaturized**: Smaller sized and lower weight satellites are launched at an economical cost used for the limited purpose of scientific data gathering and radio relay.

13.**Tether**: Tether satellites are connected to another satellite by the tether. It is used as a secondary payload to another main satellite mainly used in students and mini-projects.

14.**Weather** : These satellites are used to measure and report the Earth's weather, and the reports are used in a weather forecast.

15. **Space Science and Exploration Satellites** encompasses research in areas like astronomy, astrophysics, planetary and earth sciences, atmospheric sciences and theoretical physics. • E.g – Mars Orbiter Mission, AstroSat, Chandrayaan -1, 2.

Launch Vehicles

Launch Vehicles

- ✓ Launch Vehicles are used to carry spacecraft to space.
- ✓ Following are the various launch vehicles used by ISRO
- ✓ Historic launchers - Satellite Launch Vehicle - 3 (SLV-3) and Augmented Satellite Launch Vehicle (ASLV).
- ✓ SLV was India's first experimental satellite launch vehicle with solid engines in all 4 stages. ASLV has 3 times augmented capacity of SLV-3.
- ✓ Operational launchers - Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV) and Sounding Rockets.
- ✓ Future launchers – GSLV MK-III, Reusable Launch Vehicle (RLV-TD), Scramjet Engine – TD.

SLV

- ✓ Satellite Launch Vehicle-3 (SLV-3) was India's first experimental satellite launch vehicle, which was an all solid, four stage vehicle weighing 17 tonnes with a height of 22m and capable of placing 40 kg class payloads in Low Earth Orbit (LEO).
- ✓ The first experimental flight of SLV-3, in August 1979, was only partially successful. Apart from the July 1980 launch, there were two more launches held in May 1981 and April 1983, orbiting Rohini satellites carrying remote sensing sensors.
- ✓ The successful culmination of the SLV-3 project showed the way to advanced launch vehicle projects such as the Augmented Satellite Launch Vehicle (ASLV), Polar Satellite Launch Vehicle (PSLV) and the Geosynchronous Satellite Launch Vehicle (GSLV).

ASLV

- ✓ The Augmented Satellite Launch Vehicle (ASLV) Programme was designed to augment the payload capacity to 150 kg, thrice that of SLV-3, for Low Earth Orbits (LEO). While building upon the experience gained from the SLV-3 missions. ASLV proved to be a low cost intermediate vehicle to demonstrate and validate critical technologies that would be needed for the future launch vehicles like strap-on technology, inertial navigation, bulbous heat shield, vertical integration and closed loop guidance.

PSLV

- ✓ It is the 3rd generation launch vehicle and first Indian launch vehicle to be equipped with liquid stages.
- ✓ PSLV emerged as the reliable and versatile workhorse launch vehicle of India with consecutively successful missions.
- ✓ It successfully launched two spacecraft such as Chandrayaan-1 in 2008 and Mars Orbiter Spacecraft in 2013.
- ✓ 3 variations in PSLV - PSLV-G (General), PSLV-XL variants and PSLV-CA (Core Alone).
- ✓ It has 4 stages in its operation to provide thrust in launching spacecraft to different orbits.
- ✓ Stage I: It uses solid rocket motor that is augmented by 6 solid strap-on boosters. Strap on boosters are used only in G and XL variation.
- ✓ Stage II: It uses an Earth storable liquid rocket engine, known as the Vikas engine.
- ✓ Stage III: It uses solid rocket motor that provides high thrust after the atmospheric phase of the launch.
- ✓ Stage IV: It comprises two Earth storable liquid engines.
- ✓ Capacity - 1,750 kg of payload to Sun-Synchronous Polar Orbits of 600 km altitude and to 1,425 kg of payload to Geosynchronous and Geostationary orbits, like satellites from the IRNSS constellation.
- ✓ PSLV launches– PSLV-C48/RISAT-2BR1, PSLV-C47 / Cartosat-3, PSLV-C46/RISAT-2B, PSLV-C45/EMISAT MISSION, PSLV - C44/Microsat, Kalamsat etc

GSLV

- ✓ The Geosynchronous Satellite Launch Vehicle (GSLV) project was initiated in 1990 with the objective of acquiring an Indian launch capability for geosynchronous satellites.
- ✓ GSLV uses major components that are already proven in the Polar Satellite Launch Vehicle (PSLV) launch vehicles in the form of the S125/S139 solid rocket booster and the liquid-fuelled Vikas engine. Due to the thrust required for injecting the satellite in a geostationary transfer orbit (GTO) the third stage was to be powered by a LOX/LH2 Cryogenic engine which at that time India did not possess or had the technology know-how to build one.
- ✓ GSLV rockets using the Russian Cryogenic Stage (CS) are designated as the GSLV Mark I while versions using the indigenous Cryogenic Upper Stage (CUS) are designated the GSLV Mark II. All GSLV launches have been conducted from the Satish Dhawan Space Centre in Sriharikota.
- ✓ **Geosynchronous Satellite Launch Vehicle Mark II** (GSLV Mk II) is the largest launch vehicle developed by India, which is currently in operation. This fourth generation launch vehicle is a three stage vehicle with four liquid strap-ons. The indigenously developed cryogenic Upper Stage (CUS), which is flight proven, forms the third stage of GSLV Mk II. From January 2014, the vehicle has achieved four consecutive successes.
- ✓ **GSLV Mk III,** chosen to launch Chandrayaan-2 spacecraft, is a three-stage heavy lift launch vehicle developed by ISRO. The vehicle has two solid strap-ons, a core liquid booster and a cryogenic upper stage.
- ✓ GSLV Mk III is designed to carry 4 ton class of satellites into Geosynchronous Transfer Orbit (GTO) or about 10 tons to Low Earth Orbit (LEO), which is about twice the capability of the GSLV Mk II.
- ✓ The first developmental flight of GSLV Mk III, the GSLV-Mk III-D1 successfully placed GSAT-19 satellite to a Geosynchronous Transfer Orbit (GTO) on June 05, 2017 from SDSC SHAR, Sriharikota.
- ✓ GSLV Mk III-D2, the second developmental flight of GSLV MkIII successfully launched GSAT-29, a high throughput communication satellite on November 14, 2018 from Satish Dhawan Space Centre SHAR, Sriharikota
- ✓ GSLV MkIII-M1, successfully injected Chandrayaan-2, India's second Lunar Mission, in to Earth Parking Orbit on July 22, 2019 from Satish Dhawan Space Centre SHAR, Sriharikota
- ✓ **Significance:** It strengthens INDIA's soft power diplomacy. It reduces our dependency on foreign launch vehicles. It has multiplier effect on other innovations like chandrayan 2,human space flights etc. It leads to commercial. Self reliance.

- ✓ Recent Launches – GSLV-Mk III - M1 / Chandrayaan-2 Mission, GSLV Mk III-D2 / GSAT-29, GSLV MK III D1/GSAT – 19 and LVM-3 /CARE (Crew module Atmospheric Re-entry Experiment) mission.
- ✓ It is the designated launch vehicle for India's upcoming second moon mission and the first human space flight scheduled for 2022-23.

RLV-TD

- ✓ Reusable Launch Vehicle – Technology Demonstrator (RLV-TD) is a fully reusable launch vehicle to enable low cost access to space.
- ✓ The configuration of RLV-TD is similar to that of an aircraft and combines the complexity of both launch vehicles and aircraft.
- ✓ The winged RLV-TD has been configured to act as a flying test bed to evaluate various technologies, namely, hypersonic flight, autonomous landing and powered cruise flight.
- ✓ In future, this vehicle will be scaled up to become the first stage of India's reusable two stage orbital launch vehicle.
- ✓ Objectives of RLV-TD - Hypersonic aero thermodynamic characterisation of wing body, Evaluation of autonomous Navigation, Guidance and Control (NGC) schemes, Integrated flight management and Thermal Protection System Evaluation
- ✓ It was successfully flight tested in 2016 from Sriharikota.

Small Satellite Launch Vehicle

- ✓ The first developmental flight of Small Satellite Launch Vehicle (SSLV) is scheduled in fourth quarter of 2021 from Satish Dhawan Space Centre, Sriharikota.
- ✓ SSLV was developed by the ISRO as a cost-effective, three-stage, all-solid launch vehicle.
- ✓ It has a payload capability of 500 kg to 500 km planar orbit or 300 kg to Sun Synchronous Polar Orbit.
- ✓ It is shorter in length than the PSLV and GSLV. Unlike the PSLV and GSLV, the SSLV can be assembled both vertically and horizontally.
- ✓ The major technologies developed as part of realization of SSLV are, 1. Flexible nozzle control with electro-mechanical actuators for all stages, 2. Miniaturized avionics and 3. A velocity trimming module in the upper stage for precise satellite injection.
- ✓ SSLV is ideal for on-demand, quick turn-around launch of small satellites.

Sounding Rockets

- ✓ Indian Space Research Organisation (ISRO) has launched RH-560, a sounding rocket to study attitudinal variations in the neutral winds and plasma dynamics.
- ✓ Sounding rockets are one or two stage solid propellant rockets used for probing the upper atmospheric regions and for space research.

- ✓ They serve as platforms to test or prove prototypes of new components or subsystems intended for use in launch vehicles and satellites.
- ✓ It is possible to conduct coordinated campaigns by simultaneously launching sounding rockets from different locations in a single day.
- ✓ ISRO started launching indigenously made sounding rockets from 1965.
- ✓ In 1975, ISRO consolidated all its sounding rocket activities under the Rohini Sounding Rocket (RSR) Programme.
- ✓ RH-75 was the first truly Indian sounding rocket from the Thumba Equatorial Rocket Launching Station (TERLS) [Numbers in the name indicates the diameter of the rocket in mm]

Vikas Engine

- ✓ ISRO successfully conducted a 25-second qualification test for its liquid propellant-based Vikas engine to be used under the Gaganyaan mission.
- ✓ Vikas is a family of liquid fuelled rocket engines that powers India's launch vehicles PSLV and GSLV.
- ✓ The engine uses up about 40 metric tons of Unsymmetrical dimethylhydrazine (UDMH) as fuel and Nitrogen tetroxide (N_2O_4) as oxidizer with a maximum thrust of 725 kN.
- ✓ It is aimed at improving the payload capability of PSLV, GSLV and GSLV Mk-III launch vehicles.
- ✓ The Vikas Engine is the workhorse liquid rocket engine powering
  - ➢ The second stage of India's Polar Satellite Launch Vehicle (PSLV),
  - ➢ The second stage and the four strap on stages of Geosynchronous Launch Vehicle (GSLV) and
  - ➢ The twin engine core liquid stage (L110) of GSLV Mk-III.
- ✓ ISRO has recently improved the thrust of the Vikas engine which is expected to boost the rocket engine.
- ✓ The main beneficiary of the high-thrust Vikas engine is GSLV-Mark III launcher, which is expected to lift 4,000- kg satellites to space.

What's the difference between liquid and solid-fuel rockets?

- ✓ There are two main types of rockets: liquid-fuel and solid-fuel. Liquid-fuel rockets consist of a fuel and oxygen (or other oxidizer) in liquid state. They are combined in a combustion chamber and ignited. The fuel flow to the engine can be controlled, the amount of thrust produced can be regulated and the engine can be turned off or on as needed. Solid-fuel rockets consist of a fuel and oxidizer that are pre-mixed in a solid form. Once the solid fuel is ignited, the resulting thrust cannot be regulated or turned off. This fuel system is simpler, safer, and cheaper—but less efficient—than that of a liquid-fuel rocket.

Functioning of Engines

Cryogenic Engine:

- ✓ Rocket engine needs enormous amount of thrust to escape Earth's gravitational pull. However the chemicals used for engines are Hydrogen and Oxygen (Hydrogen used as a fuel, while Oxygen as a oxidiser) that produces a good thrust, found in Earth in the form of gas.
- ✓ Carrying hydrogen and oxygen in their gaseous form will require a bigger fuel chamber, which not only increase the size but also weight of the rockets and this will mean undertaking of impossible task to send a launch vehicle into space.
- ✓ So the solution is to use hydrogen and oxygen in their liquid form or in a cryogenic form which is easier to transport, as the volume of propellent decrease.
- ✓ As density increases in liquid form, more thrust can be produce in less burning time. Such engines are called Cryogenic engine.
- ✓ Cryogenic fuel is used in rockets, spaceships or satellites because ordinary fuel can not be used in space due to the absence of an environment that supports combustion. This fuel requires storage at an extremely low temperature (-253 degree Celsius) to maintain them in a liquid state.

Semi-Cryogenic Engine:

- ✓ Unlike a Cryogenic engine, a Semi Cryogenic engine uses Refined kerosene instead of liquid hydrogen.
- ✓ The liquid oxygen is used as a Oxidiser. That's the advantage of using a Semi Cryogenic engine as it requires Refined Kerosene which is lighter than liquid fuel and can be stored in a normal temperature.
- ✓ Kerosene combined with liquid oxygen provide a higher thrust to the rocket. Refined Kerosene occupies less space, making it possible to carry more propellant in a Semi Cryogenic engines fuel compartment.
- ✓ A semi cryogenic engine is more powerful, environment friendly and cost effective as compared to a cryogenic engine.

Green Propellants

- ✓ ISRO is developing green propellants to eliminate the emission of chlorinated exhaust products from rocket.
- ✓ The propellants are based on Glycidyl Azide Polymer (GAP) as fuel and Ammonium Di-Nitramide (ADN) as oxidizer.
- ✓ ISRO is also carrying out various technology demonstration projects involving green propellant combinations such as Hydrogen Peroxide (H_2O_2), Kerosene, Liquid Oxygen (LOX), Liquid Methane etc.
- ✓ It has successfully developed ISROSENE, which is a rocket grade version of kerosene as an alternative to conventional hydrazine rocket fuel.

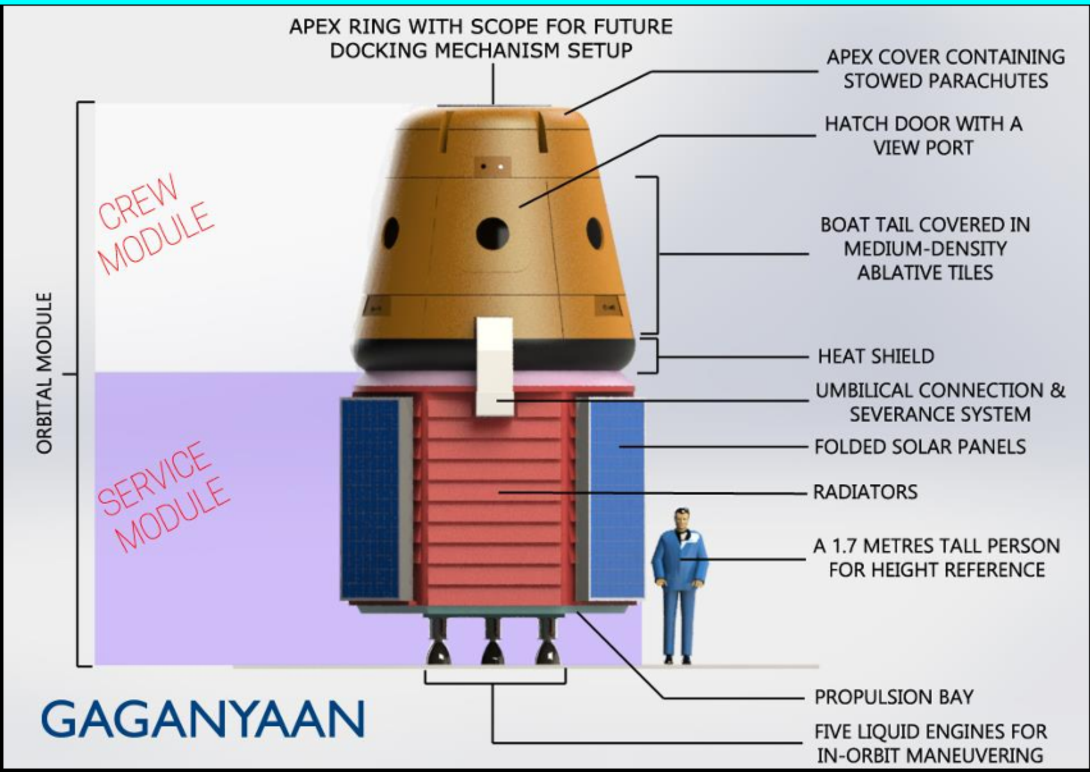
- ✓ It has already used Liquid oxygen and liquid hydrogen combination in cryogenic upper stage of GSLV MK-III.

The International Space Station (ISS)

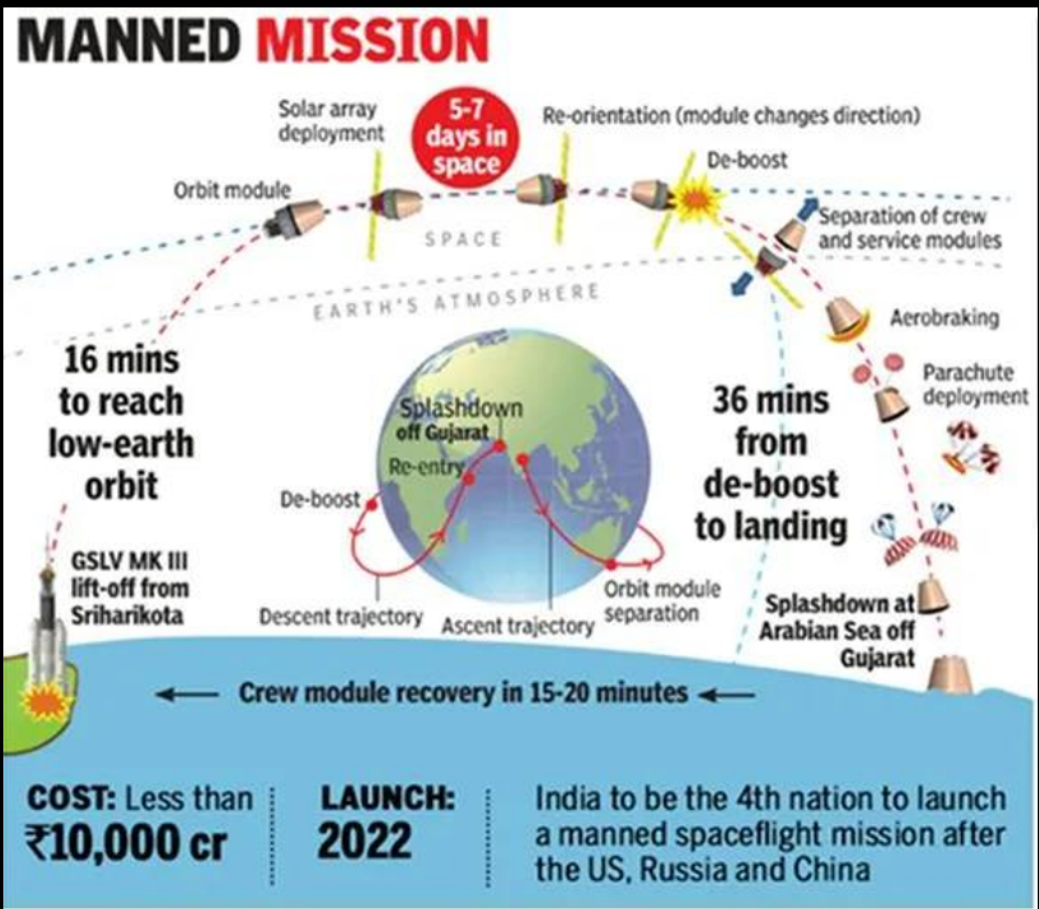
- ✓ It is a modular space station (habitable artificial satellite) in low Earth orbit.
- ✓ The ISS programme is a multi-national collaborative project between five participating space agencies:
  1. NASA (United States),
  2. Roscosmos (Russia),
  3. JAXA (Japan),
  4. ESA (Europe),
  5. CSA (Canada).
- ✓ The ownership and use of the space station are established by intergovernmental treaties and agreements.
- ✓ It is suited for testing the spacecraft systems and equipment required for possible future long-duration missions to the Moon and Mars.
- ✓ It is the only active modular space station (habitable artificial satellite) in the Low-Earth Orbit (LEO).
- ✓ It is the largest artificial object in space and the largest satellite in low Earth orbit, regularly visible to the naked eye from Earth's surface.
- ✓ It circles the Earth in roughly 93 minutes, completing 15.5 orbits per day.
- ✓ It is like a large laboratory in space that has been there since 1998. It allows astronauts to come aboard and stay for weeks or months to carry out experiments in microgravity.
- ✓ Recent Developments - Russia announced that it would be withdrawing from the International Space Station in 2025, and build and manage its own floating laboratory that will be launched into orbit by 2030.

Gaganyaan Mission

- ✓ India's **maiden space mission**, **Gaganyaan**, will be launched in **2023**: Union Minister of Atomic Energy and Space.
- ✓ **Aim:** Gaganyaan is an Indian crewed orbital spacecraft that is intended to **send 3 astronauts** to space for a minimum of seven days by 2022 (delayed due to COVID-19).
- ✓ **Launched by:** ISRO's Geosynchronous Satellite Launch Vehicle **GSLV Mk III** (3 stages heavy-lift vehicle)
- ✓ **Components:** Consists of a **service module** and a **crew module**, collectively known as an **Orbital Module** (Crew Module carries astronauts & Service Modules carries propellants.)



- ✓ **LEO:** It will circle Earth at a **low-earth-orbit** at an altitude of 300-400 km from the earth for 5-7 days.
- ✓ **Vyom Mitra:** ISRO to send **humanoid Vyommitra** in unmanned Gaganyaan spacecraft **ahead of human spaceflight** (Monitoring module parameters).



Significance

- ✓ Establish India as the **World leader** in **Manned missions** (**USA, China and Russia**)
- ✓ Enhancement of science and technology levels in the country.
- ✓ A national project involving several institutes, academia and industry.
- ✓ Improvement of industrial growth (**IN-SPACe** to ↑ **Pvt. participation**).
- ✓ Inspiring youth.
- ✓ Development of technology for social benefits.
- ✓ Improving international collaboration.

Challenges

- ✓ **Financial Cost:** 10,000 crores, critics questions about this over poor & undernourished.
- ✓ **Technological Know-how:** Rocket, Crew Escape Mechanism, Radiation exposure, Transitioning of one gravity field to another (cause osteoporosis) & simulating Earth-like conditions.
- ✓ **Health Issues:** Like Behavioral issues, depression, fatigue, sleep disorder.

Other Major Space Projects

- ✓ **Venus mission:** This will be the first mission to Venus by the ISRO.
- ✓ **L-1 Aditya solar:** India's first scientific expedition to study the Sun
- ✓ **Chandrayaan-3:** It is a lander-and rover-specific mission, a follow-up of the Chandrayaan-2 mission.

GSLV-Mk III – M1 / Chandrayaan-2 Mission

- ✓ GSLV MkIII-M1, successfully launched Chandrayaan-2 spacecraft into its planned orbit but failed to soft-land the lander on the moon.
- ✓ Chandrayaan-1 was designed to just orbit the Moon and make observations, while Chandrayaan-2 is created to land on the Moon.
- ✓ It has three important components — the Orbiter, the Lander 'Vikram', and Rover 'Pragyan'
- ✓ The mission aims to explore the unexplored South Pole of the Moon.
- ✓ According to ISRO, there is a possibility of the presence of water in permanently shadowed areas around it. South Pole region also has craters that are cold traps and contain a fossil record of the early Solar System.
- ✓ GSLV MK – III also called as 'Baahubali', the country's heaviest and most powerful rocket to date.
- ✓ ISRO provides four reasons for what made the Chandrayaan-2 mission "special".
- ✓ Chandryaan-2 would be - 1. the first space mission to conduct a soft landing on the moon's south pole 2. the first Indian expedition to attempt a landing on lunar surface using home-grown technology 3. the first Indian mission to explore lunar terrain with home-grown technology 4. the mission that would make India only the 4th country to soft land on the moon • Orbiter - The Orbiter will 100 km away from the moon, which will observe lunar surface and relay communication between Earth and the Lander.

- ✓ The orbiter is equipped with different kinds of camera to take create high-resolution three-dimensional maps of the surface, would remain in orbit for a year. • Vikram Lander - Lander module Vikram was named after Vikram Sarabhai.
- ✓ It is the first time that ISRO is attempting to soft-land a module in extra-terrestrial space to mainly study the moon's atmosphere and look out for seismic activity. However, it failed in its attempt.
- ✓ Pragyaan Rover - Rover module Pragyaan means wisdom.
- ✓ The 6-wheeled, AI Solar powered rover was designed, developed and build indigenously by ISRO. The rover will be landed closer to the Moon's equator to receive more sun light.
- ✓ Its primary objective will be to study the composition of the surface near the lunar landing site, and determine its abundance of various elements.
- ✓ Both the Lander and Rover are designed to work for only 14 days (1 lunar day).
- ✓ This mission will help us to better understand the origin and evolution of the moon. Studies of lunar topography, mineralogy, elemental abundance, and signatures of water ice are the prime objectives.
- ✓ The orbiter has 8 instruments fitted into it and 7 of them are India's. NASA has one payload onboard called the Laser Retroreflector Array (LRA).
- ✓ Recent Developments - ISRO released the information gathered by the scientific payloads on board the Orbiter of Chandrayaan-2.
- ✓ Chandrayaan-2 has found signatures of water at all latitudes, although its abundance varies from place to place. Imaging Infra-Red Spectrometer (IIRS) on board Chandrayaan-2 has distinguished between hydroxyl and water molecules, and found unique signatures of both.
- ✓ Water ice - Dual Frequency Synthetic Aperture Radar, a microwave imaging instrument, studied the subsurface features of the Moon.
- ✓ It has detected signatures of the sub-surface water-ice and potential water ice at the poles.

Chandrayaan-3

- ✓ Chandrayaan-3 is likely to be launched in 2022-23 (earlier scheduled to be launched in late 2020), which is India's third mission to Moon.
- ✓ It aims to make a soft-landing in the Lunar South Pole's Aitken basin.
- ✓ It will consist of only a lander and rover, as the orbiter of Chandrayaan-2 is still functioning and providing data.

Aditya L-1 Mission

- ✓ The Aditya-L1 mission will be placed into a point called L1 Lagrange point.
- ✓ This mission will be ISRO's 2nd space-based astronomy mission after AstroSat. AstroSat was launched in 2015.
- ✓ Aditya-L1 was earlier named as Aditya 1 and was meant to observe only the solar corona.

Launch Vehicle

- ✓ Solar probe, Aditya L1 will be launched on Polar Satellite Launch Vehicle (PSLV) XL, carrying 7 payloads or instruments on board.

Objective of the mission

- ✓ Aditya L1 mission will be launched to study Sun's corona (Visible and Near infrared rays), chromosphere (Ultra Violet), Sun's photosphere (soft and hard X-ray), solar winds & flares, solar emissions, and Coronal Mass Ejections (CMEs). It will also carry out round-the-clock imaging of the Sun.

What are the Challenges?

- ✓ The biggest challenge associated with Aditya L1 mission is distance of Sun from Earth, which is approximately 15 crore kms.
- ✓ Because of several risks, payloads in previous ISRO missions have largely remained stationary in space. But Aditya L1 comprise of some moving components which increases the risks of collision.
- ✓ Other issues include super-hot temperatures and radiation coming from solar atmosphere. Though, Aditya L1 will stay much farther away.

Significance of the mission

- ✓ This mission is significant because, it is important to study the Sun in light that, evolution of planets and exoplanets beyond the Solar System is governed by the Sun. Solar weather and environment affect the weather of entire system.
- ✓ It will help in studying the Effects of Variation in Solar Weather System. Variations in this weather can change orbits of satellites or even shorten their lives.

- It will help in learning about and tracking Earth-directed storms.

Lagrange Point 1

- ✓ Lagrange Points has been named after Italian-French mathematician Josephy-Louis Lagrange. These points are positioned in space, where gravitational forces of a two-body system produce enhanced regions of repulsion and attraction.

Why do we study the sun and the solar wind?

- ✓ The sun is **the only star we can study up close.** By studying this star we live with, we learn more about stars throughout the universe. The sun is **a source of light and heat for life on Earth.**

- ✓ The more we know about it, the more we can understand how life on Earth developed. It is **the source of the solar wind;** a flow of ionized gases from the sun that streams past Earth at speeds of more than 500 km per second (a million miles per hour).

- ✓ **Disturbanc*es in the solar wind shake Earth's magnetic field* and pump energy into the radiation belts,** part of a set of changes in near-Earth space known as space weather.

- ✓ **Effects On satellites:** Space weather can change the orbits of satellites, shorten their lifetimes, or interfere with onboard electronics. The more we learn about what causes space weather – and how to predict it – the more we can protect the satellites we depend on.

- ✓ **Safety and preparedness:** The solar wind dominates the space environment. As we send spacecraft and astronauts further and further from home, we must understand this space environment just as early seafarers needed to understand the ocean.

Mangalyaan Mission

- ✓ Mangalyaan Mission India's Mars Orbiter spacecraft has completed more than 7 years in its orbit, well beyond its designed mission life of six months.
- ✓ Also known as Mangalyaan, Mars Orbiter Mission (MOM) is the maiden interplanetary mission of the Indian Space Research Oranisation (ISRO).
- ✓ Launched in 2013, the probe was successfully inserted into Martian orbit on September 24, 2014.
- ✓ The spacecraft has already covered 3 Martian years (1 Martian year = 2 Earth years or 687 days).
- ✓ Launch - PSLV-C25, the 25th flight of PSLV launched MOM Spacecraft. • PSLV was used to launch MOM as GSLV was not in operational condition then. So, ISRO could apportion only about 15 kg for scientific instruments.
- ✓ Purpose - MOM is primarily a technology demonstration venture and all the mission objectives were successfully met.
- ✓ MOM will explore and observe Mars surface features, morphology, mineralogy and the Martian atmosphere.
- ✓ Further, a specific search for methane in the Martian atmosphere will provide information about the possibility or the past existence of life on the planet.

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