1. Space Technology

1.1. Meaning

- Space Technology is the **exploration and utilisation of outer space** by the systematic application of engineering and scientific disciplines.
- It includes space vehicles such as spacecraft, satellites, space stations, orbital launch vehicles and a wide variety of other technologies including support infrastructure equipment, and procedures.

1.2. Applications of Space Technology

Agriculture

- Space-based technology is of value to farmers, agronomists, food manufacturers and agricultural policymakers to enhance production and profitability.
- Remote sensing satellites provide key data for **monitoring soil, snow cover, drought and crop development.**
- Rainfall assessments from satellites, for example, help farmers plan the timing and amount of irrigation they will need for their crops.
- Accurate information and analysis can also help **predict a region's agricultural output** well in advance and can be critical in anticipating and mitigating the effects of food shortages and famines.

Global Health

- Information from remote sensing technologies can be applied **to study the epidemiology of infectious diseases.**
- Data can be used to monitor disease patterns, understand environmental triggers for the spread of diseases, predict risk areas and define regions that require disease-control planning.
    - This **tele-epidemiology** is of particular relevance in developing countries like India, where infectious diseases remain among the top causes of death.
- By bringing medical specialists into virtual contact with patients and health practitioners in remote, rural and underserved areas, **tele-health and tele-medicine** can improve access to medical and health-related services.

Environment

- Space-based technologies have enhanced **scientific understanding of water cycles, air quality, forests and other aspects** of the natural environment.
- These surveying and monitoring tools provide valuable information on the state of ecosystems, which offers objective support for positive environmental action, including **conservation and sustainable resource management.**

Sustainable Development

- Earth observation is a vital tool for facilitating the sustainable development of the world's cities.
- Sustainable Goals and their universality can only be attained through **readily available data from affordable sources** such as satellite images and similar commonly available sources.

- Decision makers use this information to understand trends, evaluate needs, and create sustainable development policies and programmes in the best interest of all populations.

Disaster Management

- Space-based technologies can **contribute to all phases of the disaster management** cycle, including prevention, preparedness, early warning, response and reconstruction.
- Before a disaster takes place, remotely sensed data provides information for systems and models which can **predict disasters and provide early warnings.**
- Various kinds of satellites, including meteorology and geophysics satellites provide operational capability for storm warnings and search-and-rescue efforts.

Education

- Technologies like web and videoconferencing and voice over Internet protocol allow educators and students to create virtual classrooms, regardless of physical locations.
- **Tele-education** has become so popular that many institutions worldwide now offer distance education options ranging from the simplest instruction to degree and doctoral programs.

Human Settlements

- Space-based technologies provide unique tools for planning socially and environmentally sustainable human settlements.
- Central government policymakers, city planners, engineers and landscape architects are among those who use remote sensing tools that **measure and monitor existing patterns of land use** and infrastructure development.

Communication

- Space-based technologies, namely communications satellites, enable global telecommunications systems by relaying signals with voice, video and data to and from one or many locations.
- While Earth-based alternatives to space technologies are sometimes possible, space-based technology can often **reduce infrastructure requirements** and offer more **cost effective service delivery options.**
- For instance, instead of constructing a series of transmission and relay towers to broadcast television programmes to far-to-reach places, one satellite dish could be provided to a remote community to pick up broadcast signals sent from a satellite.

Humanitarian Assistance

- Space-based communications technologies often provide valuable assistance with logistical planning, rapid decision-making and resource allocation and can thereby improve the ways in which humanitarian assistance is designed and delivered.

2. Orbits and its types

2.1.What is an orbit?

- An orbit is a **regular, repeating path** that an object in space takes around another one **due to gravity.**
- **An object in an orbit is called a satellite.** A satellite can be natural, like the moon, or human made.

2.2. Shape of the orbit

- All orbits are **elliptical**.
- For the planets, the orbits are almost circular.
- The orbits of comets have a different shape. They are highly **eccentric** or "squashed."
- The **closest point a satellite** comes to Earth is called its **perigee**. The **farthest point** is the **apogee.**
- For planets, the **point in their orbit closest to the sun** is **perihelion.** The **farthest point** is called **aphelion.**

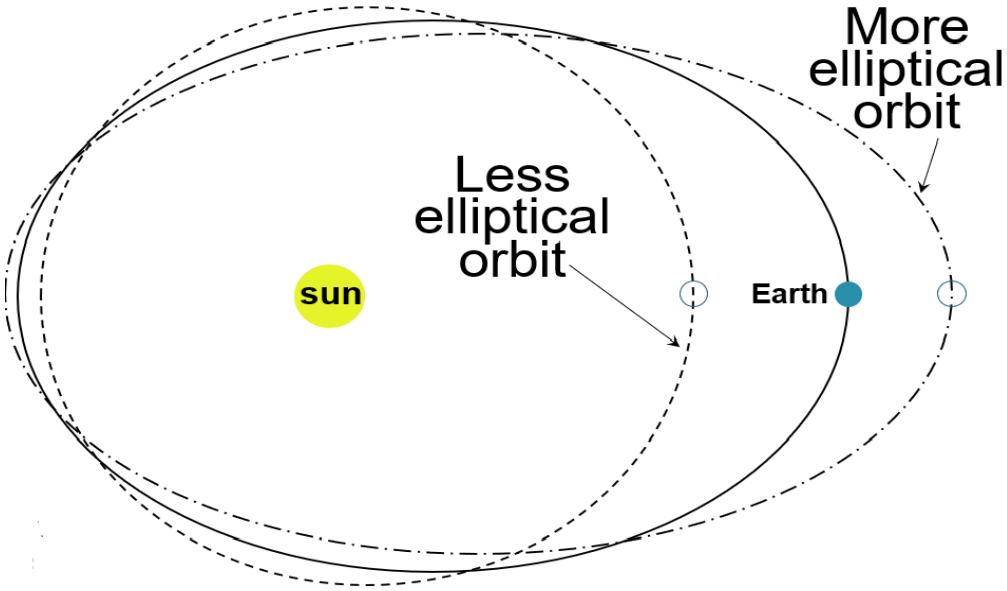


Figure.1. Shape of the Orbit

2.3. Types of Orbits

2.3.1. Low Earth Orbit (LEO)

- A low Earth orbit (LEO) is an orbit that is relatively **close to Earth's surface.**
- It is normally at an altitude of less than 1000 km and could be as low as 160 km above Earth.
- 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.
- LEO 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.
- Individual LEO satellites are **less useful for tasks such as telecommunication.**
    - They move so fast across the sky and therefore require a lot of effort to track from ground stations.
- Therefore, communications satellites in LEO often work as part of a large combination or constellation of multiple satellites to give constant coverage.

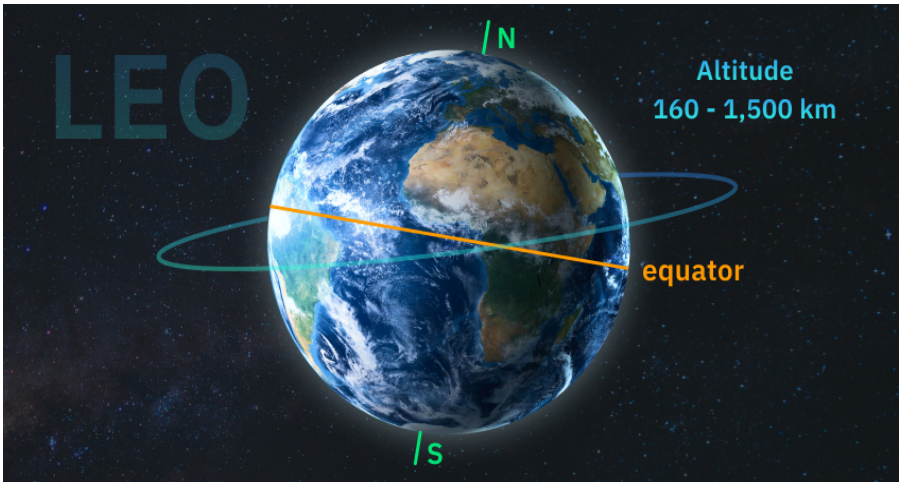


Figure.2. Low Earth Orbit

2.3.2. Medium Earth Orbit (MEO)

- Medium Earth orbit comprises a wide range of orbits anywhere **between low Earth and geostationary orbits.**
- MEO 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.
- Positioning and navigation services, like GPS (Global Positioning System), extensively use MEO type of satellites because MEO satellites are located at a medium altitude, so they have a wider field of view.
- This allows the satellites to pick up a greater number of navigational signals, resulting in a more precise and reliable navigational system.

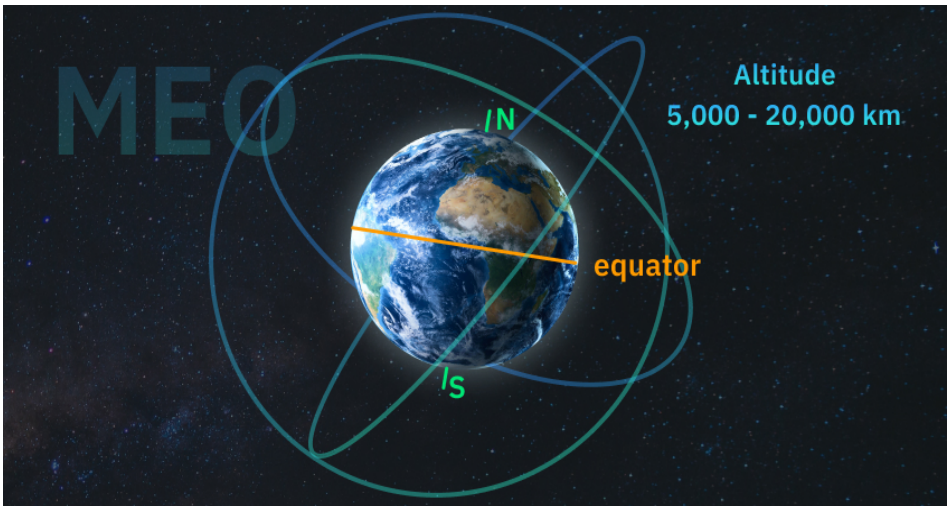


Figure.3. Medium Earth orbit

2.3.3. Geosynchronous Orbit (GSO)

- When a satellite reaches exactly **42,164 kilometres from the centre of the Earth** (about 36,000 kilometres from Earth's surface), it enters a spot in which its orbit matches Earth's rotation. This special, high Earth orbit is called geosynchronous.
- Satellites in GSO **take 24 hours to complete one rotation** around the Earth.

- Most of the communication satellites are placed in the geosynchronous orbit so that they appear stationary at the same point in the sky, making it easier for ground-based satellite antennas to communicate with them.
- A satellite in a circular geosynchronous orbit directly over the equator (eccentricity and inclination at zero) will have a geostationary orbit that does not move at all relative to the ground.

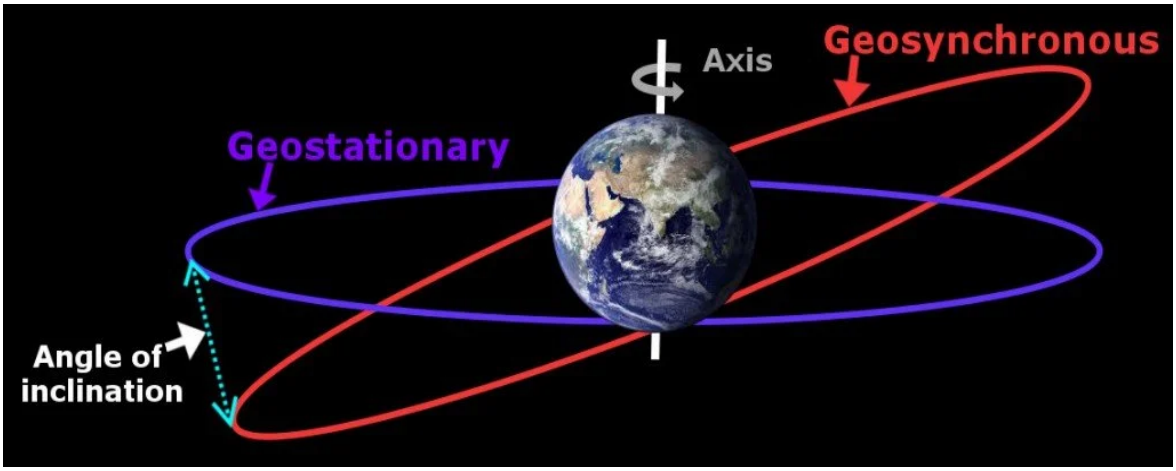


Figure.4. Geosynchronous Orbit

2.3.4. Geostationary Orbit (GEO)

- Satellites in geostationary orbit (GEO) circle Earth above the equator **from west to east following Earth's rotation** and travel at exactly the **same rate as Earth, i.e., 23 hours 56 minutes and 4 seconds.**
    - This makes satellites in GEO appear to be 'stationary' over a fixed position.
- The speed of GEO satellites should be about **3 km per second at an altitude of 35,786 km** to perfectly match the Earth's rotation.
- **Telecommunications satellites** are often placed in a GEO so that earth-based satellite antennas (located on Earth) do not have to rotate to track them but can be pointed permanently at the position in the sky where the satellites are located.
- It can also be used in **meteorology** to keep an eye on the weather in particular regions and track the development of local patterns.
- The downside of GEO type of spacecraft for real-time communication is the **longer signal delay caused** by their great distance from Earth.

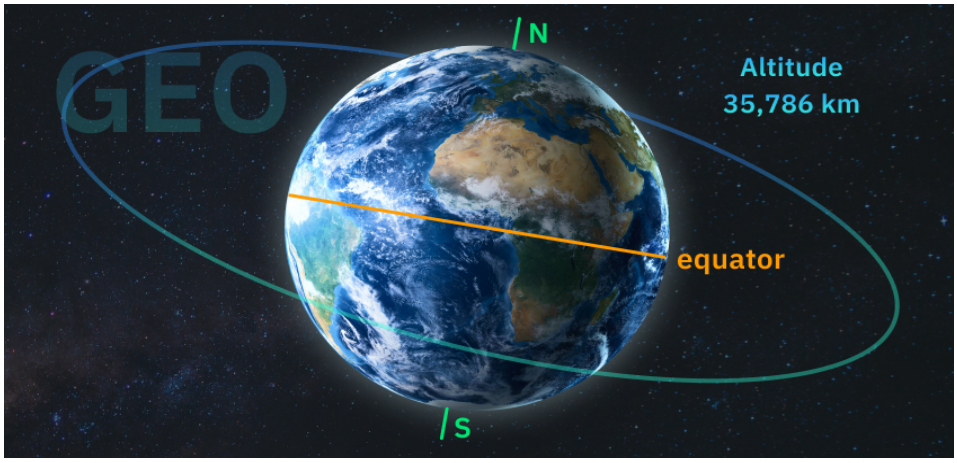


Figure.5. Geostationary Orbit

2.3.5. Sun-Synchronous Orbit (SSO)

- Satellites in Sun-synchronous orbit go from north to south across the polar regions at an altitude of 600 to 800 km above the Earth.
- The orbital inclination and altitude of SSO spacecraft are calibrated so that they **always cross any given location at precisely the same local solar time.**

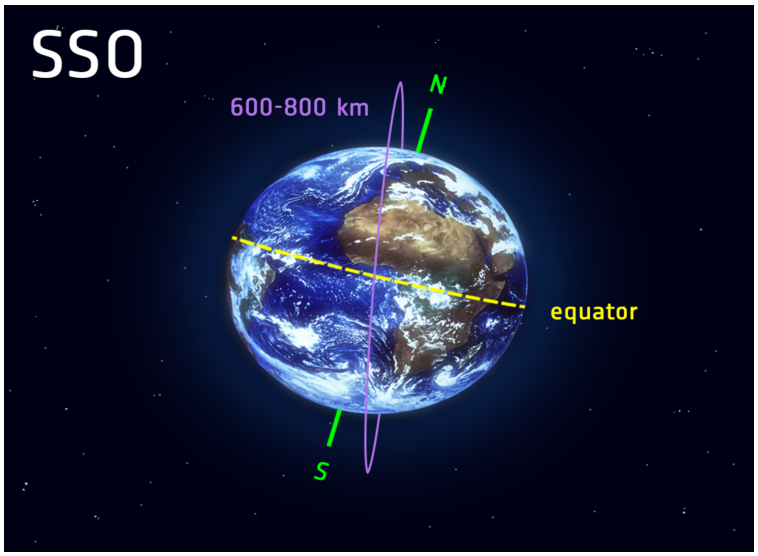


Figure.6. Sun-Synchronous Orbit

- Thus, the lighting conditions are consistent for imaging, making this type of satellite **ideal for earth observation and environmental monitoring.**
- Scientists use these image sequences to learn about the development of weather patterns, forecast cyclones, prevent wildfires and floods, and gather information on issues like deforestation and coastline changes.

2.3.6. Geostationary Transfer Orbit (GTO)

- Often, the satellites are 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 a high-altitude orbit** like GEO **without actually needing the launch vehicle** to go all the way to this altitude.

- Reaching GEO in this way is an example of one of the most common transfer orbits, called the geostationary transfer orbit (GTO).
- When the payload reaches the apogee at the GEO altitude of 35,786 km, it fires its engines in such a way that it enters onto the circular GEO orbit and stays there.

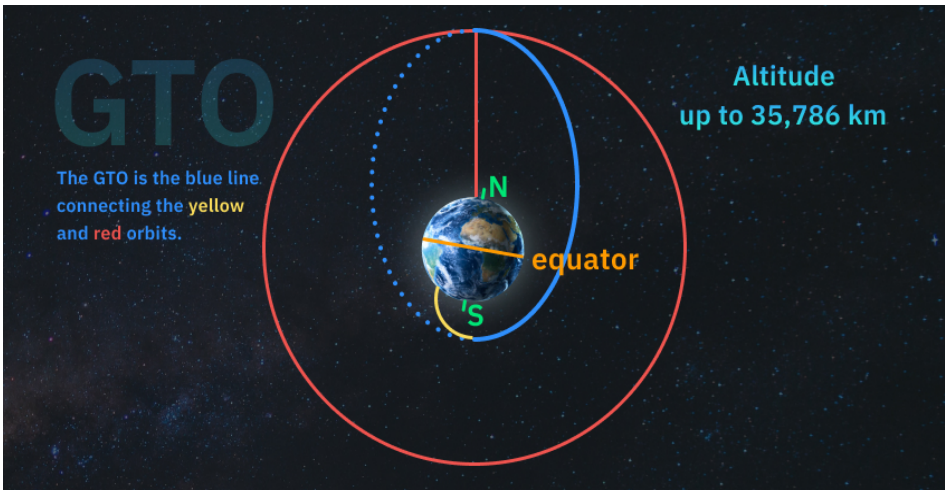


Figure.7. Geostationary Transfer Orbit

3. Lagrange Points

3.1.What is a Lagrange Point?

- A Lagrange point is a location in space where the **combined gravitational forces of two large bodies,** such as Earth and the Sun or Earth and the Moon, **equal the centrifugal force felt by a much smaller third body.**
- The interaction of the forces creates a point of equilibrium where a spacecraft may be "parked" to make observations.
- These points are named after **Joseph-Louis Lagrange,** an 18th-century mathematician who wrote about them in a 1772 paper concerning what he called the **"three-body problem."** They are also called **Lagrangian points and libration points.**

3.2. Different Points

- There are **five special points** where a small mass can orbit in a constant pattern with two larger masses. Of the five Lagrange points, **three are unstable and two are stable.**
- The unstable Lagrange points – labelled L1, L2, and L3 – lie along the line connecting the two large masses.
- The stable Lagrange points – labelled L4 and L5 – form the apex of two equilateral triangles that have the large masses at their vertices.

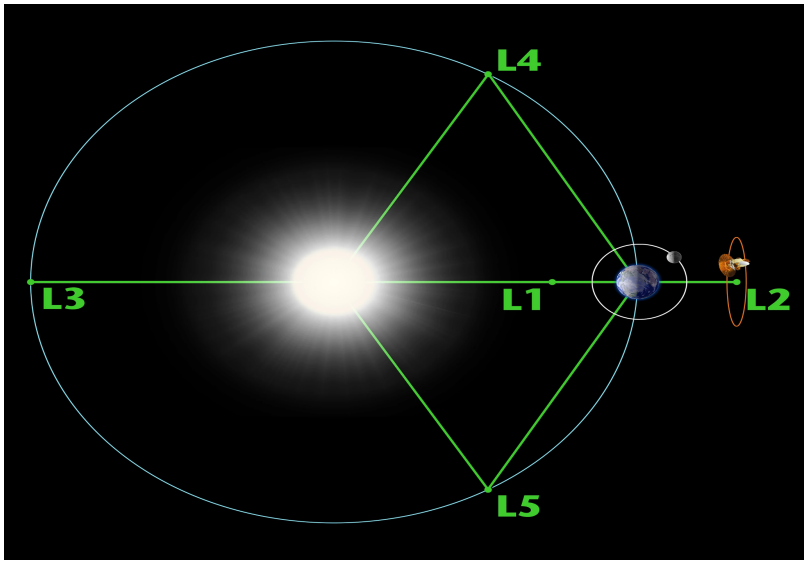


Figure.8. Lagrange Points

- **L1 point** of the Earth-Sun system affords an **uninterrupted view of the Sun,** and is currently home to the **Solar and Heliospheric Observatory Satellite** (SOHO). **Aditya-L1** of ISRO is positioned at the L1 point.
- **L2 point is ideal for astronomy** because a spacecraft is close enough to readily communicate with Earth, can keep Sun, Earth and Moon behind the spacecraft for solar power and provides a clear view of deep space for telescopes.
- **L3 lies behind the sun,** opposite Earth's orbit. For now, science has not found a use for this spot.
- **L4 and L5 points** are home to stable orbits so long as the **mass ratio between the two large masses exceeds 24.96.**
    - This condition is satisfied for both the Earth-Sun and Earth-Moon systems, and for many other pairs of bodies in the solar system.

4. Satellite Launch Vehicles

4.1. What are Launch Vehicles?

- Launch vehicles or launch systems, as the names imply, are **used to carry spacecraft from the surface of the Earth into space.**
- Most launch vehicles operate from a launch pad, supported by a launch control center and systems such as vehicle assembly and fueling.
- They are classified by their orbital payload capacity, ranging from small-, medium-, heavy- to super-heavy lift.

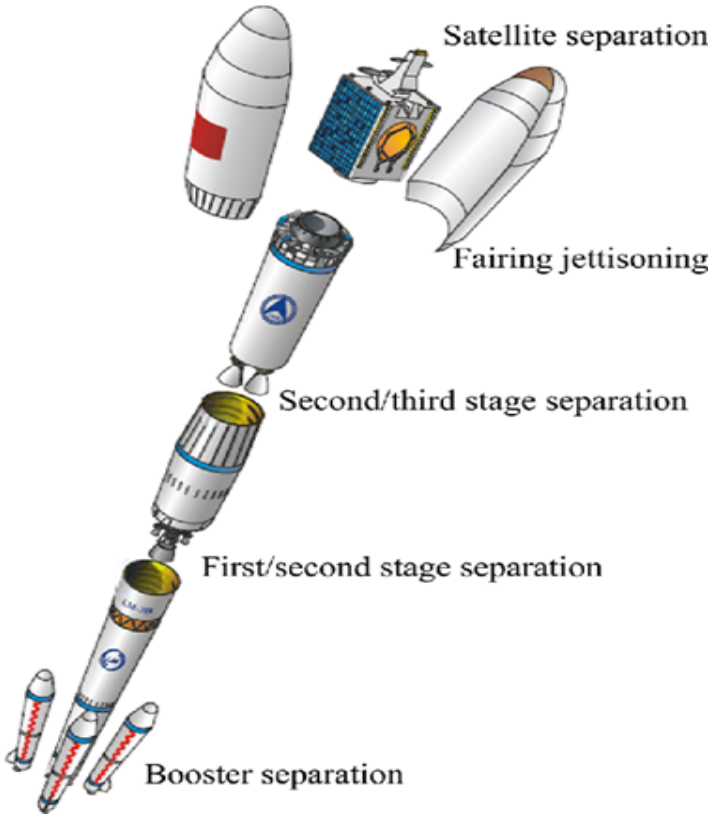


Figure.9. Structure of Launch Vehicle

4.2. Launching of Satellite

- The process of placing the satellite in a proper orbit is known as the launching process.
- A launch vehicle is a good illustration of **Newton's third law of motion,** i.e., "for every action, there is an equal and opposite reaction."
- In the case of a launch vehicle,
    - "Action" is the flow out the rear of the vehicle of exhaust gases produced by the combustion of the vehicle's fuel in its rocket engine, and
    - "Reaction" is the pressure, called thrust, applied to the internal structure of the launch vehicle that pushes it in the direction opposite to the exhaust flow.
- The launch of a spacecraft comprises a period of powered flight during which the vehicle rises above Earth's atmosphere and accelerates at least to orbital velocity.
- Powered flight ends when the rocket's last stage burns out, and the spacecraft separates and continues in freefall.

4.3. Types of Satellite Launch Vehicle

The launch vehicles are basically multi-stage rockets and thus are mainly classified as:

Expendable Launch Vehicles (ELV)

- An expendable launch vehicle is a **single-use launch vehicle** usually used to launch a payload into space. Most satellites are launched into orbit using expendable launchers.
- Expendable launch vehicles typically consist of stages which are discarded one by one, in order not to have to carry and accelerate parts that are no longer needed.
- The ELV contains three stages. First and second stages of ELV raise the satellite to about 50 miles and 100 miles. Third stage of ELV places the satellite in transfer orbit.

- Once the satellite reaches the transfer orbit then the task of the launch vehicle will get completed and the various parts will get destroyed by themselves generally by falling to the earth.

Reusable Launch Vehicles (RLV)

- This category of launch vehicles **offers reusability** and so can be used various times for launching satellites in space.
- Generally, this type of launch vehicle will return back to earth after leaving the satellite in space. Sometimes it is given the name, space shuttle.
- Functions of RLV are similar to the functions of first and second stages of ELV.
- However, in the third stage, the satellite is inserted with a cargo bay and the satellite gets ejected from the cargo bay when the RLV attains an elevation of around 150 to 200 miles.
- Once this height is achieved then the shuttle will be fired thereby placing the satellite in the transfer orbit. After this, the space shuttle will return back to earth for reuse.

4.4. Advantages and Limitations of Satellite Launch Vehicles

Launch Vehicles	Advantages	Limitations
Expendable Launch Vehicles	● Simpler in design than reusable launch systems. ● Lower Development Costs. ● Low risk of mission failure. ● Short time to launch. ● Offer greater payloads.	● Usable only once. ● Have a significantly higher per-launch cost than modern reusable vehicles.
Reusable Launch Vehicles	● Lower Cost per Launch. ● Improved Environmental Footprint. ● Reduced material cost due to reusability. ● Increased Launch Flexibility.	● Landing and recovery requires a high degree of precision and accuracy. ● High Development Costs. ● Technical Complexity.

1. Artificial Satellites

1.1. What are Artificial Satellites?

- Artificial satellites are **human-built objects orbiting the Earth and other planets** in the Solar System.
- They are used to study the Earth, other planets, aiding communication, and even to observe the distant universe. Satellites can even have people in them, like the International Space Station.
- The first artificial satellite was the Soviet Sputnik 1 mission, launched in 1957.

1.2. Types of Artificial Satellites

The most common types of artificial satellites based on their application are:

- Communication
- Earth observation
- Navigation
- Astronomical

2. Communication Satellites

2.1. What are Communication Satellites?

- Communication satellites are launched to orbit around the earth or any other planet to collect information and transmit it back to the planet.
- They are launched to **expand the ability of networks and connections** on the planet.
- Such a satellite can make long-distance communication and information transfer much more effortless.

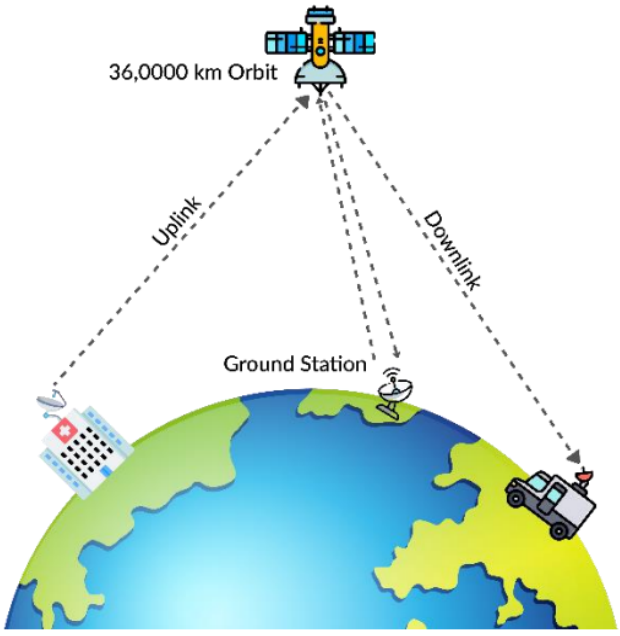


Figure.1. Working of Communication Satellite

2.2. Working of Communication Satellite

The process of communicating with satellites involves four significant steps:

- A **signal transmission** will occur from an **Uplink Earth station** or other equipment transmitting the desired signal to the satellite.
- The received signal is **amplified** by the satellite.
- The signal is transmitted back to the earth as a **downlink.**
- The antennas or **receiving equipment** will receive this signal.

2.3. Applications of Communication Satellites

- **Telecommunication:** To efficiently provide voice and data communication with the local and far-flung areas.
- **Telemedicine:** Mobile units are being connected seamlessly to the major hospitals and medical hubs, and medical practitioners are able to access the data rapidly.
- **Tele-education:** Communication satellites make education available to the students and professionals in remote locations.
- **Banking:** Banks and ATMs require a secured and reliable connectivity to transmit data and satellites provide that reliable connectivity for all the limitless transactions.
- **Development of Internet of Things (IoT) technology through smallsats:** Through the launch of small communication satellites in low earth orbits, the number of IoT devices being connected with the internet can be increased.
- **Real-time tracking:** To track the real-time data for earth observations such as climate change, disaster management, and also for military applications.
- **TV Broadcasting:** Various programs such as movies, live sports and live news are available on television through direct broadcast satellite.
- **Radio Broadcast:** A satellite radio provider uses satellites to broadcast audio channels of entertainment, sports, and news programs.

3. Indian National Satellite (INSAT) system

- The Indian National Satellite (INSAT) system is one of the largest domestic communication satellite systems in the Asia-Pacific region with nine operational communication satellites placed in Geo-stationary orbit.
- It was **established in 1983** with commissioning of the first satellite in the series, INSAT-1B.

3.1. Impact of INSAT Programme on India

- The communication satellite series of India has grown into a very large constellation of satellites in the INSAT and GSAT series.
- The INSAT satellite system is one of the largest domestic communication satellite systems providing regular services in the areas of television, telecommunications, radio networking, business and personal communication and weather forecasting and meteorological services.
- Newer initiatives have been taken to expand the INSAT applications to newer areas like:
    - Tele-education
        - **EDUSAT**: used extensively to cater to a wide range of interactive educational delivery modes like one-way TV broadcast, video conferencing, web-based instructions, etc.

    - Tele-medicine
        - ISRO Telemedicine pilot project was started in the year 2001 as part of proof-of-concept demonstration programme.
    - Village Resource Centre (VRC)
        - VRCs have provided various space technology enabled services such as tele-healthcare, tele-education, natural resources information, etc.
        - Major benefits include advisories related to agriculture like crop pests and diseases, crop insurance etc.; career guidance to rural students, skill development and vocational training etc., to the rural population.
    - Disaster Management Support (DMS)
        - ISRO disseminates relevant information in interactive **geo-spatial domains** through various geoportals like Bhuvan, National Database for Emergency Management and MOSDAC (Meteorological and Oceanographic Satellite Data Archival Centre).
    - Satellite news gathering
    - Satellite Aided Search and Rescue (SAS&R)
    - Internet services and e-governance
    - Financial service network, such as the banking, the stock exchanges etc.
    - Standard Time and Frequency Signal (STFS) Dissemination Services
- The INSAT system has also extended the outreach to less accessible areas like North-East, other far-flung areas and islands.

3.2. List of Important Communication Satellites

Satellite	Launch Date	Launch Vehicle	Application
CMS-01	Dec 17, 2020	PSLV-C50/CMS-01	Communication
GSAT-30	Jan 17, 2020	Ariane-5 VA-251	Communication
GSAT-31	Feb 06, 2019	Ariane-5 VA-247	Communication
GSAT-11 Mission	Dec 05, 2018	Ariane-5 VA-246	Communication
GSAT-17	Jun 29, 2017	Ariane-5 VA-238	Communication
GSAT-15	Nov 11, 2015	Ariane-5 VA-227	Communication, Navigation
GSAT-8	May 21, 2011	Ariane-5 VA-202	Communication, Navigation
EDUSAT	Sep 20, 2004	GSLV-F01 / EDUSAT(GSAT-3)	Communication

INSAT-3A	Apr 10, 2003	Ariane5-V160	Climate & Environment, Communication
KALPANA-1	Sep 12, 2002	PSLV-C4 /KALPANA-1	Climate & Environment, Communication

4. Earth Observation Systems

4.1. What is Earth Observation?

- Earth Observation (EO) refers to the **use of remote sensing technologies to monitor land, marine** (seas, rivers, lakes) **and atmosphere.**

4.2. Earth Observation Satellites

- The purpose of Earth observation type of satellites is to monitor the Earth from space and report back on any changes they observe.
- The equipped sensors are different depending on the purpose such as observation of natural phenomena, disaster monitoring, changes in the Earth caused by human activity and so on.
- Observation results are provided as satellite images or observation data, and can be interpreted into various information regarding the Earth.
- Earth observation spacecraft can be classified as:
    - **Weather satellites:** employed for monitoring and forecasting weather trends and providing actual weather data.
    - **Remote sensing satellites:** its primary applications are all types of environmental monitoring and geographical mapping.

4.3. Applications of Earth Observation Satellites

- **Agriculture and Soil:** Information on crop statistics such as distribution and storage of food grains, government policies, pricing, procurement and food security, saline/sodic soils mapping.
- **Renewable Energy:** Winds, solar and wave energy resources can be assessed with the help of Earth observation data.
- **Forest and Environment:** Biodiversity characterization, wetlands, forest and biomass mapping, land degradation and desertification processes, coastal wetlands, coral reefs, mangroves, glaciers, air and water pollution assessment, etc.
- **Geology, Geomorphology and Mineral Resources:** Lithological, geomorphological and structural mapping, landslide hazard zonation, mineral /oil exploration, mining areas, seismotectonic studies, and geo-environmental studies.
- **Land Resources:** Coverage of natural resources, land use coverage, land degradation mapping, wasteland mapping, and desertification status mapping.
- **Ocean Science:** Identification of potential fishing zones, sea state forecasting, coastal zone studies and inputs for weather forecasting and climatic studies.

- **Rural Development:** Wasteland mapping/updation, watershed development and monitoring and land records modernization plan.
- **Urban Development:** Satellite-based remote sensing is advantageous in monitoring urban land use dynamics because of the extensive spatial coverage for mapping applications, frequent revisit periods, and wide availability.
- **Water Resources:** Irrigation infrastructure assessment, water resource information system, snowmelt run-off estimation, reservoir capacity evaluation and site selection for hydro-power.
- **Weather and Climate:** Weather satellites carry instruments called radiometers that scan the Earth to form images. Through these data, hurricanes, tornadoes, heavy rainfall, cloudy sky and even the high temperature in summer, drought, etc. can be predicted.
- **Disaster Management Support:** Operationally addressing various natural disasters like floods, cyclone, drought, landslide, earthquake and forest fire; research and development on early warning systems and decision support tools.

5. Earth Observation Satellites of India

- Starting with IRS-1A in 1988, ISRO has launched many Earth Observation satellites.
- The data from these satellites are used for several applications covering agriculture, water resources, urban planning, rural development, mineral prospecting, environment, forestry, ocean resources and disaster management.

5.1. List of Important Earth Observation Satellites

Satellite	Launch Date	Launch Vehicle	Application
EOS-04	Feb 14, 2022	PSLV-C52/ EOS-04 Mission	Earth Observation
EOS-01	Nov 07, 2020	PSLV-C49/ EOS-01	Disaster Management System, Earth Observation
RISAT-2BR1	Dec 11, 2019	PSLV-C48/ RISAT-2BR1	Disaster Management System, Earth Observation
Cartosat-3	Nov 27, 2019	PSLV-C47 / Cartosat-3 Mission	Earth Observation

Cartosat-2 Series Satellite	Jan 12, 2018	PSLV-C40/Cartosat-2 Series Satellite Mission	Earth Observation
RESOURCESAT-2A	Dec 07, 2016	PSLV-C36 / RESOURCESAT-2 A	Earth Observation
INSAT-3DR	Sep 08, 2016	GSLV-F05 / INSAT-3DR	Climate & Environment, Disaster Management System
Oceansat-2	Sep 23, 2009	PSLV-C14 / OCEANSAT-2	Climate & Environment, Earth Observation
Rohini Satellite RS-D1	May 31, 1981	SLV-3D1	Earth Observation
Bhaskara-I	Jun 07, 1979	C-1 Intercosmos	Earth Observation, Experimental

6. Satellite Navigation Systems

6.1. What is a Satellite Navigation System?

- Satellite navigation or SatNav system is a system of artificial **satellites capable of providing geo specific positioning** everywhere in the world.
- Satellite navigation allows satellite navigation devices to determine their location to high precision using time signals transmitted along a line of sight by radio from satellites.
- Global coverage for each system is generally achieved by a satellite constellation of 18–30 medium Earth orbit (MEO) satellites spread between several orbital planes.

6.2. Types of Space Navigation System

There are two major types of space navigation systems:

Global Navigation Satellite System (GNSS)

- The spacecraft of the Global Navigation Satellite System (GNSS) broadcast signals that GNSS receivers pick up and utilize for geolocation purposes, providing global coverage.
- As of 2023, four global systems are operational:
    - United States' Global Positioning System (GPS) (became fully operational in 1993),
    - Russia's Global Navigation Satellite System (GLONASS),

    - China's BeiDou Navigation Satellite System, and
    - European Union's Galileo.

Regional Navigation Satellite System (RNSS)

- The Regional Navigation Satellite System (RNSS) is an autonomous regional navigation system that provides coverage on a regional scale.
- RNSS in operation are:
    - Japan's Quasi-Zenith Satellite System (QZSS), and
    - Indian Regional Navigation Satellite System (IRNSS) or NavIC.

6.3. Applications of Satellite Navigation

- **Travel:** Satellite navigation made travel to unknown places simple.
- **Tracking & Monitoring:** It has become common to track a package location, whether a parcel or food delivery.
- **Aviation:** Aircraft with SatNav services decreases the load on the pilot and decreases accidents.
- **Marine:** Navigation aid, self steering and automatic chart plotters technology made sailing easy.
- **Surveying:** Building, roads and other construction companies used SatNav technologies for precise and accurate readings.
- **Mining and Archaeology:** Both sectors use satnav for 3D mapping of sites for excavation and detailed site features.
- **Space Applications:** Spacecraft with SatNav receivers enables orbit determination precisely. It also helps in performing autonomous navigation and rendezvous tasks.
- **Military Operations:** Unmanned Aerial Vehicles (UAV), missiles, and bombers are updated with guided technology that was achieved with the integration of SatNav technology.

7. Navigation Satellites of India

7.1. GPS Aided GEO Augmented Navigation (GAGAN)

- It is a **Space Based Augmentation System** (SBAS) **jointly developed by ISRO and Airport Authority of India** to provide the best possible **navigational services over Indian FIR** (Flight Information Region) with the capability of expanding to neighbouring FIRs.
- After launching the GAGAN on 13 July, 2015, India joined the select league comprising the United States, Europe Union (EU) and Japan which have similar systems.
- GAGAN is a system of satellites and ground stations that **provide GPS signal corrections.** It corrects for GPS signal errors caused by Ionospheric disturbances, timing and satellite orbit errors and also it provides vital information regarding the health of each satellite.

Working of GAGAN

- GAGAN consists of a set of ground reference stations positioned across various locations in India called **Indian Reference Station** (INRES), which gathers GPS satellite data.

- A master station, **Indian Master Control Centre** (INMCC) collects data from reference stations and creates GPS correction messages.
- The corrected differential messages are uplinked via **Indian Uplink Station** (INLUS) and then broadcasted on a signal from three geostationary satellites (GSAT-8, GSAT-10 and GSAT-15).
- The information on this signal is compatible with basic GPS signal structure, which means any SBAS enabled GPS receiver can read this signal.

Coverage Area

- Two GEOs simultaneously transmit the GAGAN signal in space. GAGAN GEO footprint **expands from Africa to Australia** and GAGAN system has capability to cater 45 reference stations for expansion to neighbouring countries.
- GAGAN provides a **civil aeronautical navigation signal consistent with International Civil Aviation Organization (ICAO) Standards** and Recommended Practices (SARPs) as established by the **Global Navigation Satellite System (GNSS) Panel.**
- The system is interoperable with other international SBAS systems such as the United States Wide Area Augmentation System (WAAS), the European Geostationary Navigation Overlay Service (EGNOS), and the Japanese MTSAT Satellite Augmentation System (MSAS), and provides seamless air navigation across regional boundaries.

Gagan Applications

- The GAGAN system is being used for effective management of wildlife resources and monitoring of forests.
- It can provide navigational support to the Indian railway for signaling when a train approaches a no man crossing and also for alignment of railway tracks.
- The Road Asset Management System (RAMS) is likely to be developed for all National Highways in the country and a modern management system that will use the GAGAN system.
- GAGAN signals can also be used to manage traffic in real time to avoid traffic jams.
- Other areas include scientific research for atmospheric studies, natural resource and land management, location based services, mobile and tourism.

7.2. Navigation with Indian Constellation (NavIC)

- To meet the **positioning, navigation and timing requirements** of the nation, ISRO has established a regional navigation satellite system called Navigation with Indian Constellation (NavIC).
- NavIC was **erstwhile known as Indian Regional Navigation Satellite System** (IRNSS).
- The main objective is to provide Reliable Position, Navigation and Timing services over India and its neighbourhood, and to provide fairly good accuracy to the user.
- NavIC offers two services:
    - **Standard Position Service** (SPS) for civilian users
    - **Restricted Service** (RS) for strategic users

Organisation of the NavIC

- The system has essentially two-part. The first part is the **Space Segment,** made up of seven navigation satellites. Then there is **Ground Segment,** which receives signals from these satellites and puts them to different applications.

- In the space segment, there are **three satellites in Geostationary orbit** (GEO) and **four satellites in Geosynchronous orbit** (GSO) with inclination of 29° to the equatorial plane. All the satellites are visible at all times in the Indian region.
- India finished the launching of all the seven navigation satellites by the year 2016. In the middle of 2016, the satellite system also became operational. It has started with providing restricted services for military and other strategic operations.
- The ground network consists of a control centre, precise timing facility, range and integrity monitoring stations, two-way ranging stations, etc.
- Ground Segment is responsible for the maintenance and operation of the IRNSS constellation. It provides the monitoring of the constellation status, computation of the orbital and clock parameters and navigation data uploading.
- The system is intended to provide an absolute position accuracy of better than 10 meters throughout Indian landmass and better than 20 meters in the Indian Ocean as well as a region extending approximately 1,500 km around India.
- ISRO, in May, 2023, launched a new NavIC satellite (NVS-01), that belongs to the second generation of the NavIC, to overcome some of the previous issues faced by NavIC.
    - Issues faced by NavIC include atomic clock failure, satellite replacement, limited coverage, mobile incompatibility, security and encryption.

Why Does India Need its Own Navigation System?

- The requirement of such a navigation system is driven by the fact that access to foreign government-controlled global navigation satellite systems is not guaranteed in hostile situations.
- Furthermore, its own navigation system will allow India to have a greater accuracy in positioning services.

What are the Other Services Available from the System?

- Apart from navigation, the system helps in **precise time keeping, disaster management, fleet management and mapping.**
- The applications of NavIC include terrestrial, aerial and marine navigation, vehicle tracking, integration with mobile phones, geodetic data capture, terrestrial navigation aid for hikers and travellers and visual and voice navigation for drivers.

8. Astronomical Satellites

8.1. What is an Astronomical Satellite?

- An astronomical satellite is a giant telescope in orbit. It is able to see well without interference from the Earth's atmosphere.
- Its infrared imaging technology can function normally without being disturbed by the planet's surface temperature.

8.2. Types of Spacecraft Used in Astronomy

Spacecraft used in astronomy can be broken down into several distinct types:

- **Astronomy satellites:** used to investigate different types of celestial bodies and phenomena in space.

- **Climate research satellites:** fitted with specific types of sensors that allows scientists to gather comprehensive, multi-faceted data on the world's oceans and ice, land, biosphere, and atmosphere.
- **Biosatellites:** space-based studies on plant and animal cells and structures; plays a crucial role in the progress of medicine and biology.

8.3. Applications of Astronomical Satellites

- Make star maps and study mysterious phenomena such as black holes and quasars.
- Take pictures of the planets in the solar system.
- Make maps of different planetary surfaces.

9. Research Satellite: ASTROSAT

- PSLV-C30 successfully launched ASTROSAT, India's **Multi Wavelength Space Observatory** in lower earth orbit on September 28, 2015.
- ASTROSAT is designed to observe the universe in the Visible, Ultraviolet, low and high energy X-ray regions of the electromagnetic spectrum simultaneously with the help of its five payloads.
- With the success of this satellite, ISRO has proposed launching AstroSat-2 as a successor for ASTROSAT.
- The observatory had a planned lifespan of five years but completed its mission in 2022.
- With the successful launch of the space observatory, ASTROSAT, ISRO had put India in a select group of countries that have a space telescope to study celestial objects and processes.

Scientific Objectives of ASTROSAT

- To understand high energy processes in binary star systems containing neutron stars and black holes.
- Estimate magnetic fields of neutron stars.
- Study star birth regions and high energy processes in star systems lying beyond our galaxy.
- Detect new briefly bright X-ray sources in the sky.
- Perform a limited deep field survey of the Universe in the Ultraviolet region.

10. Remote Sensing Applications

10.1. What is Remote Sensing?

- Remote sensing is the process of **detecting and monitoring the physical characteristics of an area by measuring** its reflected and **emitted radiation energy** without going physically into that particular area.
- Special cameras collect remotely sensed images, which help researchers sense things about the Earth.

10.2. Applications of Remote Sensing

- **Agriculture:** identifying crop conditions; determining crop type, soil moisture content and water content of the field crop; mapping of soil characteristics, soil management practices, crop production forecasting; and drought monitoring.

- **Forestry:** determine the forest cover and type of forest; vegetation density; control of deforestation and forest fires; and biomass estimation.
- **Oceans and Coastal Monitoring:** identification of ocean patterns; assessment of fish stock and marine mammal; monitoring of water quality, temperature and effects of tides and storms; mapping of coastal vegetation; and determining ocean salinity.
- **Geology:** bedrock and structural mapping; mineral and hydrocarbon exploration; environmental geology; sedimentation mapping and monitoring; and geo-hazard mapping.
- **Hydrology**: wetlands mapping and monitoring; measuring snow thickness; river and lake ice monitoring; flood mapping and monitoring; monitoring of glacier dynamics; and mapping of drainage basin.

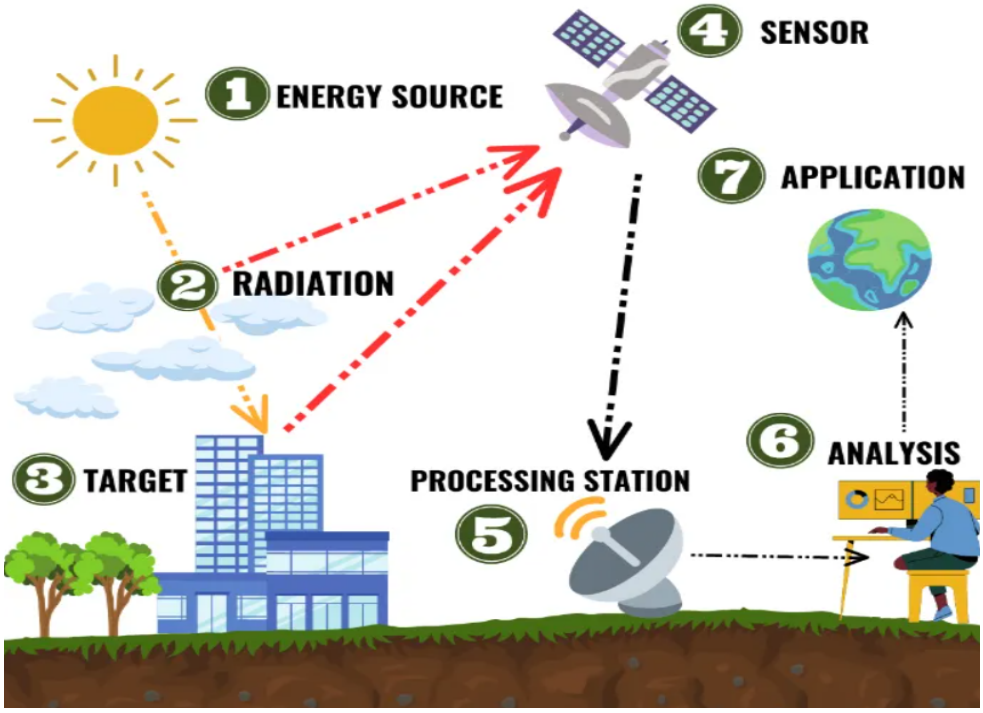


Figure.2. Remote Sensing Process

11. Indian Remote Sensing (IRS) Satellite Program

11.1. Introduction

- Following the successful demonstration flights of **Bhaskara-1 and Bhaskara-2** satellites launched in 1979 and 1981, respectively, India began to develop the indigenous IRS satellite program.
- The program was developed to support the national economy in the areas of agriculture, water resources, forestry and ecology, geology, watersheds, marine fisheries and coastal management.
- The remote sensing programme in India under the ISRO **started off in 1988 with the IRS-1A** (first of the series of indigenous state-of-art operating remote sensing satellites).

11.2. Principal Capabilities

The program involved the expansion of three principal capabilities:

- To design, build and launch satellites to a sun synchronous orbit.
- To establish and operate ground stations for spacecraft control, data transfer along with data processing and archival.
- To use the data obtained for various applications on the ground.

11.3. Important Indian Remote Sensing Satellites

Name		Launch Year	Importance
IRS	IRS-1A	1988	Used for remote sensing applications such as cartography, land use mapping, and forestry.
	IRS-1B	1991	
	IRS-1C	1995	Had improved capabilities. Used for a wide range of applications such as mineral exploration, coastal monitoring, and disaster management.
	IRS-1D	1997	
Resourcesat	Resourcesat-1	2003	Used for resource mapping and management applications such as soil moisture mapping, crop inventory, and forestry.
	Resourcesat-2	2011	
	Resourcesat-2A	2016	
Cartosat	Cartosat-1	2005	Used for cartography and high-resolution imaging applications. Cartosat-3 also has an additional capability of capturing hyperspectral images.
	Cartosat-2	2007	
	Cartosat-3	2019	
Oceansat	Oceansat-1	1999	Used for oceanographic applications such as sea surface temperature mapping, ocean color mapping, and ocean wind vector mapping.
	Oceansat-2	2009	
RISAT	RISAT-1	2012	These satellites had synthetic aperture radar (SAR) sensors that allowed them to capture images of the earth even in cloudy or dark conditions.
	RISAT-2	2009	

About ISRO and India's National Space Programmes

1. Institutional Structure Related to Space Programme in India

- Space activities in the country were initiated with the setting up of the **Indian National Committee for Space Research (INCOSPAR) in 1962.**
- In the same year, work on Thumba Equatorial Rocket Launching Station (TERLS) near Thiruvananthapuram was also started.
- Indian Space Research Organisation (ISRO) was established in August 1969.
- The Government of India constituted the Space Commission and established the **Department of Space (DOS) in June 1972** and brought ISRO under DOS in September 1972.
- The Space Commission formulates the policies and oversees the implementation of the Indian space programme to promote the development and application of space science and technology for the socio-economic benefit of the country.
- DOS implements these programmes through, mainly, ISRO, Physical Research Laboratory (PRL), National Atmospheric Research Laboratory (NARL), North Eastern-Space Applications Centre (NE-SAC) and Semi-Conductor Laboratory (SCL).
- **Antrix Corporation, established in 1992** as a government owned company, markets the space products and services.
- Programme offices at ISRO headquarters coordinate the programmes like satellite communication, earth observation, launch vehicle, space science, disaster management support, international cooperation, system reliability, safety, etc.

2. Indian Space Research Organisation (ISRO)

2.1. Introduction

- ISRO is the space agency of India.
- The organization is involved in science, engineering and technology to harvest the benefits of outer space for India and mankind.
- ISRO was previously the **Indian National Committee for Space Research** (INCOSPAR), **set up in 1962**, as envisioned by Dr. Vikram Sarabhai.
- ISRO was formed on **August 15, 1969** and superseded INCOSPAR.

2.2. Objective

- The prime objective of ISRO/DOS is the development and application of space technology for various national needs.
- To fulfill this objective, ISRO has established a major space system for
    - communication, television broadcasting and meteorological services;
    - resources monitoring and management;
    - space-based navigation services.

- ISRO has developed satellite launch vehicles, PSLV and GSLV, to place the satellites in the required orbits.

2.3. Headquarters

- ISRO has its headquarters in **Bengaluru.**
- Launch Vehicles are built at Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram.
- Satellites are designed and developed at U R Rao Satellite Centre (URSC), Bangalore.
- Integration and launching of satellites and launch vehicles are carried out from Satish Dhawan Space Centre (SDSC), Sriharikota.

2.4. Execution of Indian Space Programme

DOS, through its agency ISRO, has evolved the following programmes with the objective of promoting and developing application of space science and space technology:

- **Launch Vehicle programme** having indigenous capability for launching satellites.
- **INSAT Programme** for telecommunications, broadcasting, meteorology, development of education etc.
- **Remote Sensing Programme** for application of satellite imagery for various developmental purposes.
- Research and Development in Space Sciences and Technology for serving the end of applying them for national development.

3. National Space Missions

3.1. Mangalyaan (Mars Orbiter Mission)

- Mars Orbiter Mission (MOM), popularly known as Mangalyaan, marks **India's first venture into interplanetary space.**
- The spacecraft launched on November 5, 2013, arrived safely into Mars orbit on September 24, 2014.
- ISRO has become the fourth space agency to reach Mars, after the Soviet space program, NASA, and the European Space Agency.
- As a result, India made history by becoming the **first-ever country to reach Mars on the first attempt** and it was done on a light budget.
- MOM was designed to explore and observe the Mars surface features, mineralogy and the Martian atmosphere.
- Further, it also performed a focused research in search of methane in the Martian atmosphere to enquire about the possibility or the past existence of life on the planet.

3.1.1. Equipment on board MOM

- **Lyman Alpha Photometer (LAP)** is an absorption cell photometer. It measures the relative abundance of Deuterium and Hydrogen from spectral studies of the Martian upper atmosphere (Exosphere and Exobase).
- **Methane Sensor for Mars (MSM)** was designed to measure methane in the Martian atmosphere with a particle-per-billion accuracy and also capacity to map the sources.
- **Mars Exospheric Neutral Composition Analyser (MENCA)** is a quadrupole mass spectrometer capable of analysing the neutral composition in the range of 1 to 300 amu, the range in which the bulk proportion of gases of the Martian atmosphere falls.

- **Mars Colour Camera (MCC)** images give useful inputs about the surface features and composition of the Martian surface and to monitor the dynamic events and weather of Mars.
- **Thermal Imaging Spectrometer (TIS)** is for surface and atmospheric exploration using thermal remote sensing and also detecting the sources of thermal radiation in the Martian environment.

3.1.2. Duration of Mars Mission

- Mangalyaan was planned for a mission life of six months. However, due to fuel-saving manoeuvres and accurate orbital injections and firings saved 20 Kg of fuel, making 40 Kg of fuel at the time of Mars's high elliptical orbit insertion.
- The functioning of instruments with no or less degradation even after six months of working under such harsh conditions is another great feat of the orbiter.
- ISRO utilized this opportunity to make use of the data and worked towards familiarizing the Martian conditions.
- The Control and Command Unit made necessary orbital corrections to further prolong the life of MOM to endure solar eclipse, bursts, flares and other mission unplanned phenomena.
- MOM instruments' prolonged functioning also helped to understand the response and health of the instrument to work in such harsh conditions.
- On October 02, 2022, it was reported that the orbiter had irrecoverably lost communications with Earth after entering a seven-hour eclipse period in April 2022 that it was not designed to survive.
- The following day, ISRO released a statement that all attempts to revive MOM had failed and officially declared it dead.

3.2. Chandrayaan I

- Chandrayaan I was India's first Moon mission.
- The mission had 11 payloads built by India, the United Kingdom, the United States of America, Germany, Bulgaria and Sweden.
- Chandrayaan mission, launched on a PSLV rocket on October 22, 2008 from Sriharikota, was designed to collect data about the topography of the Moon.
- The spacecraft was orbiting around the Moon at the height of 100 km from the lunar surface.

3.2.1. Significance of Chandrayaan I Mission

- It collected data on chemical, mineralogical and photo-geologic mapping of the Moon.
- The data from Chandrayaan I helped discover the presence of water on the Moon in September 2009.

3.3. Chandrayaan II

- Chandrayaan II is the second lunar exploration mission of the ISRO after Chandrayaan I.
- It consisted of an orbiter, a lander named Vikram and a rover named Pragyan.
- The spacecraft was launched from the second launch pad at the Satish Dhawan Space Centre in Andhra Pradesh on 22 July 2019 by GSLV MkIII-M1.
- The lander and the rover were scheduled to land on the near side of the Moon, in the south polar region on 6 September 2019.

- A successful soft landing would have made India the fourth country to land on the moon after the Soviet Union, United States and China.
- However, the lander crashed when it deviated from its intended trajectory while attempting to land.

3.3.1. Mission Objectives

- To develop and demonstrate the key technologies for end-to-end lunar mission capability, including soft-landing and roving on the lunar surface.

3.3.2. Science Objectives

- To expand the lunar scientific knowledge through detailed study of topography, mineralogy, surface chemical composition, thermo-physical characteristics and tenuous lunar atmosphere leading to a better understanding of the origin and evolution of the Moon.

3.3.3. Relevance of Chandrayaan II Mission

- Despite the failure, the mission's orbiter and other parts had functioned normally and gathered information.
- The information included the presence of water molecules on the moon, information about solar flares and discovery of minor elements.

3.4. Chandrayaan III

- Chandrayaan III is a follow-on mission to Chandrayaan II to demonstrate end-to-end capability in safe landing and roving on the lunar surface.
- It was **launched on 14 July 2023 by LVM3 M4** from the Satish Dhawan Space Center, and the lander and rover **landed near the lunar south pole region on 23 August 2023.**
- With this, **India has become the fourth country** – after Russia, the United States and China – to land on the moon and **also the first to land on the moon's South Pole.**

3.4.1. Mission objectives of Chandrayaan III

- To demonstrate Safe and Soft Landing on the Lunar Surface.
- To demonstrate Rover roving on the moon.
- To conduct in-situ scientific experiments.

3.4.2. Components of Chandrayaan III

It consists of an **indigenous Lander module (LM), Propulsion module (PM) and a Rover.** The lander (Vikram) and rover payloads (Pragyan) of Chandrayaan III remain the same as the Chandrayaan II mission.

Propulsion module

- It is a box-like structure with one large solar panel mounted on one side and a large cylinder on top that acts as a mounting structure for the lander.
- It has one instrument called the **Spectropolarimetry of HAbitable Planet Earth** (SHAPE) to study Earth from lunar orbit.

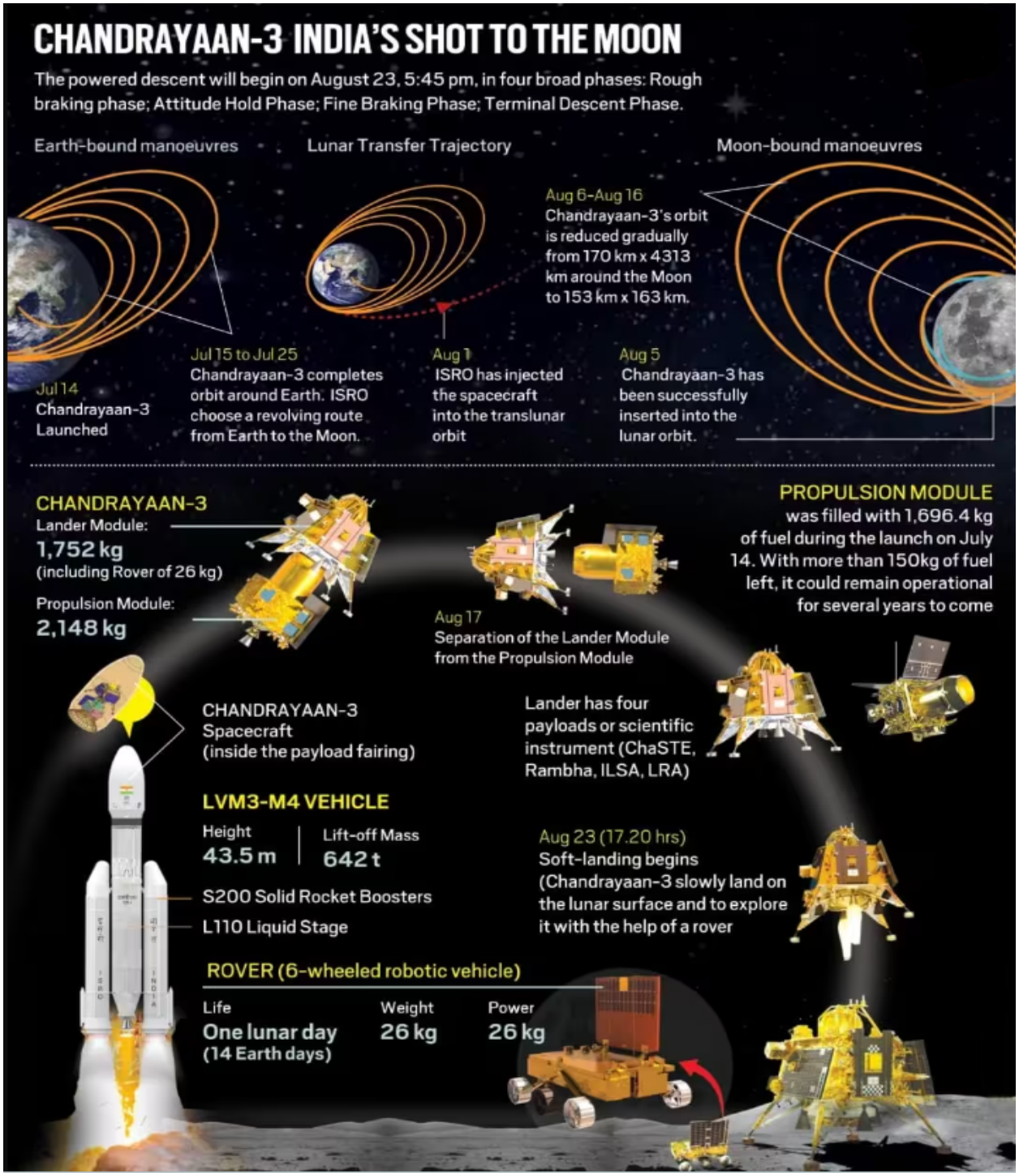
Vikram

- The Vikram lander is **responsible for the soft landing** on the Moon. It is box-shaped, with four landing legs and four landing thrusters capable of producing 800 newtons of thrust each.
- Payloads of Vikram lander are:

    - an instrument called **Chandra's Surface Thermophysical Experiment** (ChaSTE) to measure surface thermal properties,
    - the **Instrument for Lunar Seismic Activity** (ILSA) to measure seismicity around the landing site,
    - the **Radio Anatomy of Moon Bound Hypersensitive ionosphere and Atmosphere** (RAMBHA) to study the gas and plasma environment, and
    - a passive **laser retroreflector array** provided by NASA for lunar ranging studies.

Pragyan

- Pragyan rover has navigation cameras and a solar panel that can generate 50 W.
- It has two instruments to study the local surface elemental composition, an **Alpha Particle X-ray Spectrometer** (APXS) and **Laser Induced Breakdown Spectroscopy** (LIBS).



Infographic: How the Chandrayaan III Reached the Lunar Orbit

3.4.3. Changes and Improvements in Chandrayaan III

Simplified Payload

- Unlike Chandrayaan II, which comprised the Vikram lander, Pragyan rover, and an orbiter, Chandrayaan III is **equipped with a lander and a rover only.**
- While Chandrayaan II's orbiter carried nine in-situ instruments, Chandrayaan III's propulsion module housed a single instrument called SHAPE.

Enhanced Lander Capabilities

- Chandrayaan III incorporates "lander hazard detection & avoidance cameras" to assist in coordination with the orbiter and mission control during the lander's descent to the lunar surface.

Strengthened Legs

- The legs of the new Vikram lander have been strengthened to ensure that it can land safely up to a speed of 10.8 kilometres per hour.

Bigger Fuel Tank

- The Chandrayaan III mission carries more fuel than its predecessor to make sure that it can make last-minute changes if necessary.

More Solar Panels

- The new Vikram lander has solar panels on all four of its faces instead of just two, as seen with its predecessor.

Additional Instruments and Improved Software

- The Chandrayaan III mission has additional instruments and improvements to its software to aid the soft-landing effort.

3.4.4. Why Do Space Agencies Want to Explore the Moon's South Pole?

- All of the previous spacecraft to have landed on the Moon have landed in the region near the Moon's equator firstly because it is easier and safer there.
- The terrain and temperature are more conducive for a long and sustained operation of instruments.
- Sunlight is also present, offering a regular supply of energy to solar-powered instruments.
- The polar regions of the Moon, however, are different. Many parts lie in a completely dark region without sunlight, and temperatures can go below 230 degrees Celsius. This creates difficulty in the operation of instruments.
- In addition, there are large craters all over the place. As a result, the polar regions of the Moon have remained unexplored.
- Chandrayaan II also planned to land in that region in 2019, but it was not able to accomplish a soft landing and lost contact after it hit the surface.
- South pole of the Moon is of special interest to scientists because of the **occurrence of water ice in permanently shadowed areas** around it.
- The lunar south pole has **craters on its surface that contain a fossil record of hydrogen, water ice, and other volatiles** dating from the early Solar System.
- Considering these cold temperatures, the matter trapped in the southern lunar region would not have witnessed much change over the years and could thereby **hold clues to early life.**

3.5. Aditya L1 Mission

- ISRO launched the Aditya-L1 mission (Aditya in Sanskrit means the Sun), **India's first** dedicated scientific **mission to study the Sun,** on September 02, 2023.
- After the four months, the spacecraft will be placed at Lagrange Point 1 (L1) of the Sun-Earth system, which is about 1.5 million km from Earth. It is carrying 7 distinct payloads, all developed indigenously that will study the Sun.

- If it reaches Lagrange point L1 in space, ISRO will join the ranks of NASA and the European Space Agency as the **third space agency to station a solar observatory** there.
- From L1, which serves as a special vantage point for the Sun, Aditya-L1's four payloads will directly view the Sun and three payloads will carry out in-situ studies of particles and fields at the Lagrange Point L1, thus providing important scientific studies of the propagatory effect of solar dynamics in the interplanetary medium.
- The suits of Aditya L1 payloads are expected to provide the information to understand the problem of coronal heating, coronal mass ejection (CME), pre-flare and flare activities, dynamics of space weather, propagation of particles etc.

3.5.1. Launch Vehicle

- The solar probe was carried into space by the Polar Satellite Launch Vehicle (PSLV) in **'XL' configuration.**
    - Missions like Chandrayaan-1 in 2008 and Mangalyaan in 2013 were also launched using PSLV.
- The rocket is most powerful in the 'XL' configuration as it is equipped with six extended strap-on boosters — they are larger than the boosters of other configurations and, therefore, can carry heavier payloads.
- PSLV-XL can lift 1,750 kg of payloads to the sun-synchronous polar orbit. As **Aditya L-1 weighs 1,472 kg,** it was launched aboard PSLV.
- The PSLV will initially place the Aditya L-1 in a lower Earth orbit. Subsequently, the spacecraft's orbit around the Earth will be raised multiple times before it is put on a path to a halo orbit around the L1 Lagrange point.

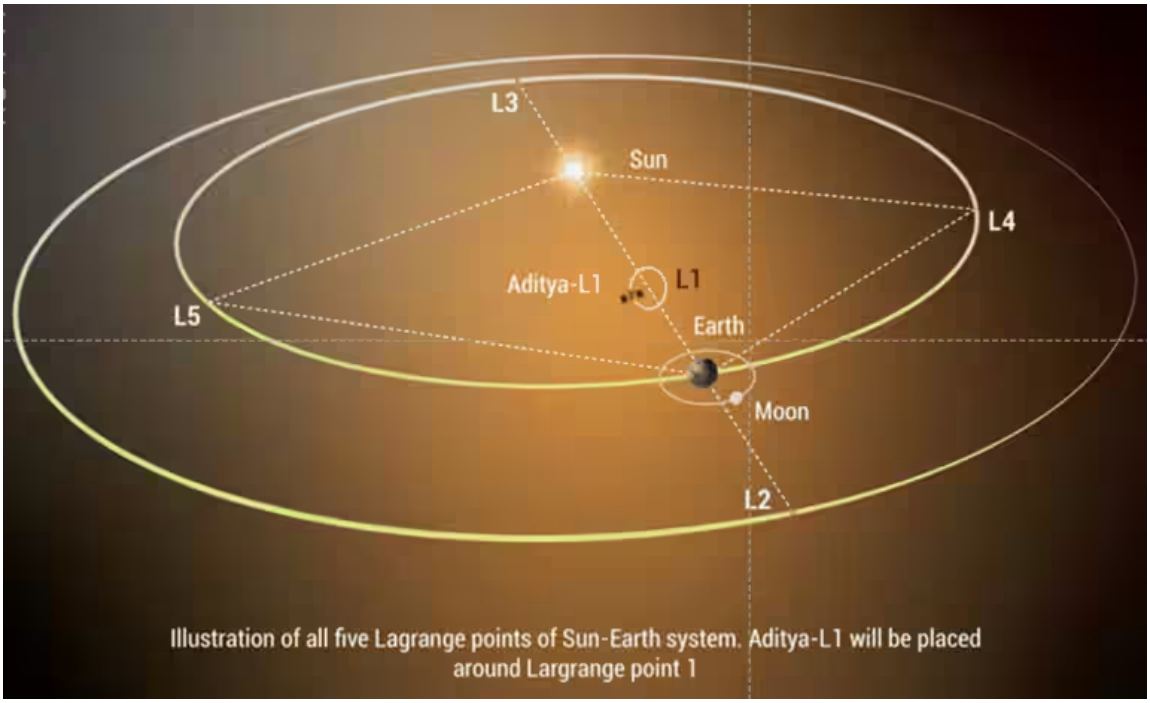


Figure.1. Aditya L1 and Lagrange Point 1

3.5.2. Major Objectives of Aditya-L1 mission

- Study of Solar upper atmospheric (chromosphere and corona) dynamics.

- Study of chromospheric and coronal heating, physics of the partially ionized plasma, initiation of the coronal mass ejections, and flares.
- Observe the in-situ particle and plasma environment providing data for the study of particle dynamics from the Sun.
- Physics of solar corona and its heating mechanism.
- Diagnostics of the coronal and coronal loops plasma: Temperature, velocity and density.
- Development, dynamics and origin of coronal mass ejections.
- Identify the sequence of processes that occur at multiple layers (chromosphere, base and extended corona) which eventually leads to solar eruptive events.
- Magnetic field topology and magnetic field measurements in the solar corona.
- Drivers for space weather (origin, composition and dynamics of solar wind.

3.5.3. Payloads

Remote Sensing Payloads

- **Visible Emission Line Coronagraph (VLEC):** the prime payload designed as a reflective coronagraph with a multi-slit spectrograph. The payload will send 1,440 images of the Sun every day to the ground station on Earth for analysis and research of the intended orbit.
- **Solar Ultraviolet Imaging Telescope (SUIT):** to picture the solar disk in the near ultraviolet wavelength range.
- **Solar Low Energy X-ray Spectrometer (SoLEXS):** to measure the solar soft X-ray flux to study solar flares.
- **High Energy L1 Orbiting X-ray Spectrometer (HEL1OS):** to observe the Sun and study solar flares in the high-energy X-rays.

In-Situ Payloads

- **Aditya Solar Wind Particle Experiment (ASPEX):** it consists of two subsystems – Solar Wind Ion Spectrometer (SWIS) and Suprathermal and Energetic Particle Spectrometer (STEPS).
    - SWIS is a low-energy spectrometer that will measure the proton and particles of the solar wind and STEPS is a high-energy version of it tasked with measuring high-energy ions of the solar wind.
- **Plasma Analyser Package For Aditya (PAPA):** the instrument will help scientists understand the solar winds and their composition. It will also carry out mass analysis of solar wind ions.
- **Advanced Triaxial High-Resolution Digital Magnetometers:** it will measure the low intensity interplanetary magnetic field in space.

3.5.4. Why Study the Sun From Space?

- The Sun emits radiation/light in nearly all wavelengths along with various energetic particles and magnetic fields.
- The atmosphere of the Earth as well as its magnetic field acts as a protective shield and blocks a number of harmful wavelength radiations including particles and fields.
- This means studying the Sun from Earth can’t provide a complete picture and it becomes crucial to observations from outside the planet’s atmosphere i.e., from space.

Space Weather Conditions

- Space weather refers to changing environmental conditions in space. It is mainly influenced by activity on the Sun's surface. In other words, the solar wind, magnetic field, as well as solar events like CME affect the nature of space.
- During such events, the nature of the magnetic field and charged particle environment near to the planet change.
- In the case of the Earth, the interaction of the Earth's magnetic field with the field carried by CME can trigger a magnetic disturbance near the Earth. Such events can affect the functioning of space assets.
- The mission hopes to generate user-friendly information that can help safeguard a range of satellite-dependent operations such as telecommunications, mobile-based Internet services, navigation, power grids, etc.

3.6. Gaganyaan

- The Gaganyaan Mission is an **indigenous mission** that would **take Indian astronauts to space** for the first time.
- The abort mission demonstration for Gaganyaan is expected around the last week of October of 2023.
- So far, **Wing Commander Rakesh Sharma** is the only Indian to have gone to space. In 1984, he went to space as part of an India-Soviet Union joint mission and spent eight days aboard the Salyut 7 Space Station.
- The project envisages demonstration of human spaceflight capability by launching a crew of three members to an orbit of 400km for a three-day mission and bringing them back safely to earth, by landing in Indian sea waters.
- The prerequisites for Gaganyaan mission include
    - development of many critical technologies including human rated launch vehicle for carrying crew safely to space,
    - life support system to provide an earth like environment to crew in space, crew emergency escape provision and
    - evolving crew management aspects for training, recovery and rehabilitation of crew.

1. Renewable Energy in India

- India stands **4th globally in Renewable Energy Installed Capacity** (including Large Hydro), **4th in Wind Power capacity** and **4th in Solar Power capacity** (as per REN21 Renewables 2022 Global Status Report).
- The country has set an enhanced target at the COP26 of **500 GW of non-fossil fuel-based energy by 2030.** This has been a key pledge under the Panchamrit (climate commitments by India). This is the world's largest expansion plan in renewable energy.
- India's installed non-fossil fuel capacity has **increased 396% in the last 8.5 years** and stands at more than 179.322 Giga Watts (including large Hydro and nuclear), **about 43% of the country's total capacity** (as of July 2023).

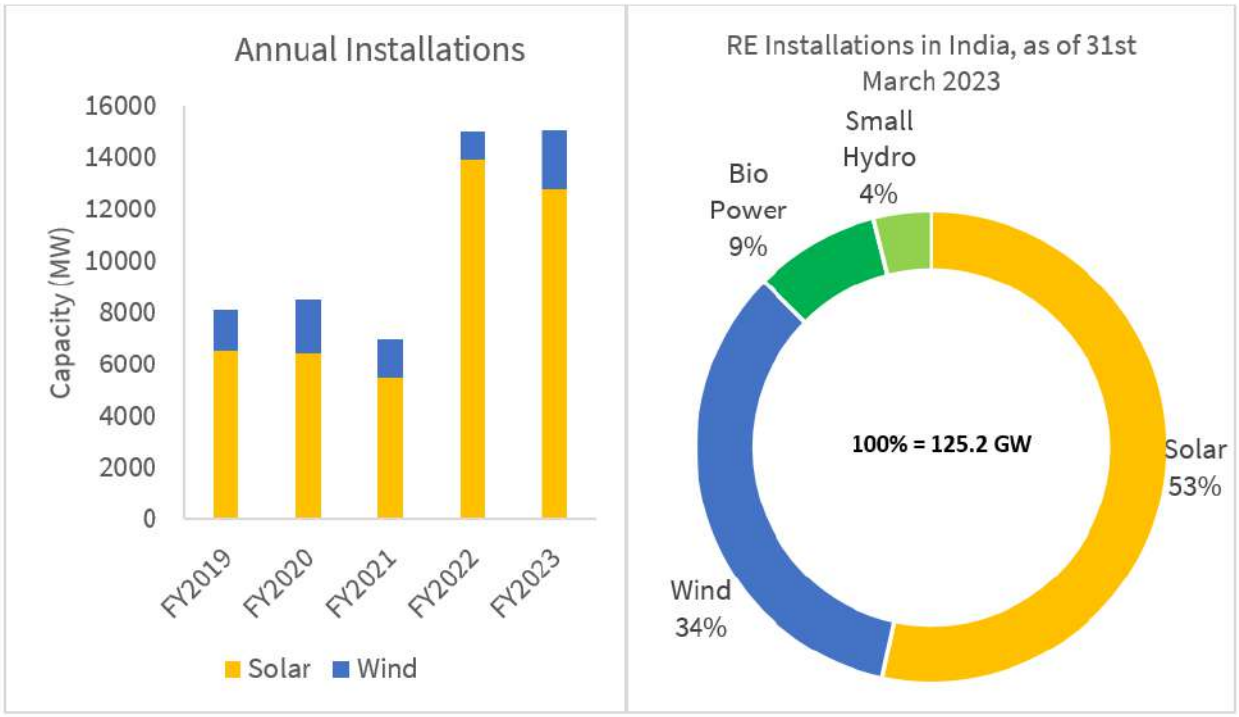


Figure.1. Renewable Energy in India

- India saw the highest year-on-year growth in renewable energy additions of 9.83% in 2022. The installed **solar energy capacity has increased by 24.4 times** in the last 9 years and stands at 67.07 GW as of July 2023.
- **Up to 100% FDI** is allowed under the automatic route for renewable energy generation and distribution projects subject to provisions of The Electricity Act 2003.
- India is the market with the fastest growth in renewable electricity, and **by 2026, new capacity additions are expected to double.**
- As per the Central Electricity Authority (CEA) estimates, by 2029-30, the **share of renewable energy generation would increase from 18% to 44%,** while that of thermal power is expected to reduce from 78% to 52%.

1.1. Energy Capacity

- India has a total renewable **energy capacity of 168.96 GW** (as on 28th February 2023) with about 82 GW at various stages of implementation and about 41 GW under tendering stage. This includes 64.38 GW Solar Power, 51.79 GW Hydro Power, 42.02 GW Wind Power and 10.77 GW Bio Power.
- India has set a target to reduce the carbon intensity of the nation's economy by less than 45% by the end of the decade, achieve 50 percent cumulative electric power installed by 2030 from renewables, and achieve **net-zero carbon emissions by 2070.**
- 57 solar parks with an aggregate capacity of 39.28 GW have been approved in India. Wind Energy has an off-shore target of 30 GW by 2030, with potential sites identified.

2. Nuclear Energy

- Nuclear energy is a form of energy **released from the nucleus,** the core of atoms, made up of protons and neutrons.
- This source of energy can be produced in two ways: **fission** – when nuclei of atoms split into several parts – or **fusion** – when nuclei fuse together.

2.1. Types of Nuclear Reactions: Fission and Fusion

2.1.1. Nuclear Fission

- In 1938, German scientists **Otto Hahn and Fritz Strassman** discovered that when a uranium nucleus is bombarded with a neutron, it breaks up into two fragments of comparable masses with the release of energy.
- The process of **breaking up the nucleus of a heavier atom into two fragments** with the **release of a large amount of energy** is called nuclear fission. The fission is accompanied by the release of neutrons. The fission reactions with $_{92}U^{235}$ are represented as:
    - $_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\ {}_{0}n^{1} + \text{Energy}$

2.1.1.1. Chain Reaction

- Consider a neutron causing fission in a uranium nucleus producing three neutrons. The three neutrons in turn may cause fission in three uranium nuclei producing nine neutrons. These nine neutrons in turn may produce twenty seven neutrons and so on.
- A chain reaction is a **self propagating process** in which the **number of neutrons goes on multiplying** rapidly almost in a geometrical progression.
- Two types of chain reactions are possible:
    - In the **uncontrolled chain reaction,** the **number of neutrons multiply indefinitely** and the entire amount of energy is released within a fraction of a second. This type of chain reaction takes place in atom bombs.
    - In the **controlled chain reaction,** the number of **fission producing neutrons is kept constant** and is always equal to one. The reaction is sustained in a controlled manner. Controlled chain reaction takes place in a nuclear reactor.
- When a thermal neutron bombards the U^{235} nucleus, it breaks into two fission fragments and three fast neutrons. One neutron may escape and one neutron may be captured by U^{238} which decays to Np^{239} (Neptunium-239) and then to Pu^{239} (Plutonium-239). One neutron is available for carrying out chain reactions.

- The chain reaction is possible, only when the loss of neutrons is less than the neutrons produced.

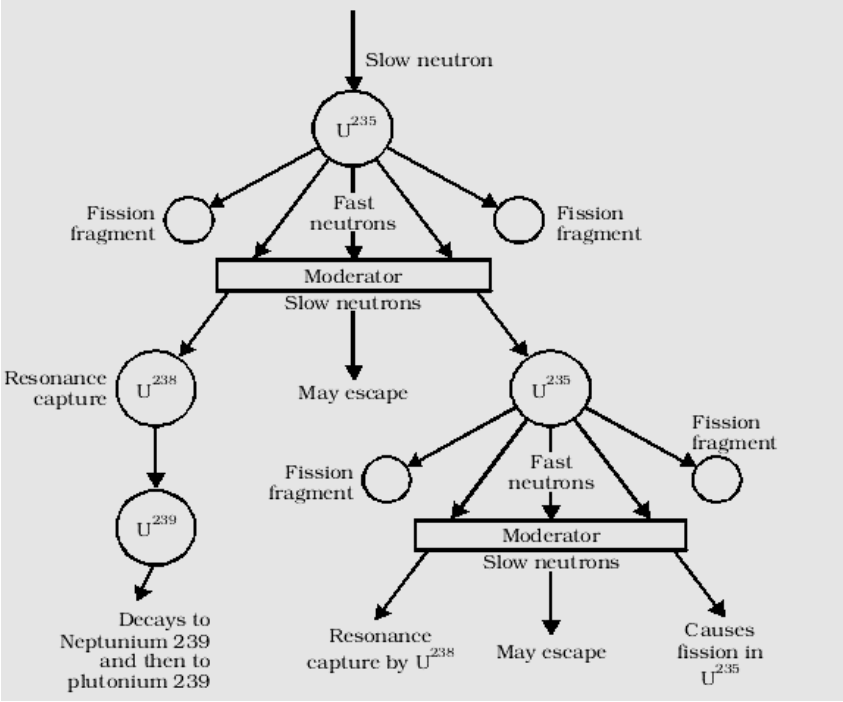


Figure.2. Controlled Chain Reaction

2.1.1.2. Nuclear Reactor

- A nuclear reactor is a device in which the nuclear fission reaction takes place in a self sustained and controlled manner. The **first nuclear reactor was built in 1942 at Chicago, USA.**
- Depending on the purpose for which the reactors are used, they may be classified into research reactors, production reactors and power reactors.
- Research reactors are used primarily to supply neutrons for research purposes and for production of radio-isotopes. The purpose of production reactors is to convert fertile (non-fissile but abundant) material into fissile material.
- The power reactor converts nuclear fission energy into electric power. The power reactors can be further classified into boiling water reactor, pressurized water reactor, pressurized heavy water reactor and fast breeder reactor depending upon the choice of the moderator and the coolant used.
- Numerous reactors of different designs have been constructed all over the world for a variety of purposes, but there exists a number of general features common to all the reactors.

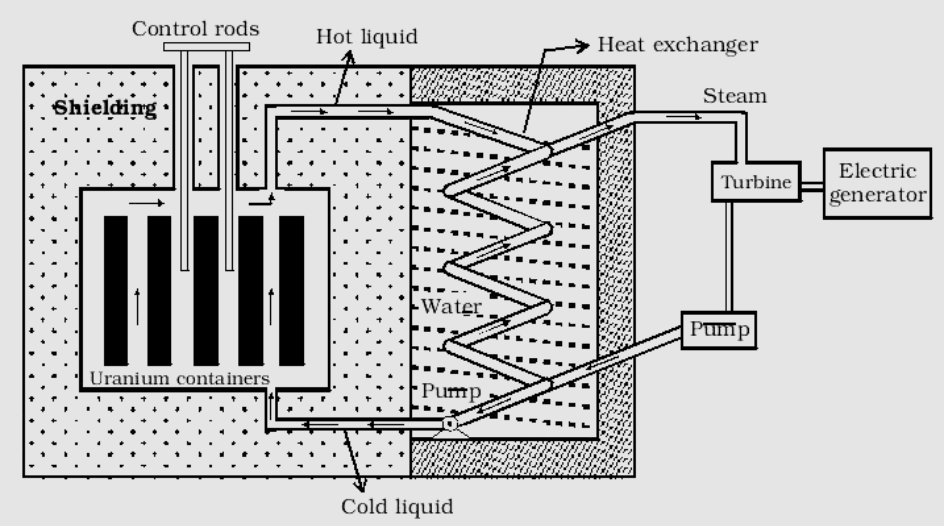


Figure.3. Schematic Design of a Nuclear Reactor

Fissile Material

- The fissile material or nuclear fuel generally used is $_{92}U^{235}$. But this exists only in a small amount (0.7%) in natural uranium.
- **Natural uranium is enriched with more** $_{92}U^{235}$ (2 – 5%) and this low enriched uranium is used as fuel in some reactors. Other than $_{92}U^{235}$, the fissile isotopes U^{233} and Pu^{239} are also used as fuel in some of the reactors.
- In the pressurized heavy water reactors (PHWR) built in India, natural uranium oxide is used as fuel. Tiny pellets of uranium oxide are packed in thin tubes of zirconium alloy and sealed to form a fuel rod. Nineteen such rods are tied together to form a fuel bundle.
- The reactor vessel which goes by the name 'Calandria' has about three hundred tubes passing through it. The fuel bundles are placed in these tubes. The part of the reactor vessel which contains the fuel rods is known as reactor core.

Moderator

- The function of a moderator is to **slow down fast neutrons** produced in the fission process. Ordinary water and heavy water are the commonly used moderators.
- A good moderator slows down neutrons by elastic collisions and it does not remove them by absorption. The moderator is present in the space between the fuel rods in a channel. Graphite is also used as a moderator in some countries.
- In fast breeder reactors, the fission chain reaction is sustained by fast neutrons and hence no moderator is required.

Neutron source

- A source of neutrons is required to initiate the fission chain reaction for the first time. **A mixture of beryllium with plutonium or radium or polonium** is commonly used as a source of neutrons.

Control Rods

- The control rods are used to control the chain reaction. They are very good absorbers of neutrons. They take up neutrons without fissioning. Lowering them into the reactor core will slow down the reaction.

- They are **held on electromagnetic clamps** so that if there is a dangerous increase in core temperature they can be dropped into the reactor and so shut down the chain reaction.
- The commonly used control rods are made up of elements like boron or cadmium. By pushing them in or pulling out, the reaction rate can be controlled.

Cooling System

- The cooling system removes the heat generated in the reactor core. Ordinary water, heavy water and liquid sodium are the commonly used coolants. **A good coolant must possess a large specific heat capacity and high boiling point.**
- The coolant passes through the tubes containing the fuel bundle and carries the heat from the fuel rods to the steam generator through heat exchanger. The steam runs the turbines to produce electricity in power reactors.
- The coolant and the moderator are the same in the PHWR and PWR. In fast breeder reactors, liquid sodium is used as the coolant. A high temperature is produced in the reactor core of the fast breeder reactors.
- Sodium is solid at room temperature but liquefies at 98°C. It has a wide working temperature since it does not boil until 892°C.
- That brackets the range of operating temperatures for the reactor so that it does not need to be pressurized as does a water-steam coolant system. It has a large specific heat so that it is an efficient heat-transfer fluid.

Neutron Reflectors

- Neutron reflectors **prevent the leakage of neutrons** to a large extent, by reflecting them back. In pressurized heavy water reactors the moderator itself acts as the reflector.
- In the fast breeder reactors, the reactor core is surrounded by depleted uranium (uranium which contains less than 0.7% of $_{92}U^{235}$) or thorium ($_{90}Th^{232}$) which acts as a neutron reflector. Neutrons escaping from the reactor core convert these materials into Pu^{239} or U^{233} respectively.

Shielding

- As a protection against the harmful radiations, the reactor is surrounded by a concrete wall of thickness about 2 to 2.5 m.

2.1.1.3. Different Types of Nuclear Reactors

Pressurized Water Reactors (PWRs)

- Most common type of Nuclear Reactor deployed to date.
- PWRs use **natural Uranium** as fuel.
- Ordinary water is used as both neutron moderators and coolant. In a PWR, the water used as moderator and primary coolant is separate to the water used to generate steam and to drive a turbine.
- In order to efficiently convert the heat produced by the nuclear reaction into electricity, the water that moderates the neutron and cools the fuel elements is contained at pressures 150 times greater than atmospheric pressure.

Boiling Water Reactors

- These are the second most commonly used types of reactors.
- Ordinary light water is used as both a moderator and coolant, like the PWR.

- However unlike the PWR, in a Boiling Water Reactor there is no separate secondary steam cycle. The water from the reactor is converted into steam and used to directly drive the generator turbine.

High Temperature Gas Cooled Reactors

- High Temperature gas cooled reactors operate at significantly higher temperatures than PWRs.
- They **use a gas as the primary coolant.**
- The nuclear reaction is mostly moderated by carbon.
- These reactors can achieve significantly higher efficiencies than PWRs but the power output per reactor is limited by the less efficient cooling power of the gas.

Heavy Water Reactors

- Heavy Water reactors are similar to PWRs but **use water enriched with the deuterium isotope** of Hydrogen as the moderator and coolant.
- This type of water is called "heavy water" and makes up about 0.022 parts per million of water found on Earth.
- The advantage of using Heavy water as the moderator is that natural, unenriched Uranium can be used to drive the nuclear reactor.

Uranium Fast Breeder Reactors

- These reactors **use the unmoderated "fast" neutrons** directly produced via the fission process.
- These reactors "breed" 239Pu from 238U and so produce more fuel than they consume.
- The use of fast-breeder technology makes it possible to increase the efficiency of Uranium use by over a factor of 50.
- In addition, the excess neutrons can be used to transmute the long-lived transuranic waste from current Nuclear Power reactors to ever-heavier isotopes until they eventually fission. Thus these reactors can be used to "burn" the most troublesome component of nuclear waste.
- This type of reactor is more costly to construct and more difficult to operate than a conventional second-generation Power Reactor.

Thorium Breeder Reactors

- Thorium is an element that is 3 times more abundant than Uranium on earth. It has a single stable isotope 232Th.
- In a nuclear reactor this isotope **can capture a neutron and be converted to 233U.** 233U undergoes fission like 235U and 239Pu.
- However when 233U fissions it releases more neutrons than either 235U or 239Pu.
- Consequently it is possible to construct a breeder reactor that utilizes thermal neutrons to both generate energy and to breed 233U from Thorium given sufficient initial quantities of 233U mixed with 232Th.
- A further advantage of Thorium breeders is that the **amount of transuranic waste is vastly decreased** compared to Uranium or Plutonium based reactors.

2.2.2. Nuclear Fusion

- Nuclear fusion is a process by which nuclear reactions between **light elements form heavier elements** (up to iron).

- In cases where the interacting nuclei belong to elements with low atomic numbers (e.g., hydrogen [atomic number 1] or its isotopes deuterium and tritium), substantial amounts of energy are released.
- Fusion is the process that **powers active stars.** The energy released from nuclear fusion reactions accounted for the longevity of the Sun and other stars as a source of heat and light.
- The prime energy producer in the Sun is the **fusion of hydrogen to form helium.** It takes four hydrogen atoms to fuse into each helium atom. During the process some of the mass is converted into energy.

2.2.2.1. Fusion Reaction

- An important fusion reaction for practical energy generation is that between deuterium and tritium (the D-T fusion reaction). It produces helium (He) and a neutron (n) and is written:
  - $\mathbf{D + T \rightarrow He + } \boldsymbol{n}$
- Fusion reactions between light elements release energy because of the mass difference between the Z protons and N neutrons considered separately and the nucleons bound together (Z + N) in a nucleus of mass M.
- M is less than (Z + N). The mass difference is converted into energy under the equation ($e=mc^2$).

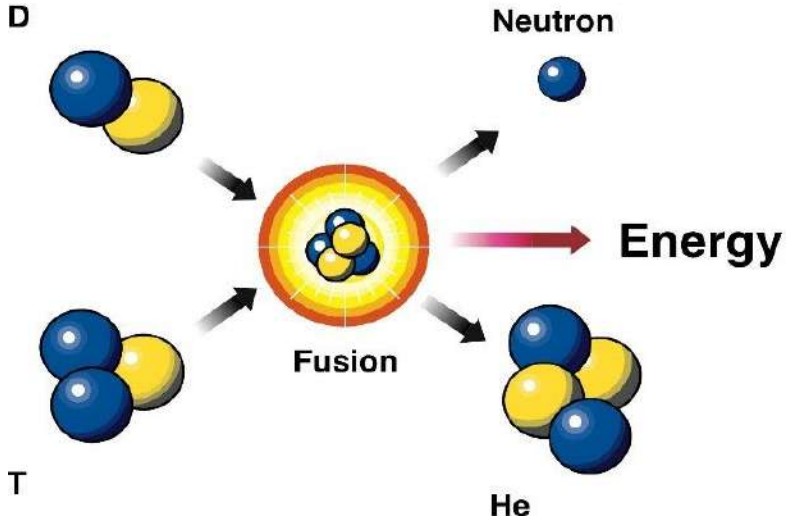


Figure.4. Nuclear Fusion

Two Basic Types of Fusion Reactions

- Those that preserve the number of protons and neutrons: Most important for practical fusion energy production.
- Those that involve a conversion between protons and neutrons: Crucial to the initiation of star burning.

Principle

- Fusion reactions are inhibited by the electrical repulsive force, called the **Coulomb force,** that acts between two positively charged nuclei.

- For fusion to occur, the two nuclei must approach each other at high speed in order to overcome their electrical repulsion and attain a sufficiently small separation (less than one-trillionth of a centimetre) so that the short-range strong force dominates.
- For the production of useful amounts of energy, a large number of nuclei must undergo fusion; that is to say, a gas of fusing nuclei must be produced.
- In a gas at extremely high temperatures, the average nucleus contains sufficient kinetic energy to undergo fusion.
- Such a medium can be produced by heating an ordinary gas beyond the temperature at which electrons are knocked out of their atoms. The result is an ionized gas consisting of free negative electrons and positive nuclei.
- **This ionized gas is in a plasma state,** the fourth state of matter. Most of the matter in the universe is in the plasma state.

2.2.2.2. ITER (International Thermonuclear Experimental Reactor)

- ITER (meaning "the way" or "the path" in Latin) is an international nuclear fusion research and engineering megaproject **aimed at creating energy through a fusion process** similar to that of the Sun.
- It is being built next to the Cadarache facility in southern France.
- It is the **world's largest tokamak,** a magnetic fusion device that has been designed to prove the feasibility of fusion as a large-scale and carbon-free source of energy.
- The primary objective of ITER is the investigation and demonstration of burning plasmas—plasmas in which the energy of the helium nuclei produced by the fusion reactions is enough to maintain the temperature of the plasma, thereby reducing or eliminating the need for external heating.
- ITER will also test the availability and integration of technologies essential for a fusion reactor (such as superconducting magnets, remote maintenance, and systems to exhaust power from the plasma) and the validity of tritium breeding module concepts that would lead in a future reactor to tritium self-sufficiency.
- Thousands of engineers and scientists have contributed to the design of ITER since the idea for an international joint experiment in fusion was first launched in 1985.

ITER Organization

- The ITER Organization is an intergovernmental organization that was **created by an international agreement signed in 2006,** and formally established on 24 October 2007 after its ratification by all Parties.
- The Parties to the ITER Agreement (the ITER Members) are China, the European Union (through Euratom), India, Japan, Korea, Russia and the United States of America (**35 countries** in total).
- The purpose of the ITER Organization is to provide for and promote cooperation among its Members for the benefit of the ITER Project, an international collaboration to demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes.
- It acts as the **overall integrator of the project** and nuclear operator of the ITER facility.

What is Tokamak?

- Construction of the ITER complex in France **started in 2013,** and assembly of the tokamak began in 2020.

- The tokamak is an experimental machine **designed to harness the energy of fusion.**
- Inside a tokamak, the energy produced through the fusion of atoms is absorbed as heat in the walls of the vessel. Just like a conventional power plant, a fusion power plant will use this heat to produce steam and then electricity by way of turbines and generators.
- The heart of a tokamak is its doughnut-shaped vacuum chamber. Inside, under the influence of extreme heat and pressure, gaseous hydrogen fuel becomes a plasma—the very environment in which hydrogen atoms can be brought to fuse and yield energy.
- The charged particles of the plasma can be shaped and controlled by the massive magnetic coils placed around the vessel; physicists use this important property to confine the hot plasma away from the vessel walls.
- The term "tokamak" comes to us from a **Russian acronym** that stands for **"toroidal chamber with magnetic coils."**
- First developed by Soviet research in the late 1960s, the tokamak has been adopted around the world as the most promising configuration of magnetic fusion device.

3. Nuclear Energy in India

- Nuclear energy is the **fifth-largest source of electricity** for India which contributes about 3% of the total electricity generation in the country.
- India entered the atomic age, more correctly the nuclear age, on 4th August 1956 when **Apsara, India's first nuclear reactor,** went into operation. This reactor was designed and built by India with the nuclear fuel supplied from the United Kingdom under a lease agreement.
- India's second reactor for research purposes, CIRUS, was built with cooperation with Canada and went into operation in the early 1960's.
- India entered into a collaboration with the former Soviet Union in 1988 to build two 1000 MW reactor power units using enriched uranium as fuel.
- In 1998, India and Russia decided to embark on this project, and work at the site commenced in 2003. The first unit at Kudankulam went into operation in 2014 and the second in 2016.
- India now has 22 reactors in operation (as of 2021), with a combined capacity of 6780 MW. Twelve more reactors are being built.
- In 2021, the government stated in the Parliament that nuclear power generation capacity would increase to 22,480 MW by 2031. This figure was reiterated in the Parliament in 2022.
- The **Nuclear Power Corporation of India Limited,** or NPCIL, is an Indian government-owned corporation with headquarters in Mumbai that is in **charge of producing electricity using nuclear energy.**
- The Department of Atomic Energy (DEA) is responsible for running NPCIL.

3.1. List of Operational Nuclear Power Plants in India

Name	Operational Year	Location	Capacity (MWe)
Kakrapar Atomic Power Station	1993	Gujarat	440

(Kalpakkam) Madras Atomic Power Station	1984	Tamil Nadu	440
Narora Atomic Power Station	1991	Uttar Pradesh	440
Kaiga Nuclear Power Plant	2000	Karnataka	880
Rajasthan Atomic Power Station	1973	Rajasthan	1180
Tarapur Atomic Power Station (oldest nuclear facility)	1969	Maharashtra	1400
Kudankulam Nuclear Power Plant (Largest)	2013	Tamil Nadu	2000

3.2. India's Nuclear Energy Programme

- India's 3 stage Nuclear Power Program was **devised by Dr. Homi J Bhaba,** the father of India's Nuclear program, in 1954.
- The main aim was **to capitalize on India's vase thorium reserves** while accounting for its low uranium reserves.
- India has only about 2% of the global uranium reserves but 25% of the world's thorium reserves.
- The three stages are:
    - Natural uranium fuelled Pressurized Heavy Water Reactors (PWHR)
    - Fast Breeder Reactors (FBRs) utilizing plutonium based fuel
    - Advanced nuclear power systems for utilization of thorium

Stage 1

- The first stage involved **using natural uranium to fuel Pressurized Heavy Water Reactors** to produce electricity and producing plutonium-239 as a byproduct.
    - U-238 → Plutonium-239 + Heat
- Using Pressurized Heavy Water Reactors rather than Light Water Reactors was the best choice for India given its infrastructure. While Pressurized Heavy Water Reactors used unenriched uranium, Light Water Reactors required enriched uranium.
- Also, the components of PWHR could be domestically manufactured in India, as opposed to LWRs, which would need some components to be imported. Furthermore the byproduct plutonium-293 would be used in the second stage.

Stage 2

- The second stage **involves using plutonium-239 to produce mixed-oxide fuel,** which would be used in Fast Breeder Reactors.
- These reactors have two processes. Firstly plutonium 293 undergoes fission to produce energy, and metal oxide is reacted with enriched uranium reacts with mixed-oxide fuel to produce more plutonium-239.
- Furthermore once a sufficient amount of plutonium-239 is built up, thorium will be used in the reactor, to produce Uranium-233. This uranium is crucial for the third stage.

Stage 3

- The main purpose of stage-3 is to achieve a sustainable nuclear fuel cycle. The advanced nuclear system **would use a combination of Uranium-233 and Thorium.** Thus India's vast thorium would be exploited, using a thermal breeder reactor.
- Currently this stage is still in the research stage. Thus India is looking to simultaneously use its thorium in other technologies.
- The options include Accelerator Driven Systems (ADS), Advanced Heavy Water Reactor (AHWR) and Compact High Temperature Reactor (CHTR).

4. Solar Energy

- Solar energy is the most abundant & cleanest energy resource on earth. The amount of solar energy that hits the earth's surface in an hour is almost the same as the amount required by all human activities in a year.
- Solar energy can be used mainly in three ways one is direct conversion of sunlight into electricity through PV cells, the two others being concentrating solar power (CSP) and solar thermal collectors for heating and cooling (SHC).

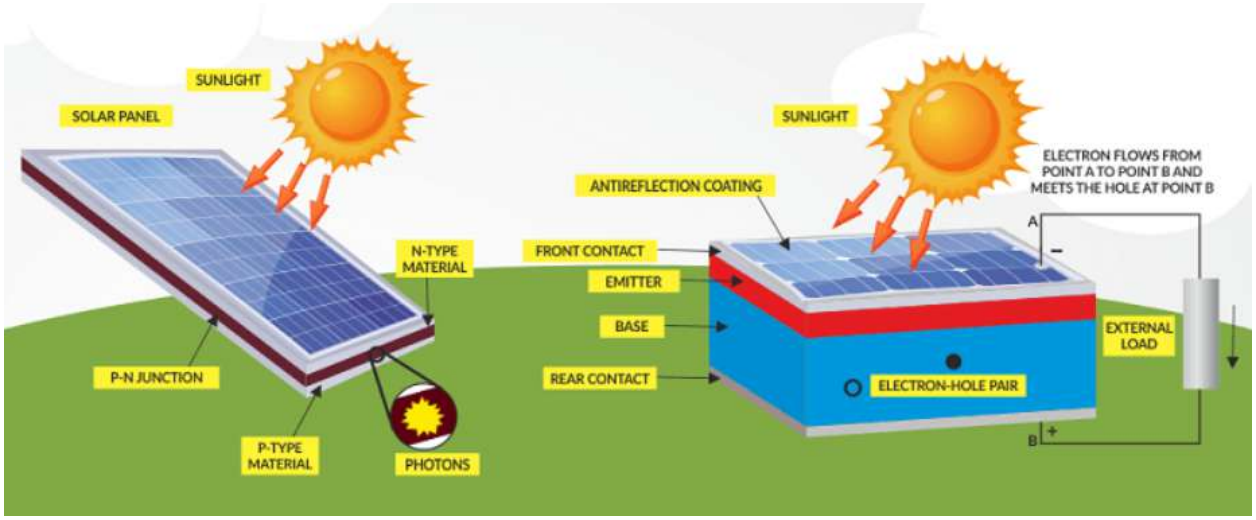


Figure.5. Working of Solar Panels

4.1. Role of Solar Panels

- Solar panels are responsible for generating electricity and in most cases they are located on the roof of any building.
- These solar panels also known as the **modules** are usually southern faced for maximum potential and electricity production.
- Each of these solar panels is made up of a special **layer of silicon cells,** a metal frame, a glassed casing which is further surrounded by special film and wiring.
- For maximum electricity production, the solar panels are **arranged together into "arrays".** Through these solar cells also known as photovoltaic cells, the sunlight is absorbed during the daylight hours.

4.2. Conversion of Absorbed Solar Energy into Electrical Energy

- Installing solar cells or photovoltaic cells is the first initial step to convert solar energy.

- Each Solar cell has a thin semiconductor wafer which is made up of two layers of silicon. Silicon semiconductors **can act as both conductors as well as insulators.**
- One silicon layer is positively charged known as the **N-type** and the other silicon layer is negatively charged known as the **P-type.**
- N-type gives away electrons easily while on the other side P-side semiconductor receives the extra electrons in the electric field. This positive and negative layer hence compliments the formation of an electric field on the solar panel.
- Energy from the sun comes on the earth in the form of **little packets called photons** When the sunlight strikes these photovoltaic cells already forming an electric field, the photons of sunlight startle the electrons inside these cells activating them to start flowing.
- These loose electrons that start flowing on the electric field further create the electric current.
- The electrical energy which we get from the solar energy through the photovoltaic cells is normally known as the Direct current (DC) electricity.
- To convert DC into alternating current (AC) special solar inverters need to be installed. The inverter turns DC electricity to 120 volts AC that can be further put into immediate use for the home appliances.

5. Solar Energy in India

- India is among the Tropical countries which receive ample solar insolation throughout the year. About **5,000 trillion kWh per year energy** is incident over India's land area with most parts receiving 4-7 kWh per sq. m per day.
- India ranks fourth globally in terms of solar power generation. Total solar power capacity installed in the country as on June 30, 2023 is **70.10 GW and in addition, 55.90 GW is under installation.**
- The top seven states in terms of highest installed capacity include Rajasthan (17.83GW), Gujarat (10.13 GW), Karnataka (9.05 GW), Tamil Nadu (6.89 GW), Maharashtra (4.87 GW), Telangana (4.69 GW) and Andhra Pradesh (4.55 GW).
- **National Institute of Solar Energy,** an autonomous institution of MNRE (Ministry of New and Renewable Energy) is the apex institute for research and development in the field of Solar Energy.

5.1. List of Largest Solar Power Plants In India

Sr.No.	Name	Installed Capacity (MW)
1.	Bhadla Solar Park, Rajasthan (world’s largest solar park)	2,245
2.	Pavagada Solar Park, Karnataka	2,050
3.	NP Kunta Ultra Mega Solar Park, Andhra Pradesh	1500
4.	Kurnool Ultra Mega Solar Park, Andhra Pradesh	1,000
5.	Rewa Ultra Mega Solar, Madhya Pradesh	750

5.2. Government Schemes, Policies and Initiatives

Solar Parks Scheme

- To facilitate large scale grid-connected solar power projects, a scheme for "Development of Solar Parks and Ultra Mega Solar Power Projects" is under implementation with a **target capacity of 40 GW capacity by March 2024.**
- The scheme was launched by the Ministry of New & Renewable Energy in December 2014.
- Solar Parks provide solar power developers with a **plug and play model,** by facilitating necessary infrastructure like land, power evacuation facilities, road connectivity, water facility etc. along with all statutory clearances.
- As on 31-10-2022, **56 Solar Parks** have been sanctioned with a cumulative capacity of 39.28 GW in 14 states.
- Solar power projects of an aggregate capacity of over 10 GW have already been commissioned in 17 parks and the remaining parks are at various stages of implementation.

PM-KUSUM Scheme

- Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahaabhiyan (PM-KUSUM) was launched by MNRE in 2019 to provide energy and water security, de-dieselise the farm sector and also generate additional income for farmers by producing solar power.
- The Scheme consists of three components:
    - **Component A:** Installation of 10,000 MW of Decentralized Grid Connected Solar Power Plants each of capacity up to 2 MW
    - **Component B:** Setting up of 20 lakh standalone Solar Powered Agriculture Pumps
    - **Component C:** Solarisation of 15 Lakh existing Grid-connected Agriculture Pumps
- The Scheme aims to add 30.8 GW of solar capacity with central financial support of over Rs. 34,000 Crore.

Rooftop Solar Scheme

- To generate solar power by installing solar panels on the roof of the houses, the Ministry of New and Renewable Energy is implementing the Grid-connected Rooftop Solar Scheme.
- It aims to achieve a cumulative capacity of **40,000 MW from Rooftop Solar Projects** by the year 2022.
- This scheme is being **implemented in the state by distribution companies (DISCOMs).**
- The major objective of the programme includes:
    - To promote the **grid-connected SPV rooftop and small SPV power generating plants** among the residential, community, institutional, industrial and commercial establishments.
    - To mitigate the dependence on fossil fuel based electricity generation and encourage environment-friendly Solar electricity generation.

    - To create an **enabling environment for investment** in the solar energy sector by the private sector, state government and the individuals.
    - To create an enabling environment for the supply of solar power from rooftop and small plants to the grid.
- The programme has been extended till 31.03.2026 and therefore, subsidy under the programme will be available until the target under the programme is achieved.

International Solar Alliance (ISA)

- The International Solar Alliance is a **common platform for cooperation among sun-rich countries** lying fully or partially between the Tropics of Cancer and Capricorn who are seeking to increase solar energy, thereby helping to bend the global greenhouse emissions curve whilst providing clean and cheap energy.
- The ISA was conceived as a **joint effort by India and France** to mobilize efforts against climate change through deployment of solar energy solutions.
- It was conceptualized on the sidelines of the **COP21** of the UNFCCC which was held in Paris in 2015.
- With the amendment of its Framework Agreement in 2020, **all member states of the United Nations are now eligible** to join the ISA.
- At present (September 2023), **116 countries are signatories** to the ISA Framework Agreement, of which 92 countries have submitted the necessary instruments of ratification to become full members of the ISA.
- The ISA is **headquartered in Gurugram,** Haryana, India.
- Key focus areas include
    - Promote solar technologies, new business models and investment in the solar sector to enhance prosperity.
    - Formulate projects and programmes to promote solar applications.
    - Develop innovative financial mechanisms to reduce cost of capital.
    - Build a common knowledge e-Portal.
    - Facilitate capacity building for promotion and absorption of solar technologies and R&D among member countries.

National Solar Mission (NSM)

- It was **launched in January 2010.**
- The initial target of NSM was to install 20 GW solar power by 2022. This was upscaled to **100 GW** in early 2015.
- The objective of the National Solar Mission is to establish India as a global leader in solar energy.
- The Mission adopts a **three-phase approach,** Phase 1 (up to 2012 -13), Phase 2 (2013 - 17) and Phase 3 (2017 - 22).
- The immediate aim of the Mission is to focus on setting up an enabling environment for solar technology penetration in the country both at a centralized and decentralized level.

Selected Notes: Defence Technology – Class 1

India's Nuclear Tests: Pokhran I and II

Pokhran I

- **Date and Codename**: Conducted on **May 18, 1974**, this single nuclear test was codenamed **"Smiling Buddha."**
- **Device Type and Yield**: The device was a **fission bomb** with a yield of **12 kilotons**.
- **Stated Objective**: The test was declared to be a **peaceful nuclear explosion**.

Pokhran II

- **Series and Location**: A series of **five nuclear bomb test explosions** conducted at the **Indian Army's Pokhran Test Range** in **May 1998**.
- **Date, Codename, and Detonations**: The tests began on **May 11, 1998**, under the codename **Operation Shakti**. Initially, one fusion and two fission bombs were detonated. On **May 13, 1998**, two more fission devices were set off.
- **Yield and Capability**: The tests enabled India to build **fission and thermonuclear weapons** with yields up to **200 kilotons**.
- **Scientific Milestone**: The then-Chairman of the **Indian Atomic Energy Commission** stated that each explosion in Pokhran II was "equivalent to several tests carried out by other nuclear weapon states over decades."
- **Subsequent Developments**: India subsequently developed **computer simulation capabilities** to predict the yields of nuclear explosives based on the designs used in these tests.

Impact and Consequences

- **Global Engagement**: These tests ended India's **isolation from the global nuclear order** and redefined its terms of engagement with the world.
- **National Security**: They provided India with a **nuclear deterrent**, thereby enhancing national security.

- **Sanctions**: The tests led to **sanctions** against India by several major countries, including **Japan and the United States**. Later these sanctions were taken back.

पोखरण I

- **तिथि और कोडनाम**: **18 मई 1974** को आयोजित, इस एकल परमाणु परीक्षण को कोडनाम **"स्माइलिंग बुद्धा"** दिया गया था।
- **डिवाइस प्रकार और क्षमता**: डिवाइस एक **विखंडन बम** था जिसकी क्षमता **12 किलोटन** थी।
- **घोषित उद्देश्य**: परीक्षण को **शांतिपूर्ण परमाणु विस्फोट** घोषित किया गया।

पोखरण II

- **श्रृंखला और स्थान**: **मई 1998** में **भारतीय सेना के पोखरण परीक्षण रेंज** में आयोजित **पांच परमाणु बम परीक्षण विस्फोटों** की एक श्रृंखला।
- **तारीख, कोडनेम और विस्फोट**: परीक्षण **11 मई, 1998** को कोडनेम **ऑपरेशन शक्ति** के तहत शुरू हुए। प्रारंभ में, एक संलयन और दो विखंडन बमों का विस्फोट किया गया। **13 मई, 1998** को, दो और विखंडन उपकरण टेस्ट किए गए।
- **क्षमता**: इन परीक्षणों ने भारत को **200 किलोटन** तक की क्षमता वाले **विखंडन और थर्मोन्यूक्लियर हथियार** बनाने में सक्षम बनाया।
- **वैज्ञानिक मील का पत्थर**: **भारतीय परमाणु ऊर्जा आयोग** के तत्कालीन अध्यक्ष ने कहा कि पोखरण II में प्रत्येक विस्फोट "दशकों में अन्य परमाणु हथियार वाले देशों द्वारा किए गए कई परीक्षणों के बराबर था।"
- **बाद के विकास**: भारत ने बाद में इन परीक्षणों में इस्तेमाल किए गए डिजाइनों के आधार पर परमाणु विस्फोटकों की क्षमता की भविष्यवाणी करने के लिए **कंप्यूटर सिमुलेशन क्षमताएं** विकसित कीं।

प्रभाव और परिणाम

- **वैश्विक**: इन परीक्षणों ने भारत के **वैश्विक परमाणु व्यवस्था से अलगाव** को समाप्त कर दिया और दुनिया के साथ इसके जुड़ाव की शर्तों को फिर से परिभाषित किया।
- **राष्ट्रीय सुरक्षा**: उन्होंने भारत को **परमाणु प्रतोरोध** प्रदान किया, जिससे राष्ट्रीय सुरक्षा में वृद्धि हुई।
- **प्रतिबंध**: परीक्षणों के कारण **जापान और संयुक्त राज्य अमेरिका** सहित कई प्रमुख देशों द्वारा भारत के खिलाफ **प्रतिबंध** लगाए गए. बाद में इस प्रतिबधों को वापस ले लिया गया.

India's Nuclear Doctrine

Introduction

- **Enunciation Date**: India's nuclear doctrine was first announced after a **Cabinet Committee on Security (CCS)**meeting in **January 2003**, more than four years following the nuclear tests conducted in May 1998.

Key Principles

1. **Credible Minimum Deterrence**: India aims to build and maintain a nuclear arsenal that serves as a credible deterrent against aggression.
2. **No First Use Policy**: India commits to a **"No First Use"** posture. Nuclear weapons will be used only **in retaliation against a nuclear attack** on Indian territory or on Indian forces, wherever they may be located.
3. **Retaliation Strategy**: In the event of a nuclear first strike against it, India's nuclear retaliation will be **"massive"**and designed to inflict **"unacceptable damage."**
4. **Authorization for Retaliation**: Nuclear retaliatory attacks can only be authorized by **civilian political leadership** via the Nuclear Command Authority.
5. **Non-Use Against Non-Nuclear States**: India pledges not to use nuclear weapons against states that do not possess nuclear weapons.

Additional Stipulations

1. **Retaliation to Biological or Chemical Attacks**: India retains the option to retaliate with nuclear weapons if subjected to a **major biological or chemical attack**.
2. **Export Controls and FMCT Negotiations**: India will continue to enforce strict controls on the export of **nuclear and missile-related materials and technologies** and will participate in **Fissile Material Cut-off Treaty (FMCT) negotiations**.
3. **Commitment to Disarmament**: India remains committed to the ultimate goal of a **nuclear-weapon-free world**, through **global, verifiable, and non-discriminatory disarmament**.

In summary, India's nuclear doctrine is built on the principles of credible minimum deterrence and a "No First Use" policy. The doctrine also outlines strict conditions under which nuclear retaliation would be considered, including in the face of

biological or chemical attacks. It emphasizes civilian control over nuclear decisions and reflects India's continued commitment to nuclear disarmament.

परिचय

- **घोषणा तिथि**: भारत के परमाणु सिद्धांत की घोषणा पहली बार **सुरक्षा पर कैबिनेट समिति (सीसीएस)** की बैठक के बाद जनवरी 2003 में की गई।

प्रमुख सिद्धांत

1. **विश्वसनीय न्यूनतम प्रतिरोध**: भारत का लक्ष्य एक ऐसे परमाणु अस्त्र भंडार का निर्माण और रखरखाव करना है जो आक्रामकता के खिलाफ एक विश्वसनीय प्रतिरोध के रूप में कार्य करे।
2. **पहले प्रयोग नहीं करने की नीति**: भारत **"पहले प्रयोग नहीं"** की नीति के लिए प्रतिबद्ध है। परमाणु हथियारों का उपयोग केवल भारतीय क्षेत्र या भारतीय बलों पर किये गये **परमाणु हमले के खिलाफ जवाबी कार्रवाई में** जाएगा.
3. **प्रतिशोध की रणनीति**: भारत के खिलाफ पहले परमाणु हमले की स्थिति में, भारत का परमाणु प्रतिशोध **"बड़े पैमाने पर"** होगा और "**अस्वीकार्य क्षति**" पहुंचाने के लिए डिज़ाइन किया गया होगा।
4. **प्रतिशोध के लिए प्राधिकरण**: परमाणु जवाबी हमलों को केवल **नागरिक राजनीतिक नेतृत्व** द्वारा परमाणु कमान प्राधिकरण के माध्यम से अधिकृत किया जा सकता है।
5. **गैर-परमाणु राष्ट्रों के खिलाफ गैर-उपयोग**: भारत उन राष्ट्रों के खिलाफ परमाणु हथियारों का उपयोग नहीं करने की प्रतिज्ञा करता है जिनके पास परमाणु हथियार नहीं हैं।

अतिरिक्त शर्तें

1. **जैविक या रासायनिक हमलों का प्रतिशोध**: यदि **बड़े जैविक या रासायनिक हमले** का सामना करना पड़ता है तो भारत परमाणु हथियारों से जवाबी कार्रवाई करने का विकल्प बरकरार रखता है।
2. **निर्यात नियंत्रण और एफएमसीटी वार्ता**: भारत **परमाणु और मिसाइल से संबंधित सामग्रियों और प्रौद्योगिकियों** के निर्यात पर सख्त नियंत्रण लागू करना जारी रखेगा और **विखंडनीय सामग्री कट-ऑफ संधि (एफएमसीटी) में भाग लेगा।**
3. **निरस्त्रीकरण के प्रति प्रतिबद्धता**: भारत **वैश्विक, सत्यापन योग्य और गैर-भेदभावपूर्ण निरस्त्रीकरण** के माध्यम से **परमाणु-हथियार मुक्त दुनिया** के अंतिम लक्ष्य के लिए प्रतिबद्ध है।

संक्षेप में, भारत का परमाणु सिद्धांत **विश्वसनीय न्यूनतम प्रतिरोध** और "**पहले उपयोग नहीं**" नीति के सिद्धांतों पर बनाया गया है। सिद्धांत उन सख्त शर्तों को भी रेखांकित करता है जिनके तहत परमाणु प्रतिशोध पर विचार किया जाएगा, जिसमें जैविक या रासायनिक हमलों का सामना करना भी शामिल है।

यह परमाणु निर्णयों पर नागरिक नियंत्रण पर जोर देता है और परमाणु निरस्त्रीकरण के प्रति भारत की निरंतर प्रतिबद्धता को दर्शाता है।

Treaty on the Non-Proliferation of Nuclear Weapons (NPT)

Overview and Objectives

The **Treaty on the Non-Proliferation of Nuclear Weapons (NPT)** is a pivotal international instrument for global security. It has three main goals:

1. **Prevention of nuclear proliferation**: Inhibiting the spread of nuclear weapons to additional states.
2. **Access to peaceful nuclear technology**: Ensuring fair access under international safeguards, which include audits and inspections.
3. **Nuclear disarmament**: Promoting negotiations aimed at eliminating nuclear weapons.

Categories of Member States

The treaty distinguishes between two categories of parties:

1. **Nuclear Weapon States (NWS)**: Defined as the five states that detonated a nuclear device before January 1, 1967, namely the United States, Soviet Union (now Russia), United Kingdom, France, and China.
2. **Non-Nuclear Weapon States (NNWS)**: All other signatories.

Key Provisions

The treaty, signed in **1968** and effective from **1970**, stipulates:

1. **NWS Non-Transfer**: Prohibits NWS from transferring nuclear weapons to other states.
2. **NNWS Non-Acquisition**: Forbids NNWS from developing or acquiring nuclear weapons.
3. **International Safeguards**: Ensures peaceful nuclear activities in NNWS are not diverted to nuclear weapons, through the application of international audits and inspections.
4. **Peaceful Nuclear Cooperation**: Facilitates NNWS access to peaceful nuclear technology under international safeguards.
5. **Commitment to Disarmament**: All members must engage in good-faith negotiations toward ending the nuclear arms race and achieving disarmament.

Associated Test Ban Treaties

The NPT regime also encompasses treaties that restrict nuclear testing:

1. **Partial Test Ban Treaty (1963)**: Outlaws atmospheric, space, and underwater nuclear testing.
2. **Threshold Test Ban Treaty (1974)**: Prohibits underground tests exceeding 150 kilotons.
3. **Comprehensive Nuclear-Test-Ban Treaty (CTBT)**: Aims to ban all nuclear explosions but has not entered into force due to non-ratification by specific states.

Global Impact and Signatories

The NPT is broadly considered the foundation of the international nuclear nonproliferation regime and works under **International Atomic Energy Agency (IAEA) safeguards**.

As of the current data, **191 states** have acceded to the **Treaty on the Non-Proliferation of Nuclear Weapons (NPT)**. This treaty includes the **five recognized nuclear-weapon states**: the United States, Russia, the United Kingdom, France, and China. The NPT holds the distinction of being the **most widely subscribed to nuclear arms control treaty in history**.

As of April 2023, **India, Israel, and Pakistan** have not signed the treaty. **North Korea** withdrew from the NPT in 2003. These states are not classified as NWS under the treaty's provisions, meaning they would have to eliminate their arsenals and accept comprehensive IAEA inspections should they decide to join.

India's Stance on the Non-Proliferation Treaty (NPT)

India has consistently viewed the **NPT as discriminatory** and has consequently **refused to sign it**.

Grounds for Rejection

India's refusal to accede to the NPT is rooted in multiple reasons:

1. **Discriminatory**: India argues that the treaty inherently divides the world into "nuclear haves" and "nuclear have-nots," creating an imbalanced global order.
2. **Imbalance of Obligations**: India asserts that the treaty fails to equally distribute obligations to prevent all types of nuclear proliferation among member states.

3. **One-Sided Restrictions**: India finds the treaty's restrictions on Peaceful Nuclear Explosions (PNE) technology to be biased in favour of nuclear-armed states.
4. **Lack of Time-Limit on Disarmament**: India disapproves of the absence of a specific time-frame to halt vertical proliferation and for the dismantling of existing arsenals.
5. **Imperfect Obligation on Disarmament**: India notes that the treaty's commitment to disarmament lacks juridical force and describes it as an "imperfect obligation with no sanction behind it."

परिचय और उद्देश्य

परमाणु हथियारों के अप्रसार पर संधि (NPT) वैश्विक सुरक्षा के लिए एक महत्वपूर्ण अंतरराष्ट्रीय संधि है। इसके तीन मुख्य लक्ष्य हैं:

1. **परमाणु प्रसार की रोकथाम**: गैर-परमाणु हथियार राज्यों में परमाणु हथियारों के प्रसार को रोकना।
2. **शांतिपूर्ण परमाणु प्रौद्योगिकी**: अंतरराष्ट्रीय सुरक्षा उपायों के तहत शांतिपूर्ण परमाणु प्रौद्योगिकी के विकास को सुनिश्चित करना
3. **परमाणु निरस्त्रीकरण**: परमाणु हथियारों को नष्ट करने के उद्देश्य से विमर्श को बढ़ावा देना।

सदस्य राज्यों की श्रेणियाँ

यह संधि पार्टियों की दो श्रेणियों को स्वीकार करती है:

1. **परमाणु हथियार राज्य (एनडब्ल्यूएस)**: उन पांच राज्यों के रूप में परिभाषित किया गया है जिन्होंने 1 जनवरी, 1967 से पहले परमाणु उपकरण का विस्फोट किया था, अर्थात् संयुक्त राज्य अमेरिका, सोवियत संघ (अब रूस), यूनाइटेड किंगडम, फ्रांस और चीन।
2. **गैर-परमाणु हथियार राज्य (एनएनडब्ल्यूएस)**: अन्य सभी हस्ताक्षरकर्ता।

प्रमुख प्रावधान

1968 में हस्ताक्षरित और **1970** से प्रभावी यह संधि, निम्नलिखित मुद्दों को निर्धारित करती है:

1. **परमाणु हथियार राज्य (एनडब्ल्यूएस) गैर-हस्तांतरण**: परमाणु हथियार राज्य (एनडब्ल्यूएस) को परमाणु हथियारों को अन्य राज्यों को स्थानांतरित करने से रोकता है।
2. **गैर-परमाणु हथियार राज्य (एनएनडब्ल्यूएस) के द्वारा गैर-अधिग्रहण**: एनएनडब्ल्यूएस को परमाणु हथियार विकसित करने या हासिल करने से रोकता है।
3. **अंतर्राष्ट्रीय सुरक्षा उपाय**: अंतरराष्ट्रीय ऑडिट और निरीक्षण के माध्यम से यह सुनिश्चित करता है कि एनएनडब्ल्यूएस में शांतिपूर्ण परमाणु गतिविधियों को परमाणु हथियारों की ओर न मोड़ा जाए।

4. **शांतिपूर्ण परमाणु सहयोग**: अंतरराष्ट्रीय सुरक्षा उपायों के तहत एनएनडब्ल्यूएस को शांतिपूर्ण परमाणु प्रौद्योगिकी तक पहुंच की सुविधा प्रदान करता है।
5. **निरस्त्रीकरण के प्रति प्रतिबद्धता**: सभी सदस्यों को परमाणु हथियारों की दौड़ को समाप्त करने और निरस्त्रीकरण प्राप्त करने की दिशा में सद्भावना वार्ता में शामिल होना चाहिए।

संबद्ध परीक्षण प्रतिबंध संधियाँ

एनपीटी व्यवस्था में ऐसी संधियाँ भी शामिल हैं जो परमाणु परीक्षण को प्रतिबंधित करती हैं:

1. **आंशिक परीक्षण प्रतिबंध संधि (1963)**: वायुमंडलीय, अंतरिक्ष और पानी के भीतर परमाणु परीक्षण को गैरकानूनी घोषित करता है।
2. **सीमा परीक्षण प्रतिबंध संधि (1974)**: 150 किलोटन से अधिक के भूमिगत परीक्षणों पर रोक लगाती है।
3. **व्यापक परमाणु-परीक्षण-प्रतिबंध संधि (सीटीबीटी)**: इसका उद्देश्य सभी परमाणु विस्फोटों पर प्रतिबंध लगाना है, लेकिन विशिष्ट राज्यों द्वारा अनुसमर्थन न किए जाने के कारण यह लागू नहीं हो पाई है।

वैश्विक प्रभाव और हस्ताक्षरकर्ता

एनपीटी को मोटे तौर पर अंतरराष्ट्रीय परमाणु अप्रसार व्यवस्था की नींव माना जाता है और यह **अंतर्राष्ट्रीय परमाणु ऊर्जा एजेंसी (आईएईए) सुरक्षा उपायों** के तहत काम करता है।

वर्तमान आंकड़ों के अनुसार, **191 राज्यों** ने **परमाणु हथियारों के अप्रसार (एनपीटी) पर संधि** को स्वीकार कर लिया है। इस संधि में **पांच मान्यता प्राप्त परमाणु हथियार संपन्न देश** शामिल हैं: संयुक्त राज्य अमेरिका, रूस, यूनाइटेड किंगडम, फ्रांस और चीन। एनपीटी को **इतिहास में परमाणु हथियार नियंत्रण संधि के लिए सबसे व्यापक रूप से सदस्यता प्राप्त** होने का गौरव प्राप्त है।

अप्रैल 2023 तक, **भारत, इज़राइल और पाकिस्तान** ने संधि पर हस्ताक्षर नहीं किए हैं। **उत्तर कोरिया** 2003 में एनपीटी से हट गया था।

संधि के प्रावधानों के तहत इन राज्यों को एनडब्ल्यूएस के रूप में वर्गीकृत नहीं किया गया है, जिसका अर्थ है कि उन्हें अपने शस्त्रागार को खत्म करना होगा और इसमें शामिल होने का निर्णय लेने पर व्यापक आईएईए निरीक्षण स्वीकार करना होगा।

परमाणु अप्रसार संधि (एनपीटी) पर भारत का रुख

भारत ने **एनपीटी को लगातार भेदभावपूर्ण** के रूप में देखा है और परिणामस्वरूप **इस पर हस्ताक्षर करने से इनकार कर दिया है**।

अस्वीकृति का आधार

एनपीटी में शामिल होने से भारत का इनकार कई कारणों से निहित है:

1. **भेदभावपूर्ण**: भारत का तर्क है कि संधि स्वाभाविक रूप से दुनिया को "परमाणु संपन्न" और "परमाणु संपन्न नहीं" में विभाजित करती है, जिससे एक असंतुलित वैश्विक व्यवस्था बनती है।
2. **दायित्वों का असंतुलन**: भारत का मानना है कि संधि सदस्य देशों के बीच सभी प्रकार के परमाणु प्रसार को रोकने के लिए दायित्वों को समान रूप से वितरित करने में विफल है।
3. **एकतरफा प्रतिबंध**: भारत शांतिपूर्ण परमाणु विस्फोट (पीएनई) तकनीक पर संधि के प्रतिबंधों को परमाणु-सशस्त्र राज्यों के पक्ष में पक्षपातपूर्ण मानता है।
4. **निरस्त्रीकरण पर समय-सीमा का अभाव**: भारत प्रसार को रोकने और मौजूदा शस्त्रागारों को नष्ट करने के लिए एक विशिष्ट समय-सीमा के अभाव को अस्वीकार करता है।
5. **निरस्त्रीकरण पर अपूर्ण दायित्व**: भारत का कहना है कि निरस्त्रीकरण के लिए संधि की प्रतिबद्धता में न्यायिक बल का अभाव है और इसे "इसके पीछे कोई मंजूरी नहीं होने के साथ अपूर्ण दायित्व" के रूप में वर्णित किया गया है।

Defence Technology: Aerial Defence of India

Missiles

A missile is a self-propelled guided projectile designed to be launched into the air and directed towards a specific target. Missiles can be classified into different types based on their propulsion systems, flight paths, and intended use.

- **Ballistic missiles** are initially propelled by rockets and follow an unpowered, arched trajectory to reach their target. They can carry either nuclear or conventional warheads and are classified into short-range, medium-range, intermediate-range, and long-range missiles.
- **Cruise missiles** are unmanned, self-propelled guided missiles that maintain low, horizontal flight paths to avoid anti-missile systems. They have significant payload capacity and high precision. Cruise missiles can be launched from air, land, ship, or submarine. They are classified as subsonic, supersonic, or hypersonic based on their speeds.
- **Quasi-ballistic missiles** combine features of both ballistic and cruise missiles. They initially follow a ballistic trajectory and then transition to a low-altitude, high-speed cruise trajectory.
- **Hypersonic missiles** are designed to travel at speeds equal to or greater than Mach 5. They are highly maneuverable and can alter their flight paths. Hypersonic weapons can be in the form of hypersonic glide vehicles, hypersonic cruise missiles, or hypersonic aircraft.

Missiles play a crucial role in defense technology, providing nations with the ability to strike targets accurately and efficiently across various ranges.

मिसाइल एक स्व-चालित निर्देशित प्रक्षेप्य है जिसे हवा में लॉन्च करने और एक विशिष्ट लक्ष्य की ओर निर्देशित करने के लिए डिज़ाइन किया जाता है। मिसाइलों को उनके प्रणोदन प्रणाली, उड़ान पथ और इच्छित उपयोग के आधार पर विभिन्न प्रकारों में वर्गीकृत किया जा सकता है।

- **बैलिस्टिक मिसाइलें** प्रारंभ में रॉकेट द्वारा संचालित होती हैं और अपने लक्ष्य तक पहुंचने के लिए एक धनुषाकार प्रक्षेप पथ का अनुसरण करती हैं। वे परमाणु या पारंपरिक हथियार ले जा सकते हैं और उन्हें कम दूरी, मध्यम दूरी, मध्यवर्ती दूरी और लंबी दूरी की मिसाइलों में वर्गीकृत किया जाता है।

- **क्रूज़ मिसाइलें** मानवरहित, स्व-चालित निर्देशित मिसाइलें हैं जो मिसाइल-विरोधी प्रणालियों से बचने के लिए कम, क्षैतिज उड़ान पथ बनाए रखती हैं। उनके पास महत्वपूर्ण पेलोड क्षमता और उच्च परिशुद्धता होती है। क्रूज़ मिसाइलों को हवा, ज़मीन, जहाज़ या पनडुब्बी से लॉन्च किया जा सकता है। उनकी गति के आधार पर उन्हें सबसोनिक, सुपरसोनिक या हाइपरसोनिक के रूप में वर्गीकृत किया जाता है।
- **अर्ध-बैलिस्टिक मिसाइलें** बैलिस्टिक और क्रूज मिसाइलों दोनों की विशेषताओं को दर्शाती हैं। वे शुरू में एक बैलिस्टिक प्रक्षेप पथ का अनुसरण करते हैं और फिर कम ऊंचाई, उच्च गति वाले क्रूज प्रक्षेप पथ पर चले जाते हैं।
- **हाइपरसोनिक मिसाइल** को मैक 5 के बराबर या उससे अधिक गति से यात्रा करने के लिए डिज़ाइन किया गया है। वे अत्यधिक गतिशील होते हैं और अपने उड़ान पथ को बदल सकते हैं। हाइपरसोनिक हथियार हाइपरसोनिक ग्लाइड वाहन, हाइपरसोनिक क्रूज मिसाइल या हाइपरसोनिक विमान के रूप में हो सकते हैं।

मिसाइलें रक्षा प्रौद्योगिकी में महत्वपूर्ण भूमिका निभाती हैं, जो राष्ट्रों को विभिन्न दूरी पर लक्ष्य पर सटीक और कुशलतापूर्वक हमला करने की क्षमता प्रदान करती हैं।

Types of missiles

Ballistic Missiles

Ballistic missiles are initially propelled by rockets and follow an unpowered, arched trajectory to reach their target. These missiles are capable of carrying either **nuclear** or **conventional warheads**. Launch platforms include ships and land-based facilities. Notable examples from the Indian defence arsenal are **Prithvi I, Prithvi II, Agni I, Agni II**, and **Dhanush**.

Classification of Ballistic Missiles

- **Short-range**: Tactical missiles with a range less than 1,000 kilometres.
- **Medium-range**: Theatre missiles with a range between 1,000 and 3,000 kilometres.
- **Intermediate-range**: Missiles with a range between 3,000 and 5,500 kilometres.
- **Long-range**: Intercontinental or strategic missiles with a range exceeding 5,500 kilometres.

Three Stages of Ballistic Missile Flight

- **Boost Phase**: Starts at launch and ends when rockets cease firing; usually lasts three to five minutes and occurs within the atmosphere.

- **Midcourse Phase**: Follows the boost phase, comprises the longest portion of the flight; ICBMs can reach speeds around 24,000 kilometres per hour.
- **Terminal Phase**: Begins when warheads re-enter Earth's atmosphere and ends upon impact; strategic warheads can exceed speeds of 3,200 kilometres per hour.

PHASES OF BALLISTIC MISSILE FLIGHT

बैलिस्टिक मिसाइलें प्रारंभ में रॉकेट द्वारा संचालित होती हैं और अपने लक्ष्य तक पहुंचने के लिए एक powerless, धनुषाकार प्रक्षेप पथ का अनुसरण करती हैं। ये मिसाइलें **परमाणु** या **पारंपरिक हथियार** ले जाने में सक्षम होती हैं। लॉन्च प्लेटफार्मों में जहाज और भूमि-आधारित सुविधाएं शामिल हैं। भारतीय सेना के उल्लेखनीय उदाहरण हैं **पृथ्वी I, पृथ्वी II, अग्नि I, अग्नि II**, और **धनुष.**

बैलिस्टिक मिसाइलों का वर्गीकरण

- **कम दूरी**: 1,000 किलोमीटर से कम दूरी की सामरिक मिसाइलें।
- **मध्यम दूरी**: 1,000 से 3,000 किलोमीटर के बीच की रेंज वाली थिएटर मिसाइलें।
- **मध्यवर्ती-सीमा**: 3,000 से 5,500 किलोमीटर के बीच की मारक क्षमता वाली मिसाइलें।
- **लंबी दूरी**: 5,500 किलोमीटर से अधिक की मारक क्षमता वाली अंतरमहाद्वीपीय या रणनीतिक मिसाइलें।

बैलिस्टिक मिसाइल उड़ान के तीन चरण

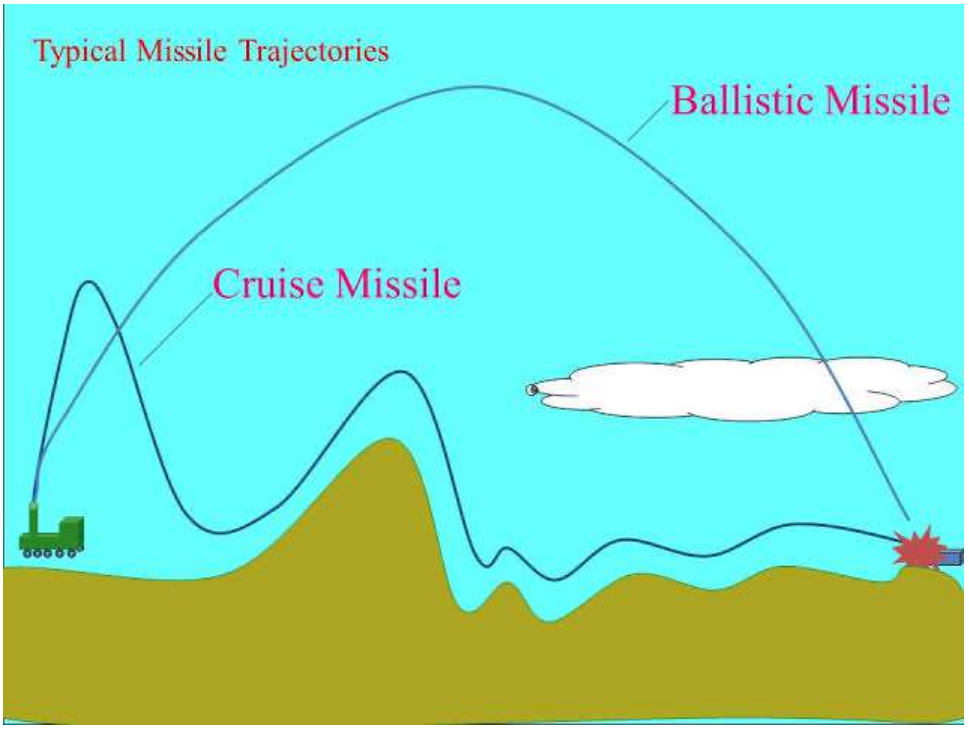
- **बूस्ट चरण**: प्रक्षेपण के समय शुरू होता है और तब समाप्त होता है जब रॉकेट फायरिंग बंद कर देते हैं; आमतौर पर तीन से पांच मिनट तक रहता है और वायुमंडल के भीतर होता है।

- **मिडकोर्स चरण**: बूस्ट चरण के बाद, उड़ान का सबसे लंबा हिस्सा शामिल होता है; ICBM लगभग 24,000 किलोमीटर प्रति घंटे की गति तक पहुँच सकते हैं।
- **टर्मिनल चरण**: तब शुरू होता है जब हथियार पृथ्वी के वायुमंडल में फिर से प्रवेश करते हैं और प्रभाव पर समाप्त होते हैं; रणनीतिक हथियार 3,200 किलोमीटर प्रति घंटे की गति से अधिक हो सकते हैं।

Cruise Missiles

Cruise missiles are unmanned, self-propelled guided missiles with significant payload capacity and high precision. They **maintain low, horizontal flight paths** to avoid anti-missile systems. These can be launched from **air, land, ship, or submarine**.

क्रूज़ मिसाइलें महत्वपूर्ण पेलोड क्षमता और उच्च परिशुद्धता वाली मानवरहित, स्व-चालित निर्देशित मिसाइलें हैं। वे मिसाइल-विरोधी प्रणालियों से बचने के लिए कम ऊँचाई पर क्षैतिज उड़ान पथ बनाए रखते हैं। इन्हें हवा, ज़मीन, जहाज़ या पनडुब्बी से लॉन्च किया जा सकता है।



Classification of Cruise Missiles

- **Subsonic cruise missiles**: Travel below the speed of sound, approximately at 0.8 Mach. Example: Tomahawk missile of the USA.
- **Supersonic cruise missiles**: Travel at speeds between 2-3 Mach, with high kinetic energy due to their speed and warhead mass. Example: BrahMos missile.

- **Hypersonic cruise missiles**: Travel at speeds exceeding 5 Mach; under active development in several countries.

- **सबसोनिक क्रूज़ मिसाइलें**: ध्वनि की गति से कम, लगभग 0.8 मैक पर यात्रा करती हैं। उदाहरण: संयुक्त राज्य अमेरिका की टॉमहॉक मिसाइल।
- **सुपरसोनिक क्रूज़ मिसाइलें**: अपनी गति और वारहेड द्रव्यमान के कारण उच्च गतिज ऊर्जा के साथ 2-3 मैक के बीच की गति से यात्रा करती हैं। उदाहरण: ब्रह्मोस मिसाइल।
- **हाइपरसोनिक क्रूज़ मिसाइलें**: 5 मैक से अधिक गति से यात्रा करती हैं; भारत सहित कई देशों में सक्रिय विकास के तहत।

Quasi-Ballistic Missiles

A **quasi-ballistic missile** incorporates features of both **ballistic missiles** and **cruise missiles**. Specifically, it follows a **ballistic trajectory** during the initial portion of its flight. Subsequently, it transitions to a **low-altitude, high-speed cruise trajectory**. This hybrid flight path allows the missile to take advantage of the benefits of both ballistic and cruise missile technologies.

एक अर्ध-बैलिस्टिक मिसाइल में बैलिस्टिक मिसाइल और क्रूज़ मिसाइल दोनों की विशेषताएं शामिल होती हैं। विशेष रूप से, यह अपनी उड़ान के प्रारंभिक भाग के दौरान एक बैलिस्टिक प्रक्षेपवक्र का अनुसरण करता है। इसके बाद, यह कम ऊंचाई, उच्च गति वाले क्रूज़ प्रक्षेप पथ में परिवर्तित हो जाता है। यह हाइब्रिड उड़ान पथ मिसाइल को बैलिस्टिक और क्रूज़ मिसाइल प्रौद्योगिकियों दोनों का लाभ उठाने की अनुमति देता है।

Hypersonic Missiles

A **hypersonic missile** is designed to travel at speeds equal to or greater than **Mach 5**, which is approximately 1 to 5 miles per second or 1.6 to 8.0 km/s. What distinguishes these missiles from ballistic missiles is their **manoeuvrability**. Unlike ballistic missiles that adhere to a predetermined course, hypersonic missiles have the capability to alter their flight paths.

एक हाइपरसोनिक मिसाइल को मैक 5 के बराबर या उससे अधिक गति से यात्रा करने के लिए डिज़ाइन किया जाता है, जो लगभग 1 से 5 मील प्रति सेकंड या 1.6 से 8.0 किमी/सेकेंड है। इन मिसाइलों को बैलिस्टिक मिसाइलों से अलग करने वाली बात उनकी गतिशीलता है। पूर्व निर्धारित मार्ग का पालन करने वाली बैलिस्टिक मिसाइलों के विपरीत, हाइपरसोनिक मिसाइलों में अपने उड़ान पथ को बदलने की क्षमता होती है।

Types of Hypersonic Weapons

Hypersonic weapons come in various forms:

- **Hypersonic Glide Vehicle (HGV)**: These are warheads that, following an initial ballistic launch, manoeuvre and glide through the atmosphere at hypersonic

speeds.

- **Hypersonic Cruise Missile**: These missiles utilise air-breathing engines such as **scramjets** to achieve hypersonic speeds.
- **Hypersonic Aircraft**: Similar to hypersonic cruise missiles, these aircraft also employ air-breathing engines like scramjets to reach high velocities.

Russia has claimed its first use of the **Kinzhal hypersonic missile** in the Ukraine conflict, targeting a large underground arms depot in western Ukraine. The missile, capable of speeds exceeding **Mach 5**, was likely launched from a **MiG-31 warplane**

हाइपरसोनिक हथियार विभिन्न रूपों में आते हैं:

- **हाइपरसोनिक ग्लाइड व्हीकल (एचजीवी)**: ये ऐसे हथियार हैं, जो प्रारंभिक बैलिस्टिक प्रक्षेपण के बाद हाइपरसोनिक गति से वायुमंडल में ग्लाइड करते हैं।
- **हाइपरसोनिक क्रूज़ मिसाइल**: ये मिसाइलें हाइपरसोनिक गति प्राप्त करने के लिए **स्क्रैमजेट** जैसे वायु-श्वास इंजन का उपयोग करती हैं।
- **हाइपरसोनिक विमान**: हाइपरसोनिक क्रूज मिसाइलों के समान, ये विमान भी उच्च वेग तक पहुंचने के लिए स्क्रैमजेट जैसे वायु-श्वास इंजन का उपयोग करते हैं।

हाल का उदाहरण: रूस ने यूक्रेन संघर्ष में पश्चिमी यूक्रेन में एक बड़े भूमिगत हथियार डिपो को निशाना बनाते हुए **किंझल हाइपरसोनिक मिसाइल** के पहले इस्तेमाल का दावा किया है। **मैक 5** से अधिक गति में सक्षम मिसाइल को संभवतः **मिग-31 युद्धक विमान** से लॉन्च किया गया था।

Countries with Hypersonic Missiles as of 2023

- **United States**: Actively developing and testing, $3.8 billion budget for 2022.
- **China**: Possesses operational missile, focus on cruise missiles and glide vehicles.
- **Russia**: Research since the 1980s, deployed missile in Ukraine in 2019.
- **India**: Entered hypersonic research in September 2020.
- **Other Developed Countries**: Australia, France, Germany, and Japan in development phase.
- **Nascent Research Countries**: Iran, Israel, and South Korea conducting foundational research.

2023 तक हाइपरसोनिक मिसाइलों वाले देश

- **संयुक्त राज्य अमेरिका**: सक्रिय रूप से विकास और परीक्षण, 2022 के लिए $3.8 बिलियन का बजट।
- **चीन**: इसके पास ऑपरेशनल मिसाइल है, क्रूज़ मिसाइलों और ग्लाइड वाहनों पर ध्यान केंद्रित है।

- **रूस**: 1980 के दशक से रिसर्च, 2019 में यूक्रेन में मिसाइल तैनात।
- **भारत**: सितंबर 2020 में हाइपरसोनिक अनुसंधान में प्रवेश किया।
- **अन्य विकसित देश**: ऑस्ट्रेलिया, फ्रांस, जर्मनी और जापान विकास चरण में।
- **नवोदित अनुसंधान देश**: ईरान, इज़राइल और दक्षिण कोरिया मूलभूत अनुसंधान कर रहे हैं।

Integrated Guided Missile Development Programme (IGMDP)

- **Programme Inception**: Conceived by Dr. A P J Abdul Kalam to achieve self-sufficiency for India in missile technology.
- **Government Approval and Feasibility Study**: Approved by the Government of India on July 26, 1983. A feasibility study was conducted by a team comprising members from DRDO, the army, navy, air force, and defence production. The team recommended the development of five missile systems.
- **कार्यक्रम की शुरुआत**: मिसाइल प्रौद्योगिकी में भारत के लिए आत्मनिर्भरता हासिल करने के लिए डॉ. ए.पी.जे. अब्दुल कलाम द्वारा कल्पना की गई।
- **सरकारी अनुमोदन और व्यवहार्यता अध्ययन**: **26 जुलाई, 1983** को भारत सरकार द्वारा अनुमोदित। डीआरडीओ, सेना, नौसेना, वायु सेना और रक्षा उत्पादन के सदस्यों वाली एक टीम द्वारा एक व्यवहार्यता अध्ययन आयोजित किया गया था। टीम ने पांच मिसाइल प्रणालियों के विकास की सिफारिश की।

Missiles Developed Under IGMDP

- **Prithvi**: Short-range surface-to-surface ballistic missile.
- **Agni**: Intermediate to long-range surface-to-surface ballistic missile. Initially developed as a technology demonstrator for a re-entry vehicle, it was later upgraded to serve as a ballistic missile with varied ranges.
- **Trishul**: Short-range low-level surface-to-air missile.
- **Akash**: Medium-range surface-to-air missile.
- **Nag**: Third-generation anti-tank missile.
- **पृथ्वी**: कम दूरी की सतह से सतह पर मार करने वाली बैलिस्टिक मिसाइल।
- **अग्नि**: मध्यम से लंबी दूरी की सतह से सतह पर मार करने वाली बैलिस्टिक मिसाइल। प्रारंभ में इसे पुनः प्रवेश वाहन के लिए एक प्रौद्योगिकी प्रदर्शक के रूप में विकसित किया गया था, बाद में इसे विभिन्न रेंज वाली बैलिस्टिक मिसाइल के रूप में काम करने के लिए उन्नत किया गया।
- **त्रिशूल**: कम दूरी की निम्न स्तरीय सतह से हवा में मार करने वाली मिसाइल।
- **आकाश**: मध्यम दूरी की सतह से हवा में मार करने वाली मिसाइल।

- **नाग**: तीसरी पीढ़ी की एंटी टैंक मिसाइल।

Programme Completion

- **Achievement and Announcement**: After accomplishing its goal of making India self-reliant in missile technology, DRDO formally announced the successful completion of IGMDP on January 8, 2008.

कार्यक्रम समापन

- **उपलब्धि और घोषणा**: भारत को मिसाइल प्रौद्योगिकी में आत्मनिर्भर बनाने के अपने लक्ष्य को पूरा करने के बाद, डीआरडीओ ने औपचारिक रूप से 8 जनवरी, 2008 को आईजीएमडीपी के सफल समापन की घोषणा की।

Missiles of India

Sr. No.	Missile Name	Range	Payload	Features
Surface to Surface Missiles				
Short Range				
1.	Agni 1	700-1000 km	1000 kg	• Single-stage solid propellant • Travels at a speed of 7.5 mach • Nuclear Capable
2	Prithvi- I	40-150 km	1000 kg	• Single-stage liquid-fueled • Can be launched from transporter erector launchers
3	Prithvi- II	350 km	500 kg	• Single stage liquid propellant • Nuclear Capable
4	Prithvi-III	350 Km	1000 kg	• Two-stage, solid propellant motor. • Nuclear capable missile

5	Dhanush	350 km	1000 kg	• Single-stage, liquid-propelled • Naval Variant of Prithvi-II • Nuclear capable
6	Shaurya	700 Km- 1000 Km	200 to 1000 kg	• Two stage solid fuelled missile capable of carrying • Travels at a speed of 7.5 mach • Nuclear capable • Hybrid missile • Capable of manoeuvring like a cruise missile and utilizing its air fins to cruise at sustained hypersonic speeds. • Less vulnerable to enemy’s anti-ballistic missile defence.
7	Prahaar	150 km	200 kg	• Solid-fuelled short-range missile fitted with inertial navigation system • Travels at a speed of Mach 2 • Contemporary weapon system capable of carrying a number of different warheads, nuclear, high-explosives (HE)

				and submunitions
8	Pralay	350 km- 500 km	1000 kg	• Designed to fly faster and is a derivative of Prithvi Defence Vehicle (PDV) exoatmospheric interceptor missile • It is capable of destroying enemy weapons at high altitudes • It has unconventional flight profile and the ability to change directions to make it more unpredictable and raise difficulty level for Air Defence Systems
Intermediate Range				
1.	Agni II	2000-3,500 km	1000kg	• Two and a half stage, solid fuelled missile • A part of the "credible deterrence" against China and Pakistan • Nuclear capable
2.	Agni III	3000-3500 km	1500 kg	• Two stage solid propellant • Nuclear capable • Missile's circular error

				probable (CEP) lies in the range of 40 meters • This makes Agni-III the most accurate strategic ballistic missile of its range class in the world
3.	Agni IV	3500-4000 Km	1000 kg	• Two stage solid propellant • Nuclear capable • The payload, with a re-entry heat shield can withstand temperature of more than 3000 degree Celsius
Intercontinental Ballistic Missile				
1.	Agni V	More than 5000 Km	1500 kg	• Three stage solid propellant • Speed of 24 Mach • Multiple Independently Targetable Re-entry Vehicles (MITRV) capability. • Nuclear capable
2.	Agni VI	6000-12000 km	1000kg	• It will be a Three stage solid propellant missile • Multiple Independently Targetable Re-entry Vehicles (MITRV) capability • Nuclear capable

				missile currently under development
Submarine Launched Ballistic Missile				
1.	K4 missile system	3500 Km	2000 kg	• Difficult to be tracked and destroyed by any anti-ballistic weapon • Its Circular Error Probability (CEP determines the accuracy of missiles; lower the CEP, greater is the accuracy) is more accurate • Support the Arihant class of nuclear submarines • Provides capability to launch nuclear weapons from underwater
2.	K-15 –Sagarika	750–1,500 km	1000 kg	• Solid rocket Motor • SLBM version of land based Shaurya Missile • Integrated with the Arihant class submarine. • K series missiles are faster, lighter & stealthier than Agni series. • Boosts second strike

				capabilities of India
3.	K5	5,000–6,000 km	2000 kg	• It is being developed by DRDO for the Indian strategic forces' underwater platforms. • It will arm the future variants of Arihant class submarines of the Indian Navy. • Capable of carrying four MIRV (Multiple Independently targetable Re-entry Vehicle) warheads of 500 kgs each.
4.	K6	8,000 to 12,000 km	3000 kg	• A three-stage missile and is solid fuelled. • It is planned to armed with multiple independently targetable re-entry vehicle.
Surface to Air Missile System				
1.	Trishul	9 Km	5.5 Kg	• Designed to counter a low level attack with a very quick reaction time ability to skim over the sea at a very low altitude and hit against

				sea skimming missiles • All-weather missile • Supersonic Speed
2.	BARAK-8	100 Km	60 kg	• Jointly developed by DRDO & Israeli Aerospace Industry. • Supported by multi-function surveillance track and guidance radars, which enables it to hit targets with precision. • Can engage multiple targets at the same time during day and night in all weather conditions.
3.	MAITRI	25-30 Km	10Kg	• Next generation Quick-reaction surface-to-air missile (QRSAM) • Joint project of India & France
4.	Akash	30Km	30Kg	• Supersonic Speed • Capability to neutralise aerial targets. • Can engage in multiple targets from multiple directions. • Supported by

				‘Rajendra’, an indigenously developed radar system, that has the capability to lock-on to multiple targets in group or autonomous mode. • Its ramjet propulsion and its electronic counter-counter measure equipment helps it to break any electronic jamming system.
Air-to-air Missile				
1.	ASTRA	70 km	15 kg	• First indigenously developed air-to-air missile • Developed by DRDO • Works on the Beyond Visual Range Air-to-Air Missile (BVRAAM) technology • It enables the fighter-pilots to shoot precisely at the enemy targets which are beyond their visual range • All weather, day and night capability

2.	Novator KS-172	200-400 km	50 kg	• Developed initially by Russia in the 1980s • Still being used by the Russian Air Force, as well as the Indian Air Force • Has a range of 400 kms and a top speed of over 4,000 km/hr
Cruise Missile System				
1.	Nirbhay	800-1,000 km	450 kg	• Long range, all-weather subsonic cruise missile • Can be launched from multiple platforms • Nuclear capable • Can fly at low altitude
2	Brahmos	300 Km	Ship and Land based- 200 kg and Aircraft variant- 300 kg	• Joint project of Russia and India • Medium range ramjet supersonic missile • Two-stage (first stage is solid propellant engine and liquid ramjet in second) • Travels at a speed of 2.8 Mach and can be launched from land, air, ship and

				submarine; operational with army, air force & navy.
3	Brahmos II	Expected: 1,500 km		• Under development • Hypersonic version (India’s first hypersonic missile) of Brahmos with a scramjet engine • Expected speed: around 8 Mach • May have technology from Russia’s Zircon missile
Anti-Tank Guided Missiles				
1.	NAG	500m- 20Km	8 kg	• Fire and Forget, lock on after launch • All-weather missile with day and night capabilities • Can be launched from land and air • Five variants: a land version, for a mast-mounted system; the helicopter-launched Nag (HELINA) also known as Dhruvastra; a "man-portable" version (MPATGM); an air-launched

				version; and the Nag Missile Carrier (NAMICA) "tank buster".
2.	SPIKE	4 km		• Israeli fourth generation anti tank guided missile • Fire & forget system • Ability to switch to a different target mid-flight. • Overall hit percentage is more than 95 per cent. • Variants: man-portable, vehicle launched & helicopter launched
3.	Spice 2000	60 km	An add-on kit for 900 kg warheads	• Developed by Israel • Stands for Smart, Precise, Impact, Cost Effective • Consists of inertial navigation, satellite guidance, and electro-optical sensors for pinpoint accuracy • Difficult to be detected on radars • It is not a bomb, but a 'guidance kit' that is attached to a standard

				warhead or bomb

About some recent agni missiles

Agni-IV Specifications

- **Series and Naming**: Fourth in the Agni series, formerly known as Agni II prime.
- **Test History**: First tested in 2011 and again in 2012 from Wheeler Island, off the coast of Orissa.
- **Technical Details**:
  - A two-stage missile powered by solid propellant.
  - Length: 20 meters
  - Launch weight: 17 tonnes
  - Range: Up to 4,000 km
  - Warhead capacity: 1 tonne
- **Advanced Technologies**: Equipped with indigenously developed ring laser gyro and composite rocket motor.
- **Launch Capabilities**: Can be fired from a road-mobile launcher.

अग्नि-IV विशिष्टताएँ

- **श्रृंखला और नामकरण**: अग्नि श्रृंखला में चौथा, जिसे पहले अग्नि II प्राइम के नाम से जाना जाता था।
- **परीक्षण इतिहास**: पहली बार 2011 में और फिर 2012 में उड़ीसा के तट पर व्हीलर द्वीप से परीक्षण किया गया।
- **टेक्निकल डिटेल**:
  - ठोस प्रणोदक द्वारा संचालित दो चरणों वाली मिसाइल।
  - लंबाई: 20 मीटर
  - लॉन्च वजन: 17 टन
  - रेंज: 4,000 किमी तक
  - वारहेड क्षमता: 1 टन
- **उन्नत प्रौद्योगिकियाँ**: स्वदेशी रूप से विकसित रिंग लेजर जाइरो और मिश्रित रॉकेट मोटर से सुसज्जित।
- **प्रक्षेपण क्षमताएं**: सड़क-मोबाइल लांचर से दागा जा सकता है।

Agni-V Specifications

- **Development Timeframe**: Developed indigenously in a span of just three years.
- **Technical Details**:
  - A three-stage missile
  - All stages based on solid fuel
  - Nuclear-capable
  - Payload capacity: 1.5 tonnes
  - Range: 5,000+ km
  - Total weight: 50 tonnes
- **Advanced Technologies**: Equipped with composite rocket motors, advanced navigation systems, onboard computers, and re-entry vehicles. Capable of MIRV (Multiple Independently Targetable Re-entry Vehicle) for anti-satellite systems.
- **Launch Capabilities**: Can be fired from a road-mobile launcher.

Strategic Significance of Agni-V

- **Global Context**: Considered a game changer for India, placing it among the elite group of countries with the capability to launch intercontinental ballistic missiles, including the US, Russia, France, and China.
- **Geopolitical Implications**: Provides almost complete coverage of China, enhancing India's deterrence capabilities.

अग्नि-V विशिष्टताएँ

- **विकास की समयसीमा**: केवल तीन वर्षों की अवधि में स्वदेशी रूप से विकसित।
- **टेक्निकल डिटेल**:
  - तीन चरणों वाली मिसाइल
  - सभी चरण ठोस ईंधन पर आधारित
    -परमाणु-सक्षम
  - पेलोड क्षमता: 1.5 टन
  - रेंज: 5,000+ किमी
  - कुल वजन: 50 टन
- **उन्नत प्रौद्योगिकियाँ**: मिश्रित रॉकेट मोटर्स, उन्नत नेविगेशन सिस्टम, ऑनबोर्ड कंप्यूटर और पुनः प्रवेश वाहनों से सुसज्जित। एंटी-सैटेलाइट सिस्टम के लिए MIRV (मल्टीपल इंडिपेंडेंटली टारगेटेबल री-एंट्री

व्हीकल) में सक्षम।

- **प्रक्षेपण क्षमताएं**: सड़क-मोबाइल लांचर से दागा जा सकता है।

अग्नि-V का सामरिक महत्व

- **वैश्विक संदर्भ**: इसे भारत के लिए गेम चेंजर माना जाता है, जो इसे अमेरिका, रूस, फ्रांस और चीन सहित अंतरमहाद्वीपीय बैलिस्टिक मिसाइलों को लॉन्च करने की क्षमता वाले देशों के विशिष्ट समूह में रखता है।
- **भूराजनीतिक निहितार्थ**: भारत की निवारक क्षमताओं को बढ़ाते हुए, चीन का लगभग पूर्ण कवरेज प्रदान करता है।

Agni-VI: In Development

- **Status**: Reported to be in early stages of development, intended to be the most advanced version in the Agni missile programme.
- **Technical Expectations**:
  - Capable of being launched from both submarines and land.
  - Projected strike range of 11,000–12,000 km.
  - Expected to be equipped with MIRVed warheads.

अग्नि-VI: विकास में

- **स्थिति**: विकास के प्रारंभिक चरण में होने की सूचना है, अग्नि मिसाइल कार्यक्रम में सबसे उन्नत संस्करण होने का लक्ष्य है।
- **तकनीकी अपेक्षाएँ**:
  - पनडुब्बियों और जमीन दोनों से लॉन्च करने में सक्षम।
  - 11,000-12,000 किमी की अनुमानित मारक क्षमता।
  - MIRVed वॉरहेड्स से लैस होने की उम्मीद है।

India's Nuclear Triad: Components and Strategic Importance

India's nuclear triad refers to its capability to deliver **nuclear weapons** through three distinct platforms: **land, air, and sea**. This diversified approach ensures the effectiveness of India's nuclear deterrence by making it challenging for any adversary to neutralise all of the country's nuclear forces in a first strike.

Components of the Nuclear Triad

- **Land-Based Missiles**: Includes missiles like the **Agni 2**, **Agni 4**, and **Agni 5**. These provide India with a robust land-based delivery system for nuclear

weapons.

- **Air-Based Delivery**: Aircraft such as **Sukhoi Su-30MKIs**, **Mirage 2000s**, and **Jaguars** serve as airborne platforms capable of launching nuclear payloads.
- **Sea-Based Capability**: The **INS Arihant**, a 6,000-tonne indigenous Ship Submersible Ballistic Nuclear (SSBN), represents the maritime component. Additionally, the **K-4 Sagarika** is an Indian 3500 km-range **submarine-launched nuclear warhead capable ballistic missile (SLBM)**. It is designed to be launched from India's **indigenous nuclear submarines**.

Strategic Importance

The operationalisation of this triad contributes to maintaining a **credible nuclear deterrent**. It supports India's **No First Use policy**, making it highly difficult for an adversary to incapacitate India's nuclear arsenal through a first strike. This forms a cornerstone of India's **Nuclear Doctrine**.

भारत का परमाणु त्रय तीन अलग-अलग प्लेटफार्मों के माध्यम से **परमाणु हथियार** पहुंचाने की इसकी क्षमता को दर्शाता है: **भूमि, वायु और समुद्र**। यह भारत की परमाणु प्रतिरोधक क्षमता की प्रभावशीलता को सुनिश्चित करता है, जिससे किसी भी प्रतिद्वंद्वी के लिए पहले हमले में देश की सभी परमाणु ताकतों को बेअसर करना चुनौतीपूर्ण हो जाता है।

परमाणु त्रय के घटक

- **भूमि-आधारित मिसाइलें**: **अग्नि 2**, **अग्नि 4**, और **अग्नि 5** जैसी मिसाइलें शामिल हैं। ये भारत को परमाणु हथियारों के लिए एक मजबूत भूमि-आधारित वितरण प्रणाली प्रदान करते हैं।
- **वायु-आधारित डिलीवरी**: **सुखोई Su-30MKIs**, **मिराज 2000s**, और **जगुआर** जैसे विमान परमाणु पेलोड लॉन्च करने में सक्षम हवाई प्लेटफार्मों के रूप में काम करते हैं।
- **समुद्र आधारित क्षमता**: **आईएनएस अरिहंत**, एक 6,000 टन का स्वदेशी जहाज सबमर्सिबल बैलिस्टिक न्यूक्लियर (एसएसबीएन), समुद्री घटक का प्रतिनिधित्व करता है। इसके अतिरिक्त, **K-4 सागरिका** एक भारतीय 3500 किमी-रेंज वाली **पनडुब्बी से प्रक्षेपित परमाणु हथियार सक्षम बैलिस्टिक मिसाइल (SLBM)** है। इसे भारत की **स्वदेशी परमाणु पनडुब्बियों** से लॉन्च करने के लिए डिज़ाइन किया गया है।

रणनीतिक महत्व

इस त्रय का संचालन **विश्वसनीय परमाणु निवारक** बनाए रखने में योगदान देता है। यह भारत की **पहले इस्तेमाल न करने की नीति** का समर्थन करता है, जिससे किसी प्रतिद्वंद्वी के लिए पहले हमले के जरिए भारत के परमाणु शस्त्रागार को निष्क्रिय करना बेहद मुश्किल हो जाता है। यह भारत के **परमाणु सिद्धांत** की आधारशिला है।

India’s Missile Defence Programme

Indian Ballistic Missile Defence (BMD) Programme

Historical Context

- **Initiation**: Commenced in 1999 post-Kargil War and as a counter to China and Pakistan's missile capabilities.

System Architecture

- **Two-Tiered System**: Comprises Prithvi Air Defense (PAD)/Pradyumna and Advanced Air Defence (AAD).
    - **First Layer (Exo-atmospheric)**: PAD/Pradyumna and Prithvi Defense Vehicle (PDV) intercept missiles at altitudes of 50–180 km.
    - **Second Layer (Endo-atmospheric)**: AAD/Ashwin intercepts missiles at altitudes of 15-40 km.
- **Target Range**: Capable of intercepting missiles launched from up to 5,000 km away.

Components

- **Radars and Control Posts**: Overlapping network of early warning and tracking radars, along with command and control posts.

Testing and Status

- **Initial Tests**: Started in 2006; multiple successful tests, including one in August 2018.
- **Completion**: First phase completed as of January 2020; awaiting government approval for deployment around the national capital.

भारतीय बैलिस्टिक मिसाइल रक्षा (बीएमडी) कार्यक्रम

ऐतिहासिक संदर्भ

- **पहल**: 1999 में कारगिल युद्ध के बाद और चीन और पाकिस्तान की मिसाइल क्षमताओं के जवाब में शुरू हुई।

सिस्टम आर्किटेक्चर

- **दो-स्तरीय प्रणाली**: इसमें पृथ्वी वायु रक्षा (पीएडी)/प्रद्युम्न और उन्नत वायु रक्षा (एएडी) शामिल हैं।

    - **पहली परत (एक्सो-वायुमंडलीय)**: पीएडी/प्रद्युम्न और पृथ्वी रक्षा वाहन (पीडीवी) 50-180 किमी की ऊंचाई पर मिसाइलों को रोकते हैं।
    - **दूसरी परत (एंडो-वायुमंडलीय)**: एएडी/अश्विन 15-40 किमी की ऊंचाई पर मिसाइलों को रोकता है।
- **लक्ष्य सीमा**: 5,000 किमी दूर से प्रक्षेपित मिसाइलों को रोकने में सक्षम।

अवयव

- **रडार और नियंत्रण पोस्ट**: कमांड और नियंत्रण पोस्ट के साथ-साथ प्रारंभिक चेतावनी और ट्रैकिंग रडार का ओवरलैपिंग नेटवर्क।

परीक्षण और स्थिति

- **प्रारंभिक परीक्षण**: 2006 में प्रारंभ; कई सफल परीक्षण, जिनमें अगस्त 2018 में हुआ एक परीक्षण भी शामिल है।
- **समापन**: पहला चरण जनवरी 2020 तक पूरा हो गया; राष्ट्रीय राजधानी के आसपास तैनाती के लिए सरकार की मंजूरी का इंतजार है।

Iron Dome System

Overview

- **Purpose**: Developed by Israel to intercept and destroy short-range rockets and artillery shells.
- **Detection Range**: Identifies rockets at a distance of 4 to 70 km.

Milestones

- **Final Testing**: Completed in July 2010.
- **Operational Status**: Declared operational in 2011; used in conflicts against Hamas in 2012 and 2014.

Deployment and Collaboration

- **Operators**: Israel and Singapore.
- **India-Israel Deal**: A $2 billion deal signed in 2017 for India to acquire the Iron Dome system.

परिचय

- **उद्देश्य**: कम दूरी के रॉकेट और artillery shells को रोकने और नष्ट करने के लिए इज़राइल द्वारा विकसित।
- **डिटेक्शन रेंज**: 4 से 70 किमी की दूरी पर रॉकेट की पहचान करता है।

मील के पत्थर

- **अंतिम परीक्षण**: जुलाई 2010 में पूरा हुआ।
- **परिचालन स्थिति**: 2011 में परिचालन की घोषणा की गई; 2012 और 2014 में हमास के खिलाफ संघर्ष में इस्तेमाल किया गया।

परिनियोजन और सहयोग

- **ऑपरेटर**: इज़राइल और सिंगापुर।
- **भारत-इज़राइल डील**: आयरन डोम सिस्टम हासिल करने के लिए भारत के लिए 2017 में 2 बिलियन डॉलर के समझौते पर हस्ताक्षर किए गए।

Comparative Analysis

Common Objectives

- Both Indian BMD and Iron Dome aim to protect against incoming missile threats but differ significantly in the types of threats they are designed to counteract.

Technical Capabilities

- Indian BMD is designed for longer ranges and higher altitudes, whereas Iron Dome targets short-range threats.

International Collaboration

- While Indian BMD is an indigenous programme, the Iron Dome system represents international defence collaboration, particularly between India and Israel.

Status and Future Developments

- Indian BMD is waiting for government approval for further deployment, whereas the Iron Dome is already operational and has been combat-tested.

सामान्य उद्देश्य

- भारतीय बीएमडी और आयरन डोम दोनों का उद्देश्य आने वाले मिसाइल खतरों से रक्षा करना है, लेकिन वे जिस प्रकार के खतरों का मुकाबला करने के लिए डिज़ाइन किए गए हैं, उनमें काफी भिन्नता है।

तकनीकी क्षमताएँ

- भारतीय बीएमडी को लंबी दूरी और अधिक ऊंचाई के लिए डिज़ाइन किया गया है, जबकि आयरन डोम कम दूरी के खतरों को लक्षित करता है।

अंतर्राष्ट्रीय सहयोग

- जबकि भारतीय बीएमडी एक स्वदेशी कार्यक्रम है, आयरन डोम प्रणाली विशेष रूप से भारत और इज़राइल के बीच अंतरराष्ट्रीय रक्षा सहयोग का प्रतिनिधित्व करती है।

स्थिति और भविष्य के विकास

- भारतीय बीएमडी आगे की तैनाती के लिए सरकार की मंजूरी का इंतजार कर रहा है, जबकि आयरन डोम पहले से ही चालू है और इसका युद्ध परीक्षण किया जा चुका है।

S-400 Triumf

The **S-400 Triumf** is a **mobile surface-to-air missile system (SAM)** designed by Russia. It holds the distinction of being the most advanced operationally deployed **modern long-range SAM**, surpassing the United States' **Terminal High Altitude Area Defense system (THAAD)**. The S-400 Triumf is equipped to engage a wide array of aerial threats. These include **aircraft**, **unmanned aerial vehicles (UAVs)**, and **ballistic and cruise missiles**.

The system has a range of **400 km** and can operate at altitudes up to **30 km**. Furthermore, it can track **100 airborne targets** and engage up to **six of them simultaneously**.

एस-400 ट्रायम्फ एक **सतह से हवा में मार करने वाली मोबाइल मिसाइल प्रणाली (एसएएम)** है जिसे रूस द्वारा डिजाइन किया गया है। इसे संयुक्त राज्य अमेरिका के **टर्मिनल हाई एल्टीट्यूड एरिया डिफेंस सिस्टम (THAAD)** को पीछे छोड़ते हुए सबसे उन्नत परिचालन रूप से तैनात **आधुनिक लंबी दूरी की एसएएम** होने का गौरव प्राप्त है।

एस-400 ट्रायम्फ विभिन्न प्रकार के हवाई खतरों से निपटने के लिए सुसज्जित है। इनमें **विमान**, **मानवरहित हवाई वाहन (यूएवी)**, और **बैलिस्टिक और क्रूज़ मिसाइलें** शामिल हैं।

सिस्टम की सीमा **400 किमी** है और यह **30 किमी** तक की ऊंचाई पर काम कर सकता है। इसके अलावा, यह **100 हवाई लक्ष्यों** को ट्रैक कर सकता है और **उनमें से छह को एक साथ निशाना बना सकता है**।

India's Acquisition of S-400 Triumf

India entered into a **$5.43 billion USD agreement** with Russia in October 2018 for the acquisition of the S-400 Triumf missile system. The deliveries have already begun and are expected to conclude by **late 2023 / 2024**. This acquisition is going to substantially enhance India's ability to neutralise **enemy fighter aircraft and cruise missiles at long range**.

भारत ने एस-400 ट्रायम्फ मिसाइल प्रणाली के अधिग्रहण के लिए अक्टूबर 2018 में रूस के साथ 5.43 बिलियन अमेरिकी डॉलर का समझौता किया। डिलीवरी पहले ही शुरू हो चुकी है और 2023/2024 के अंत तक समाप्त होने की उम्मीद है। इस अधिग्रहण से लंबी दूरी पर दुश्मन के लड़ाकू विमानों और क्रूज मिसाइलों को बेअसर करने की भारत की क्षमता में काफी वृद्धि होने जा रही है।

Geopolitical Implications

While the deal significantly boosts India's defensive capabilities, it has faced diplomatic challenges. The United States has expressed objections and has threatened to impose sanctions under the **Countering America's Adversaries Through Sanctions Act (CAATSA)**. Despite such international pressure, India has opted to proceed with the acquisition, underscoring the strategic importance it attributes to the S-400 system for its defence infrastructure.

Design and Capabilities

- **Origin**: Designed by Russia, the **S-400 Triumf** is a mobile surface-to-air missile system (SAM).
- **NATO Designation**: Also known as **SA-21 Growler** by NATO.
- **Operational Superiority**: Considered the most advanced **Modern Long-Range SAM (MLR SAM)**, surpassing the US-developed **Terminal High Altitude Area Defense system (THAAD)**.
- **Aerial Engagement**: Capable of targeting a variety of aerial objects including **aircraft**, **Unmanned Aerial Vehicles (UAVs)**, and **ballistic and cruise missiles** within a range of **400 km** and up to an altitude of **30 km**.
- **उत्पत्ति**: रूस द्वारा डिज़ाइन किया गया, **एस-400 ट्रायम्फ** एक मोबाइल सतह से हवा में मार करने वाली मिसाइल प्रणाली (एसएएम) है।
- **नाटो के द्वारा दिया नाम**: नाटो द्वारा इसे **SA-21 ग्रोलर** के नाम से भी जाना जाता है।
- **ऑपरेशनल उत्कृष्टता**: सबसे उन्नत **आधुनिक लंबी दूरी की एसएएम (एमएलआर एसएएम)** मानी जाती है, जो अमेरिका द्वारा विकसित **टर्मिनल हाई एल्टीट्यूड एरिया डिफेंस सिस्टम (टीएचएएडी)** को पीछे छोड़ती है।

- **हवाई गतिविधि**: **400 की सीमा के भीतर विमान, मानवरहित हवाई वाहन (यूएवी), और बैलिस्टिक और क्रूज़ मिसाइलों सहित विभिन्न हवाई वस्तुओं को लक्षित करने में सक्षम किमी** और **30 किमी** की ऊंचाई तक।

Technical Specifications

- **Target Tracking**: Can monitor **100 airborne targets** and engage up to **six of them simultaneously**.
- **Generational Advancement**: Represents the **fourth generation** of long-range Russian SAMs, succeeding the S-200 and S-300.
- **Integrated Systems**: Comprises a **multifunction radar**, **autonomous detection and targeting systems**, **anti-aircraft missile systems**, **launchers**, and a **command and control centre**.
- **Missile Variants**: Capable of launching **three types of missiles** for layered defence.
- **लक्ष्य ट्रैकिंग**: **100 हवाई लक्ष्यों** की निगरानी कर सकता है और **उनमें से छह को एक साथ निशाना बना सकता है**।
- **पीढ़ीगत उन्नति**: एस-200 और एस-300 के बाद लंबी दूरी के रूसी एसएएम की **चौथी पीढ़ी** का प्रतिनिधित्व करता है।
- **एकीकृत सिस्टम**: इसमें एक **मल्टीफ़ंक्शन रडार**, **स्वायत्त पहचान और लक्ष्यीकरण सिस्टम**, **एंटी-एयरक्राफ्ट मिसाइल सिस्टम**, **लॉन्चर**, और एक **कमांड और नियंत्रण केंद्र शामिल है** ।
- **मिसाइल वेरिएंट**: स्तरित रक्षा के लिए **तीन प्रकार की मिसाइलों** को लॉन्च करने में सक्षम।

Efficiency and Deployment

- **Effectiveness**: Two times more effective than previous Russian air defence systems.
- **Rapid Deployment**: Can be operational within **five minutes**.
- **Operational Status**: First became operational in **2007** and is tasked with defending Russia.
- **Interoperability**: Can be integrated with **Air Force**, **Army**, and **Navy** air defence units.

- **प्रभावशीलता**: पिछली रूसी वायु रक्षा प्रणालियों की तुलना में दो गुना अधिक प्रभावी।
- **रैपिड डिप्लॉयमेंट**: **पांच मिनट** के भीतर चालू किया जा सकता है।

- **संचालन स्थिति**: पहली बार **2007** में परिचालन शुरू हुआ और इसे रूस की रक्षा करने का काम सौंपा गया है।
- **इंटरऑपरेबिलिटी**: **वायु सेना**, **सेना**, और **नौसेना** वायु रक्षा इकाइयों के साथ एकीकृत किया जा सकता है।

Strategic Deployment

- **Location**: Systems are already deployed to counter threats from **China in the northern sector** and along the **frontier with Pakistan**.
- स्थान: उत्तरी क्षेत्र और पाकिस्तान से लगी सीमा पर चीन के खतरों का मुकाबला करने के लिए सिस्टम पहले से ही तैनात हैं।

LCA Tejas

Overview of HAL Tejas

- **HAL Tejas**, also known as **Light Combat Aircraft (LCA) Tejas**, is an Indian **single-engine, delta wing, multirole light fighter**.
- Designed by the **Aeronautical Development Agency (ADA)** in collaboration with the **Aircraft Research and Design Centre (ARDC)** of **Hindustan**

Aeronautics Limited (HAL).

- Developed for the **Indian Air Force (IAF)** and **Indian Navy**.
- **एचएएल तेजस**, जिसे **लाइट कॉम्बैट एयरक्राफ्ट (एलसीए) तेजस** के नाम से भी जाना जाता है, एक भारतीय **सिंगल-इंजन, डेल्टा विंग, मल्टीरोल लाइट फाइटर** है।
- **एयरोनॉटिकल डेवलपमेंट एजेंसी (ADA)** द्वारा **हिंदुस्तान एयरोनॉटिक्स लिमिटेड (HAL)** के **एयरक्राफ्ट रिसर्च एंड डिज़ाइन सेंटर (ARDC)** के सहयोग से डिज़ाइन किया गया।
- **भारतीय वायु सेना (आईएएफ)** और **भारतीय नौसेना** के लिए विकसित।

Origin and Development

- The LCA programme began in the **1980s**.
- Aims:
  - **Replacement** for India's ageing **MiG-21** fighters.
  - Boost **domestic aviation capability**.
  - Achieve **aerospace self-reliance**.
  - Build a local industry for **state-of-the-art products with commercial spin-offs**.
- एलसीए कार्यक्रम **1980** में शुरू हुआ।
- लक्ष्य:
  - भारत के पुराने **मिग-21** लड़ाकू विमानों के लिए **प्रतिस्थापन**।
  - **घरेलू विमानन क्षमता** को बढ़ावा देना।
  - **एयरोस्पेस आत्मनिर्भरता** हासिल करना।
  - **वाणिज्यिक स्पिन-ऑफ के साथ अत्याधुनिक उत्पादों** के लिए एक स्थानीय उद्योग विकसित करना।

Organisational Structure

- **Aeronautical Development Agency (ADA)** was established in **1984** by the Government of India.
- Principal partner: **Hindustan Aeronautics Limited (HAL)**.
- Collaboration with **DRDO & CSIR Laboratories, public and private sector industries, and academic institutions**.
- **एयरोनॉटिकल डेवलपमेंट एजेंसी (एडीए)** की स्थापना **1984** में भारत सरकार द्वारा की गई थी।

- प्रमुख भागीदार: **हिंदुस्तान एयरोनॉटिक्स लिमिटेड (एचएएल)**।
- **डीआरडीओ और सीएसआईआर प्रयोगशालाओं, सार्वजनिक और निजी क्षेत्र के उद्योगों और शैक्षणिक संस्थानों** के साथ सहयोग।

Technical Features

- **Aerodynamically unstable tailless compound delta-wing configuration** optimised primarily for **manoeuvrability and agility**.
- **Maximum speed**: **Mach 1.8**.
- **Range**: **3,200 km**.
- **Combat range**: **500 km**.
- **Ferry range**: **1,850 km**.
- Constructed of **aluminium-lithium alloys, carbon-fibre composites, and titanium alloys**.
- **Composite materials** make up **45% of the airframe by weight and 95% by surface area**.
- **वायुगतिकीय रूप से अस्थिर टेललेस कंपाउंड डेल्टा-विंग कॉन्फ़िगरेशन** मुख्य रूप से **गतिशीलता और चपलता** के लिए अनुकूलित।
- **अधिकतम गति**: मैक **1.8**।
- **रेंज**: **3,200 किमी**।
- **लड़ाकू रेंज**: **500 किमी**।
- **फेरी रेंज**: **1,850 किमी**।
- **एल्यूमीनियम-लिथियम मिश्र धातु, कार्बन-फाइबर कंपोजिट और टाइटेनियम मिश्र धातु** से निर्मित।
- **मिश्रित सामग्री** वजन के हिसाब से एयरफ्रेम का **45% और सतह क्षेत्र के हिसाब से 95%** बनाती है।

Avionics and Systems

- **Night Vision Goggles (NVG)-compatible "glass cockpit"**.
- **Domestically-developed head-up display (HUD)** by **Central Scientific Instruments Organization (CSIO)**.
- **Multi-function displays**, **Smart Standby Display Units (SSDU)**, and a **"get-you-home" panel**.
- **नाइट विजन गॉगल्स (एनवीजी)-संगत "ग्लास कॉकपिट"**।

- **केंद्रीय वैज्ञानिक उपकरण (सीएसआईओ)** द्वारा घरेलू रूप से विकसित हेड-अप डिस्प्ले (एचयूडी)।
- **मल्टी-फंक्शन डिस्प्ले**, **स्मार्ट स्टैंडबाय डिस्प्ले यूनिट्स (एसएसडीयू)**, और एक **"गेट-यू-होम" पैनल**।

Variants and Orders

- **Mark 1**, **Mark 1A**, and a **trainer version**.
- IAF has ordered **32 Mark 1s, 73 Mark 1As, and 18 Mark 1 trainers**.
- Planned procurement: **324 aircraft in all variants** including **Tejas Mark 2** under development.
- **43 improvements** in the Mark-1A jets including **AESA radar, long-range beyond visual range missiles, air-to-air refuelling, and advanced electronic warfare**.
- **मार्क 1**, **मार्क 1ए**, और एक **ट्रेनर संस्करण**।
- IAF ने **32 मार्क 1s, 73 मार्क 1As, और 18 मार्क 1 ट्रेनर्स** का ऑर्डर दिया है।
- नियोजित खरीद: **तेजस मार्क 2** सहित सभी वेरिएंट में 324 विमान विकासाधीन।
- एईएसए रडार, दृश्य सीमा से परे लंबी दूरी की मिसाइलें, हवा से हवा में ईंधन भरने और उन्नत इलेक्ट्रॉनिक युद्ध सहित मार्क -1 ए जेट में 43 सम्मिलित हैं।

Deployment

- First Tejas squadron became operational in **2016**. (IAF fighter squadrons typically have 18 operationally deployed aircraft, with three crafts kept as a reserve.)
- Participated in military exercises like **Gagan Shakti 2018 and Vayu Shakti 2019**.
- **83 single-engine Tejas Mark-1A** aircrafts by the Indian Air Force were finalised in **January 2020**.
- **Argentina and Egypt have shown interest in Tejas**, the Light Combat Aircraft (LCA) manufactured by Hindustan Aeronautics Limited (HAL).
- पहला तेजस स्क्वाड्रन **2016** में चालू हुआ। (आईएएफ लड़ाकू स्क्वाड्रन में आमतौर पर 18 परिचालन रूप से तैनात विमान होते हैं, जिसमें तीन रिजर्व के रूप में रखे जाते हैं।)
- **गगन शक्ति 2018 और वायु शक्ति 2019** जैसे सैन्य अभ्यासों में भाग लिया।
- **भारतीय वायु सेना द्वारा 83 सिंगल-इंजन तेजस मार्क-1ए** विमानों को **जनवरी 2020** में अंतिम रूप दिया गया।

- **अर्जेंटीना और मिस्र ने हिंदुस्तान एयरोनॉटिक्स लिमिटेड (HAL) द्वारा निर्मित हल्के लड़ाकू विमान (LCA) तेजस** में रुचि दिखाई है।

Comparative Advantages and Significance

- Lightest in its category at **nine tons**.
- Cost-effective at **Rs.180 crore apiece**.
- Comparable to **French Mirage 2000, U.S. F-16, and Swedish Gripen**.
- No accidents during trials.
- Contributes to **indigenisation of military hardware** and provides valuable experience for future aircraft development.

- अपनी श्रेणी में सबसे हल्का **नौ टन**।
- लागत **प्रत्येक 180 करोड़ रुपये**।
- **फ्रेंच मिराज 2000, यू.एस. एफ-16, और स्वीडिश ग्रिपेन** से तुलनीय।
- ट्रायल के दौरान कोई दुर्घटना नहीं।
- **सैन्य हार्डवेयर के स्वदेशीकरण** में योगदान देता है और भविष्य के विमान विकास के लिए मूल्यवान अनुभव प्रदान करता है।

Challenges and Future Prospects

- **Long development period** costing **Rs.172.69 billion**.
- **Limited payload and agility** due to the current **GE F404 engine**.
- **Tejas Mark II** with **GE 414 engine** is awaited but may require re-engineering.
- **लंबी विकास अवधि** लागत **172.69 अरब रुपये**।
- वर्तमान **GE F404 इंजन** के कारण **सीमित पेलोड और चपलता**।
- **GE 414 इंजन** के साथ **तेजस मार्क II** का इंतजार है, लेकिन री-इंजीनियरिंग की आवश्यकता हो सकती है।

Robots and Robotics

What are robots?

Robots are **programmable and smart machines** that are designed to carry out a range of tasks, often complex in nature.

They mostly contain multiple systems (mechanical, electrical, electronic, software) working in harmony, and mostly equipped with sensors to perceive its environment and actuators to perform actions.

Robots have a wide range of applications across different fields, from manufacturing to space exploration.

1. Manufacturing: Robots are commonly used in manufacturing processes to assemble, package, and transport products.
2. Healthcare: Robots can be used to assist with surgery, monitor vital signs, and provide physical therapy.
3. Agriculture: Robots can be used for tasks such as planting, harvesting, and monitoring crops.
4. Space Exploration: Robots are used in space exploration to gather data, perform experiments, and conduct repairs.
5. Military: Robots are used by the military for tasks such as bomb disposal, reconnaissance, and surveillance.
6. Construction: Robots can be used in construction for tasks such as demolition and excavation.
7. Transportation: Robots are used in transportation for tasks such as driving and delivery.

8. Environmental: Robots can be used to monitor environmental conditions and collect data for research purposes.
9. Entertainment: Robots are used in entertainment for tasks such as animatronics and special effects. (Animatronics refers to the use of robotic technology to create lifelike movements in objects or characters, often for use in entertainment or media. Animatronics are commonly used in movies, theme parks.)

रोबोट **प्रोग्राम करने योग्य और स्मार्ट मशीनें** हैं जिन्हें कई प्रकार के कार्यों को करने के लिए डिज़ाइन किया गया है, जो अक्सर जटिल प्रकृति के होते हैं।

इनमें कई प्रणालियाँ (मैकेनिकल, इलेक्ट्रिकल, इलेक्ट्रॉनिक, सॉफ्टवेयर) होती हैं जो एक साथ काम करती हैं, और अधिकतर अपने वातावरण को समझने के लिए सेंसर और कार्य करने के लिए एक्चुएटर्स से सुसज्जित होती हैं।

विनिर्माण से लेकर अंतरिक्ष अन्वेषण तक विभिन्न क्षेत्रों में रोबोट के अनुप्रयोग होते हैं.

1. विनिर्माण: रोबोट का उपयोग आमतौर पर विनिर्माण प्रक्रियाओं में उत्पादों को इकट्ठा करने, पैकेज करने और परिवहन करने के लिए किया जाता है।
2. स्वास्थ्य देखभाल: रोबोट का उपयोग सर्जरी में सहायता करने, महत्वपूर्ण संकेतों की निगरानी करने और फ़िज़ियोथेपी चिकित्सा प्रदान करने के लिए किया जा सकता है।
3. कृषि: रोबोट का उपयोग फसलों की रोपाई, कटाई और निगरानी जैसे कार्यों के लिए किया जा सकता है।
4. अंतरिक्ष अन्वेषण: रोबोटों का उपयोग अंतरिक्ष अन्वेषण में डेटा इकट्ठा करने, प्रयोग करने और मरम्मत करने के लिए किया जाता है।
5. सेना: रोबोटों का उपयोग सेना द्वारा बम निरोधक, टोही और निगरानी जैसे कार्यों के लिए किया जाता है।
6. निर्माण कार्य: रोबोट का उपयोग निर्माण कार्य में तोड़फोड़ और खुदाई जैसे कार्यों के लिए किया जा सकता है।
7. परिवहन: रोबोट का उपयोग परिवहन में ड्राइविंग और डिलीवरी जैसे कार्यों के लिए किया जाता है।
8. पर्यावरण: रोबोट का उपयोग पर्यावरणीय स्थितियों की निगरानी करने और अनुसंधान उद्देश्यों के लिए डेटा एकत्र करने के लिए किया जा सकता है।
9. मनोरंजन: रोबोट का उपयोग मनोरंजन में एनिमेट्रॉनिक्स और विशेष प्रभावों जैसे कार्यों के लिए किया जाता है। (एनिमेट्रॉनिक्स वस्तुओं या पात्रों में जीवंत हलचल पैदा करने के लिए रोबोटिक तकनीक के उपयोग को कहते हैं, अक्सर मनोरंजन या मीडिया में उपयोग के लिए। एनिमेट्रॉनिक्स का उपयोग आमतौर पर फिल्मों, थीम पार्कों में किया जाता है।)

Robotics

Robotics is the branch of technology that deals with the design, construction, and operation of robots.

It combines multiple fields such as mechanical engineering, electronics, and computer science to create machines that can work autonomously or semi-autonomously, with the ability to perceive their environment and adapt to changing circumstances.

रोबोटिक्स प्रौद्योगिकी की वह शाखा है जो रोबोट के डिजाइन, निर्माण और संचालन से संबंधित है।

यह मैकेनिकल इंजीनियरिंग, इलेक्ट्रॉनिक्स और कंप्यूटर विज्ञान जैसे कई क्षेत्रों को मिलाकर ऐसी मशीनें बनाता है जो अपने वातावरण को समझने और बदलती परिस्थितियों के अनुकूल होने की क्षमता के साथ स्वायत्त या अर्ध-स्वायत्त रूप से काम कर सकती हैं।

Difference between robots and ordinary machines

Machines and robots both serve to automate tasks or actions, but they differ fundamentally in their complexity, adaptability, and autonomy. Following are the main differences between a machine and a robot:

1. **Functionality**:
    - **Machine**: Typically designed for a specific task or a set of closely related tasks. It doesn't have the capability to perform outside its designated function without being retooled or modified.
        - *Example*: A washing machine is designed to wash clothes. You can't ask it to brew coffee or mow the lawn.
    - **Robot**: Can often perform a range of tasks and might be reprogrammed to undertake different activities without physical modifications.
        - *Example*: A robotic arm in a car manufacturing plant can be reprogrammed to weld different parts of a vehicle or even to paint them.
2. **Adaptability**:
    - **Machine**: Generally static in its operation. If a problem arises during its operation, a human usually needs to intervene to correct it.
        - *Example*: If a paper jam occurs in a printer, it stops working and waits for human intervention.
    - **Robot**: Can be designed to adapt to new situations or problems using sensors and feedback mechanisms.
        - *Example*: Some robotic vacuum cleaners can detect obstacles and navigate around them while cleaning a room.

3. **Autonomy**:
    - **Machine**: Operates based on human initiation and oversight. It doesn’t make decisions on its own.
        - *Example*: A microwave oven will cook food for a set time, but it won't decide on its own when the food is ready.
    - **Robot**: Has a degree of autonomy and can make decisions based on pre-programmed logic and sensory input.
        - *Example*: A self-driving car can make decisions about speed, direction, and when to stop based on its surroundings.
4. **Complexity**:
    - **Machine**: Usually has a straightforward mechanism or set of mechanisms.
        - *Example*: A manual hand drill is turned by hand to create a hole.
    - **Robot**: Contains multiple systems (mechanical, electrical, software) working in harmony, often equipped with sensors to perceive its environment and actuators to perform actions.
        - *Example*: A drone that can autonomously navigate through a forest, avoiding trees using onboard cameras and sensors.
5. **Programming & Control**:
    - **Machine**: Typically controlled manually or has a very fixed set of operations.
        - *Example*: A fan can be turned on or off, and maybe its speed can be adjusted.
    - **Robot**: Operates based on a set of instructions or a program that can be updated, changed, or modified to fit different scenarios.
        - *Example*: A robot used in a warehouse can be reprogrammed to pick different items or navigate a newly arranged layout.

In essence, while all robots can be considered machines, not all machines qualify as robots. Robots generally possess a higher level of autonomy, adaptability, and multifunctionality compared to other machines.

मशीनें और रोबोट दोनों कार्यों या कार्यों को स्वचालित करने का काम करते हैं, लेकिन वे अपनी जटिलता, अनुकूलनशीलता और स्वायत्तता में मौलिक रूप से भिन्न होते हैं। मशीन और रोबोट के बीच मुख्य अंतर निम्नलिखित हैं:

1. **कार्यक्षमता**:
    - **मशीन**: आमतौर पर किसी विशिष्ट कार्य या निकट से संबंधित कार्यों के समूह के लिए डिज़ाइन की गई है। इसमें पुनर्निर्मित या संशोधित किए बिना अपने निर्दिष्ट कार्य से बाहर प्रदर्शन करने की क्षमता नहीं है।
        - *उदाहरण*: एक वॉशिंग मशीन कपड़े धोने के लिए डिज़ाइन की गई है। आप उससे कॉफ़ी बनाने या लॉन में घास काटने के लिए नहीं कह सकते।
    - **रोबोट**: अक्सर कई प्रकार के कार्य कर सकता है और संशोधनों के बिना विभिन्न गतिविधियों को करने के लिए इसे पुन: प्रोग्राम किया जा सकता है।
        - *उदाहरण*: कार निर्माण संयंत्र में एक रोबोटिक भुजा को वाहन के विभिन्न हिस्सों को वेल्ड करने या यहां तक कि उन्हें पेंट करने के लिए पुन: प्रोग्राम किया जा सकता है।
2. **अनुकूलनशीलता**:
    - **मशीन**: आम तौर पर इसका संचालन स्थिर होता है। यदि इसके संचालन के दौरान कोई समस्या उत्पन्न होती है, तो इसे ठीक करने के लिए आमतौर पर मनुष्य को हस्तक्षेप करने की आवश्यकता होती है।
        - *उदाहरण*: यदि प्रिंटर में पेपर जाम हो जाता है, तो यह काम करना बंद कर देता है और मानवीय हस्तक्षेप की प्रतीक्षा करता है।
    - **रोबोट**: सेंसर और फीडबैक तंत्र का उपयोग करके नई स्थितियों या समस्याओं के अनुकूल होने के लिए डिज़ाइन किया जा सकता है।
        - *उदाहरण*: कुछ रोबोटिक वैक्यूम क्लीनर किसी कमरे की सफाई करते समय बाधाओं का पता लगा सकते हैं और उनके चारों ओर नेविगेट कर सकते हैं।
3. **स्वायत्तता**:
    - **मशीन**: मानव निर्देश और निरीक्षण के आधार पर संचालित होती है। यह स्वयं निर्णय नहीं लेता.
        - *उदाहरण*: एक माइक्रोवेव ओवन एक निर्धारित समय के लिए खाना पकाएगा, लेकिन खाना कब तैयार होगा यह खुद तय नहीं करेगा।
    - **रोबोट**: इसमें कुछ हद तक स्वायत्तता होती है और यह पूर्व-प्रोग्राम किए गए तर्क और संवेदी इनपुट के आधार पर निर्णय ले सकता है।
        - *उदाहरण*: एक स्व-चालित कार अपने परिवेश के आधार पर गति, दिशा और कब रुकना है, इसके बारे में निर्णय ले सकती है।
4. **जटिलता**:
    - **मशीन**: आमतौर पर एक सीधा तंत्र या तंत्रों का सेट होता है।
        - *उदाहरण*: एक छेद बनाने के लिए एक मैनुअल हैंड ड्रिल को हाथ से घुमाया जाता है।

- **रोबोट**: इसमें एक साथ काम करने वाले कई सिस्टम (मैकेनिकल, इलेक्ट्रिकल, सॉफ्टवेयर) होते हैं, जो अक्सर अपने वातावरण को समझने के लिए सेंसर और कार्य करने के लिए एक्चुएटर्स से लैस होते हैं।
    - *उदाहरण*: एक ड्रोन जो ऑनबोर्ड कैमरे और सेंसर का उपयोग करके पेड़ों से बचते हुए, जंगल में स्वायत्त रूप से नेविगेट कर सकता है।

5. **प्रोग्रामिंग एवं नियंत्रण**:
    - **मशीन**: आमतौर पर मैन्युअल रूप से नियंत्रित किया जाता है या संचालन का एक निश्चित सेट होता है।
        - *उदाहरण*: एक पंखे को चालू या बंद किया जा सकता है, और इसकी गति को समायोजित किया जा सकता है।
    - **रोबोट**: निर्देशों के एक सेट या एक प्रोग्राम के आधार पर संचालित होता है जिसे विभिन्न परिदृश्यों में फिट करने के लिए अद्यतन, परिवर्तित या संशोधित किया जा सकता है।
        - *उदाहरण*: गोदाम में उपयोग किए जाने वाले रोबोट को विभिन्न वस्तुओं को चुनने या नए व्यवस्थित लेआउट को नेविगेट करने के लिए पुन: प्रोग्राम किया जा सकता है।

संक्षेप में, जबकि सभी रोबोटों को मशीन माना जा सकता है, सभी मशीनें रोबोट के रूप में योग्य नहीं हैं। रोबोट में आम तौर पर अन्य मशीनों की तुलना में उच्च स्तर की स्वायत्तता, अनुकूलनशीलता और बहुक्रियाशीलता होती है।

Developmental milestones in the field of robotics

1. **Early 20th Century**:
    - The term "robot" was coined in the 1920 play "R.U.R." (Rossum's Universal Robots) by Czech writer Karel Čapek.
    - Westinghouse Electric Corporation introduced "Televox" in 1927 – one of the first machines controlled by voice commands.
    - The first patent for an industrial robot was granted in 1939 to Griffith P. Taylor.
2. **1950s and 1960s**:
    - George Devol patented the first programmable robot in 1954 and, together with Joseph Engelberger, founded the world's first robot company.
    - The Unimate robot (1961) – the first industrial robot to work on an assembly line in a General Motors plant.
3. **1970s**:

- The development of the Stanford Arm in 1969, an early precursor to today's more advanced robotic arms.
- The ASEA IRB 6/60, developed in 1975, was the first robot to be controlled by a microprocessor.
- MIT’s Silver Arm in 1974, which had touch and pressure sensing capabilities.

4. **1980s**:
    - The introduction of direct drive motors, which enhanced the speed and precision of robotic movements.
    - The PUMA (Programmable Universal Machine for Assembly) robotic arm became an industry standard.
5. **1990s**:
    - Honda introduced the humanoid robot "P3" in 1996. It was designed to walk and climb stairs, and had the ability to recognize and respond to human voice commands. "P3" was an improvement over Honda's previous humanoid robot, "P2", which was much less advanced. "P3" was also notable for its use of artificial muscles, which allowed for smoother and more natural movement. However, "P3" was not intended for commercial production, and was primarily used for research purposes.
    - Development of smaller, collaborative robots designed to work alongside humans without protective barriers - Co-bots.
6. **2000s**:
    - Boston Dynamics introduced BigDog in 2005, a quadruped robot designed for the U.S. military.
    - The DARPA (Defence Advanced Research Projects Agency of USA) Grand Challenge (2004 & 2005) boosted developments in autonomous vehicles.
7. **2010s**:
    - Robots became more interconnected with the Internet of Things (IoT).
    - Open-source robot operating systems, such as ROS (Robot Operating System), gained popularity, enabling more collaboration and faster innovation.
    - Soft robotics emerged, inspired by the flexibility and adaptability of biological organisms.

- Boston Dynamics unveiled "Spot" and "Atlas", showcasing advanced mobility and balance. Boston Dynamics unveiled "Spot" and "Atlas" as their most advanced robots in 2016 and 2013, respectively. "Spot" is a four-legged robot designed for mobility and rough terrain, while "Atlas" is a humanoid robot with impressive mobility and balance. Both robots are equipped with advanced sensors and software that enable them to navigate complex environments and perform a range of tasks. "Spot" has been used for applications such as remote inspection of oil rigs and construction sites, while "Atlas" has been used for disaster response and search and rescue missions.
- Advancements in deep learning and artificial intelligence resulted in robots with better perception, decision-making, and task performance.

8. **2020s and Beyond**:
    - Continued integration of AI and machine learning in robotics for more intelligent decision-making.
    - Greater emphasis on human-robot collaboration and co-bots.
    - Expansion of robotics in healthcare, especially in surgeries and patient care.
    - Autonomous vehicles and drones became more commercialized and integrated into societal infrastructures.

1. **20वीं सदी की शुरुआत**:
    - "रोबोट" शब्द 1920 के नाटक "आर.यू.आर." में गढ़ा गया था। (रॉसम के यूनिवर्सल रोबोट्स) चेक लेखक कारेल कापेक द्वारा।
    - वेस्टिंगहाउस इलेक्ट्रिक कॉर्पोरेशन ने 1927 में "टेलीवोक्स" पेश किया - वॉयस कमांड द्वारा नियंत्रित पहली मशीनों में से एक।
    - औद्योगिक रोबोट के लिए पहला पेटेंट 1939 में ग्रिफ़िथ पी. टेलर को दिया गया था।
2. **1950 और 1960**:
    - जॉर्ज डेवोल ने 1954 में पहले प्रोग्रामेबल रोबोट का पेटेंट कराया और जोसेफ एंगेलबर्गर के साथ मिलकर दुनिया की पहली रोबोट कंपनी की स्थापना की।
    - द यूनीमेट रोबोट (1961) - जनरल मोटर्स प्लांट में असेंबली लाइन पर काम करने वाला पहला औद्योगिक रोबोट।
3. **1970**:

- 1969 में स्टैनफोर्ड आर्म का विकास, आज के अधिक उन्नत रोबोटिक आर्म का प्रारंभिक अग्रदूत।
- 1975 में विकसित ASEA IRB 6/60, माइक्रोप्रोसेसर द्वारा नियंत्रित होने वाला पहला रोबोट था।
- 1974 में एमआईटी की सिल्वर आर्म, जिसमें स्पर्श और दबाव संवेदन क्षमताएं थीं।

4. **1980 का दशक**:
    - डायरेक्ट ड्राइव मोटर्स की शुरूआत, जिसने रोबोटिक गतिविधियों की गति और सटीकता को बढ़ाया।
    - PUMA (प्रोग्रामेबल यूनिवर्सल मशीन फॉर असेंबली) रोबोटिक आर्म एक उद्योग मानक बन गया।
5. **1990**:
    - होंडा ने 1996 में ह्यूमनॉइड रोबोट "पी3" पेश किया। इसे चलने और सीढ़ियाँ चढ़ने के लिए डिज़ाइन किया गया था, और इसमें मानव आवाज आदेशों को पहचानने और प्रतिक्रिया देने की क्षमता थी। "पी3" होंडा के पिछले ह्यूमनॉइड रोबोट, "पी2" से बेहतर था, जो बहुत कम उन्नत था। "पी3" कृत्रिम मांसपेशियों के उपयोग के लिए भी उल्लेखनीय था, जो सहज और अधिक प्राकृतिक गति की अनुमति देता था। हालाँकि, "पी3" का उद्देश्य व्यावसायिक उत्पादन नहीं था, और इसका उपयोग मुख्य रूप से अनुसंधान उद्देश्यों के लिए किया गया था।
    - सुरक्षात्मक बाधाओं के बिना मनुष्यों के साथ काम करने के लिए डिज़ाइन किए गए छोटे, सहयोगी रोबोटों का विकास - सह-बॉट।
6. **2000**:
    - बोस्टन डायनेमिक्स ने 2005 में बिगडॉग पेश किया, जो अमेरिकी सेना के लिए डिज़ाइन किया गया एक रोबोट था।
    - DARPA (यूएसए की रक्षा उन्नत अनुसंधान परियोजना एजेंसी) ग्रैंड चैलेंज (2004 और 2005) ने स्वायत्त वाहनों में विकास को बढ़ावा दिया।
7. **2010**:
    - रोबोट इंटरनेट ऑफ थिंग्स (IoT) से अधिक जुड़ गए।
    - ओपन-सोर्स रोबोट ऑपरेटिंग सिस्टम, जैसे कि आरओएस (रोबोट ऑपरेटिंग सिस्टम) ने लोकप्रियता हासिल की, जिससे अधिक सहयोग और तेज नवाचार संभव हुआ।
    - जीवों के लचीलेपन और अनुकूलन क्षमता से प्रेरित होकर सॉफ्ट रोबोटिक्स का उदय हुआ।
    - बोस्टन डायनेमिक्स ने उन्नत गतिशीलता और संतुलन का प्रदर्शन करते हुए "स्पॉट" और "एटलस" का निर्माण किया। "स्पॉट" एक चार पैरों वाला रोबोट है जिसे गतिशीलता और उबड़-खाबड़ इलाकों के लिए डिज़ाइन किया गया है, जबकि "एटलस" प्रभावशाली गतिशीलता और संतुलन वाला एक ह्यूमनॉइड रोबोट है। दोनों रोबोट उन्नत सेंसर और सॉफ्टवेयर से लैस हैं जो उन्हें जटिल वातावरण में नेविगेट करने और कई प्रकार के कार्य करने में सक्षम बनाते हैं। "स्पॉट" का उपयोग

तेल रिसाव और निर्माण स्थलों के दूरस्थ निरीक्षण जैसे अनुप्रयोगों के लिए किया गया है, जबकि "एटलस" का उपयोग आपदा प्रतिक्रिया और खोज और बचाव अभियानों के लिए किया गया है।

- गहन शिक्षण और कृत्रिम बुद्धिमत्ता में प्रगति के परिणामस्वरूप बेहतर धारणा, निर्णय लेने और कार्य प्रदर्शन वाले रोबोट सामने आए।

8. **2020 और उससे आगे**:
    - अधिक बुद्धिमान निर्णय लेने के लिए रोबोटिक्स में एआई और मशीन लर्निंग का निरंतर एकीकरण।
    - मानव-रोबोट सहयोग और सह-बॉट पर अधिक जोर।
    - स्वास्थ्य देखभाल में रोबोटिक्स का विस्तार, विशेषकर सर्जरी और रोगी देखभाल में।
    - स्वायत्त वाहनों और ड्रोनों का अधिक व्यावसायीकरण हो गया और उन्हें सामाजिक बुनियादी ढांचे में एकीकृत किया गया।

Components of a robot

Robots are multifaceted systems made up of several components. These components are typically designed to grant the robot its sensing, actuation, and processing capabilities. Here's an overview of the primary components found in many robots:

1. **Mechanical Components**:
    - **Frame/Body**: Provides structure and shape to the robot.
    - **Actuators**: Convert energy into movement. Common actuators include motors (DC, servo, and stepper motors), linear actuators, and pneumatics.
    - **End Effectors**: The device at the end of a robotic arm, designed to interact with the environment. Examples are grippers, tools, or sensors.
    - **Transmission**: Systems like gears, belts, or chains that transfer the movement generated by the actuator to the end effector.
    - **Joints**: Allow relative movement between different parts of the robot. They can be rotary (rotational) or prismatic (linear).
2. **Sensors**:
    - **Position and Velocity Sensors**: Detect changes in position or speed of robot parts.
    - **Proximity and Range Sensors**: Measure the distance between the robot and an object, like ultrasonic or infrared sensors.

- **Vision Systems (Cameras)**: Allow the robot to receive visual information from its surroundings.
- **Inertial Measurement Units (IMUs)**: Measure linear and angular motion.
- **Environmental Sensors**: Such as temperature, humidity, or gas sensors.
- **Tactile Sensors**: Detect touch or pressure.

3. **Control System**:
   - **Microcontroller or Microprocessor**: Acts as the brain of the robot, processing information and sending commands.
   - **Motor Drivers**: Control and drive the motors based on commands from the microcontroller.
   - **Feedback Systems**: Integrate sensors to provide real-time data back to the controller, enabling responsive actions.
   - **Control Algorithms**: Software methods used to achieve desired motions or actions.
4. **Power Supply**:
   - **Batteries**: Commonly used in mobile robots.
   - **Mains Power**: Used for stationary robots or those with high energy demands.
   - **Solar Panels**: Provide power in some outdoor robots.
   - **Fuel Cells**: An emerging energy source for some robotic applications.
5. **Communication System**:
   - **Wired Systems**: Ethernet, USB, etc.
   - **Wireless Systems**: Wi-Fi, Bluetooth, Zigbee, cellular networks, etc.
6. **User Interface**:
   - **Software Interface**: Allows users to program or give commands to the robot.
   - **Physical Interface**: Buttons, joysticks, or touchscreens used to control the robot.
7. **Software and Programming**:
   - **Operating System**: Systems like the Robot Operating System (ROS) provide a platform for robot software development.

- **Middleware**: Facilitates communication and data sharing between different software components.
- **Algorithms**: Dictate the robot's decision-making, planning, and behavior.

8. **Safety Systems**:
    - **Emergency Stop**: Ensures the robot can be immediately deactivated.
    - **Collision Detection**: Prevents the robot from causing harm due to unexpected collisions.

It's worth noting that the specific components of a robot can vary widely based on its intended function and design.

रोबोट कई घटकों से बनी बहुआयामी प्रणालियाँ हैं। इन घटकों को आम तौर पर रोबोट को उसकी सेंसिंग, एक्चुएशन और प्रोसेसिंग क्षमताएं प्रदान करने के लिए डिज़ाइन किया गया है।

1. **यांत्रिक घटक**:
    - **फ़्रेम/बॉडी**: रोबोट को संरचना और आकार प्रदान करता है।
    - **एक्चुएटर्स**: ऊर्जा को गति में परिवर्तित करते हैं। सामान्य एक्चुएटर्स में मोटर (डीसी, सर्वो और स्टेपर मोटर्स), लीनियर एक्चुएटर्स और न्यूमेटिक्स शामिल हैं।
    - **अंत प्रभावकारक**: रोबोटिक भुजा के अंत में स्थित उपकरण, जिसे पर्यावरण के साथ इंटरैक्ट करने के लिए डिज़ाइन किया गया है। उदाहरण ग्रिपर, उपकरण या सेंसर हैं।
    - **ट्रांसमिशन**: गियर, बेल्ट या चेन जैसी प्रणालियाँ जो एक्चुएटर द्वारा उत्पन्न गति को अंतिम प्रभावक तक स्थानांतरित करती हैं।
    - **जोड़.** : रोबोट के विभिन्न हिस्सों के बीच सापेक्ष गति की अनुमति देंदेते हैं वे रोटरी (घूर्णी) या प्रिज्मीय (रैखिक) हो सकते हैं।
2. **सेंसर**:
    - **स्थिति और वेग सेंसर**: रोबोट भागों की स्थिति या गति में परिवर्तन का पता लगाते हैं।
    - **निकटता और रेंज सेंसर**: रोबोट और किसी वस्तु के बीच की दूरी को मापते हैं, जैसे अल्ट्रासोनिक या इन्फ्रारेड सेंसर।
    - **विज़न सिस्टम (कैमरा)**: रोबोट को उसके परिवेश से दृश्य जानकारी प्राप्त करने की अनुमति देंदेते हैं.
    - **जड़त्व माप इकाइयाँ (आईएमयू)**: रैखिक और कोणीय गति को मापते हैं।
    - **पर्यावरण सेंसर**: जैसे तापमान, आर्द्रता, या गैस सेंसर।
    - **स्पर्शीय सेंसर**: स्पर्श या दबाव का पता लगाते हैं।

3. **नियंत्रण प्रणाली**:
    - **माइक्रोकंट्रोलर या माइक्रोप्रोसेसर**: रोबोट के मस्तिष्क के रूप में कार्य करता है, जानकारी संसाधित करता है और कमांड भेजता है।
    - **मोटर ड्राइवर**: माइक्रोकंट्रोलर के आदेशों के आधार पर मोटरों को नियंत्रित करता है ।
    - **फीडबैक सिस्टम**: प्रतिक्रियाशील कार्रवाइयों को सक्षम करते हुए, नियंत्रक को वास्तविक समय डेटा वापस प्रदान करने के लिए सेंसर को एकीकृत करता है।
    - **नियंत्रण एल्गोरिदम**: वांछित गतियों या कार्यों को प्राप्त करने के लिए उपयोग की जाने वाली सॉफ़्टवेयर विधियाँ।
4. **बिजली आपूर्ति**:
    - **बैटरी**: आमतौर पर मोबाइल रोबोट में उपयोग किया जाता है।
    - **मेन पावर**: स्थिर रोबोट या उच्च ऊर्जा मांग वाले रोबोट के लिए उपयोग किया जाता है।
    - **सौर पैनल**: कुछ आउटडोर रोबोटों में बिजली प्रदान करता है ।
    - **ईंधन सेल**: कुछ रोबोटिक अनुप्रयोगों के लिए एक उभरता हुआ ऊर्जा स्रोत।
5. **संचार प्रणाली**:
    - **वायर्ड सिस्टम**: ईथरनेट, यूएसबी, आदि।
    - **वायरलेस सिस्टम**: वाई-फाई, ब्लूटूथ, ज़िग्बी, सेल्युलर नेटवर्क, आदि।
6. **उपयोगकर्ता इंटरफ़ेस**:
    - **सॉफ़्टवेयर इंटरफ़ेस**: उपयोगकर्ताओं को रोबोट को प्रोग्राम करने या कमांड देने की अनुमति देता है।
    - **भौतिक इंटरफ़ेस**: रोबोट को नियंत्रित करने के लिए उपयोग किए जाने वाले बटन, जॉयस्टिक या टचस्क्रीन।
7. **सॉफ्टवेयर और प्रोग्रामिंग**:
    - **ऑपरेटिंग सिस्टम**: रोबोट ऑपरेटिंग सिस्टम (आरओएस) जैसे सिस्टम रोबोट सॉफ्टवेयर विकास के लिए एक मंच प्रदान करते हैं।
    - **मिडलवेयर**: विभिन्न सॉफ्टवेयर घटकों के बीच संचार और डेटा साझा करने की सुविधा प्रदान करता है।
    - **एल्गोरिदम**: रोबोट के निर्णय लेने, योजना बनाने और व्यवहार को निर्देशित करता है।
8. **सुरक्षा प्रणालियाँ**:
    - **आपातकालीन रोक**: सुनिश्चित करता है कि रोबोट को तुरंत निष्क्रिय किया जा सकता है।
    - **टकराव का पता लगाना**: अप्रत्याशित टकराव के कारण रोबोट को नुकसान पहुंचाने से रोकता है।

यह ध्यान देने योग्य है कि रोबोट के विशिष्ट घटक उसके इच्छित कार्य और डिज़ाइन के आधार पर व्यापक रूप से भिन्न हो सकते हैं।

Types of robots

Robots can be classified in various ways, depending on their application, design, locomotion, or function.

1. **Industrial Robots**:
    - **Articulated Robots**: These are like mechanical arms with joints that allow them to move and reach in different directions.
    - **Cartesian Robots**: These robots move in straight lines along tracks that go up and down, left and right, forward and backward.
    - **SCARA Robots**: Used for putting things together with precision, like in a factory assembling small parts.
2. **Service Robots**:
    - **Professional Service Robots**: These do specific jobs such as helping in surgeries, farming, or even fighting fires.
    - **Personal Service Robots**: These are for use around the house or for fun, like robots that clean floors or mow the lawn.
3. **Medical Robots**:
    - **Surgical Robots**: These assist doctors during operations, offering precision.
    - **Rehabilitation Robots**: Help people recover their movement after injuries.
4. **Mobile Robots**:
    - **Wheeled Robots**: They roll on wheels and are quite stable and easy to control.
    - **Tracked Robots**: Have tracks like tanks and can move over rough or slippery surfaces.
    - **Legged Robots**: Can have two or more legs, and some can even jump or climb.
    - **Swarm Robots**: Tiny robots that work together in big groups to do tasks.
5. **Autonomous Vehicles**:

- **Ground Vehicles**: These robots move goods around places like factories without needing a human driver.
- **Drones**: Fly in the air for watching over places, taking photos, or carrying things.
- **Underwater Robots**: Explore or work in the ocean.

6. **Collaborative Robots (Cobots)**: These robots are safe to be around and can work right next to people.
7. **Exoskeletons**: Special suits that people can wear to make them stronger or help them heal.
8. **Social Robots**: These are made to hang out with humans, like robots that can talk or pet robots.
9. **Nano Robots**: Super tiny robots that can do tasks, especially in medicine, at a very small scale.
10. **Soft Robots**: These are made of bendy materials and are designed to be gentle and safe around people.
11. **Space Robots**: These are used for exploring space and can be rovers on other planets or robotic arms in space stations.
12. **Educational Robots**: These are used to learn about robots and technology, like building and programming a LEGO robot.

1. **औद्योगिक रोबोट**:
   - **आर्टिकुलेटेड रोबोट**: ये जोड़ों वाले यांत्रिक आर्म्स की तरह हैं जो उन्हें अलग-अलग दिशाओं में चलने और पहुंचने की अनुमति देते हैं।
   - **कार्टेशियन रोबोट**: ये रोबोट पटरियों पर सीधी रेखाओं में चलते हैं जो ऊपर और नीचे, बाएँ और दाएँ, आगे और पीछे जाते हैं।
   - **SCARA रोबोट**: चीजों को परिशुद्धता के साथ एक साथ रखने के लिए उपयोग किया जाता है, जैसे किसी कारखाने में छोटे भागों को जोड़ना।
2. **सेवा रोबोट**:
   - **पेशेवर सेवा रोबोट**: ये विशिष्ट कार्य करते हैं जैसे खनन, खेती, या यहां तक कि आग से लड़ने में मदद करना।
   - **व्यक्तिगत सेवा रोबोट**: ये घर के आसपास या मनोरंजन के लिए उपयोग के लिए हैं, जैसे रोबोट जो फर्श साफ करते हैं या लॉन में घास काटते हैं।

3. **मेडिकल रोबोट**:
    - **सर्जिकल रोबोट**: ये ऑपरेशन के दौरान डॉक्टरों की सहायता करते हैं, सटीकता प्रदान करते हैं।
    - **पुनर्वास रोबोट**: चोटों के बाद लोगों को उनकी गतिविधि ठीक करने में मदद करते हैं।
4. **मोबाइल रोबोट**:
    - **पहिए वाले रोबोट**: वे पहियों पर चलते हैं और काफी स्थिर और नियंत्रित करने में आसान होते हैं।
    - **ट्रैक किए गए रोबोट**: इनमें टैंक जैसे ट्रैक होते हैं और ये उबड़-खाबड़ या फिसलन वाली सतहों पर चल सकते हैं।
    - **पैर वाले रोबोट**: दो या दो से अधिक पैर हो सकते हैं, और कुछ कूद या चढ़ भी सकते हैं।
    - **झुंड रोबोट**: छोटे रोबोट जो बड़े समूहों में एक साथ काम करते हैं।
5. **स्वायत्त वाहन**:
    - **ग्राउंड वाहन**: ये रोबोट मानव चालक की आवश्यकता के बिना कारखानों जैसी जगहों पर सामान ले जाते हैं।
    - **ड्रोन**: स्थानों पर नज़र रखने, फ़ोटो लेने या चीज़ें ले जाने के लिए हवा में उड़ते हैं ।
    - **अंडरवॉटर रोबोट**: समुद्र में खोजबीन करें या काम ।
6. **सहयोगी रोबोट (कोबोट्स)**: ये रोबोट मनुष्यों के आसपास रहने के लिए सुरक्षित हैं और लोगों साथ काम कर सकते हैं।
7. **एक्सोस्केलेटन**: विशेष सूट जिन्हें लोग मजबूत बनाने या ठीक होने में मदद करने के लिए पहन सकते हैं।
8. **सोशल रोबोट**: इन्हें इंसानों के साथ घूमने के लिए बनाया जाता है, जैसे बात करने वाले रोबोट या पालतू रोबोट।
9. **नैनो रोबोट**: बहुत छोटे रोबोट जो विशेष रूप से चिकित्सा में, बहुत छोटे पैमाने पर कार्य कर सकते हैं।
10. **सॉफ्ट रोबोट**: ये लचीले पदार्थों से बने होते हैं और लोगों के आसपास सौम्य और सुरक्षित रहने के लिए डिज़ाइन किए गए हैं।
11. **अंतरिक्ष रोबोट**: इनका उपयोग अंतरिक्ष की खोज के लिए किया जाता है और ये अन्य ग्रहों पर रोवर या अंतरिक्ष स्टेशनों में रोबोटिक आर्म्स (भुजा) हो सकते हैं।
12. **शैक्षिक रोबोट**: इनका उपयोग रोबोट और प्रौद्योगिकी के बारे में सीखने के लिए किया जाता है, जैसे लेगो रोबोट का निर्माण और प्रोग्रामिंग।

Benefits

Robots offer a wide range of benefits across various sectors. Here are some of the major benefits of robots:

1. **Increased Productivity**:

- Robots can operate continuously without breaks, vacations, or shifts, leading to higher output.
- They can achieve faster cycle times compared to human workers in many tasks.

2. **Cost Savings**:
   - Over the long term, robots can reduce labor costs, especially in repetitive and high-volume production scenarios.
   - Decrease in waste due to higher precision.
3. **Improved Quality**:
   - Robots offer consistent and precise operations, leading to fewer errors and higher product quality.
   - They can maintain exact specifications and tolerances, ensuring product uniformity.
4. **Enhanced Safety**:
   - Robots can handle hazardous tasks, reducing human exposure to dangerous situations.
   - They can operate in environments unsuitable for humans, such as extreme temperatures or toxic atmospheres.
5. **Flexibility**:
   - Robots can be reprogrammed to perform different tasks, offering adaptability to changing production needs.
6. **Labor Shortage Alleviation**:
   - Robots can fill jobs where there's a shortage of skilled workers.
   - They can perform mundane and repetitive tasks, allowing human workers to focus on more value-added activities.
7. **Accessibility and Exploration**:
   - Robots can access environments that are inaccessible to humans, such as deep underwater, space, or disaster-stricken areas.
   - They have been instrumental in space exploration, deep-sea investigations, and studying inaccessible terrains.
8. **Scalability**:

- Robots can be replicated and scaled more easily than human labor, especially for growing production demands.

9. **Operational Reliability**:
    - Robots are less prone to fatigue, leading to consistent performance and fewer mistakes over extended periods.
10. **Reduction in Lead Time**:

- Automated processes can streamline operations, reducing production and delivery times.

11. **Customization**:

- With advances in AI and machine learning, robots can cater to individual customer specifications, facilitating mass customization.

12. **Global Competitiveness**:

- For businesses, automation and robotics can enhance global competitiveness by reducing production costs and improving product quality.

13. **Medical and Healthcare Improvements**:

- Surgical robots can assist surgeons in performing delicate and complex operations with precision.
- Robots can facilitate rehabilitation and provide care, especially for the elderly.

14. **Environmental Benefits**:

- Robots can be employed in recycling and waste management, promoting environmental sustainability.
- Precision agriculture robots can optimize the use of resources, reducing waste and environmental impact.

रोबोट विभिन्न क्षेत्रों में व्यापक लाभ प्रदान करते हैं। यहां रोबोट के कुछ प्रमुख लाभ दिए गए हैं:

1. **उत्पादकता में वृद्धि**:
    - रोबोट बिना ब्रेक, छुट्टियों या शिफ्ट के लगातार काम कर सकते हैं, जिससे उच्च आउटपुट मिलता है।
    - वे कई कार्यों में मानव श्रमिकों की तुलना में तेज़ चक्र समय प्राप्त कर सकते हैं।
2. **लागत बचत**:

- लंबी अवधि में, रोबोट श्रम लागत को कम कर सकते हैं, विशेष रूप से दोहराव वाले और उच्च मात्रा वाले उत्पादन परिदृश्यों में।
- उच्च परिशुद्धता के कारण अपशिष्ट में कमी।

3. **बेहतर गुणवत्ता**:
   - रोबोट सुसंगत और सटीक संचालन प्रदान करते हैं, जिससे त्रुटियां कम होती हैं और उत्पाद की गुणवत्ता बेहतर होती है।
   - वे उत्पाद की एकरूपता सुनिश्चित करते हुए सटीक विशिष्टताओं और सहनशीलता को बनाए रख सकते हैं।
4. **उन्नत सुरक्षा**:
   - रोबोट खतरनाक कार्यों को संभाल सकते हैं, जिससे खतरनाक स्थितियों में मानव जोखिम कम हो सकता है।
   - वे मनुष्यों के लिए अनुपयुक्त वातावरण में काम कर सकते हैं, जैसे अत्यधिक तापमान या विषाक्त वातावरण।
5. **लचीलापन**:
   - रोबोटों को विभिन्न कार्यों को करने के लिए पुन: प्रोग्राम किया जा सकता है, जो बदलती उत्पादन आवश्यकताओं के लिए अनुकूलन क्षमता प्रदान करते हैं।
6. **श्रम की कमी निवारण**:
   - रोबोट उन नौकरियों को भर सकते हैं जहां कुशल श्रमिकों की कमी है।
   - वे दोहराव वाले कार्य कर सकते हैं, जिससे मानव श्रमिकों को अधिक मूल्यवर्धित गतिविधियों पर ध्यान केंद्रित करने की अनुमति मिलती है।
7. **पहुंच-योग्यता और अन्वेषण**:
   - रोबोट उन वातावरणों तक पहुंच सकते हैं जो मनुष्यों के लिए दुर्गम हैं, जैसे गहरे पानी के नीचे, अंतरिक्ष, या आपदाग्रस्त क्षेत्र।
   - वे अंतरिक्ष अन्वेषण, गहरे समुद्र की जांच और दुर्गम इलाकों का अध्ययन करने में सहायक रहे हैं।
8. **स्केलेबिलिटी**:
   - रोबोट को मानव श्रम की तुलना में अधिक आसानी से दोहराया और स्केल किया जा सकता है, खासकर बढ़ती उत्पादन मांगों के लिए।
9. **परिचालन विश्वसनीयता**:
   - रोबोटों में थकान की संभावना कम होती है, जिससे लगातार प्रदर्शन होता है और लंबे समय तक गलतियाँ कम होती हैं।

10. **लीड टाइम में कमी**:
    - स्वचालित प्रक्रियाएं परिचालन को सुव्यवस्थित कर सकती हैं, उत्पादन और वितरण समय को कम कर सकती हैं।
11. **अनुकूलन**:
    - एआई और मशीन लर्निंग में प्रगति के साथ, रोबोट व्यक्तिगत ग्राहक विशिष्टताओं को पूरा कर सकते हैं, जिससे बड़े पैमाने पर अनुकूलन की सुविधा मिल सकती है।
12. **वैश्विक प्रतिस्पर्धा**:
    - व्यवसायों के लिए, स्वचालन और रोबोटिक्स उत्पादन लागत को कम करके और उत्पाद की गुणवत्ता में सुधार करके वैश्विक प्रतिस्पर्धात्मकता को बढ़ा सकते हैं।
13. **चिकित्सा और स्वास्थ्य देखभाल में सुधार**:
    - सर्जिकल रोबोट नाजुक और जटिल ऑपरेशनों को सटीकता के साथ करने में सर्जनों की सहायता कर सकते हैं।
    - रोबोट पुनर्वास की सुविधा प्रदान कर सकते हैं और देखभाल प्रदान कर सकते हैं, खासकर बुजुर्गों के लिए।
14. **पर्यावरणीय लाभ**:
    - रोबोटों को पर्यावरणीय स्थिरता को बढ़ावा देने, रीसाइक्लिंग और अपशिष्ट प्रबंधन में नियोजित किया जा सकता है।
    - सटीक कृषि रोबोट अपशिष्ट और पर्यावरणीय प्रभाव को कम करके संसाधनों के उपयोग को अनुकूलित कर सकते हैं।

Major areas where the robots are already applied

Robots have been applied in a variety of sectors due to their versatility, efficiency, and capability to operate in challenging environments. The following are major areas where robots are currently applied, along with specific examples:

- **Manufacturing**:
    - **Automobile Production**: Robots assist in tasks like welding, painting, and assembly. For example, robotic arms in Tesla factories.
    - **Electronics Manufacturing**: Robots place and solder components on circuit boards.
- **Healthcare**:
    - **Surgery**: The da Vinci Surgical System allows surgeons to perform minimally invasive procedures with robotic assistance.

    - **Rehabilitation**: Robots like the Lokomat aid patients in physical therapy by helping them relearn walking motions.
    - **Telepresence**: Robots like the InTouch Health's RP-VITA enable physicians to interact with patients remotely.
- **Agriculture**:
    - **Harvesting**: Robots like Ripe Robotics' fruit-picking robot can identify ripe fruits and pick them.
    - **Weed Control**: Robots like Blue River Technology's "See & Spray" can identify and precisely spray weeds, reducing herbicide use.
- **Retail**:
    - **Inventory Management**: Robots like Tally from Simbe Robotics autonomously scan shelves and take inventory.
    - **Delivery**: Starship Technologies has robots that deliver food and parcels in urban settings.
- **Logistics & Warehousing**:
    - **Material Handling**: Amazon uses Kiva robots to transport shelves and items within their fulfillment centers.
    - **Sorting**: Robots sort parcels in facilities like FedEx or DHL.
- **Domestic Use**:
    - **Cleaning**: iRobot's Roomba vacuums floors autonomously.
    - **Lawn Care**: Robots like the Husqvarna Automower can mow lawns without human intervention.
- **Military and Defense**:
    - **Surveillance**: Drones like the MQ-9 Reaper provide aerial reconnaissance.
    - **Bomb Disposal**: Robots like the iRobot PackBot can safely disarm explosives.
- **Space Exploration**:
    - **Planetary Exploration**: NASA's Perseverance rover explores Mars, conducting scientific experiments and taking samples.
    - **Maintenance & Repair**: Robotic arms on the International Space Station, like Canadarm2, assist in various tasks.

- **Entertainment**:
  - **Theme Park Attractions**: Disney has developed animatronics and robots for use in their parks.
  - **Filmmaking**: Robots can create complex and precise camera movements for specific shots.
- **Education**:
  - **Teaching Tools**: Robots like LEGO Mindstorms and Sphero provide hands-on learning experiences in coding and robotics.
  - **Research**: Universities use robots like the NAO humanoid for research in robotics and AI.
- **Construction**:
  - **Bricklaying**: SAM (Semi-Automated Mason) can lay bricks alongside human masons.
  - **3D Printing**: Robots are used in large-scale 3D printing projects to construct architectural structures.
- **Mining & Drilling**:
  - **Exploration**: Robots can explore and map underground mines, improving safety and efficiency.
  - **Deep-sea Drilling**: Autonomous robots can drill in deep-sea environments for oil and gas extraction.
- **Transportation**:
  - **Autonomous Vehicles**: Companies like Waymo and Tesla are pioneering self-driving vehicle technology.
  - **Delivery Drones**: Companies like Wing (an offshoot of Google's parent company, Alphabet) are exploring drone deliveries.
- **Emergency Response**:
  - **Disaster Response**: Robots like the Boston Dynamics' Spot can be deployed in disaster-stricken areas for search and rescue.
  - **Firefighting**: Robots can assist in situations too dangerous for human firefighters.
- **Research & Development**:

- **Testing & Experimentation**: Robots can perform repetitive tasks in labs, such as pipetting or sample processing.

रोबोटों को उनकी बहुमुखी क्षमता, दक्षता और चुनौतीपूर्ण वातावरण में काम करने की क्षमता के कारण विभिन्न क्षेत्रों में इस्तेमाल किया गया है। विशिष्ट उदाहरणों के साथ निम्नलिखित प्रमुख क्षेत्र हैं जहां रोबोट वर्तमान में कार्यरत हैं:

- **उत्पादन**:
  - **ऑटोमोबाइल उत्पादन**: रोबोट वेल्डिंग, पेंटिंग और असेंबली जैसे कार्यों में सहायता करते हैं। उदाहरण के लिए, टेस्ला कारखानों में रोबोटिक भुजा।
  - **इलेक्ट्रॉनिक्स विनिर्माण**: रोबोट सर्किट बोर्डों पर घटकों को रखते हैं और जोड़ते हैं।
- **स्वास्थ्य देखभाल**:
  - **सर्जरी**: दा विंची सर्जिकल सिस्टम सर्जनों को रोबोटिक सहायता से न्यूनतम इनवेसिव प्रक्रियाएं करने की अनुमति देता है।
  - **पुनर्वास**: लोकोमैट जैसे रोबोट मरीजों को फिर से चलने की गति सीखने में मदद करके फ़िज़ियोथ्रेपी चिकित्सा में सहायता करते हैं।
  - **टेलीप्रेजेंस**: इनटच हेल्थ के आरपी-वीटा जैसे रोबोट चिकित्सकों को दूर से मरीजों के साथ बातचीत करने में सक्षम बनाते हैं।
- **कृषि**:
  - **कटाई**: पके फल चुनने वाले रोबोट पके फलों की पहचान कर सकते हैं और उन्हें तोड़ सकते हैं।
  - **खरपतवार नियंत्रण**: ब्लू रिवर टेक्नोलॉजी के "सी एंड स्प्रे" जैसे रोबोट खरपतवारों की पहचान कर सकते हैं और उनका सटीक छिड़काव कर सकते हैं, जिससे शाकनाशी का उपयोग कम हो जाता है।
- **खुदरा**:
  - **इन्वेंटरी प्रबंधन**: सिम्बे रोबोटिक्स के टैली जैसे रोबोट स्वायत्त रूप से अलमारियों को स्कैन करते हैं और इन्वेंट्री लेते हैं।
  - **डिलीवरी**: स्टारशिप टेक्नोलॉजीज के पास रोबोट हैं जो शहरी इलाकों में भोजन और पार्सल पहुंचाते हैं।
- **रसद एवं भण्डारण**:
  - **सामग्री प्रबंधन**: अमेज़ॅन अपने पूर्ति केंद्रों के भीतर अलमारियों और वस्तुओं के परिवहन के लिए किवा रोबोट का उपयोग करता है।
  - **सॉर्टिंग**: रोबोट FedEx या DHL जैसी सुविधाओं में पार्सल सॉर्ट करते हैं।

- **घरेलू उपयोग**:
  - **सफाई**: iRobot का रूंबा फर्श को स्वायत्त रूप से वैक्यूम करता है।
  - **लॉन की देखभाल**: हुस्कवर्ना ऑटोमोवर जैसे रोबोट मानवीय हस्तक्षेप के बिना लॉन की घास काट सकते हैं।
- **सैन्य और रक्षा**:
  - **निगरानी**: एमक्यू-9 रीपर जैसे ड्रोन हवाई टोही प्रदान करते हैं।
  - **बम डिस्पोजल**: आईरोबोट पैकबॉट जैसे रोबोट विस्फोटकों को सुरक्षित रूप से निष्क्रिय कर सकते हैं।
- **अंतरिक्ष की खोज**:
  - **ग्रहीय अन्वेषण**: नासा का perseverance रोवर मंगल ग्रह पर वैज्ञानिक प्रयोग करता है और नमूने लेता है।
  - **रखरखाव और मरम्मत**: अंतर्राष्ट्रीय अंतरिक्ष स्टेशन पर कनाडार्म2 जैसे रोबोटिक भुजा विभिन्न कार्यों में सहायता करते हैं।
- **मनोरंजन**:
  - **थीम पार्क आकर्षण**: डिज़्नी ने अपने पार्कों में उपयोग के लिए एनिमेट्रॉनिक्स और रोबोट विकसित किए हैं।
  - **फिल्म निर्माण**: रोबोट विशिष्ट शॉट्स के लिए जटिल और सटीक कैमरा मूवमेंट बना सकते हैं।
- **शिक्षा**:
  - **शिक्षण उपकरण**: लेगो माइंडस्टॉर्म और स्फेरो जैसे रोबोट कोडिंग और रोबोटिक्स में व्यावहारिक सीखने का अनुभव प्रदान करते हैं।
  - **अनुसंधान**: विश्वविद्यालय रोबोटिक्स और एआई में अनुसंधान के लिए एनएओ ह्यूमनॉइड जैसे रोबोट का उपयोग करते हैं।
- **निर्माण**:
  - **ईंटें बिछाना**: एसएएम (अर्ध-स्वचालित मेसन) मानव राजमिस्त्रियों के साथ-साथ ईंटें बिछा सकता है।
  - **3डी प्रिंटिंग**: वास्तुशिल्प संरचनाओं के निर्माण के लिए बड़े पैमाने पर 3डी प्रिंटिंग परियोजनाओं में रोबोट का उपयोग किया जाता है।
- **खनन एवं ड्रिलिंग**:
  - **अन्वेषण**: रोबोट भूमिगत खदानों का पता लगा सकते हैं और उनका मानचित्रण कर सकते हैं, जिससे सुरक्षा और दक्षता में सुधार होगा।

    - **गहरे समुद्र में ड्रिलिंग**: स्वायत्त रोबोट तेल और गैस निष्कर्षण के लिए गहरे समुद्र के वातावरण में ड्रिल कर सकते हैं।
- **परिवहन**:
    - **स्वायत्त वाहन**: वेमो और टेस्ला जैसी कंपनियां सेल्फ-ड्राइविंग वाहन तकनीक में अग्रणी हैं।
    - **डिलीवरी ड्रोन**: विंग (Google की मूल कंपनी, अल्फाबेट की एक शाखा) जैसी कंपनियां ड्रोन डिलीवरी की खोज कर रही हैं।
- **आपातकालीन प्रतिक्रिया**:
    - **आपदा प्रतिक्रिया**: बोस्टन डायनेमिक्स स्पॉट जैसे रोबोटों को खोज और बचाव के लिए आपदाग्रस्त क्षेत्रों में तैनात किया जा सकता है।
    - **अग्निशमन**: रोबोट मानव अग्निशामकों के लिए बहुत खतरनाक स्थितियों में सहायता कर सकते हैं।
- **अनुसंधान एवं विकास**:
    - **परीक्षण और प्रयोग**: रोबोट प्रयोगशालाओं में पिपेटिंग या नमूना प्रसंस्करण जैसे दोहराए जाने वाले कार्य कर सकते हैं।

Issue associated with robots

The rise of robotics has brought numerous benefits to various sectors; however, the integration of robots into human society and industries also presents several significant challenges and concerns.

1. **Job Displacement and Economic Impact**:
    - As robots take over repetitive, manual, and even some complex tasks, there's concern about human job displacement. While some industries benefit from the increased efficiency robots bring, many workers face job losses. This displacement can lead to increased unemployment rates, especially if retraining opportunities are not provided.
    - The economic impact is two-fold: businesses may see increased profits due to reduced labor costs, but there might also be a decrease in consumer purchasing power if large portions of the population are unemployed.
2. **Safety Concerns**:
    - **Physical Safety**: Robots in workplaces or public spaces might cause accidents if they malfunction or if there's an unpredicted interaction with humans. This is especially a concern with heavy industrial robots or fast-moving autonomous vehicles.

- **Data Safety**: As robots often rely on vast amounts of data to operate, there's potential for data breaches or misuse, particularly if personal or sensitive information is involved.

3. **Ethical and Moral Dilemmas**:
    - **Decision-making**: For instance, autonomous vehicles might have to make split-second decisions in emergencies that could have moral implications (e.g., the trolley problem where the vehicle must decide between harming its passengers or pedestrians).
    - **Social Interaction**: Robots designed to mimic human behaviors, especially in caregiving or companionship roles, raise concerns about authentic human interaction and relationships.
    - **Privacy**: Robots equipped with cameras or sensors in public or private spaces could infringe on people's privacy.
4. **Dependency and Security Vulnerabilities**:
    - As societies become more reliant on robots, there's a risk of over-dependency, where essential skills could be lost over time (e.g., if automated systems fail and there's a lack of skilled human operators).
    - Robots, especially those connected to the internet or other networks, are susceptible to hacking. A compromised robot could pose physical dangers or lead to data theft.
5. **Regulation and Legal Challenges**:
    - **Liability**: If a robot causes harm or damage, determining liability can be complex. Is it the manufacturer's fault, the software developer's, the operator's, or a combination?
    - **Standards**: Establishing safety and operation standards across different regions or countries can be challenging.
    - **Rights and Recognition**: As AI and robotics advance, questions arise about whether highly sophisticated robots should have rights or legal recognition, especially if they display traits of consciousness or self-awareness.

Addressing these issues requires collaboration between technologists, policymakers, ethicists, and other stakeholders to ensure that the development and deployment of robots are both beneficial and responsible.

रोबोटिक्स के उदय से विभिन्न क्षेत्रों को अनेक लाभ हुए हैं; हालाँकि, मानव समाज और उद्योगों में रोबोट का एकीकरण कई महत्वपूर्ण चुनौतियाँ और चिंताएँ भी प्रस्तुत करता है।

1. **नौकरी में विस्थापन और आर्थिक प्रभाव**:
    - चूंकि रोबोट दोहराए जाने वाले, मैन्युअल और यहां तक कि कुछ जटिल कार्यों को भी संभाल लेते हैं, इसलिए मानव नौकरी विस्थापन के बारे में चिंता है। जहां कुछ उद्योगों को रोबोट द्वारा लाई गई बढ़ी हुई दक्षता से लाभ होता है, वहीं कई श्रमिकों को नौकरी छूटने का सामना करना पड़ता है। इस विस्थापन से बेरोजगारी दर में वृद्धि हो सकती है, खासकर यदि पुनर्प्रशिक्षण के अवसर प्रदान नहीं किए जाते हैं।
    - आर्थिक प्रभाव दो गुना है: व्यवसायों को श्रम लागत कम होने के कारण मुनाफा बढ़ सकता है, लेकिन अगर आबादी का बड़ा हिस्सा बेरोजगार है तो उपभोक्ता क्रय शक्ति में भी कमी हो सकती है।
2. **सुरक्षा संबंधी चिंताएं**:
    - **शारीरिक सुरक्षा**: कार्यस्थलों या सार्वजनिक स्थानों पर रोबोट खराब होने या मनुष्यों के साथ अप्रत्याशित टकराव होने पर दुर्घटना का कारण बन सकते हैं। यह विशेष रूप से भारी औद्योगिक रोबोटों या तेज़ गति से चलने वाले स्वायत्त वाहनों के लिए चिंता का विषय है।
    - **डेटा सुरक्षा**: चूंकि रोबोट अक्सर काम करने के लिए बड़ी मात्रा में डेटा पर निर्भर होते हैं, इसलिए डेटा के उल्लंघन या दुरुपयोग की संभावना होती है, खासकर अगर व्यक्तिगत या संवेदनशील जानकारी शामिल हो।
3. **नैतिक और नैतिक दुविधाएं**:
    - **निर्णय लेना**: उदाहरण के लिए, स्वायत्त वाहनों को आपात स्थिति में बिना सोचे-समझे निर्णय लेना पड़ सकता है, जिसका नैतिक प्रभाव हो सकता है
    - **सामाजिक संपर्क**: मानव व्यवहार की नकल करने के लिए डिज़ाइन किए गए रोबोट, विशेष रूप से देखभाल या साथी भूमिकाओं में, प्रामाणिक मानव संपर्क और रिश्तों के बारे में चिंताएं बढ़ाते हैं।
    - **गोपनीयता**: सार्वजनिक या निजी स्थानों पर कैमरे या सेंसर से लैस रोबोट लोगों की गोपनीयता का उल्लंघन कर सकते हैं।
4. **निर्भरता और सुरक्षा कमजोरियां**:
    - जैसे-जैसे समाज रोबोटों पर अधिक निर्भर हो जाता है, अति-निर्भरता का खतरा होता है, जहां समय के साथ आवश्यक कौशल खो सकते हैं (उदाहरण के लिए, यदि स्वचालित सिस्टम विफल हो जाते हैं और कुशल मानव ऑपरेटरों की कमी होती है)।
    - रोबोट, विशेष रूप से इंटरनेट या अन्य नेटवर्क से जुड़े रोबोट, हैकिंग के प्रति संवेदनशील होते हैं। एक हैक किया गया रोबोट खतरे पैदा कर सकता है या डेटा चोरी का कारण बन सकता है।
5. **विनियमन और कानूनी चुनौतियाँ**:

- **दायित्व**: यदि कोई रोबोट नुकसान या नुकसान पहुंचाता है, तो दायित्व का निर्धारण करना जटिल हो सकता है। क्या यह निर्माता की गलती है, सॉफ़्टवेयर डेवलपर की, ऑपरेटर की, या किसी संयोजक की?
- **मानक**: विभिन्न क्षेत्रों या देशों में सुरक्षा और संचालन मानक स्थापित करना चुनौतीपूर्ण हो सकता है।
- **अधिकार और मान्यता**: जैसे-जैसे एआई और रोबोटिक्स आगे बढ़ रहे हैं, सवाल उठते हैं कि क्या अत्यधिक परिष्कृत रोबोटों के पास अधिकार या कानूनी मान्यता होनी चाहिए, खासकर यदि वे चेतना या आत्म-जागरूकता के लक्षण प्रदर्शित करते हैं।

इन मुद्दों को संबोधित करने के लिए प्रौद्योगिकीविदों, नीति निर्माताओं, नैतिकतावादियों और अन्य हितधारकों के बीच सहयोग की आवश्यकता है ताकि यह सुनिश्चित किया जा सके कि रोबोट का विकास और तैनाती फायदेमंद और जिम्मेदार दोनों हो।

1. Basic Concepts

1.1. Nanotechnology

- Nanotechnology is the engineering of functional systems on an atomic or molecular scale.
- It refers to the technology of rearranging and processing of atoms and molecules to **fabricate materials at nanoscale.**
- Nanotechnology encompasses nanoscale science, engineering, and technology in fields such as chemistry, biology, physics, and materials science engineering.
- The technology enables manipulation of matter at the molecular level, creation of new structures with fundamentally new molecular organization and exploitation of the noble property at nanoscale.

1.2. Nanoscale

- Nanoscale deals with dimensions between approximately **1 and 100 nanometers.**
- Larger than that is the micro-scale, and smaller than that is the atomic scale.
- At the nanoscale, objects are so small that they cannot be seen even with a light microscope. Nano-scientists use tools like **scanning tunneling microscopes** or atomic force microscopes to observe anything at the nanoscale.

1.3. Nanomaterials

- Nanomaterials can be defined as materials possessing **at least one external dimension that measures 100 nanometres or less** or with internal structures measuring 100 nm or less.
- They may be in the form of particles, tubes, rods or fibres.
- Nanomaterials can occur naturally, be produced purposefully through engineering or be created as the by-products of combustion reactions to perform a specialized function.

1.4. Nanoscience

- Nanoscience is the **study of structures and molecules that range between 1 and 100 nm** on the scales of nanometers.
- The technology that utilizes nanoscience in practical applications is called nanotechnology.

1.5. Nanoengineering

- Nanoengineering is the field of engineering that focuses on the study, development and refinement of materials at a very small scale.
- In short, it is the practice of engineering on the nanoscale and can be thought of as the practical application of nanoscience.

History of Nanotechnology

- The American physicist and Nobel Prize laureate **Richard Feynman** introduced the concept of nanotechnology in 1959.
    - Feynman presented a lecture entitled **“There’s Plenty of Room at the Bottom”** at the annual meeting of the American Physical Society at the California Institute of Technology (Caltech).

- The term "nanotechnology" was defined by Tokyo Science University Professor Norio Taniguchi in 1974 as follows: "'Nano-technology' mainly consists of the processing of, separation, consolidation, and deformation of materials by one atom or by one molecule."
- The technological significance of nano-scale was promoted by Dr. K. Erik Drexler in his book “Engines of Creation: The Coming Era of Nanotechnology” (1986).

2. Nanoscale

2.1. Factors that Govern the Behaviour of Nanoscale

Materials reduced to the nanoscale can show different properties compared to what they exhibit on a macro-scale, enabling unique applications of those materials in various unconventional ways. For instance:

- Opaque substances like copper become transparent.
- Inert materials like platinum and gold become catalysts.
- Stable materials like aluminum turn combustible.
- Solids like gold turn into liquids at room temperature.
- Insulators such as silicon become conductors.

The erratic behaviour of substances at the nanoscale is governed by two factors:

- **Quantum Mechanics:** When a substance is reduced to nanoscale it starts following the rules of quantum mechanics which are very different from classical physics, as a result the behaviour of substances at the nanoscale starts showing different and unique properties.
- **Surface to Volume Ratio:** At nanoscale the surface to volume ratio of a substance increases quite high resulting in different properties of the same material than usual. Melting points of materials can also change due to an increase in surface area at nanoscale.

2.2. Top-down and Bottom-up Approaches

Basically there are two ways of making nanoscale objects: top-down and bottom-up approaches.

Top-down Approach

- The top-down approach to nanotechnology involves the **creation of nano-objects from a parent entity** that is larger.
- This type of fabrication **uses lithographic patterning techniques** by which a bulk material is reduced in size to a nanoscale pattern.
- It is expensive and time-consuming for mass production but very suitable for laboratory experimentation.

Bottom-up Approach

- It is a comparatively newer approach where nanostructures can be constructed by **assembly of atoms and molecules.** These techniques include chemical synthesis, self-assembly and positional assembly.
- This approach will be able to produce devices in parallel and much cheaper than top-down methods, but could potentially be overwhelmed as the size and complexity of the desired assembly increases.

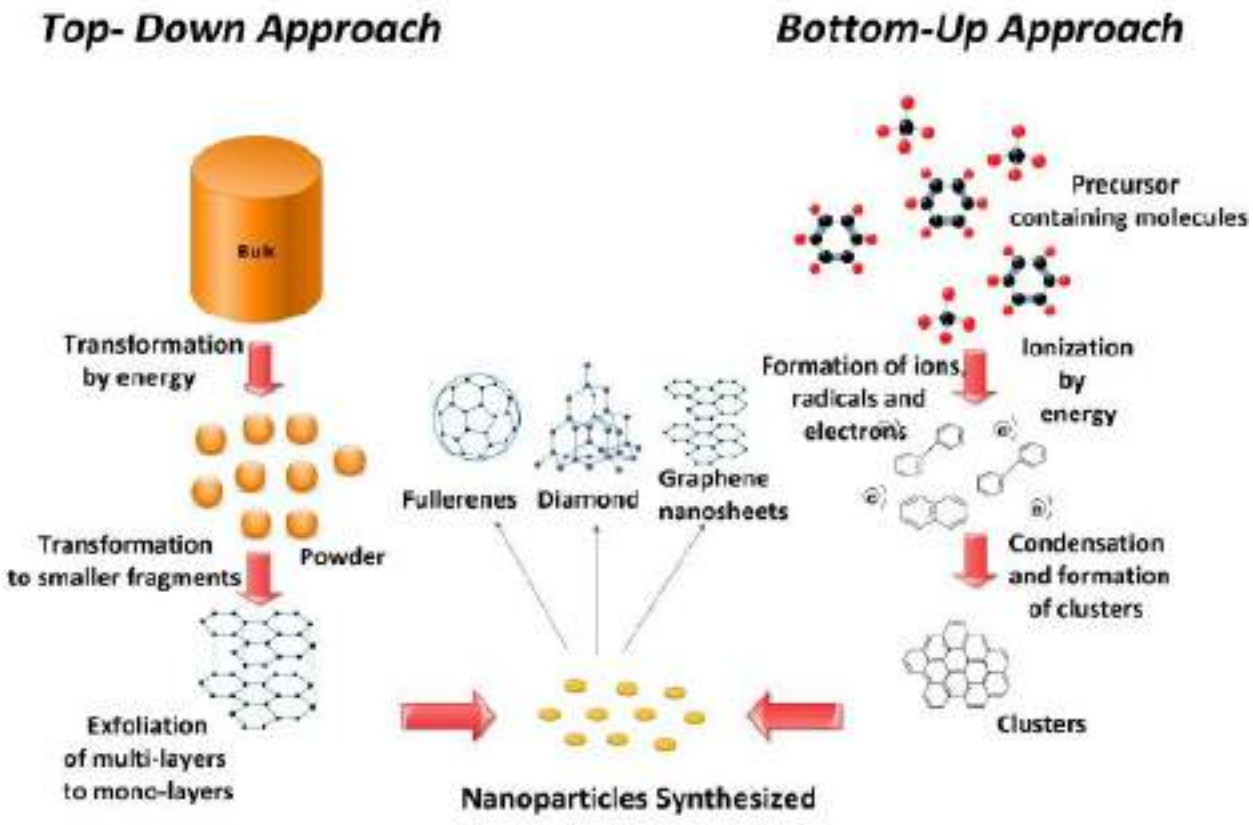


Figure.1. Top-down and bottom-up approaches in synthesis of carbon-based nanomaterials

3. Nanomaterials

3.1. Characterization of Nanomaterials

Physical Characterization Includes

- Shape, size, specific surface area, and ratio of width and height.
- Whether they stick together.
- Number size distribution and structure, including crystal structure and any crystal defects.
- How smooth or bumpy their surface is and how well they dissolve.

Chemical Characterization Includes

- Molecular structure, composition (purity, and impurity or additive) and surface chemistry.
- Whether it is held in a solid, liquid or gas, and attraction to water molecules or oils and fats.

3.2. Properties of Nanomaterials

Properties	Details
Mechanical	Nanomaterials show different mechanical properties due to the

	increased number of surface atoms and interfaces. This includes increased strength, toughness, hardness, ductility and decreased elasticity.
Thermal	Increasing the number of grain boundaries enhances phonon scattering at the disordered boundaries and results in lower thermal conductivity. Thus, nanomaterials have lower thermal conductivity compared to conventional materials.
Electrical	Nanomaterials have lower electrical conductivities than bulk materials. They have a high density of grain boundaries, which makes electric-phonon and phonon-phonon scattering effective and reduces conductivity.
Magnetic	Materials with nanostructures have higher saturation magnetization and magnetic coercivity values. Nanoparticles become magnetic in the presence of an external magnet, but revert to a nonmagnetic state when the external magnet is removed.
Melting Point	Melting-point depression phenomenon is very prominent in nanomaterials. They melt at temperatures lower than bulk materials.
Optical	Nanomaterials exhibit distinctive optical characteristics such as absorption, transmission, reflection, greater scattering, and light emission. The shape and size of nanoparticles can be altered to change their optical properties.

3.3. Types of Nanomaterials

- **Inorganic-based nanomaterials:** Include different metal and metal oxide nanomaterials.
    - **Examples of metal-based inorganic nanomaterials:** Silver, gold, cadmium, copper, iron, zinc etc.
    - **Examples of metal oxide-based inorganic nanomaterials:** Zinc oxide, copper oxide, magnesium aluminum oxide, titanium dioxide, iron oxide, etc.
- **Carbon-based nanomaterials:** It includes nanomaterials made up of non-metals and thus include graphene, fullerene, single-walled carbon nanotube, multiwalled carbon nanotube, carbon fibre, an activated carbon, and carbon black.
- **Organic-based nanomaterials:** Formed from organic materials excluding carbon materials, for instance, dendrimers, liposomes, etc.
- **Composite nanomaterials:** They are any combination of metal-based, metal oxide-based, carbon-based, and/or organic-based nanomaterials. These nanomaterials have complicated structures like a metal-organic framework.

3.3.1. Carbon Nanotube (CNT)

- Carbon nano-tubes (also known as Bucky-tube) are an **allotrope of carbon.** These are hollow, tubular and caged molecules, having a diameter measuring on the nanoscale.
- They are made up of **continuous unbroken hexagonal mesh** with carbon molecules at the apexes of the hexagons.
- The bonding in carbon nanotubes is **sp^2, with each carbon atom joined to three neighbours**, as in graphite. The tubes can therefore be considered as **rolled-up graphene sheets** (graphene is an individual graphite layer).
- CNTs are of **two types: single-wall carbon nano-tubes** (SWCN) and **multiple-wall carbon nano-tubes** (MWCN).
- These cylindrical carbon molecules have unusual properties, which are valuable for nanotechnology, electronics, optics and materials science and technology.

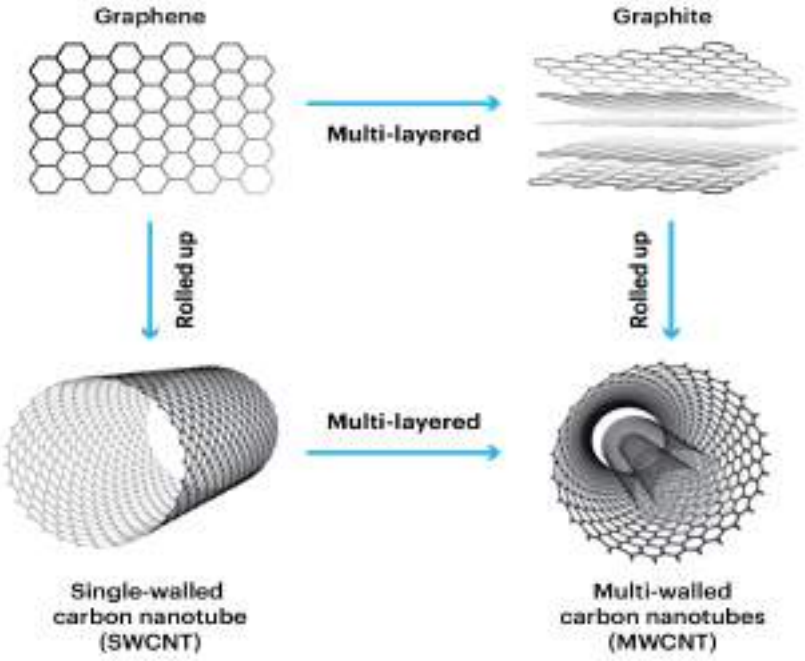


Figure.2. Carbon Nanotubes

Properties of CNT

- **Mechanical Properties:** CNT are the **strongest and stiffest** materials on earth in terms of tensile strength (ability to withstand a stretching force without breaking). They are hundred times stronger, yet six times lighter than steel. They are **one of the hardest substances known**; a standard single-walled carbon nanotube can withstand a pressure up to 24GPa without deformation.
- **Electrical Conductivity:** CNT can carry 1000 times more electric current than equivalent copper & silver wire, so is regarded as an ideal component for electric circuits.
- **Thermal Conductivity:** CNT are very good thermal conductors and the temperature stability of CNT is up to 2800℃ in vacuum & 780℃ in air.

Application of CNT

- Because of their extraordinary thermal and electrical conductivity and mechanical properties, carbon nano-tubes find applications in a wide range of materials.

- For instance, computer's processor and memory, electronic equipment, transistors, ultra-capacitors, solar cells, baseball bats, golf clubs, or car parts, combat jackets, cancer treatment and detection, etc.

3.3.2. Graphene

- Graphene is a **two dimensional allotrope** of carbon. It is one atom thick, planar and hexagonal arrangements of carbon atoms.
- The bonding of graphene is sp^2, with each carbon atom joined to three neighbours, as in graphite.
- It can be **wrapped up into 'zero-dimensional' fullerenes,** rolled into 'one-dimensional' nanotubes or stacked into 'three-dimensional' graphite. The word 'Graphene' came from graphite.
- In 2004, teams including Andre Geim and Konstantin Novoselov separated graphene from graphite and demonstrated that single layers of graphite could be isolated, resulting in the award of the Nobel Prize for Physics in 2010.

Properties of Graphene

- It is a good thermal and electric conductor and can be used to develop semiconductor circuits and computer parts. Experiments have shown it to be incredibly strong and hard.

Applications of Graphene

- Its unusual properties make it ideal for applications in various fields from composite materials to electronics.
- Graphene is a transparent conductor which can be used in touch-screen & light panel displays in smart phones & tablets. It can also be used in the making of solar cells.
- Graphene transistors are faster than those made out of silicon.
- Graphene components could pack a chip more tightly and can help make efficient and fast computers.
- Plastics could be made into electronic conductors, if only 1% of graphene were mixed into them, which will also increase the heat resistance and will make it mechanically robust.
- Graphene also helps in making new super strong materials which are thin, elastic & light weight; which can be used to make components of airplanes, cars and satellites.
- It can also be used in making many chemical and biological sensors to be used in healthcare, environmental and industrial processes.

3.3.3. Fullerenes

- Fullerenes are a carbon allotrope. They are **molecules composed entirely of carbon,** in the form of a hollow sphere, ellipsoid, or tube.
- Spherical fullerenes are called **buckyballs** whereas cylindrical fullerenes are called **buckytubes or nanotubes.**
- Fullerenes are similar in structure to graphite, which is composed of a sheet of linked hexagonal rings, but they also contain pentagonal (or sometimes heptagonal) rings that prevent the sheet from being planar.

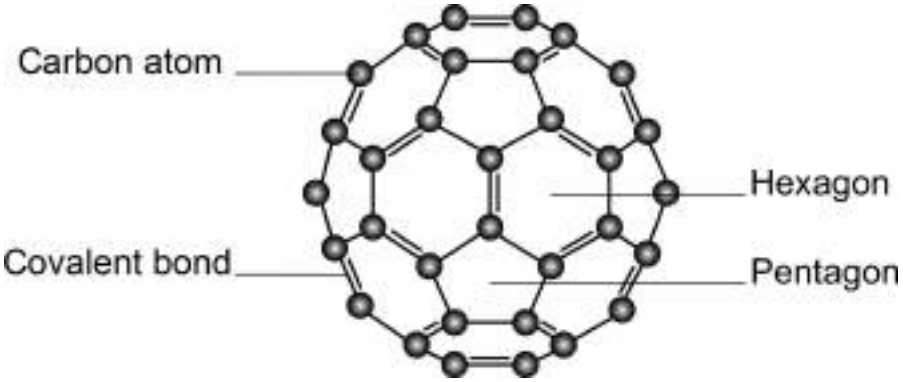


Figure.3. Fullerene C-60

Buckminster Fullerenes

- The C-60 fullerene is the most stable and was the first to be identified. It **contains 60 carbon atoms** which are arranged in the shape of a football.
- It contains 20 six-member hexagonal rings and 12 five-member pentagonal rings.
- C-60 fullerene look like **geodesic domes** designed by the United States architect Buckminster Fuller, therefore, they are called Buckminster Fullerenes.

Properties of C-60

- Buckminster Fullerenes (C-60) is a dark solid at room temperature and its hardness lies between diamond and graphite. It is neither very hard nor very soft.

Application of C-60

- It is a strong antioxidant; enough to kill resistant bacteria and cancer cells in the human body.
- C-60 molecules can engage and transport atoms and molecules (e.g. drugs, radioactive labels) through the human body.
- C-60 could also inhibit the HIV virus. The C60 molecule could block the active site in a key enzyme in the human immunodeficiency virus known as HIV-1 protease; this could inhibit reproduction of the HIV virus in immune cells.
- The C-60 molecule can also bind large numbers of hydrogen atoms without disrupting the structure. This property suggests that C60 may be a better storage medium for hydrogen than metal hydrides and hence a key factor in the development of a new class battery or even non-polluting automobiles.
- It shows the properties of superconductivity and thermal resistance which makes it perfect to be used in electronic engineering.

3.3.4. Carbon Fibres

- Carbon fibres can be defined as **fibers with a carbon content of 90% or above.**
- They are produced **by thermal conversion of organic fibers** with a lower carbon content such as polyacrylonitrile (PAN) containing several thousand filaments with diameter between 5 and 10 μm.
- Carbon fibers have high tensile strength, high stiffness, low density, and a high chemical resistance.
- The main application areas of carbon fiber-reinforced polymers are aerospace, defense, automotive, wind turbines, sport and leisure, and civil engineering.

4. Applications of Nanomaterials

4.1. Medical and Health Applications

- **Absorb and move quickly:** Nanoparticles have a significant surface-area-to-volume ratio due to their nanoscale size, which allows them to absorb vast amounts of medications and move quickly throughout the bloodstream. Their increased surface area gives them distinct capabilities, allowing them to be used in more pharmaceutical applications.
- **Quantum dots to enhance biological imaging:** Quantum dots are semiconducting nanocrystals that can enhance biological imaging for medical diagnostics. When illuminated with ultraviolet light, they emit a wide spectrum of bright colors that can be used to locate and identify specific kinds of cells and biological activities. These crystals offer optical detection up to 1,000 times better than conventional dyes used in many biological tests, such as MRIs (Magnetic Resonance Imaging), and render significantly more information.
- **Drug delivery and nanobots:** Nanobots for targeted drug delivery are meant to reach hard-to-access parts of the body. Traditional drug treatments, for example cancer chemotherapy, can come with toxic compounds that indiscriminately damage healthy tissues. Nanobots could circumvent this issue by protecting the drug until it's delivered to the intended target. Nanobots can also be used to clear the blockage in arteries.
- **Early diagnosis of plaque in arteries:** Nanotechnology has been used in the early diagnosis of atherosclerosis, or the buildup of plaque in arteries. Researchers have developed an imaging technology to measure the amount of an antibody-nanoparticle complex that accumulates specifically in plaque. Clinical scientists are able to monitor the development of plaque as well as its disappearance following treatment.
- **Use of gold nanoparticles:** Gold nanoparticles can be used to detect early-stage Alzheimer's disease. Gold nanoparticles can also be used for the detection of targeted sequences of nucleic acids, and can be clinically investigated as potential treatments for cancer and other diseases.
- **To detect molecular signals:** Molecular imaging for the early detection where sensitive biosensors constructed of nanoscale components (e.g. nanocantilevers, nanowires, and nanochannels) can recognize genetic and molecular events and have reporting capabilities, thereby offering the potential to detect rare molecular signals associated with malignancy.
- **Research enablers:** Such as microfluidic chip-based nanolabs capable of monitoring and manipulating individual cells and nanoscale probes to track the movements of cells and individual molecules as they move about in their environments.
- **Treating Glaucoma:** Blindness can be prevented by treating glaucoma using nanoparticle eye drops. Nanomaterials can incorporate the drugs in two ways: through encapsulation inside the nanomaterials or conjugation on the surface of nanomaterials. The encapsulated drug is released as the nanomaterial disassembles at the target site, while the nanomaterial-conjugated drug is released after the bond between the nanomaterial and drug is cleaved at the target site.
- **Bone Regeneration:** Nanoparticles can be used to facilitate bone regeneration in the treatment of osteoporosis.

- **Cancer nanomedicine:** Cobalt oxide nanoparticles have a lot of usage in cancer nanomedicine due to their wide variety of biological uses.
- **Repairment of spinal cord:** Researchers are studying ways to use graphene nanoribbons to help repair spinal cord injuries.
- **COVID-19:** Recently, researchers from the Pacific Northwest National Laboratory have demonstrated that they can identify SARS-CoV-2, the virus that causes COVID-19, in the air by employing a nanotechnology-packed bubble that ruptures when it comes into contact with the virus. Also, Pfizer-BioNTech and Moderna used lipid nanoparticles for the development of COVID-19 mRNA-based vaccines namely the BNT162b2 and mRNA-1273 respectively.

4.2. Everyday Materials and Processes

- **Polymer composite materials:** Nanoscale additives in polymer composite materials for baseball bats, tennis rackets, motorcycle helmets, automobile bumpers, luggage, and power tool housings can make them simultaneously lightweight, stiff, durable, and resilient.
- **Fabrics:** Nanoscale additives to or surface treatments of fabrics help them resist wrinkling, staining, and bacterial growth, and provide lightweight ballistic energy deflection in personal body armor.
- **Nanomaterial films:** Nanoscale thin films on eyeglasses, computer and camera displays, windows, and other surfaces can make them water-repellent, anti reflective, self-cleaning, resistant to ultraviolet or infrared light, anti fog, antimicrobial, scratch-resistant, or electrically conductive.
- **Cosmetic products:** Nanoscale materials in cosmetic products provide greater clarity or coverage; cleansing; absorption; personalization; and antioxidant, anti-microbial, and other health properties in cleansers, complexion treatments, creams and lotions, shampoos, and specialized makeup.
- **Food industry:** Nano-engineered materials in the food industry include nanocomposites in food containers to minimize carbon dioxide leakage out of carbonated beverages, or reduce oxygen inflow, moisture outflow, or the growth of bacteria in order to keep food fresher and safer, longer. Nanosensors built into plastic packaging can warn against spoiled food. Nanosensors are being developed to detect salmonella, pesticides, and other contaminants on food before packaging and distribution.
- **Automotive products:** Nano-engineered materials in automotive products include high-power rechargeable battery systems; thermoelectric materials for temperature control; lower-rolling-resistance tires; high-efficiency/low-cost sensors and electronics; thin-film smart solar panels; and fuel additives and improved catalytic converters for cleaner exhaust and extended range.
- **Household products:** Nano-engineered materials make superior household products such as degreasers and stain removers; environmental sensors, alert systems, air purifiers and filters; antibacterial cleansers; and specialized paints and sealing products.
- **Coating of machine parts:** Nanostructured ceramic coatings exhibit much greater toughness than conventional wear-resistant coatings for machine parts.
- **As Catalyst:** Nanoparticles are used increasingly in catalysis to boost chemical reactions. This reduces the quantity of catalytic materials necessary to produce desired

results, saving money and reducing pollutants. Two big applications are in petroleum refining and in automotive catalytic converters.

4.3. Electronics and Information Technology Applications

- **Faster, smaller and portable system:** Nanotechnology is already in use in many computing, communications, and other electronics applications to provide faster, smaller, and more portable systems that can manage and store larger and larger amounts of information.
- **Saving data:** Magnetic random access memory (MRAM) enabled by nanometer-scale magnetic tunnel junctions can quickly and effectively save even encrypted data during a system shutdown or crash, enable resume-play features, and gather vehicle accident data.
- **OLEDs:** Displays for many new TVs, laptop computers, cell phones, digital cameras, and other devices incorporate nanostructured polymer films known as organic light-emitting diodes, or OLEDs. OLED screens offer brighter images in a flat format, as well as wider viewing angles, lighter weight, better picture density, lower power consumption, and longer lifetimes.
- **Other computing and electronic products:** Include Flash memory chips for iPod nanos; ultra responsive hearing aids; antimicrobial/antibacterial coatings on mouse/keyboard/cell phone casings; conductive inks for printed electronics for RFID/smart cards/smart packaging; more life-like video games; and flexible displays for e-book readers.
- **Carbon nanotube transistor:** Because of their excellent electrical conductivity, transistors based on carbon nanotubes have also long been seen as a potential replacement for silicon transistors in a computer. Carbon nanotube transistors would let developers sidestep the problem of heat generation and leakage, enabling chip makers to put more and more transistors on a chip.

4.4. Sustainable Energy Applications

- **Nanostructured solar cells and panels:** Prototype solar panels incorporating nanotechnology are more efficient than standard designs in converting sunlight to electricity, promising inexpensive solar power in the future. Nanostructured solar cells already are cheaper to manufacture and easier to install, since they can use print-like manufacturing processes and can be made in flexible rolls rather than discrete panels.
- **Fuel production and consumption efficiency:** Nanotechnology is improving the efficiency of fuel production from normal and low-grade raw petroleum materials through better catalysis, as well as fuel consumption efficiency in vehicles and power plants through higher-efficiency combustion and decreased friction.
- **Efficient batteries:** Nanotechnology is already being used in numerous new kinds of batteries that are less flammable, quicker-charging, more efficient, lighter weight, and that have a higher power density and hold electrical charge longer.
- **Alternate transport technology:** Nanostructured materials are being pursued to greatly improve hydrogen membrane and storage materials and the catalysts needed to realize fuel cells for alternative transportation technologies at reduced cost. Researchers are also working to develop a safe, lightweight hydrogen fuel tank.

- **Conversion of waste:** Various nanoscience-based options are being pursued to convert waste heat in computers, automobiles, homes, power plants, etc., to usable electrical power.
- **Carbon nanotubes for windmill:** An epoxy containing carbon nanotubes is being used to make windmill blades that are longer, stronger, and lighter-weight than other blades to increase the amount of electricity that windmills can generate.
- **Carbon nanotube wires:** Researchers are developing wires containing carbon nanotubes to have much lower resistance than the high-tension wires currently used in the electric grid and thus reduce transmission power loss.

4.5. Environmental Remediation Applications

- **Purification of drinking water:** Nanotechnology could help meet the need for affordable, clean drinking water through rapid, low-cost detection of impurities in and filtration and purification of water. For example, researchers have discovered unexpected magnetic interactions between ultrasmall specks of rust, which can help remove arsenic or carbon tetrachloride from water; they are developing nanostructured filters that can remove virus cells from water; and they are investigating a deionization method using nano-sized fiber electrodes to reduce the cost and energy requirements of removing salts from water.
- **Cleaning industrial water pollutants:** Nanoparticles will someday be used to clean industrial water pollutants in ground water through chemical reactions that render them harmless, at much lower cost than methods that require pumping the water out of the ground for treatment.
- **Oil cleanup:** Researchers have developed a nanofabric "paper towel," woven from tiny wires of potassium manganese oxide, that can absorb 20 times its weight in oil for cleanup applications.
- **Mechanical filtration:** Many airplane cabins and other types of air filters are nanotechnology-based filters that allow “mechanical filtration,” in which the fiber material creates nanoscale pores that trap particles larger than the size of the pores. They also may contain charcoal layers that remove odors.
- **Filter and neutralize harmful agents:** New nanotechnology-enabled sensors and solutions may one day be able to detect, identify, and filter out, and/or neutralize harmful chemical or biological agents in the air and soil with much higher sensitivity than is possible today. Researchers around the world are investigating carbon nanotube “scrubbers,” and membranes to separate carbon dioxide from power plant exhaust.

4.6. National Security

- **Nano-bio-detection scheme:** They include new and powerful bio-detection schemes that can analyze a potential bioterrorism threat. It also includes nano-materials that can detoxify an area or humans exposed to a set of toxins.
- **Nano-tech for soldiers:** Another area of great importance to national security is that of protecting the country's troops. Nanomaterials can be used to produce nano-battlesuit, nano-sensors, drones, satellites, nano-weapons, etc.
- **Nano-sensors at public protection:** Nanosensors' ability to detect at the molecular or even atomic level is critical. They could be used to detect radioactive materials or toxins like anthrax. They could be embedded in clothing or painted on the side of a building.

The high sensitivity of nanosensors also means that large public works, like a water system, could be routinely tested and even extremely small amounts of contaminants would be detected.

- **Protecting information systems:** Computers and networks are the foundation of major sectors of an economy like financial institutions and electric power sectors. Researchers working in the areas of Nano-electronics and Nano-computing hope to integrate transistor-like nanoscale devices into system architecture, to provide substantial advantages over current technologies. They are also working on the creation of powerful “grid protocols” that could make the world wide web obsolete, and something called quantum cryptography that could provide the type of electronic security systems that are impossible to crack.

4.7. Transportation Applications

- Nano-engineering of steel, concrete, asphalt, and other cementitious materials, and their recycled forms, offers great promise in terms of improving the performance, resiliency, and longevity of highway and transportation infrastructure components while reducing their cost. New systems may incorporate innovative capabilities into traditional infrastructure materials, such as the ability to generate or transmit energy.
- Nanoscale sensors and devices may provide cost-effective continuous structural monitoring of the condition and performance of bridges, tunnels, rails, parking structures, and pavements over time. Nanoscale sensors and devices may also support an enhanced transportation infrastructure that can communicate with vehicle-based systems to help drivers maintain lane position, avoid collisions, adjust travel routes to circumnavigate congestion, and other such activities.

4.8. Other Applications

- **Sunscreen:** Many sunscreens contain nano-particles of zinc oxide or titanium oxide. Older sunscreen formulas use larger particles, which is what gives most sunscreens their whitish color. Smaller particles are less visible, meaning this sunscreen doesn't give a whitish tinge.
- **Self-cleaning glass:** A company called Pilkington offers a product they call Active Glass, which uses nano-particles to make the glass photo-catalytic and hydrophilic. The photo-catalytic effect means that when UV radiation from light hits the glass, nano-particles become energized and begin to break down and loosen organic molecules on the glass. Hydrophilic means that when water makes contact with the glass, it spreads across the glass evenly, which helps wash the glass clean.
- **Clothing:** Scientists are using nano-particles to enhance clothing. By coating fabrics with a thin layer of zinc oxide nano-particles, manufacturers can create clothes that give better protection from UV radiation. Some clothes have nano-particles in the form of little hairs or whiskers that help repel water and other materials, making the clothing stain-resistant.
- **Scratch-resistant coatings:** Engineers discovered that adding aluminum silicate nano-particles to scratch-resistant polymer coatings made the coatings more effective, increasing resistance to chipping and scratching. Scratch-resistant coatings are common on everything from cars to eyeglass lenses.

5. Nanotechnology in India

5.1. Developments of Nanotechnology in India

- The Department of Science and Technology (DST) under the Ministry of Science and Technology has been assigned the responsibility of development of nanotechnology in India.
- To create the background and infrastructure for research and development in the field of nano-technology, the National Nanoscience and Technology Initiative (NSTI) was rolled out in 2001.
- The motive of launching NSTI was to create research infrastructure and promote basic research in nanoscience and nanotechnology.
- DST under NSTI established the Centre of Excellence for Nano Science and Technology. 20 such centres have been established in various states of the country.

5.2. National Mission of Nano Science and Technology

- National Mission of Nano Science and Technology - an umbrella programme was launched in 2007 to promote Research & Development in this emerging area of research in a comprehensive fashion.
- Recognizing the success of Nano Mission, the Union Cabinet accorded approval for continuation of the Nano Mission in its Phase-II during the 12th Plan period.
- India has secured third position amongst nations of the world for Scientific Publications in Nanoscience & Technology due to the efforts led by the Nano Mission.

Main Objectives

- Basic research promotion
- Research infrastructure development
- Nano application and technology development
- Human Development in Nanotechnology
- International collaboration and orchestrating national dialogues
- Establishment of Development Centre for Nanosciences

1. Recombinant DNA (rDNA) Technology

1.1. Introduction to rDNA Technology

- Recombinant DNA is an **artificially made DNA strand** that is **formed by the combination of two or more gene sequences.**
- rDNA technology involves using enzymes and various laboratory techniques to manipulate and isolate DNA segments of interest.
- The method **can be used to combine (or splice) DNA** from different species or to create genes with new functions.

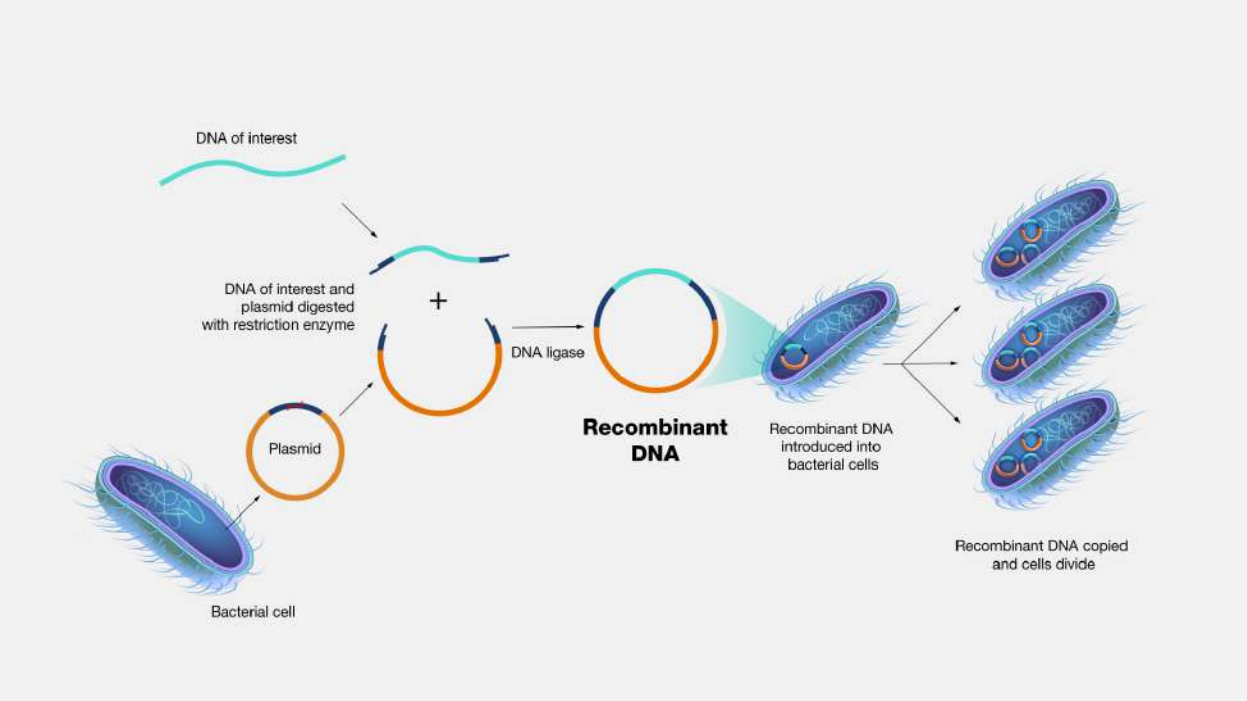


Figure.1. Recombinant DNA Technology

- rDNA is possible because the DNA of all organisms share the same chemical structure but different nucleotide sequences within the overall identical structure.
- In 1973, **Stanley N. Cohen and Herbert W. Boyer** became the first to insert recombined genes into bacterial cells.

Tools of rDNA Technology

The key tools of rDNA technology are restriction enzymes, polymerase enzymes, ligases, vectors and the host organism.

1.3. Applications of Recombinant DNA Technology

- **Medicine:** genetic engineering has been used to mass-produce insulin, human growth hormones, follistim (for treating infertility), human albumin, monoclonal antibodies, antihemophilic factors, vaccines, and many other drugs.
- **Research:** organisms are genetically engineered to discover the functions of certain genes.

- **Industrial applications:** include transforming microorganisms such as bacteria or yeast. Mass quantities of the protein can be produced by growing the transformed organism in bioreactors using fermentation, then purifying the protein.
- **Agriculture:** Genetic engineering is also used in agriculture to create genetically-modified crops or genetically-modified organisms. Crops containing genes which will enable them to withstand biotic and abiotic stresses have been developed. Crops with a number of desirable traits have also been developed such as Golden Rice, FlavrSavr Tomato etc.
- **Environment:** Organisms have been known to help in the biodegradation of waste materials. However, there are some materials like plastics which cannot be degraded by them. To help such causes, genetic research has produced modified microorganisms which not only have the capability of doing this but are also more efficient due to the speedy process. They are used in situations which may cause severe damage to the planet earth like oil spills.

2. Transgenic Bacteria

2.1. What are Transgenic Bacteria?

- Transgenic bacteria are those bacteria that **contain genes from other species.**
- They are genetically modified microorganisms (GMOs) that have been **developed through engineering of the genome.**
- Transgenic bacteria are widely used in agriculture, medicine, and biotechnology as well as to produce food additives, such as vitamins, enzymes, antibiotics, and hormones.
- In 1973**,** scientists Herbert Boyer and Stanley Cohen created the **first genetically engineered organism — E. coli** bacteria that had the gene for resistance to the antibiotic tetracycline transferred into it.

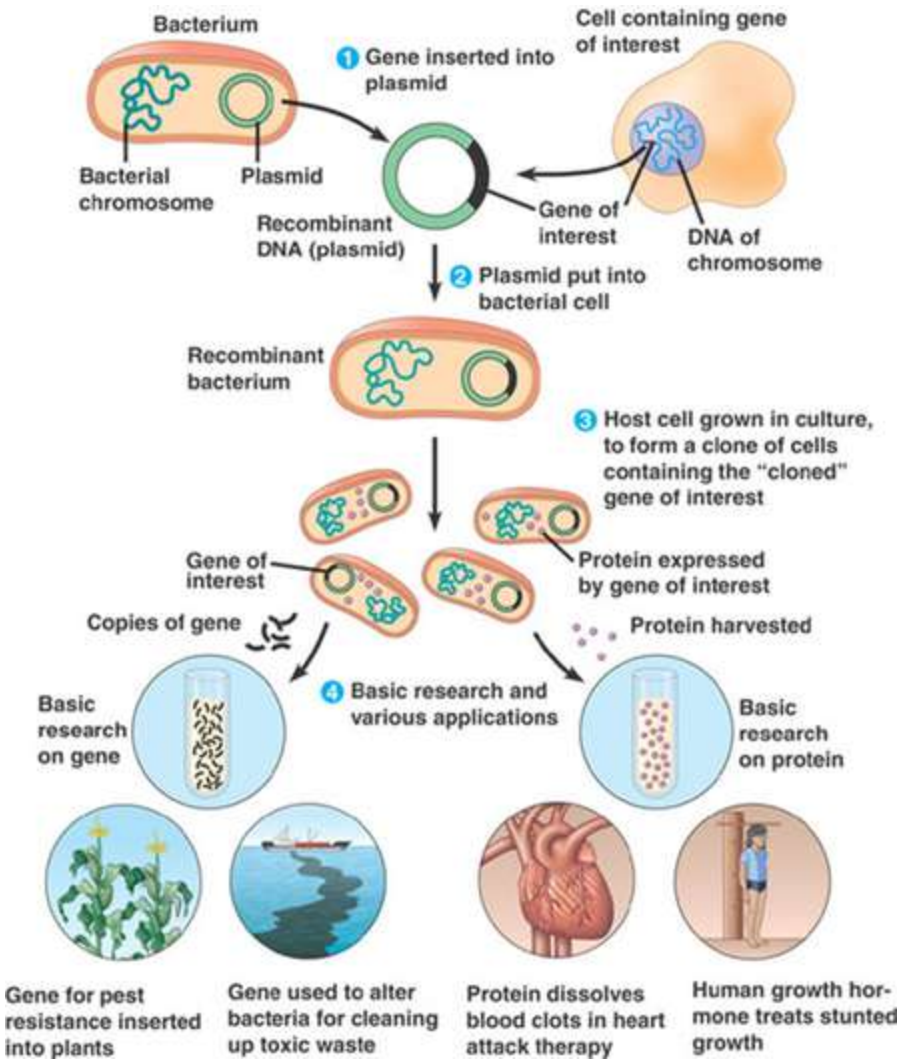


Figure.2. Procedure for Creating Transgenic Bacteria

2.2. Procedure for Creating Transgenic Bacteria

1. Take a bacterial plasmid.
2. Cut out the portion of the gene of interest using a **restriction enzyme.**
3. Same restriction enzyme is used to cut the bacterial plasmid.
4. Use DNA Ligase to **incorporate the desired portion of DNA** into the plasmid. The incorporated portion is called a **transgene.**
5. Use a vector which has a high multiplication rate to transport the transgene into the desired organism.
6. The transgene replicates within the host cell or incorporates itself into the host DNA, and commands for the production of required protein synthesis.

2.3. Application of Transgenic Bacteria

Medicine

- Production of **human insulin** to treat diabetes.
    - Before 1983, insulin was provided through animal resources that carried purified insulin similar to human insulin. The process was labour intensive, expensive and had side effects like allergic reactions.

- Other medicines produced by using transgenic bacteria include
    - **clotting factors** to treat haemophilia,
    - **human growth hormone** to treat various forms of dwarfism,
    - **interferon** to treat some cancers,
    - **erythropoietin** for anaemic patients, and
    - **tissue plasminogen activator** which dissolves blood clots.

Environment

- For **bioremediation** (where the bacteria are used to convert pollutants into a less toxic form).
- Transgenic bacteria have also been developed **to leach** copper from ore, clean up mercury pollution and detect arsenic in drinking water.
- They are used as **biofilters** in industries and can remove sulphur from coal before burning it.
- For cleaning up of oil spills by digesting hydrocarbons of crude oil.

Agriculture

- To **increase crop production** or to allow crops to be grown outside their original habitat.
- Application of *Bacillus thuringiensis* (Bt) and other bacteria can **help protect crops from insect infestation** and plant diseases.
- To increase **environmental protection** through reduced use of pesticides.
- To improve nutrition for people.
- **Increase farm profitability** through reduced cost and new product opportunities.
- Anti-freezing bacteria is sprayed onto the plants to prevent ice formation.
- Herbicides will have no effect on the transgenic crop plants and only destroy the weeds.
- Allow for crops to have a higher self life.

Mining

- To extract copper, uranium, and gold from low-grade sources.
- To **improve the bioleaching capabilities** of metals.

Industry

- Genetically modified bacteria are used to produce large amounts of proteins for industrial use.

Food

- Food products from genetically modified bacteria **include alpha-amylase,** which converts starch to simple sugars, chymosin, which clots milk protein for cheese making, and pectinesterase, which improves fruit juice clarity.

2.4. Ethical Issues and Concerns

- **Safety Concerns:** Little is known about the adaptation potential of the Transgenic Bacteria.
- **Natural VS Unnatural:** Genetic Engineering causes modifications that are not naturally possible in nature. There are unknown consequences to altering the natural state of an organism through foreign gene expression.
- **Legitimacy:** It is impossible to determine consequences linked to new scientific knowledge which could be harmful to the planet.

- **Health risks:** Potential health risks to humans include the possibility of exposure to new allergens in genetically modified foods, as well as the transfer of antibiotic-resistant genes to gut flora.
- **Patent:** The modification/usage of living organisms for public services (as food and medicine sources, for example) has also created problems with patents granted for the same.

3. Transgenic Animals

3.1. What are Transgenic Animals?

- **Animals that have had their DNA manipulated** to possess and express an extra (foreign) gene are known as transgenic animals.
- Examples include transgenic rats, rabbits, pigs, sheep, cows and fish.

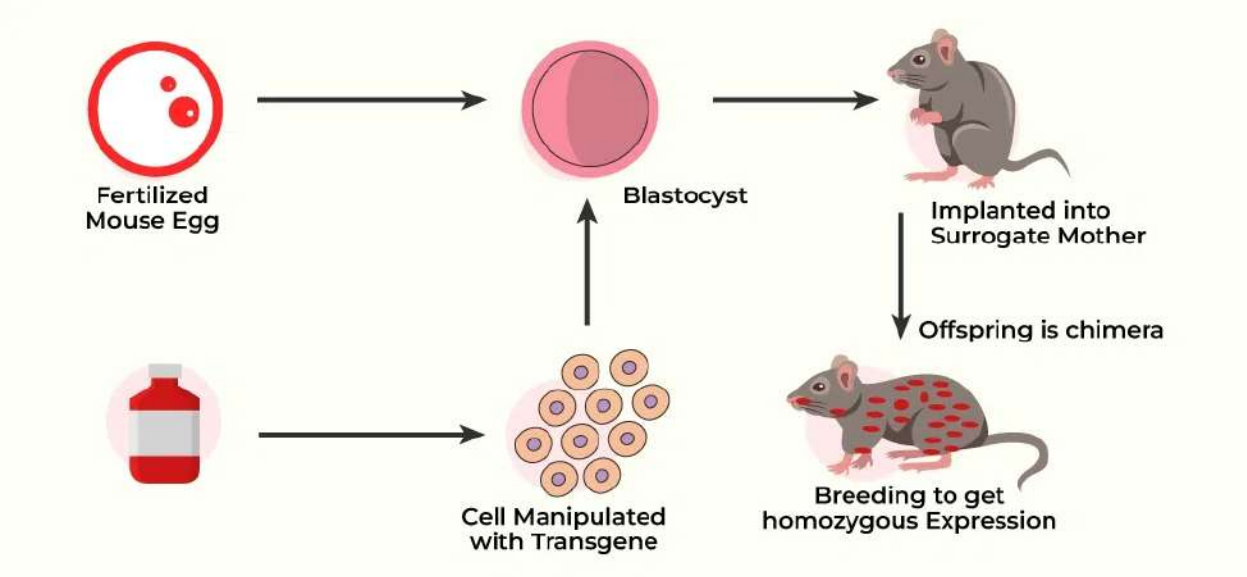


Figure.3. Procedure for Creating Transgenic Animals

3.2. Procedure for Creating Transgenic Animals

The most common method for producing transgenic animals is **gene transfer by DNA microinjection,** which involves the following steps:

- **DNA containing the desired transgene is identified** and cloned before insertion into the animal host.
- The host animals are **induced to superovulate** and their eggs are collected.
- The eggs are fertilised in a laboratory dish.
- Using a fine, hollow needle, a **solution of DNA containing the transgene is injected** into the male pronucleus of the fertilised egg before it fuses with the female pronucleus.
- The transgenic **embryos are grown in cell culture** and then **implanted into the uterus of a surrogate mother,** where they complete their development.
- Some of the baby animals will have the transgene stably integrated into their chromosomes. In others the process fails and the transgene is lost.
- Those that received the transgene and maintained it stably are called founder animals.

3.3. Applications of Transgenic Animals

Transgenic Animals in Agriculture

- Practical applications of transgenesis in livestock production include
    - enhanced prolificacy and reproductive performance,
    - increased feed utilisation and growth rate,
    - improved carcass composition,
    - improved milk production and composition, and
    - modification of hair or fibre.

Control of Vectors

- British company Oxitec has created genetically modified male mosquitoes that carry a **"self-limiting gene".** When they are released into the wild and mate with females their offspring do not reach adulthood, so they do not contribute to the spread of the Zika virus.
- Other researchers are looking at using genetic modification to curb the spread of malaria.

Advance Human Health

- Transgenic animals can improve human health by **producing novel replacement proteins,** drugs, vaccines and tissues for the treatment and prevention of human disease.

Enhanced Nutrition

- Transgenesis allows improvement of nutrients in animal products, including their quantity, the quality of the whole food, and specific nutritional composition.
- For example: Enhancing the omega-3 fatty acid in fish consumed by humans may contribute to a decreased occurrence of coronary heart disease.

Molecular Farming

- Molecular farming is also known as 'pharming', in which biopharmaceuticals are manufactured in transgenic animals.
- More than recombinant cell cultures, **animals are attractive bioreactors.** They have the correct metabolic pathways, are reproducible, easily maintained, and do not require expensive infrastructure.

Reduced Environmental Impact

- Genetically engineered animals can contribute to improving the environment and human health by consuming fewer resources and producing less waste.
- For example: Through genetic engineering, scientists have developed **Enviro-Pig.** This animal emits 30 to 60 percent **less phosphorus** than traditional pigs.
- Gene-modifying techniques also offer a **possibility to reduce the greenhouse gas emissions** from livestock.

Xenotransplantation

- A medical application of genetic modification aims to improve the suitability of animal organs for xenotransplantation.
- For example: Possibility of growing transplantable human organs in pigs.

Enhance Food Production and Quality

- Animals that are genetically engineered have improved food production capabilities, enabling them to help meet the global demand for more efficient, higher quality and lower-cost sources of food.

Improve Industrial Products

- Genetic engineering can produce high-value industrial products, such as spider silk, for both medical and defense applications.

3.4. Ethical Issues and Concerns

Ethical Issues

- Moral status of animals, animal rights and animal welfare.
- **Fear of transferring allergens** from genetically modified food to sensitive humans and animals.
- Transgenic animals may bring about **changes in natural evolutionary patterns.**
- Use of animals in biotechnology is **cruelty towards animals** which causes great suffering to them.
- Transfer of human genes into animals is a great ethnic threat for humanness.
- Where transgenic animals are concerned, it remains important to 'expect the unexpected'. Even with the best information, and the best of intentions, it is not possible to predict with certainty how they will impact upon the experimental animal.
- Many of the embryos that undergo genetic engineering procedures do not survive, and of those that do survive only a small proportion (between 1% to 30%) carry the genetic alteration of interest.

Environmental Impact

- Use of genetically engineered animals could harm the environment indirectly by changing demand for feed, number of animals used, or amount of resulting waste, and by the **effects of wastes containing novel gene products** on microbial and insect ecologies.
- Transgenic farm animals may also have harmful environmental effects if they escape or are released from captivity and mate with wild individuals of the same species.
- The risk of an escaped transgenic animal becoming established in the natural environment depends on its ability to survive and reproduce in the wild.

Patenting

- Genetic engineering also brings with it concerns over intellectual property, and patenting of created animals and/or the techniques used to create them.
- Preserving intellectual property can breed a culture of confidentiality within the scientific community, which in turn limits data and animal sharing.
- Such limits to data and animal sharing may create situations in which there is unnecessary duplication of genetically engineered animal lines, thereby challenging the principle of Reduction.

Other Concerns

- Proteins designed to produce a pharmaceutical product in the animal's milk might find their way to other parts of the animal's body, possibly causing adverse effects.
- Interfering with the genome by inserting or removing fragments of DNA **may result in alteration of the animal's normal genetic homeostasis.**
- Studies have revealed that cloned mammals may suffer from developmental abnormalities, including extended gestation, large birth weight and effects in organs and tissues.
- If the use of cloning became more widespread in the animal breeding industry, there is a danger that the level of genetic diversity could fall to an unacceptable degree.

5. Human Genome Project (HGP)

5.1. What was the Human Genome Project?

- The Human Genome Project was a large, well-organized, and highly collaborative international effort that generated the first sequence of the human genome and that of several additional well-studied organisms.
- It was **carried out from 1990–2003**.
- The idea of the HGP was **first publicly advocated by Renato Dulbecco** in an article published in 1984, in which he argued that knowing the human genome sequence would facilitate an understanding of cancer.

5.2. Whose DNA was Sequenced?

- The sequence of the human genome generated by the HGP reflects a patchwork from multiple people whose identities were intentionally made anonymous to protect their privacy.
- The project researchers used a process to recruit volunteers, acquire their informed consent, and collect their blood samples.

5.3. Who carried out the Human Genome Project?

- HGP has been completed with the participation of an international consortium of thousands of researchers.
- In the United States, the researchers were funded by the Department of Energy and the National Institutes of Health, which created the Office for Human Genome Research in 1988 (Renamed the National Human Genome Research Institute in 1997).
- The sequencing of the human genome involved researchers from 20 separate universities and research centers across the United States, United Kingdom, France, Germany, Japan and China.
- The groups in these countries became known as the **International Human Genome Sequencing Consortium.**

5.4. Significance of Human Genome Project

- HGP has transformed biology through its integrated big science approach to deciphering a reference human genome sequence.
- It established an open approach to data sharing and open-source software, thereby making the data resulting from the project accessible to all.
- The genome sequences of microbes, plants and animals have revolutionized many fields of science, including microbiology, virology, infectious disease and plant biology.
- Moreover, deeper knowledge of human sequence variation has begun to alter the practice of medicine.
- HGP has inspired subsequent large-scale data acquisition initiatives such as the International HapMap Project, 1000 Genomes, and The Cancer Genome Atlas, as well as the Human Brain Project and the emerging Human Proteome Project.

5.5. Genome India Project

Taking inspiration from the Human Genome Project, the **Department of Biotechnology** (DBT) initiated the “Genome India Project” (GIP) **on 3rd January 2020.**

Aim

- The GIP aims **to collect 10,000 genetic samples** from citizens across India, to build a reference genome.
- This project is **led by the Centre for Brain Research** at Bengaluru-based Indian Institute of Science, which acts as the central coordinator between a collaboration of 20 leading institutions.

Method

- For conducting the project, investigators in hospitals will lead the data collection through a simple blood test from participants and the information will be added to biobanks.
- Some of the priority areas are Precision health, Rare genetic disorders, Mutation spectrum of genetic and complex diseases in the Indian population, Genetic Epidemiology of Multifactorial Lifestyle Diseases, and Translational Research.

Significance

- This initiative reflects India's progress in gene therapies and precision medicine, and its movement towards emerging next-generation medicine which yields the possibilities for greater customization, safety, and earlier detection.
- The initiative would help lay the foundation of personalized healthcare for a very large group of persons on the planet.

1. Gene Therapy

1.1. What is Gene Therapy?

- Gene therapy is a technique that **uses genes to treat or prevent disease.**
- This technique allows doctors to **treat a disorder by inserting a gene** into a patient's cells instead of using drugs or surgery.
- Researchers are testing several approaches to gene therapy, including:
    - Replacing a mutated gene that causes disease with a healthy copy of the gene.
    - Inactivating, or "knocking out," a mutated gene that is functioning improperly.
    - Introducing a new gene into the body to help fight a disease.

1.2. Approach and Technique

- Gene therapy is designed to introduce genetic material into cells to compensate for abnormal genes or to make a beneficial protein.
- If a mutated gene causes a necessary protein to be faulty or missing, gene therapy may be able to introduce a normal copy of the gene to restore the function of the protein.
- A gene that is inserted directly into a cell usually does not function. Instead, **a carrier called a vector is genetically engineered** to deliver the gene.
- Certain viruses are often used as vectors because they can deliver the new gene by infecting the cell. The viruses are modified so they can't cause disease when used in people.
- Some types of virus, such as retroviruses, integrate their genetic material (including the new gene) into a chromosome in the human cell.
- The vector can be **injected or given intravenously** directly into a specific tissue in the body, where it is taken up by individual cells.
- Alternatively, a sample of the patient's cells can be removed and exposed to the vector in a laboratory setting.
- The cells containing the vector are then returned to the patient. If the treatment is successful, the new gene delivered by the vector will make a functioning protein.
- Non-viral methods of gene transfer have also been explored in recent years. Methods for non-viral gene therapy include electroporation, the gene gun, sonoporation, magnetofection, the use of oligonucleotides, lipoplexes, dendrimers, and inorganic nanoparticles.

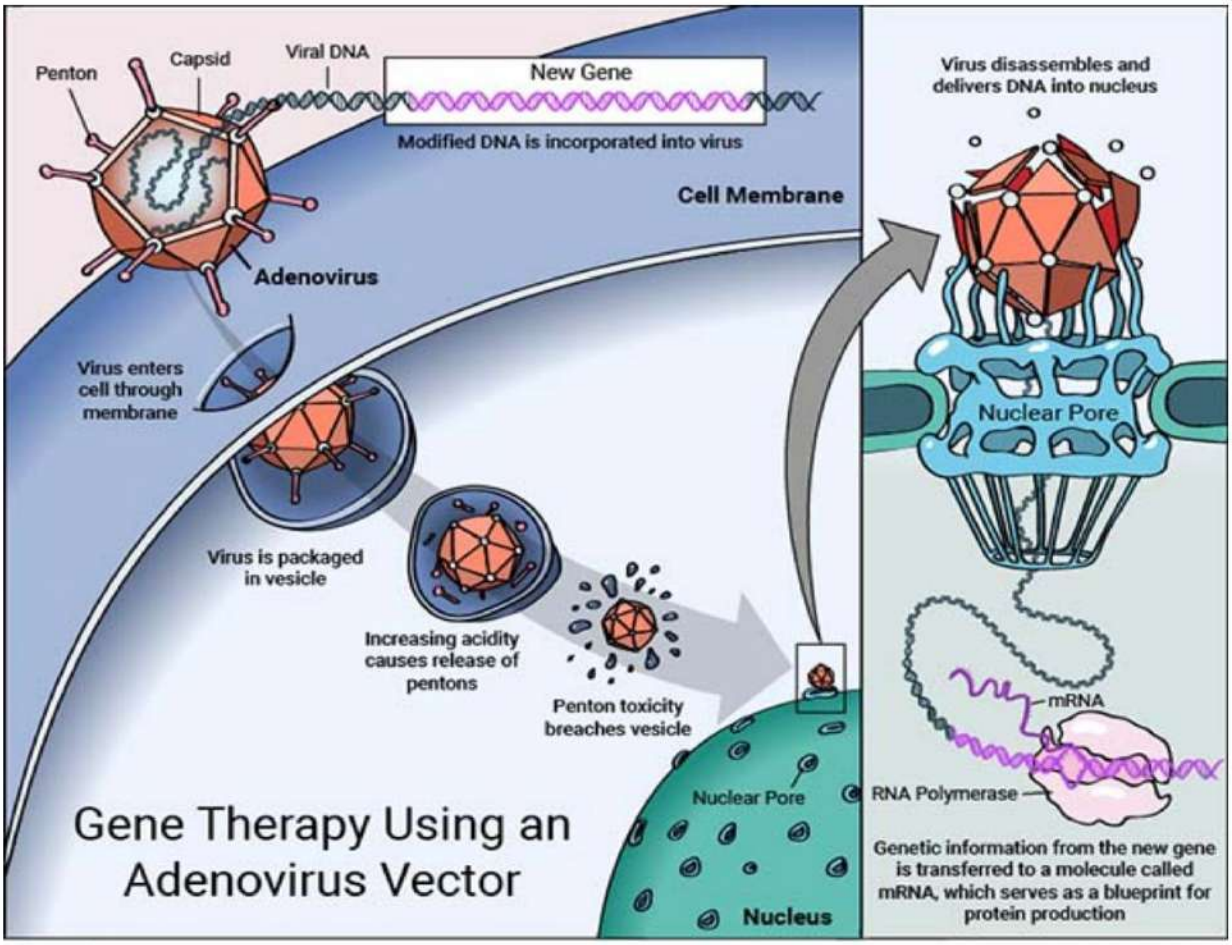


Figure.1. Virus based transfer of gene for gene therapy

1.3. Types for Gene Therapy

A. Depending upon the type of cells that are modified by the therapeutic genes:

Somatic Cell Gene Therapy

- In this type, genetic changes are directed towards somatic cells.
- As these cells are non-reproductive, the effect is not passed into future generations, making it safer.
- The disadvantage is the short duration of effects of somatic cell therapy as most tissues are be replaced by new tissues.

Germ Cell Gene Therapy

- This is the type of gene therapy, where germ cells, i.e. either sperm or ova are introduced with therapeutic genes, leading to the changes that are inheritable, i.e. changes in genes may affect future generations.

B. Based upon the technique of delivery of vectors to the target cell:

Ex-vivo Gene Therapy

- Ex -vivo gene therapy is where the defected cells are extracted out of the body and targeted with therapeutic genes.
- Once successfully modified, they are cultured ex-vivo and transferred back to the host, where now the corrected gene replicates.

In-vivo Gene Therapy

- In this modality, a vector that is capable of carrying the therapeutic gene, is used to inject host cells with normal genes.

C. The type of change brought out in the faulty gene:

Gene Replacement

- Gene replacement means replacement of defective genes with a corrected one.

Gene Addition Therapy

- Gene addition means restoration of normal function of a cell by addition of normal or functional copy of gene into the genome.
- This concept is primarily used in various gene therapy related research on cancer.

1.4. Success and Barriers

- Clinical trials of gene therapy in people have shown some success in treating certain diseases, such as:
    - Severe combined immune deficiency
    - Hemophilia
    - Blindness caused by retinitis pigmentosa
    - Leukemia
- But several significant barriers stand in the way of gene therapy becoming a reliable form of treatment, including:
    - Finding a reliable way to get genetic material into cells
    - Targeting the correct cells
    - Reducing the risk of side effects

1.5. Gene Therapy in India

- In India though interest in gene therapy took some time but with financial assistance provided by different government agencies, the country has shown rapid improvement in gene therapy-related research.
- India is at third place among the major Asian countries having gene therapy laboratories.
- The main aim is to develop new institutions for gene therapy research, strengthening existing institutions which have good expertise in this area in order to initiate work in molecular genetics for decreasing the burden of genetic disorders in the country.
- The pioneer of gene therapy-related research in India is **Advanced Centre for Treatment, Research and Education for Cancer** (ACTREC) where active work on gene therapy for head and neck cancer using synthetic vectors is being carried out.

1.5.1. Guidelines for Gene Therapy in India

- The Indian Council of Medical Research (ICMR), in December 2019, issued the National Guidelines for Gene Therapy Product Development and Clinical Trials, in consultation with experts and government agencies — including the Department of Biotechnology (DBT) and the Central Drugs Standard Control Organisation (CDSCO).
- The aim of the document is to ensure that gene therapies can be introduced in India and clinical trials for gene therapies can be performed in an ethical, scientific and safe manner.

Main features of the guidelines

- The national guidelines outline what encompasses gene therapy and GTPs. Gene Therapy Products (GTP) are defined as **any entity which includes a nucleic acid component being delivered by various means for therapeutic benefit** to patients.

- It brings new gene therapies under the umbrella of existing laws regulating drugs and medicinal practices in India — such as the Drug and Cosmetics Act, 1940 and the Drugs and Magical Remedies (The Objectionable Advertisements) Act, 1954.
- Under these guidelines, **germ-line gene therapy remains prohibited** in India.
- The national guidelines provide the general principles for developing GTPs for any human ailment and provide the framework for human clinical trials which must follow the established general principles of biomedical research for any human applications.

1.5.2. Gene Therapy Advisory and Evaluation Committee (GTAEC)

- The Gene Therapy Advisory and Evaluation Committee (GTAEC) is an independent body of experts representing diverse areas of biomedical research, concerned government agencies and other stakeholders.
- It was constituted and notified by the Department of Health Research, Ministry of Health and Family Welfare to oversee the activities in the field of gene therapy research in India.

Functions of the GTAEC

- To serve as an apex advisory body to Government of India for research and development in the field of gene therapy in India.
- To perform a comprehensive review of the pre-IND (Investigational New Drug) and IND applications of Gene Therapy Products.
- To formulate policies to inculcate scientific and ethical practices amongst stakeholders.
- To provide a forum for discussion of issues involved in basic and clinical research and progress in the field of gene therapy.
- To assess periodically the adequacy of the document in light of advancements occurring globally.
- To consider the unforeseen issues of public interests.

1.6. Mitochondrial Donation Treatment (MDT)

What is Mitochondrial Disease?

- Mitochondria are basically the **powerhouses of the cells,** they **generate the energy,** and thus are also **responsible for cell function** in the human body.
- Certain defects might occur impacting on the way the mitochondria produces energy for the cells (Specially in the ‘energy-hungry’ tissues of the brain, nerves, muscles, kidneys, heart, liver), and thereby impacting cell function.
- The diseases that arise out of such mitochondrial mutations are called mitochondrial diseases.
- When the mitochondria are impaired and do not produce sufficient energy, that affects how the organs function, leading to a broad assortment of symptoms across the body, including brain damage, organ failure and muscle wastage.
- Note: Mitochondrial diseases are **only passed on by the mother**.

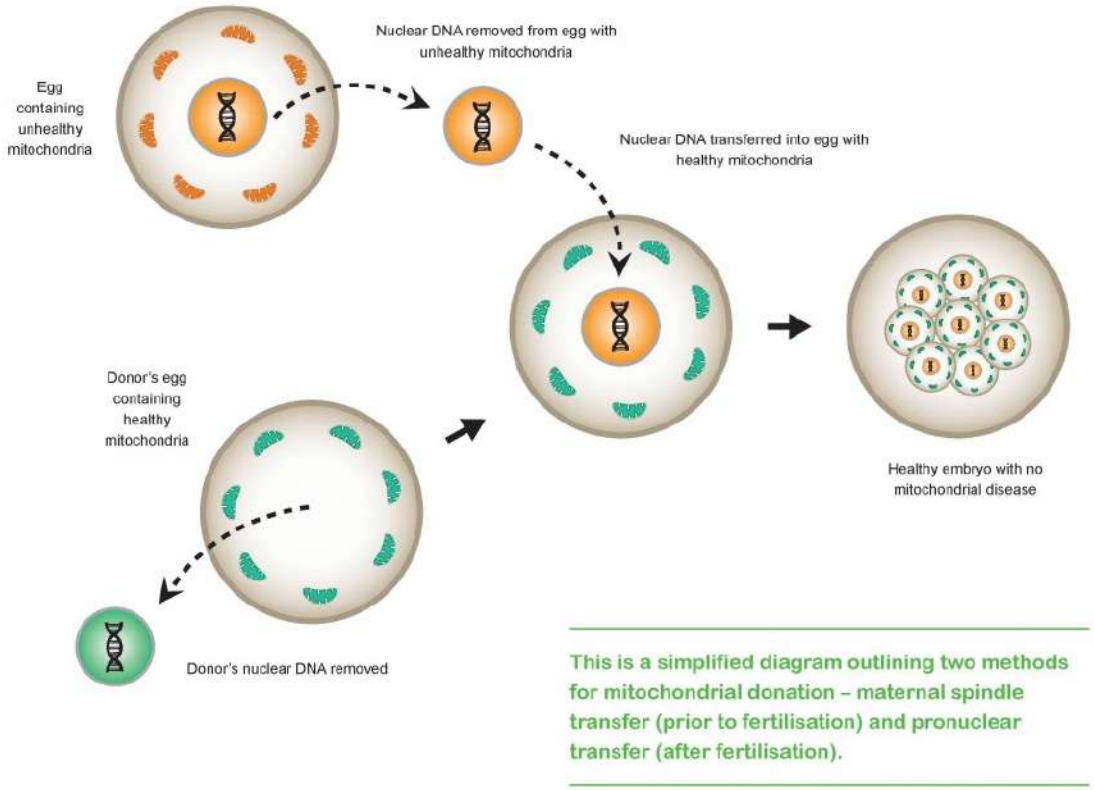


Figure.2. Mitochondrial Donation Treatment

Scientific Process

- Through an advanced In Vitro Fertilisation, the baby's **biological father's sperm was used to fertilize the eggs from the biological mother,** who has a mitochondrial disease, and **a third, female donor with clear mitochondria,** separately.
- Then, the nuclear genetic material from the donor's egg is removed and replaced with the genetic material from the biological parents'.
- The final product – the egg - which has the genetic material (DNA) from the parents, and the mitochondria from the female donor, is implanted in the uterus, and carried to full term to yield a baby who will be free from the mother's mitochondrial disease.
- The process is termed as Mitochondrial Donation Treatment (MDT).

Side Effects to the Procedure

- Sometimes it is possible that a small amount of the maternal mitochondria with errors may get passed on during the procedure. While largely helpful, the procedure is not without these minimal risks.

2. CRISPR and Gene Editing

- CRISPR (short for **"clustered regularly interspaced short palindromic repeats"**) is a technology that research scientists use to selectively modify the DNA of living organisms. It is a bacterial immune system that has been modified for genome engineering.

- The functions of CRISPR and CRISPR-associated (Cas) genes are **essential in adaptive immunity** in some bacteria, enabling the organisms to respond to and eliminate invading genetic material.
- These repeats were initially **discovered in 1987 in E. coli by Ishino,** but their function was confirmed in 2007 by Barrangou and co-workers.
- CRISPR-Cas9 enables geneticists and medical researchers to edit parts of the genome by removing, adding or altering sections of the DNA sequence.
- It is currently the simplest, most versatile and precise method of genetic manipulation.

2.1. Working Mechanism

- CRISPR consists of two components: **a "guide" RNA (gRNA) and a non-specific CRISPR-associated endonuclease (Cas9).**
- Cas9 acts as a **pair of 'molecular scissors'** that can cut the two strands of DNA at a specific location in the genome so that bits of DNA can then be added or removed.
- The gRNA is a short synthetic RNA composed of a sequence necessary for Cas9-binding and a **user-defined ~20 nucleotide "targeting" sequence** which defines the genomic target to be modified.
- Thus, one can change the genomic target of Cas9 by simply changing the targeting sequence present in the gRNA.

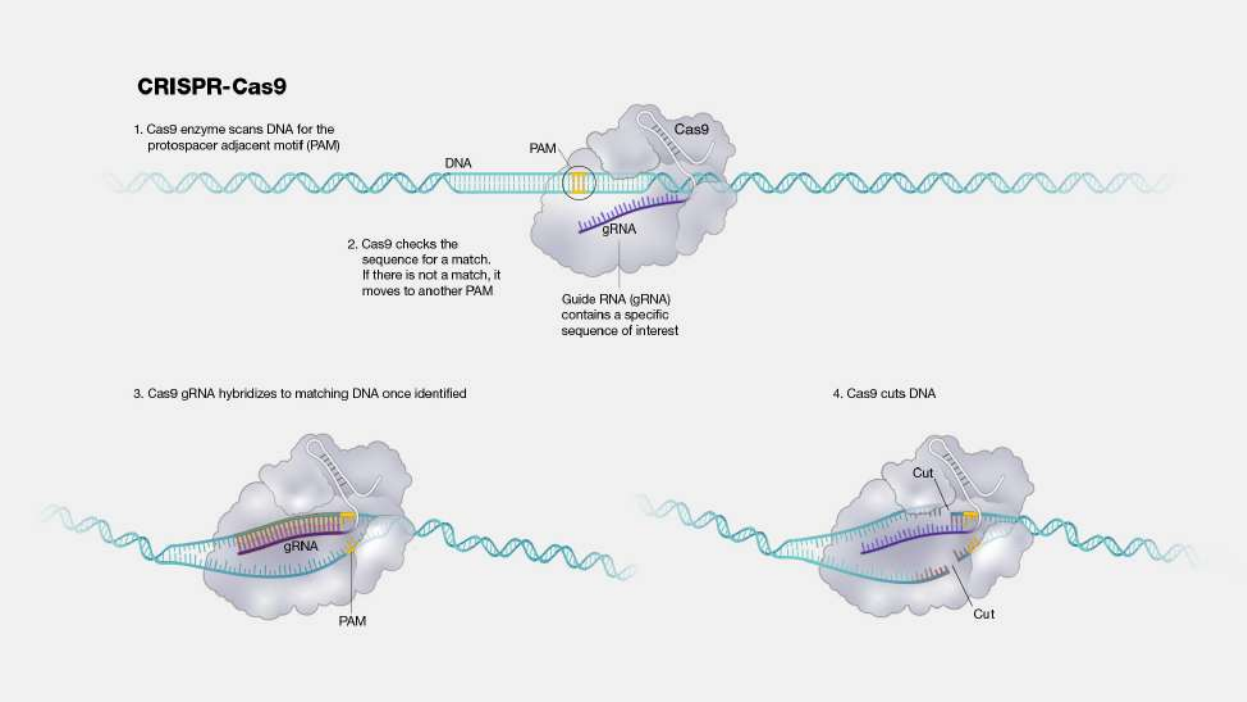


Figure.3. Method of CRISPR-Cas9

2.2. Applications

- **Targeted genome engineering:** The system can be used to facilitate a wide variety of targeted genome engineering applications. TheCas9 nuclease has enabled efficient and targeted genome modification in many species that have been intractable using traditional genetic manipulation techniques.

- **Rapid Generation of Cellular and Animal Models:** Cas9-mediated genome editing has enabled accelerated generation of transgenic models and expanded biological research beyond traditional animal model organisms.
- **Functional Genomic Screens:** The efficiency of genome editing with Cas9 makes it possible to alter many targets in parallel, thereby enabling genome-wide functional analysis to identify genes that play an important role in a phenotype of interest.
- **Transcriptional Modulation:** The technique may repress gene action which can be used in silencing the desired genes.
- **Epigenetic Control:** Complex genome functions are controlled by the highly dynamic process of epigenetic changes. CRISPR method can bring about desired epigenetic modifications.
- **Cas9 as a Therapeutic Molecule for Treating Genetic Disorders:** Cas9 can be used as a therapeutic technology for treating genetic disorders. For a monogenic recessive disorder due to loss-of-function mutations (such as cystic fibrosis, sickle-cell anemia, or Duchenne muscular dystrophy), Cas9 may be used to correct the causative mutation.

2.3. Prospect of Designer Babies

- Designer baby is a term that refers to the product of a genetically engineered baby. These babies are "designed" (fixed/changed) while still in the womb to achieve more desired health (being free from some diseases), looks, skills, or talents.

How can it be done?

- In medicine and (clinical) genetics pre-implantation genetic diagnosis (PGD or PIGD) (also known as embryo screening) refers to procedures that are performed on embryos prior to implantation, sometimes even on oocytes prior to fertilization.
- When used to screen for a specific genetic disease or for risk of getting a disease, its main advantage is that the method makes it highly likely that the baby will be free of the disease under consideration.
- This step can be followed by genetic manipulation of the egg or the zygote. Here, the standard recombinant DNA Technology is applied. After this, once again the genetic screening is done.
- If the desired genetic traits have successfully been introduced, then the zygote or the early embryo arising from it can be approved for implantation. Implantation can be done in a normal or surrogate mother.
- After the normal gestation, a "designer baby" with desired traits is born.

3. Cloning

3.1. What is Cloning?

- The term cloning describes a number of different processes that can be used to produce **genetically identical copies of a biological entity.**
- The copied material, which has the same genetic makeup as the original, is referred to as a clone.

3.2. Need for Cloning

Cloning Animal Models of Disease

- Animal models are genetically engineered **to carry disease-causing mutations** in their genes. Cloning could help reduce the time needed to make a transgenic animal model, and the result would be a population of genetically identical animals for study.

Cloning Stem Cells for Research

- Stem Cells transferred from one person to another are seen as foreign, and they usually trigger an immune response.
- Some researchers are looking at cloning as a way to create stem cells that are genetically identical to an individual. These cells could then be used for medical purposes, possibly even for growing whole organs.
- Also, stem cells cloned from someone with a disease **could be grown in culture and studied** to help researchers understand the disease and develop treatments.

Reviving Endangered or Extinct Species

- In 2009, scientists had their first near-success resurrecting an extinct animal.
    - Using goats as egg donors and surrogates, they made several clones of a wild mountain goat called the bucardo—but it died soon after birth.
- Cloning endangered species is easier than extinct species, because the surviving animals can donate healthy, living cells.
- However, the problem that endangered species face is the loss of genetic diversity, and cloning does nothing to address this problem.
- Cloning also does not address the problems of habitat destruction and hunting.

Pharming for Drug Production

- Farm animals such as cows, sheep, and goats are being genetically engineered to produce drugs or proteins that are useful in medicine.
- Just like creating animal models of disease, cloning might be a faster way to produce large herds of genetically engineered animals.

Cloning Humans

- The prospect of cloning humans is highly controversial, and it raises a number of ethical, legal, and social challenges that need to be considered.
- Even though many species have been cloned successfully, the process is still technically difficult and inefficient.
- The success rate in cloning is quite low: most embryos fail to develop, and many pregnancies end in miscarriage.
- Current efforts at human cloning are focused on creating embryonic stem cells for research and medicine.

3.3. Types of Cloning

There are three different types of cloning:

- **Gene cloning:** creates copies of genes or segments of DNA.
- **Reproductive cloning:** creates copies of whole animals.
- **Therapeutic cloning:** produces embryonic stem cells for experiments aimed at creating tissues to replace injured or diseased tissues.

3.4. Methods Used for Reproductive Cloning

Cloning Using Somatic Cell Nuclear Transfer (SCNT)

- The procedure starts with the **removal of the chromosomes** from an egg to **create an enucleated egg.**

- The chromosomes are replaced with a nucleus taken from a somatic (body) cell of the individual or embryo to be cloned. This cell could be obtained directly from the individual, from cells grown in culture, or from frozen tissue.
- The egg is then stimulated, and in some cases it starts to divide. If that happens, a series of sequential cell divisions leads to the **formation of a blastocyst,** or preimplantation embryo.
- The blastocyst is then transferred to the uterus of an animal.
- The successful implantation of the blastocyst in a uterus can result in its further development, culminating sometimes in the birth of an animal.
- This animal will be a clone of the individual that was the donor of the nucleus.
- SCNT was the method used to create Dolly the Sheep.

Cloning by Embryo Splitting

- This procedure begins with **in vitro fertilization** (IVF). The zygote divides into two and then four identical cells.
- At this stage, the cells can be separated and allowed to develop into separate but identical blastocysts, which can then be implanted in a uterus.
- The limited developmental potential of the cells means that the procedure cannot be repeated, so embryo splitting can yield only two identical individuals and probably no more than four identical humans.

3.5. The Case of Dolly

- In 1996, Ian Wilmut and his colleagues at the Roslin Institute in Edinburgh, Scotland had successfully cloned a sheep named Dolly. Dolly was the first cloned mammal.
- Wilmut and his colleagues transplanted a nucleus from a mammary gland cell of a Finn Dorsett sheep into the enucleated egg of a Scottish blackface ewe.
- The nucleus-egg combination was stimulated with electricity to fuse the two and to stimulate cell division.
- The new cell was divided and was placed in the uterus of a surrogate mother blackface ewe to develop. Dolly was born months later.
- The lamb, Dolly, was an exact genetic replica of the adult female sheep that donated the somatic cell nucleus to the egg. She was the first-ever mammal to be cloned from an adult somatic cell.

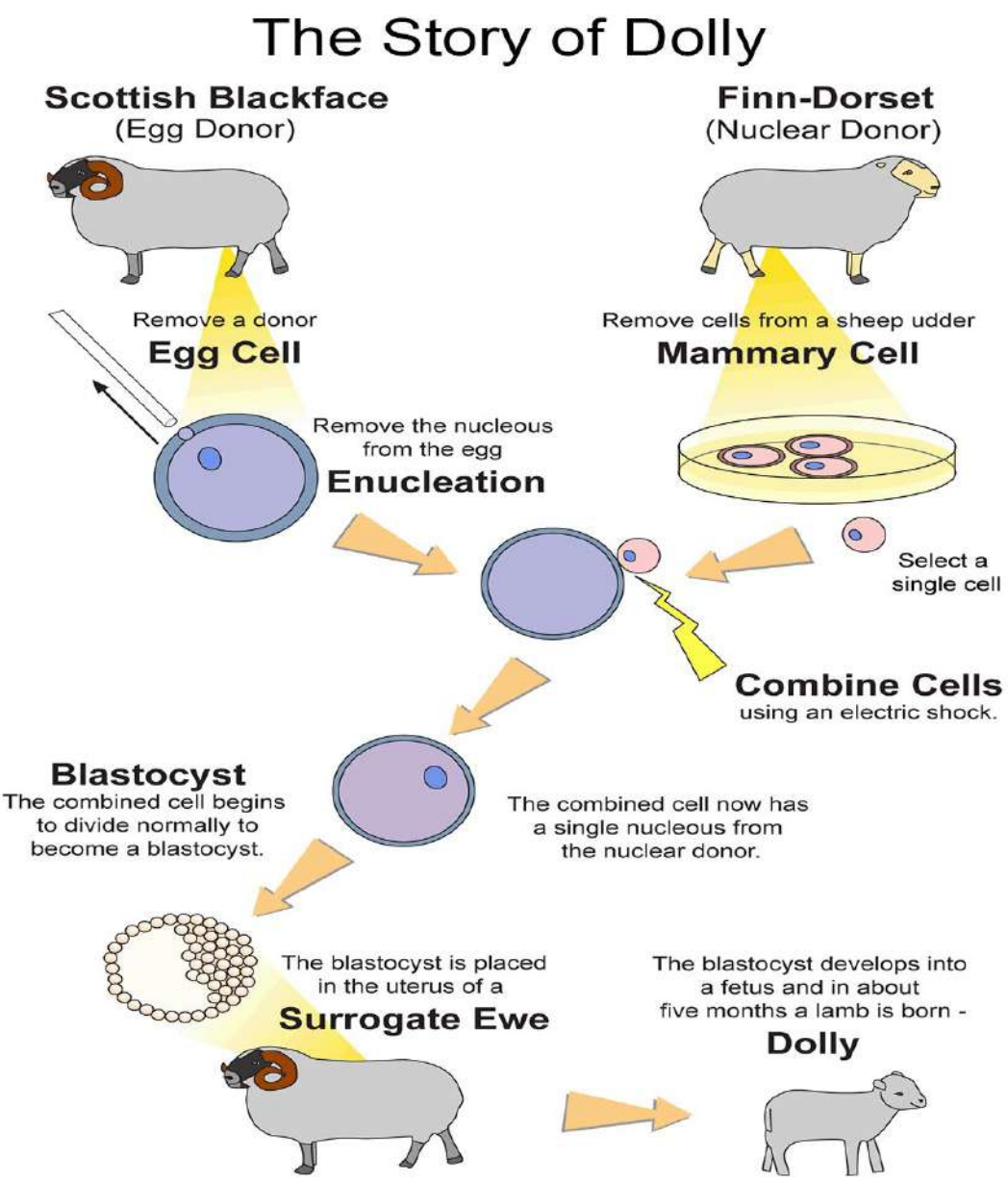


Figure.4. Production of Cloned Sheep Dolly

- **Note:** Scientists at India's National Dairy Research Institute produced the first cloned buffalo in 2009; however, the buffalo died a few days later.

3.6. Risks of Cloning

High failure rate due to one of the following reasons

- The enucleated egg and the transferred nucleus may not be compatible.
- Implantation of the embryo into the surrogate mother might fail.
- The pregnancy itself might fail.
- Problems during later development.

Large Offspring Syndrome

- Cloned animals that do survive tend to be **much bigger at birth than their natural counterparts.** This condition is called "Large Offspring Syndrome" (LOS).

- Clones with LOS have abnormally large organs. This leads to breathing, blood flow and other problems.

Telomere differences

- Cloned animals show differences in telomere length compared to naturally born animals. Therefore, they **tend to age faster.**

3.7. Ethical Issues Related to Cloning

- Reproductive cloning would present the potential of creating a human that is genetically identical to another person who has previously existed or who still exists.
    - This may conflict with long-standing religious and societal values about human dignity, possibly infringing upon principles of individual freedom, identity and autonomy.
- Therapeutic cloning, while offering the potential for treating humans suffering from disease or injury, would require the destruction of human embryos in the test tube.
    - Opponents argue that using this technique to collect embryonic stem cells is wrong, regardless of whether such cells are used to benefit sick or injured people.

India's First Cloned Desi Gir Female Calf

- Recently (March 2023), the National Dairy Research Institute (NDRI) in Karnal, Haryana, has produced India's first cloned female calf of the desi breed Gir, named 'Ganga.'
- The NDRI had initiated a project to clone indigenous cow breeds such as Gir and Sahiwal to increase milk production.
- Three animals were used for producing this calf: Oocyte was taken from the Sahiwal breed, a somatic cell from the Gir breed, and a surrogate animal was a crossbreed.

4. Therapeutic Cloning

4.1. What is Therapeutic Cloning?

- Therapeutic cloning is a technique **to produce clonal stem cells.**
- In this method, the transfer of nuclear material isolated from a somatic cell is carried out into an enucleated oocyte. This produces a clonal cell from where embryonic cell lines can be produced with the same genome as the nuclear donor.
- These embryonic cells are harvested and used for stem cell based therapies.
- While the goal of reproductive cloning is the creation of a person, the purpose of therapeutic cloning is to generate patient-specific cell lines isolated from an embryo not intended for transfer in utero.
- Therapeutic cloning offers great promises for regenerative and reproductive medicine, and in gene therapy, as a vector for gene-delivery.

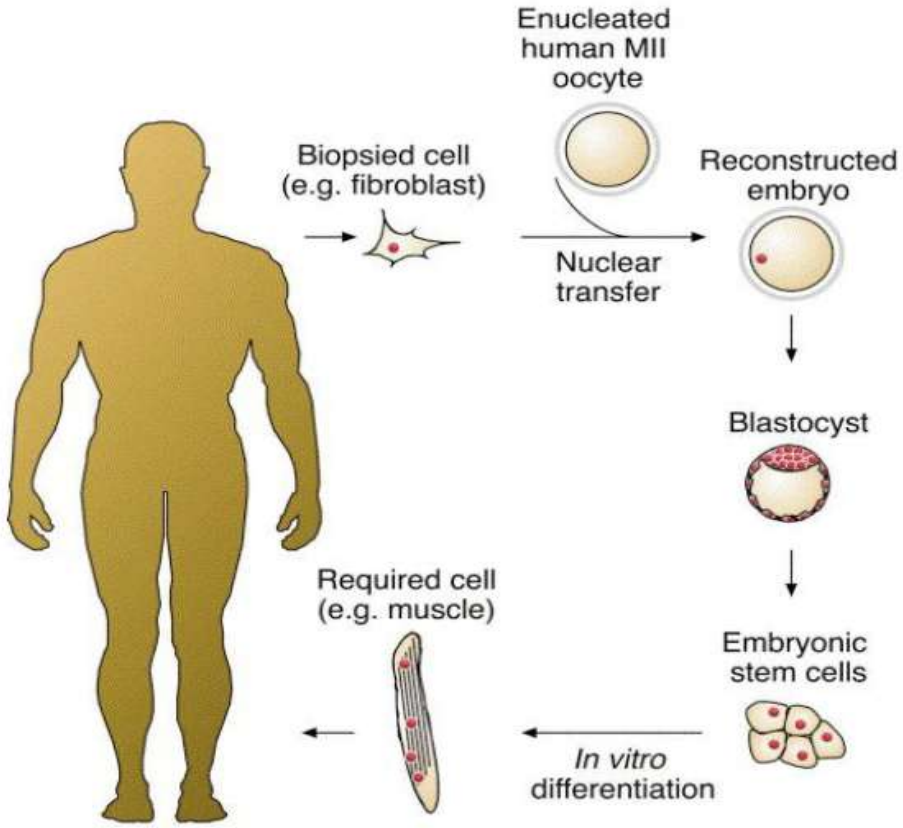


Figure.5. Therapeutic Cloning

4.2. Procedure of Therapeutic Cloning

- Nucleus is extracted from a sick person.
- The Nucleus is then inserted into an enucleated donor egg.
- The egg then divides like a typical fertilized egg and forms an embryo.
- Stem cells are removed from the embryo.
- Any kind of tissue or organ can be grown from these stem cells to treat various ailments and diseases.

4.3. Benefits

- A major benefit of therapeutic cloning is that the cells removed are pluripotent. Pluripotent cells can give rise to all cells in the body.
    - This means that pluripotent cells can potentially **treat diseases in any body organ** or tissue by replacing damaged and dysfunctional cells.
- Another advantage is that the **risk of immunological rejection is alleviated** because the patient's own genetic material is used.
- In addition, the procedure would allow scientists to create stem cell therapies that are patient specific and perfectly matched for the patient's medical condition.
- Some of the diseases that could benefit from stem cell transplants are:
    - **Parkinson's disease** - replacing destroyed brain cells with healthy ones.
    - **Type I diabetes** - providing viable functioning stem cells for the pancreas.
    - **Retinal diseases** - transplanting stem cells to replace those in the retina that have been damaged by disease.

4.4. Potential Drawbacks

- Some experts are concerned about the striking similarities between stem cells and cancer cells.
- Both cell types have the ability to proliferate indefinitely and some studies show that after 60 cycles of cell division, stem cells can accumulate mutations that could lead to cancer.
- Therefore, the relationship between stem cells and cancer cells needs to be more clearly understood if stem cells are to be used to treat human disease.

5. Stem Cells

5.1. What is a Stem Cell?

- A stem cell is a cell that is **capable of extensive proliferation,** creating more stem cells (self-renewal) as well as more differentiated cellular progeny.
- They are, in effect, a population of embryonic cells, continuously producing cells that can undergo further development within an adult organism.
- Development of the cells derived from the stem cells gives rise to the differentiated cell types.
- The stem cells possess two fundamental characteristics:
    - **Self-renewal** - the ability to go through numerous cycles of cell division while maintaining the undifferentiated state.
    - **Potency** - the capacity to differentiate into specialized cell types.

5.2. Main Potency Types of Stem Cells

The stem cell types are known on the basis of their potency. Potency means the **differentiation potential** (the potential to differentiate into different cell types) of the stem cell. The following major types of stem cells are described:

- **Totipotent stem cells** can differentiate into embryonic and extraembryonic cell types.
    - Such cells can construct a complete, viable, organism. Such cells are mostly zygotic, produced from the fusion of an egg and sperm cell. Cells produced by the first few divisions of the fertilized egg are also totipotent.
- **Pluripotent stem cells** are the descendants of totipotent cells and can differentiate into several unrelated types of cells.
- **Multipotent stem cells** can differentiate into a number of cells, but only those of a closely related family of cells.
- **Oligopotent stem cells** can differentiate into only a few cells, such as lymphoid or myeloid stem cells.
- **Unipotent cells can** produce only one cell type, their own, but have the property of self-renewal which distinguishes them from non-stem cells (e.g. muscle stem cells).

5.3. Occurrence of the Stem Cells

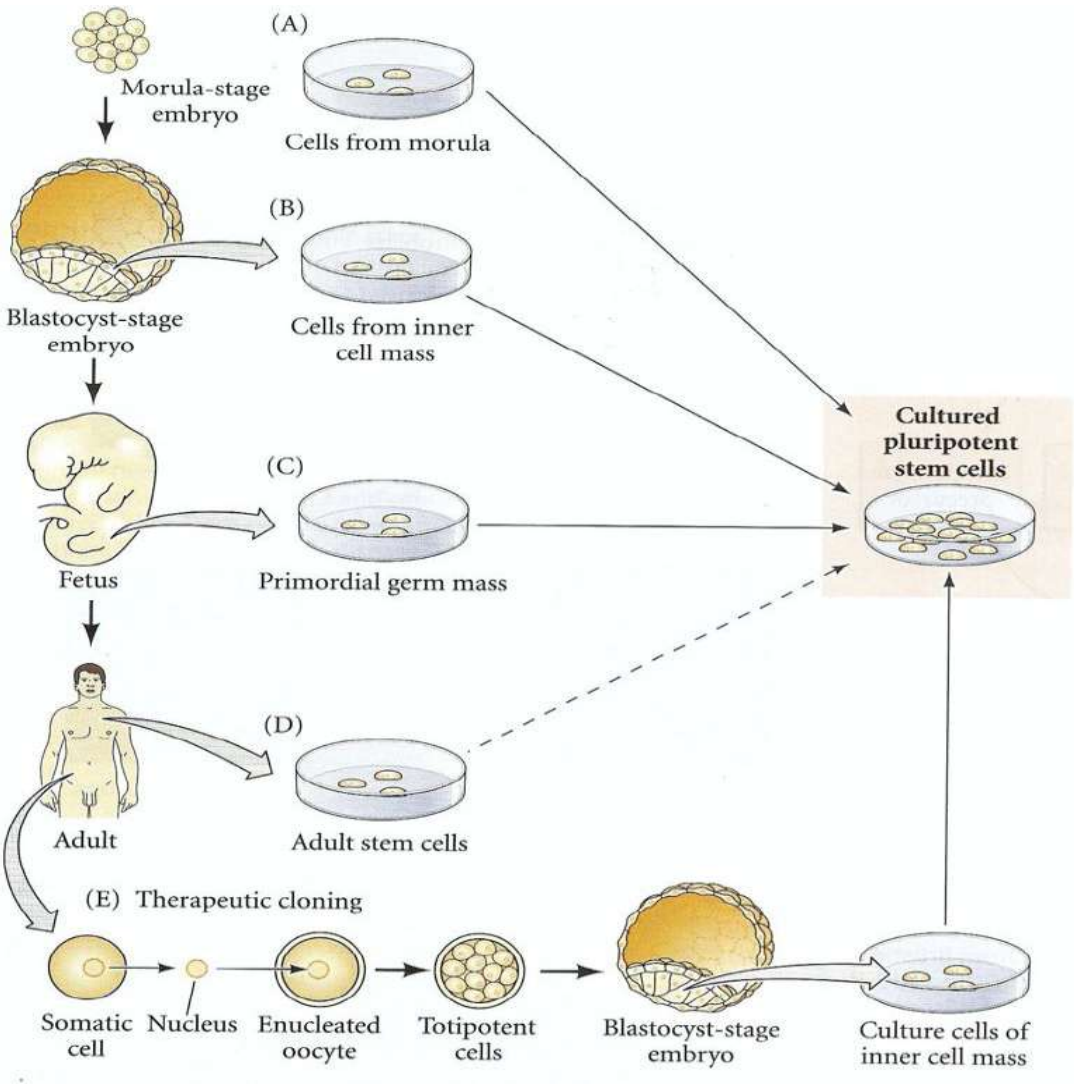


Figure.6. Sources of Stem Cells

Stem cells are found in the embryo as well as in the adult body. The important sources of stem cells are as follows:

- **Embryo:** Embryonic stem cells are derived **from the inner cell mass of a blastocyst.** They are pluripotent.
- **Foetus:** Foetal stem cells are mainly derived **from germ cells derived** from spontaneously aborted foetuses. Pluripotent stem cells are also found in the foetal brain.
- **Adult Body:** Stem cells can also be **found in small numbers** in various tissues in the adult body including brain and muscle tissues.
- **Other Sources:** Stem cells can also be obtained from other sources, for example, the **umbilical cord of a newborn baby** is a source of blood stem cells.

5.4. Induced Pluripotent Stem Cells (iPS cells)

- Induced pluripotent stem (iPS) cells are a new type of pluripotent cells that are **created by inducing the specialized cells** to express genes that are normally present in embryonic stem cells and that control cell functions.

- Embryonic stem cells and iPS cells share many characteristics, including the ability to become the cells of all organs and tissues, but they are not identical.
- iPS cells are a powerful method for creating **patient- and disease-specific cell lines** for research. These are not adult stem cells, but rather **reprogrammed cells with pluripotent capabilities.**
- iPS cells are useful tools for drug development and modeling of diseases, and scientists hope to use them in transplantation medicine.
- The Nobel Prize in Physiology or Medicine 2012 was awarded jointly to John B. Gurdon and Shinya Yamanaka for the discovery that **mature cells can be reprogrammed to become pluripotent stem cells.**

5.5. Application of Stem Cells

Treatment of Brain Diseases

- Stem cells can treat diseases such as Parkinson's disease and Alzheimer's. These can help to replenish the damaged brain cells.

Increase Understanding of How Diseases Occur

- By watching stem cells mature into cells in bones, heart muscle, nerves, and other organs and tissue, researchers may better understand how diseases and conditions develop.

Test New Drugs for Safety and Effectiveness

- Before using investigational drugs in people, researchers can use some types of stem cells to test the drugs for safety and quality.
- This type of testing will most likely first have a direct impact on drug development for cardiac toxicity testing.

Tissue Regeneration

- The stem cells can be used to grow a specific type of tissue or organ. This can be helpful in kidney and liver transplants.
- The doctors have already used the stem cells from beneath the epidermis to develop skin tissue that can repair severe burns or other injuries by tissue grafting.

Blood Disease Treatment

- The adult hematopoietic stem cells are used to treat cancers, sickle cell anemia, and other immunodeficiency diseases.
- These stem cells can be used to produce red blood cells and white blood cells in the body.

5.6. National Guidelines for Stem Cell Research

In 2017, India drafted the National Guidelines for Stem Cell Research. It was a collaborative effort of the Indian Council of Medical Research and Department of Biotechnology. The guideline focuses on:

- Monitoring mechanism and regulatory pathway for basic, clinical research and product development based on categories of research and level of manipulation.
- Procurement of gametes, embryos and somatic cells for derivation and propagation of any stem cell lines, their banking and distribution.
- Other important areas like international collaboration, exchange of cell/lines and education for stakeholders and advertisement.

1. Genetically Modified (GM) Crops

1.1. What are GM Crops?

- Plants in which one or more **genes from any other plant, animal or micro-organism have been incorporated** in their genome employing techniques of genetic engineering are referred to as transgenic plants.
- In the case of crops, transgenic plants are termed genetically modified crops or GM crops. The food prepared from GM crops is called GM food.
- The **first GM crop, an antibiotic-resistant tobacco plant**, was produced in 1982. China was the first country to commercialise transgenic plants, introducing a virus-resistant tobacco in 1992.
- Transgenic plants find use in agriculture, industry, medicine and environmental cleanup.

1.2. Features of GM Crops

Potential amenable characters which can be introduced through gene transfer to crop plants are:

- Disease resistance
- Delayed ripening of fruits
- Herbicide tolerance
- Insect pest resistance
- Drought and stress tolerance
- Production of foreign proteins
- Expression of high value products in seeds
- Efficient photosynthesis
- Production of secondary metabolites
- Improvement in vitamin A content and improvement in iron content in crops like rice
- Production of transgenics that can be used as edible vaccines
- Improvement in the content and composition (fatty acid composition) of edible oils in rapeseeds and other oilseed crops
- Improvement in the architecture, colour, fragrance and vase life of flowers of commercial value.

1.3. Traits Modified in GM Crops

Herbicide Tolerance

- The most common herbicide tolerant (HT) crops are known as Roundup Ready®, meaning they are tolerant to glyphosate (the active ingredient in Roundup herbicide).
- Roundup Ready® crops have been engineered to produce a resistant form of the enzyme, so they remain healthy even after being sprayed with glyphosate.

Insect Resistance

- Insect-resistant crops contain genes from the soil bacterium *Bacillus thuringiensis* (*Bt*).
- *Bt* produces a group of proteins known as the *Bt* toxin, which are toxic for certain insects, but do not harm beneficial insects or other animals.
- *Bt* is used as an insecticide spray in organic farming. Genes for several *Bt* toxins have been introduced into many crops by GM.

Virus Resistance

- Genetic modification has been used to resurrect the papaya industry of Hawaii as papaya ringspot virus almost destroyed its plantations in the 1990s.
- There are no known papaya varieties with natural resistance to this virus but by adding a gene to the papaya from the virus itself, resistant papaya strains were created.

1.4. Modes of Gene Transfer in Plants

Methods for plant transformation mostly utilise:

1. Direct gene transfer methods
2. *Agrobacterium* mediated transformation
3. Virus mediated gene transfer
4. Floral dip method

Of the above methods, *Agrobacterium* mediated transformation and Particle bombardment (biolistics) are the most important and most effective direct gene transfer method in regular use.

***Agrobacterium* based gene transfer**

- *Agrobacterium* is a **genus of soil borne Gram-negative bacteria** that uses horizontal gene transfer to cause tumours in plants.
- *Agrobacterium tumefaciens* is the most commonly studied species in this genus. *A. tumefaciens* causes **crown-gall disease in plants.**
- *Agrobacterium* is unique for its **ability to transfer DNA between itself and plants** (it can transfer T-DNA part of Ti plasmid to the plant), and for this reason it has become an important tool for plant improvement by genetic engineering.
- It is also called **nature's genetic engineer.** The Agrobacterium method is explained in Figure.1.

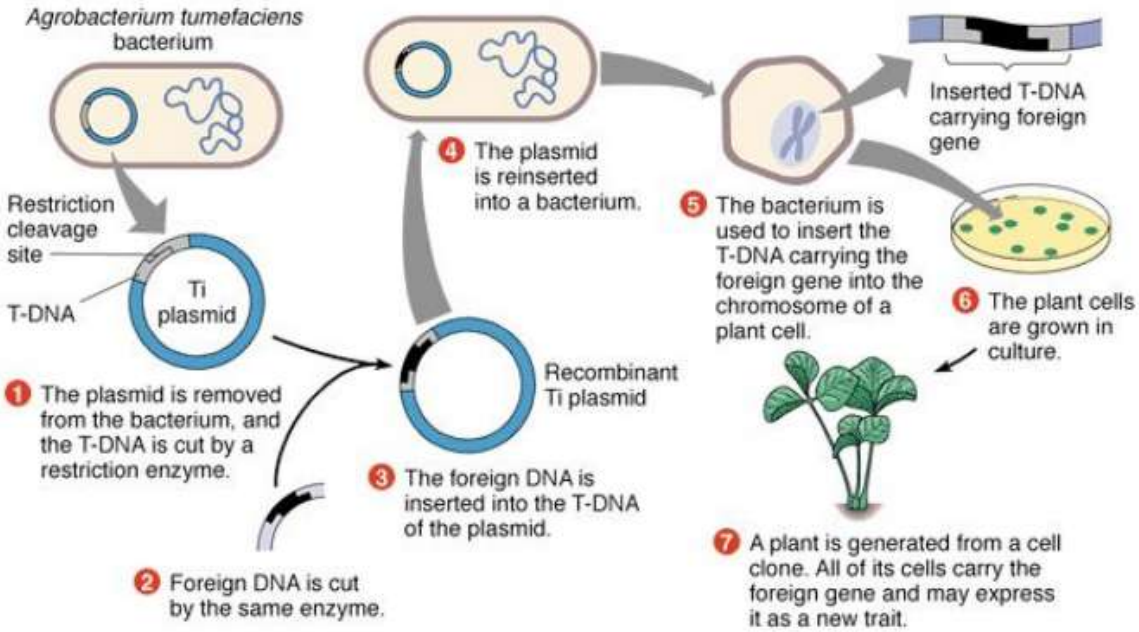


Figure.1. Agrobacterium based gene transfer method

- *Agrobacterium* does not usually infect monocot plant species, but is very effective for dicot species. *Agrobacterium* is listed as being the original source of genetic material that was transferred to these food plants:

- Soybean, Cotton, Sugar Beet, Alfalfa, Rapeseed Oil (Canola), Creeping bentgrass (for animal feed), Potato, Tobacco, Tomato and Brinjal.

Particle bombardment (biolistics)

- To genetically transform cereal crops such as rice, most varieties of wheat etc, biolistics is the most important and most effective direct gene transfer method.
- In this technique, **tungsten or gold particles are coated with the DNA** that is to be used to transform the plant tissue.
- The particles are **propelled at high speed into the target plant material,** where the DNA is released within the cell and can integrate into the genome.

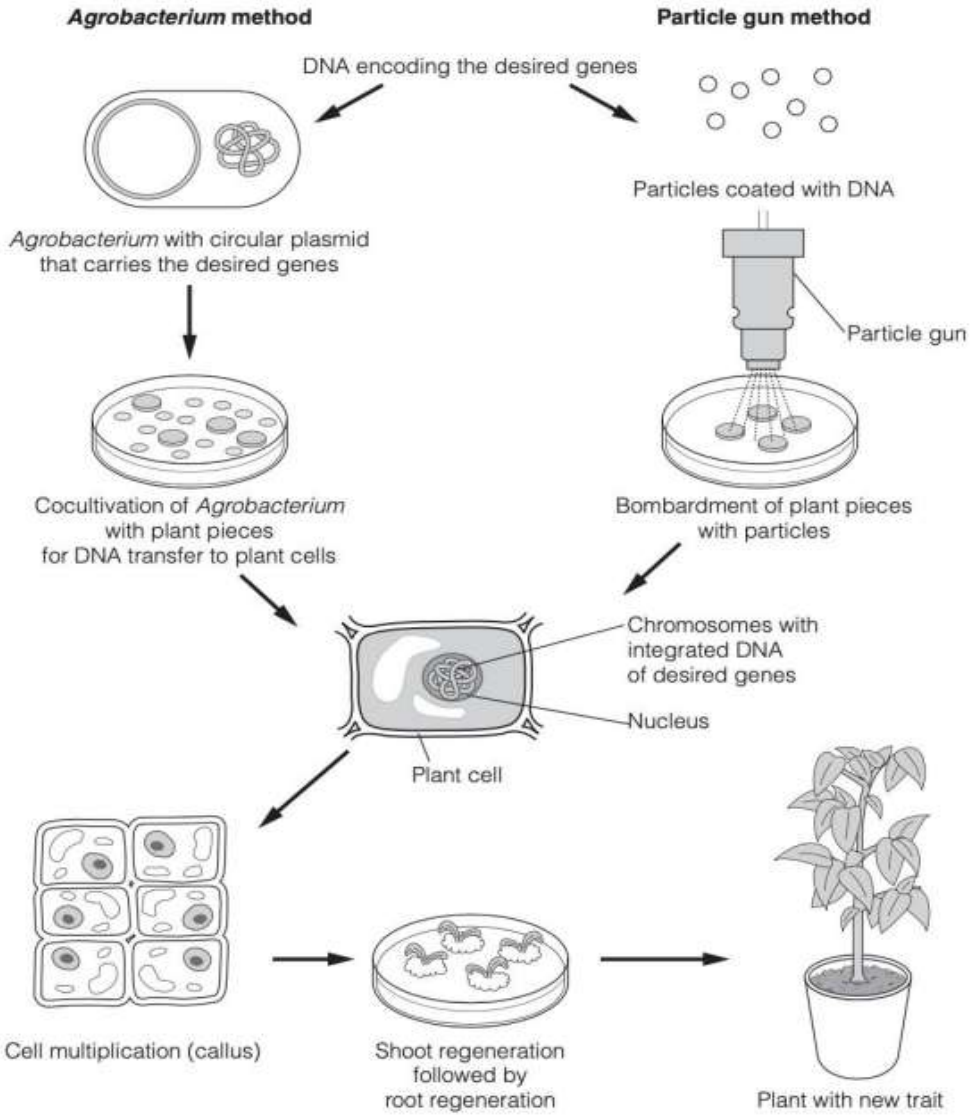


Figure.2. Plant material transformed by an *Agrobacterium* based system and by DNA from particle gun

1.5. Applications of Genetically Engineered Crops

Goal	Use	Typical Method	Examples of Crops Transformed

Herbicide Tolerance	Use of herbicides post emergence of seedlings at lower doses than required before seedling emergence	Introduce bacterial gene for enzyme which degrades the herbicide or which bypasses the point of plant metabolism inhibited	Soybean, canola, corn and cotton
Insect Resistance	Reduce losses without pesticide spraying	Insertion of gene from the bacterium *Bacillus thuringiensis* gives resistance to a range of insect pests	Corn (against European corn borer); cotton (against bollworm); potato (against Colorado beetle)
Post-harvest quality	Increasing shelf-life and reduces losses in transport and harvest	Modified activity of polygalacturonase or other ripening enzymes	Tomato
Virus resistance	Reduced losses due to viral diseases	Insertion of viral coat protein gene into plant	Tobacco (tobacco mosaic virus); potato (potato viruses X and Y)

1.6. Near future possibilities of genetically engineered crops

Goal	Application
Salinity tolerance	Increased crop yield in areas affected by salinity (e.g. in long-term irrigation)
Drought tolerance	Increased crop yield in marginal, semi-arid zones
Waterlogging tolerance	Improved survival in temporary flooding
Enhanced flavour, storage and properties	Improved consumer acceptance; decreased losses; decreased energy inputs to processing or storage; enhanced product value or usefulness
Enhanced amino acid content	Dietary improvement and health
Antibody and pharmaceutical production	Less energy input and cost than use of animal cell culture
Improved disease resistance	Reduced pesticide inputs; increased yields mean population can be fed using smaller land area

2. Areas of concern

There are several areas of concern regulating the use of genetically modified foods. This includes toxicity, allergenicity, cariogenicity, food intolerance and nutritional value. The important issues of concern are as follows:

- **Unnecessary interference** with biological states or processes that have naturally evolved over long periods of time.
- **Limitations of modern science** to fully comprehend all of the potential negative ramifications of genetic manipulation.
- The **safety concerns** of GMOs in the food chain, with issues such as the possibilities that GMOs could introduce new allergens into foods, or contribute to the spread of antibiotic resistance.
- Conventionally-bred crop plants can be cross-pollinated (bred) from the pollen of modified plants.
- GMOs, being better adapted and sometimes more stress and disease tolerant, can grow in a community as an **invasive species** and thus threaten the diversity of the ecosystem.
- Promotion of **unsustainable practices** such as overuse of herbicide, which has been taking place after development of herbicide-tolerant plants (which can withstand the overspray of herbicides).

Additionally, various arguments against herbicide-tolerant transgenics in crop plants have come up lately:

- Use of herbicide-tolerant transgenic crops can lead to **transfer of herbicide-tolerant genes** to sexually compatible wild relatives or weeds, which can be a major potential threat to the environment.
- Transgenic crops **can create "superweeds".**
- It would actually **increase the dependence** on a few herbicides rather than reducing herbicide usage.
- It may increase the **problem of weed control** if weeds develop resistance to such herbicides through gene flow from transgenic crops.
- Herbicide tolerance is being sought not only for environmentally comparatively acceptable herbicides but also for older, more toxic and persistent products.
- Non-chemical means of weed control, such as crop rotation, dense plantings, cover cropping, ridge tillage, and others, however labour-intensive for farmers, are preferable than the use of any herbicide at all. Gene flow is the primary risk in releasing transgenic plants.

3. Cultivation of GM Crops in India

3.1. Introduction

- *Bt* cotton is the **only GM crop** that has been **approved for commercial cultivation in 2002** by the Government of India.
- Long term studies were conducted by ICAR on the impact of *Bt* cotton which did not show any adverse effect on soil, microflora and animal health.

- The Parliamentary Standing Committee on Science and Technology, Environment and Forests, submitted a **report on 'Genetically modified crops and its impact on environment'** to Parliament on August 25, 2017.
- The report recommended that GM crops should be introduced in the country only after critical scientific evaluation of its benefit and safety, and also recommended restructuring of the regulatory framework for unbiased assessment of GM crops.

3.2. *Bt* Cotton

- In 2002 approval for the commercial release of *Bt* cotton hybrids/ varieties **resistant to cotton bollworm** was given by the Genetic Engineering Appraisal Committee (GEAC).
- The **Herbicide Tolerant *Bt* (HT*Bt*) cotton** is another variant of *Bt* cotton. This variant adds **another layer of modification,** making the plant resistant to the herbicide glyphosate. However, it has not been approved by regulators.
    - Fears include glyphosate having a carcinogenic effect, as well as the unchecked spread of herbicide resistance to nearby plants through pollination, creating a variety of superweeds.
- Also, *Bt* cotton has little effect on cotton yield, and although it may have led to an initial reduction in insecticide use, this effect is now diminishing due to insecticide-resistance in insect populations.

3.3. *Bt* Brinjal

- *Bt* Brinjal **resistant to brinjal shoot fly** was approved by GEAC in 2009 but due to a **10 years moratorium** imposed on GM crops by the Technical Expert Committee (TEC) appointed by the Supreme Court of India, no further action on commercialization has been taken.
- In 2020, the GEAC has again allowed biosafety research field trials of two new transgenic varieties of indigenously developed *Bt* Brinjal in eight states (during 2020-23).
    - This has been allowed only after taking no-objection certificate (NOC) from states concerned and confirmation of availability of isolated stretch of land for this purpose.
- These indigenous transgenic varieties of brinjal hybrids – namely **Janak and BSS-793, containing *Bt Cry*1Fa1 gene** (Event 142) – have been developed by the National Institute for Plant Biotechnology, ICAR.

3.4. Dhara Mustard Hybrid-11 (DMH-11)

- The GEAC has in 2022 approved the environmental release of Dhara Mustard Hybrid-11 (DMH-11), a genetically-engineered variant of mustard.
- If approved for commercial cultivation it would be the first genetically modified food crop available to Indian farmers.

3.4.1. What is DMH-11?

- DMH-11 is a hybrid variant of mustard developed by researchers at The Centre for Genetic Manipulation of Crop Plants, University of Delhi.
- DMH-11 (where 11 refers to the number of generations after which desirable traits manifest) is a **result of a cross between two varieties: Varuna and Early Heera-2.**
- This cross was done after introducing genes from two soil bacterium called **barnase and barstar.**

- Barnase in Varuna induces a temporary sterility because of which it can't naturally self-pollinate. Barstar in Heera blocks the effect of barnase allowing seeds to be produced. The result is DMH-11 that not only has better yield but is also fertile.

3.4.2. Are hybrid mustard varieties better?

- Trials conducted over three years by the Indian Council of Agricultural Research (ICAR) suggest that DMH-11 has 28% higher yields than its parent Varuna and was 37% better than local varieties.
- DMH-11 signals the proof of success of the barnase-barstar system that can act as a platform technology to develop newer hybrids.
- Having better hybrids is necessary to meet India's rising edible-oil import bill.

3.4.3. Controversy

- Use of genes that are foreign to the species.
- Preparation of mustard hybrids requires the use of another gene, called the bar gene, that makes it tolerant to a herbicide called glufosinate-ammonium.
- GM mustard plants may dissuade bees from pollinating the plant.

3.4.4. What next for GM mustard?

- In 2017 too, GEAC had cleared the environmental release of GM mustard but the process stalled after a case was lodged in the Supreme Court.
- The Ministry of Environment, Forest and Climate Change has not officially supported GM mustard despite the GEAC being a body under it.
- The GEAC go-ahead only allows DMH-11 to be grown in fields under the supervision of the ICAR.
- The crop would be commercially available after "three seasons" now that they can be grown in large quantities for evaluation.

4. Biosafety Aspects

4.1. What is Biosafety?

Biosafety is a broad term and its means 2 things:

- **In general practice:** Biosafety is the safe working practices associated with handling of biological materials, particularly infectious agents.
- **In the context of biological diversity:** Biosafety refers to protecting the native biological diversity from aggressive invasive species including living-modified organisms.

Its main objective is to keep a check on harmful biological agents, toxins, chemicals, and radiation.

4.2. Biosafety Aspects of GM Crops in India

- The Government of India has very strict guidelines to test and evaluate the agronomic value of the GM crops so as to protect the interests of the farmers. These guidelines address all concerns with regard to the safety of GM seeds.
- The regulatory system for GM crops as operative in the Department of Biotechnology, Ministry of Science and Technology and Ministry of Environment and Forests has guidelines to consider the GM crops on a case-by-case basis towards testing.

4.2.1. Genetic Engineering Appraisal Committee (GEAC)

- Genetic Engineering Appraisal Committee (GEAC) has its primary responsibility in the field of ensuring biosafety.

- It works **under the Ministry of Environment, Forests and Climate Change (MoEFCC).**
- The Committee functions as a **Statutory Body** for approval of activities involving large-scale use of hazardous living microorganisms and recombinants in research and industrial production from the environmental angle **as per the provisions of rules 1989.**
- The Committee is responsible for approval of proposals relating to release of genetically engineered organisms and products into the environment including experimental field trials as per the provisions of Rules, 1989.
- The Committee is also responsible for approval of proposals involving the use of living modified organisms (LMOs) falling in the risk category III and above in the manufacture/import of recombinant pharmaceutical products or where the end product of the recombinant pharmaceutical products per se are LMOs.

Main functions of GEAC

- To permit the use of GMOs and products thereof for commercial applications.
- To adopt producers for restriction or prohibition, production, sale, import & use of GMOs both for research and applications under the Environment Protection Act (EPA), 1986.
- To approve for conduct of large scale field trials, evaluation of large scale field trial data and final approval for release of transgenic crops into the environment.
- To authorise large scale production and release of GMOs and products thereof into the environment.
- To authorise agencies or persons to have powers to take punitive actions under the EPA.

4.2.2. Rules 1989

- For facilitating and regulating the research work on GMOs & products thereof at laboratory scale and also in commercial applications, the Government of India notified **" Rules for the Manufacture/Use/Import/Export and Storage of Hazardous Microorganisms, Genetically Engineered Organisms or Cells " in 1989** under the provisions of Environment (Protection) Act, 1986 through the Ministry of Environment & Forests (MoEF). These rules are commonly referred to as ' Rules 1989'.
- These rules are **implemented by MoEFCC, the Department of Biotechnology** (DBT), Ministry of Science and Technology **and the State Governments** through the six competent authorities notified under the Rules which are as follows:
    a. Recombinant DNA Advisory Committee (RDAC)
    b. Institutional Biosafety Committee (IBSC)
    c. Review Committee on Genetic Manipulation (RCGM)
    d. Genetic Engineering Appraisal Committee (GEAC)
    e. State Biotechnology Coordination Committee (SBCC)
    f. District Level Committee (DLC).

Scope of Rules, 1989

- These rules are very broad in scope essentially covering the entire spectrum of activities involving GMOs and products thereof.
- They also apply to any substances, cells, tissues, products, and foodstuffs, etc.
- New gene technologies apart from genetic engineering have also been included.

Mandate of Rules, 1989

- In accordance with Rules, RCGM shall function from the Department of Biotechnology to monitor the safety-related aspect in respect of ongoing research projects or activities involving hazardous microorganisms, GE organisms and cells and products thereof.
- RCGM shall bring out manuals of guidelines specifying procedure for regulatory process with respect to activities involving GE organisms in research use as well as industrial & environmental applications with a view to ensure human health and environmental safety.
- All ongoing research projects involving hazardous microorganisms, GE organisms or cells and products thereof shall be reviewed to ensure that adequate precautions and containment conditions are being met.
- RCGM shall lay down procedures restricting or prohibiting the production, sale, importation and use of such hazardous microorganisms, GE organisms or cells.

4.3. Cartagena Protocol on Biosafety

- Cartagena Protocol on Biosafety is a **legally binding,** international agreement, **supplemental to the Convention on Biological Diversity.**
- The Protocol seeks to protect biological diversity by managing the movements of Live Modified Organisms (LMOs) between countries.
- The objective of the Cartagena Protocol is **to contribute to ensuring an adequate level of protection** in the field of the safe transfer, handling and use of LMOs resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focusing on transboundary movements.
- It was **adopted on 29 January 2000** as a supplementary agreement to the CBD and **entered into force on 11 September 2003.**
- **India is a signatory** to the Cartagena Protocol on Biosafety and ratified it on January 23, 2003.

What does the Biosafety Protocol do?

- It establishes an **Advance Informed Agreement (AIA)** procedure for ensuring that countries are provided with the information necessary to make informed decisions before agreeing to the import of such organisms into their territory.
- It contains the precautionary approach of the Rio Declaration on Environment and Development.
- The Protocol provides for practical requirements that are deemed to contribute to the safe movement of LMOs.
- The Protocol also establishes a **Biosafety Clearing-House (BCH)** to facilitate the exchange of information on living modified organisms and to assist countries in the implementation of the Protocol.

1. Concept of Intellectual Property Rights (IPR)

- Intellectual property (IP) refers to **creations of the mind:** inventions, literary and artistic works, and symbols, names, images, and designs used in commerce.
- IPRs are **central to encouraging investment** in research as without some form of protection, investors and inventors would not be able to benefit from their creative efforts.

2. Types of IPR

Types	Details
1. Patents	**An exclusive right granted for an invention.** A patent provides the patent owner with the right to decide how - or whether - the invention can be used by others.
2. Copyright	A legal term used to describe the rights that creators have over their **literary and artistic works.**
3. Trademarks	It is a sign capable of distinguishing the goods or services of one enterprise from those of other enterprises.
4. Industrial Designs	An industrial design constitutes the **ornamental or aesthetic aspect** of an article. It protects that appearance or aesthetic style.
5. Geographical indications	Signs used on goods that have a specific geographical origin and possess qualities, a reputation or characteristics that are essentially attributable to that place of origin.
6. Trade Secrets	A trade secret is a **formula, practice, process, design or compilation of information** used by a business to obtain an advantage over competitors. The unauthorized acquisition, use or disclosure of such secret information is regarded as an unfair practice.

3. International Arrangements for IPR

3.1. World Intellectual Property Organization (WIPO)

3.1.1. About WIPO

- The World Intellectual Property Organization is the **United Nations agency** dedicated to the use of intellectual property (patents, copyright, trademarks, designs, etc.) as a means of stimulating innovation and creativity.
- It was **created in 1967** and **headquartered in Geneva, Switzerland.**
- WIPO currently has **193 member states. India became a member of WIPO in 1975.**

- It publishes the **Global Innovation Index,** an annual ranking of countries by their capacity for, and success in innovation.

3.1.2. Objectives

WIPO's two main objectives are:

- To promote the protection of intellectual property worldwide.
- To ensure administrative cooperation among the intellectual property Unions established by the treaties that WIPO administers.

3.1.3. Decision-making Structures

- The terms governing WIPO's mandate, functions, finances and procedures are set out in the WIPO Convention.
- All decisions governing WIPO's strategic direction and activities are made by the member states.
- The WIPO Secretariat coordinates formal and informal meetings of the member state bodies throughout the year.
- It **administers 26 treaties** including the WIPO Convention.

3.1.4. WIPO Convention

The Convention establishing the World Intellectual Property Organization (WIPO), **concluded in Stockholm on July 14, 1967** (Article 2(viii)) provides that intellectual property shall include rights relating to:

- literary, artistic and scientific works,
- performances of performing artists, phonograms and broadcasts,
- inventions in all fields of human endeavor,
- scientific discoveries,
- industrial designs,
- trademarks, service marks and commercial names and designations,
- protection against unfair competition,
- all other rights resulting from intellectual activity in the industrial, scientific, literary or artistic fields.

3.2. Trade Related Intellectual Property Rights (TRIPS)

3.2.1. Introduction

- TRIPS is the most important and comprehensive international agreement on intellectual property rights which **came into effect on 1 January 1995.**
- The Agreement on TRIPS was negotiated with other international trade agreements during the **Uruguay Round trade negotiations of the GATT** (General Agreement on Tariffs and Trade) **from 1986 to 1994.**
- As one of the World Trade Organization (WTO) agreements, it is totally **binding for all WTO Member States.**
- The Agreement covers most forms of intellectual property including patents, copyright and related rights (i.e. the rights of performers, producers of sound recordings and broadcasting organizations), industrial designs, trademarks, geographical indications, trade secrets, exclusionary rights over new plant varieties, etc.
- The **TRIPS Council** is responsible for **administering and monitoring the operation** of the TRIPS Agreement. In its regular meetings, the TRIPS Council serves as a forum for discussion between members on key issues.

3.2.2. Main Features of the Agreement

Standards

- In respect of each of the main areas of intellectual property covered by the TRIPS Agreement, the Agreement sets out the minimum standards of protection to be provided by each Member.
- Each of the main elements of protection is defined, namely the subject-matter to be protected, the rights to be conferred and permissible exceptions to those rights, and the minimum duration of protection.
- The Agreement sets these standards by requiring, first, that the substantive obligations of the main conventions of the WIPO, the Paris Convention for the Protection of Industrial Property (Paris Convention) and the Berne Convention for the Protection of Literary and Artistic Works (Berne Convention) in their most recent versions must be complied with. The TRIPS Agreement is thus sometimes referred to as a Berne and Paris-plus agreement.

Enforcement

- The Agreement lays down certain general principles applicable to all IPR enforcement procedures.
- In addition, it contains provisions on civil and administrative procedures and remedies, provisional measures, special requirements related to border measures and criminal procedures, which specify, in a certain amount of detail, the procedures and remedies that must be available so that right holders can effectively enforce their rights.

Dispute settlement

- The Agreement makes disputes between WTO members about the respect of the TRIPS obligations subject to the WTO's dispute settlement procedures.
- The obligations under the Agreement will apply equally to all member countries, but developing countries have a longer period to phase them in.
- The TRIPS Agreement is a minimum standards agreement, which allows members to provide more extensive protection of intellectual property if they so wish.
- Members are left free to determine the appropriate method of implementing the provisions of the Agreement within their own legal system and practice.

3.2.3. Substantive standards of protection under TRIPS

Copyright

- It gives the creators of a wide range of material, such as literature, art, music, sound recordings, films and broadcasts, economic rights enabling them to control use of their material in a number of ways, such as by making copies, issuing copies to the public, performing in public, broadcasting and use on-line.
- It also gives moral rights to be identified as the creator of certain kinds of material, and to object to distortion or mutilation of it.
- The purpose of copyright is to allow creators to gain economic rewards for their efforts and so encourage future creativity and the development of new material which benefits us all.
- However, copyright protection extends to expressions and not to ideas, procedures, methods of operation or mathematical concepts as such.
- **Computer programs,** whether in source or object code, **are protected as literary works.**

- Databases are eligible for copyright protection provided that they by reason of the selection or arrangement of their contents constitute intellectual creations.

Related rights

- The provisions on protection of performers, producers of phonograms and broadcasting organizations constitute the related rights.
- Performers shall have the possibility of preventing the unauthorized fixation of their performance on a phonogram (e.g. the recording of a live musical performance).
- The fixation right covers only aural, not audiovisual fixations.
- Broadcasting organizations have the right to prohibit the unauthorized fixation, the reproduction of fixations, and the rebroadcasting by wireless means of broadcasts, as well as the communication to the public of their television broadcasts.
- The term of protection is **at least 50 years for performers and producers of phonograms, and 20 years for broadcasting organizations.**

Trademarks

- The system helps consumers identify and purchase a product or service because its nature and quality, indicated by its unique trademark, meets their needs.
- Trademark provides protection to the owner of the mark by ensuring the exclusive right to use it, to identify goods or services, or to authorize another to use it in return for payment.
- The period of protection varies, but a trademark can be renewed indefinitely beyond the time limit on payment of additional fees.
- Trademark protection is enforced by the courts, which in most systems have the authority to block trademark infringement.
- Trademarks may be **one or a combination of words, letters, and numerals.**
- They may consist of drawings, symbols, three- dimensional signs such as the shape and packaging of goods, audible signs such as music or vocal sounds, fragrances, or colors used as distinguishing features.

Patent

- Patent **protects new inventions** and covers how things work, what they do, how they do it, what they are made of and how they are made.
- If a patent application is granted, it gives the owner the **ability to take a legal action under civil law** to try to stop others from making, using, importing or selling the invention without permission. This may involve suing the alleged infringer through the courts.
- The TRIPS Agreement requires member countries to make patents available for any inventions, whether products or processes, in all fields of technology without discrimination, subject to the normal tests of novelty, inventiveness and industrial applicability.

There are three permissible exceptions to the basic rule on patentability:

- One is for **inventions contrary to ordre public or morality**-this explicitly includes inventions dangerous to human, animal or plant life or health or seriously prejudicial to the environment.
- The second exception is that **members may exclude from patentability diagnostic, therapeutic and surgical methods** for the treatment of humans or animals.

- The third is that members may exclude plants and animals other than micro-organisms and essentially biological processes for the production of plants or animals other than non-biological and microbiological processes.
- Any country excluding plant varieties from patent protection must provide an effective *sui generis* system of protection. (Article 27.3 (b).

Geographical Indication (GI)

- A geographical indication is a **sign used on goods that have a specific geographical origin** and possess qualities, reputation or characteristics that are essentially attributable to that place of origin.
- Most commonly, a geographical indication includes the name of the place of origin of the goods.
- Agricultural products typically have qualities that derive from their place of production and are influenced by specific local factors, such as climate and soil.
- Whether a sign is recognized as a geographical indication is a matter of national law.
- Geographical indications may be used for a wide variety of products, whether natural, agricultural or manufactured.

Industrial Designs

- Articles 25 and 26 of the agreement says members must ensure that **fresh or unique industrial designs generated independently are protected.**
- The Agreement promises to preserve industrial designs for a **minimum of 10 years.**
- When such activities are conducted for commercial objectives, the right holder can ban third parties who do not have the holder's agreement from producing, importing or selling items that incorporate the protected design.

Layout-Designs of Integrated Circuits

- TRIPS Agreement requires Member countries to protect the layout-designs of integrated circuits in accordance with the provisions of the IPIC Treaty (the Treaty on Intellectual Property in Respect of Integrated Circuits), negotiated under the auspices of WIPO in 1989.
- These provisions deal with, inter alia, the **definitions of "integrated circuit" and "layout-design (topography)",** requirements for protection, exclusive rights, and limitations, as well as exploitation, registration and disclosure.

Protection of Undisclosed Information

- Article 39 of the Agreement requires member states to provide trade secret protection in accordance with the Agreement's provisions.
- TRIPS mandates that member countries should create national legislation to prevent such information from being revealed to, obtained by, or used by third parties without the agreement of the person who is lawfully in possession of it, in a manner that is inconsistent with fair trade practices.
- Such information must be confidential, have commercial value as a result of its confidentiality, and have been subjected to reasonable efforts to keep it hidden in order to be granted protection.

Control of Anti-competitive Practises in Contractual Licenses

- The TRIPS Agreement recognizes some licensing practices or conditions pertaining to intellectual property rights which restrain competition may have adverse effects on trade and may impede the transfer and dissemination of technology.
- Member countries may adopt, consistently with the other provisions of the Agreement, appropriate measures to prevent or control practices in the licensing of intellectual property rights which are abusive and anti-competitive.

3.3. Plant Breeder's Rights

- Plant breeder's rights came into international discourse in the 1960s, when improved varieties of crop plants began to usher several developed and developing nations in the era of high farm productivity or Green Revolution.
- Plant Breeders' Rights offers legal protection for the investment plant breeders make in breeding and developing new varieties.
- This protection is open to breeders of any species of plant; agricultural, horticultural and ornamental.
- Plant Breeders' Rights are thus a form of intellectual property designed specifically to protect new varieties of plants.

UPOV

- The **International Union for the Protection of New Varieties of Plants**, known as “UPOV,” is an intergovernmental organization with **headquarters in Geneva.**
- The mission of UPOV is to provide and promote an effective system of plant variety protection, with the aim of encouraging the development of new varieties of plants, for the benefit of society.
- It was established by the International Convention for the Protection of New Varieties of Plants (the “UPOV Convention”), which was **signed in Paris in 1961.**
- The Convention entered into force in 1968. It was revised in Geneva in 1972, 1978 and 1991. The 1991 Act **entered into force on April 24, 1998.** This is the presently accepted version of the UPOV Convention.
- The purpose of the UPOV Convention is to ensure that the members of the Union acknowledge the achievements of breeders of new varieties of plants, by granting to them an intellectual property right, on the basis of a set of clearly defined principles.
- To be eligible for protection, varieties have to be (i) distinct from existing, commonly known varieties, (ii) sufficiently uniform, (iii) stable and (iv) new in the sense that they must not have been commercialized prior to certain dates established by reference to the date of the application for protection.
- The UPOV Convention sets out a minimum scope of protection and offers members the possibility of taking national or regional circumstances into account in their legislation.

4. Indian Patent Act, 1970

- The Indian Patent Act (IPA) 1970 which **came into force in 1972** was in many ways a watershed in the history of the patent system.
- It not only disallowed the grant of product patents in the highly sensitive and socially relevant health sector, but also **restricted the validity period for process patents in**

these sectors to seven years from the date of filing or five years from the date of sealing whichever was earlier.

- Since the period required for discovering and developing a new drug is not less than 10 years, the provision for process patent with the shortened period of validity had made the system itself redundant.
- The consequence of such a radical change in the Indian patent system led to a major shift in the nature and character of the Indian industry.
- Many foreign companies discouraged by the provisions of IPA 1970 and the Foreign Exchanges Regulation Act (FERA) which allowed new investments only for companies with a foreign equity holding of 40 per cent or less opted not to operate in India.
- If India today is an accepted leader in the production of generic drugs of high quality to meet the needs of practically all the global markets, the credit should go to this piece of legislation.
- In fact, within a decade of IPA 1970, the pecking order of the Indian industry changed wholly with Indian companies occupying seven of the top ten positions, a reversal of the pre-1970 era.

4.1. The Patents Act, 1970 (as amended up to 2005)

- Through the **three amendments** to the Patents Act, 1970, India has made the India Patent Laws, **TRIPS compliant,** substantially.
- Of these the most important amendment is the inclusion of food, pharma and chemical industry within the ambit of patent protection for both process and product.
- It may be recalled that the **original Patents Act, 1970** had kept these three sectors out of product patenting and they were given a rather brief period of process patent protection.
- The Act also introduced a section which deals with compulsory licensing of pharmaceuticals for export purposes.
- This is meant to facilitate the Indian industry to continue supplying cheaper generic versions of patented drugs to those least developed countries that do not have adequate domestic manufacturing capabilities.

The Novartis case

- Novartis v. Union of India & Others was a landmark case, which was heard by a two-judge bench of the Supreme Court of India. The matter pertained to the issue of evergreening of pharmaceutical patents.
- The decision in the matter was pronounced on April 01, 2013, thus culminating a seven-year-long litigation fought by Novartis for the **granting of an Indian patent on imatinib mesylate in beta crystalline form.**
- A patent, as desired by Novartis, would have restrained Indian generic pharmaceutical manufacturers from producing drugs based on the compound.
- However, the Supreme Court decided that the substance which Novartis sought to patent is already known and thus does not qualify the test of invention as laid down in **section 2(1)(j) and section 2(1)(ja)** of the Indian Patent Act, 1970 (as amended in 2005). As a result, the Court rejected the patent application.
- Essentially, the Supreme Court upheld the Intellectual Property Appellate Board's decision to deny patent protection to Novartis's application covering a beta crystalline form of

imatinib —the medicine Novartis brands as Glivec, and which is very **effective against the form of cancer known as chronic myeloid leukaemia** (CML).

- The decision came as a decisive blow to Novartis, which attempted monopolising the Indian market for Imatinib - a widely used drug to check the spread of a specific type of Leukaemia.

Significance of the Judgement

- The significance of the Supreme Court judgment on Novartis's patent application lies in restoring the connection between patents and innovation by upholding and legitimizing a regime with a higher threshold of inventiveness.
- The decision for the **first time tested the validity and ambit of section 3(d)** of the Indian Patent Act which prevents the grant of a patent for new forms of known substances, unless the applicant can establish the new form demonstrates an increased efficacy.
- The decision also ensures steady availability of low cost generic versions of life saving drugs based on imatinib or imatinib mesylate polymorphs.

4.2. Compulsory Licensing & The Nexavar case

Compulsory License

- Compulsory licenses are generally defined as authorizations permitting a third party to make, use, or sell a patented invention without the patent owner's consent.
- In 2012, Patent office issued India's first Compulsory license (CL) to Natco for Nexavar - sorafenib tosylate, an anti-cancer drug produced by Bayer

Laws prevailing with respect to the Compulsory license: Patents Act, 1970

- **As per Section 84,** any person who is interested can make a request for grant of Compulsory Licence on patent after three years from the date of grant of that patent on the condition that the reasonable requirements of the public with respect to the patented invention have not been satisfied, or that the patented invention is not available to the public at a reasonably affordable price, or that the patented invention is not worked in the territory of India.

The Nexavar Case

- The Intellectual Property Appellate Board (IPAB) in March 2013 upheld the grant of compulsory licence (CL) to the Hyderabad-based Natco Pharma Limited, a generic drug maker, **to produce and market Sorafenib,** a patented cancer drug of multinational pharma major Bayer Corporation sells under the brand name Nexavar. The order paved the way for reduction in the prices of costly life saving drugs.
- Disposing an appeal filed by Bayer Corporation, the Board held that various international conventions and Indian laws allowed the member countries to grant such compulsory licence in order to make life-saving medicine cheaply available to the public.
- As per the licence conditions imposed by Controller, Natco had to pay a six per cent royalty to Bayer from the sales of generic drug Sorafenib. Modifying this, the IPAB directed Natco to pay seven percent royalty.

A short background

- The case involves a drug called Sorafenib, used to treat advanced liver and kidney cancer to extend the life of a patient.
- The patent — both in India and in the United States — for the drug is held by the multinational company, Bayer Corporation. Bayer obtained a patent in India in 2008.

- **Nexavar costs Rs. 2.8 lakh for a pack of 120 tablets,** equivalent to a month's dosage. The drug is a blessing for such patients to extend their life expectancy. But, the availability of the drug from Bayer at a selling price of Rs. 2.8 lakh for a month's dose is too exorbitant for India.
- On March 9, 2011, the Controller of Patents, Mumbai, granted the first-ever compulsory license to Natco to make 'sorafenib tosylate', a generic version of Bayer's high-priced anti-cancer drug Nexavar. **Natco was told to sell the pack at Rs. 8,800.**
- Bayer then appealed against the Controller's order before the IPAB. Among other reasons, it contended that Cipla had started selling its generic version at a lower price, rendering the compulsory licence unnecessary as the drug was available at a reasonable price.
- Upholding the compulsory license, the IPAB pointed out that even after obtaining a patent, Bayer had not made the drug available on a large scale and at an affordable price within the stipulated time.
- Going into various submissions and affidavits filed by Bayer, the Board also came to the conclusion that its pricing of Rs.2.8 lakh was not affordable.
- Among other setbacks for Western drug companies, India has revoked patents granted to Pfizer Inc's cancer drug Sutent, Roche Holding AG's hepatitis C drug Pegasys and Merck & Co's asthma treatment aerosol suspension formulation.

4.3. Patents (Amendment) Rules, 2021

- The Patents Rules, 2003 were amended by the Patents (Amendment) Rules, 2021 which **came into force on 21st September 2021.**
- The rules **reduced the fee for patent filing and prosecution** for educational institutions by 80 percent.
- The move has been taken to strengthen innovation and creativity in the knowledge economy.
- The "educational institution" category can be claimed by filing supporting documentary evidence to this effect. However, the nature of documentary evidence has not been specified.
- The fee applicable for an educational institution has been made the same as that for a natural person, startup or small entity.

1. Copyright Act, 1957

1.1. What is Copyright?

- Copyright is a **legal term** used to describe the **rights that creators have** over their **literary and artistic works.**
- Works covered by copyright range from books, music, paintings, sculpture, and films, to computer programs, databases, advertisements, maps, and technical drawings.

1.2. Copyright Law in India

- The Copyright Act, 1957 along with the Copyright Rules, 2013, govern the laws related to copyright protection in India.
- The Copyright Act provides an economic right to the author to **reproduce** the work, to **issue** copies, to **perform or communicate** it to the public.
- It also provides the **right to make any cinematograph film or sound recording** or to make any adaptation or translation of the work.
- The law has been amended six times since 1957 and the most recent amendment was in 2012, through the Copyright (Amendment) Act, 2012.

1.3. Sections of the Copyright Act, 1957

- **Section 13:** Copyright protection is conferred on literary works, dramatic works, musical works, artistic works, cinematograph films and sound recording.
- **Note:** Computer programs are protected under the Act as literary works.
- **Section 2:** Consists of various definitions of the work which can be covered under the definition of copyright.
- **Section 14:** Grants the copyright owner a set of exclusive rights. These rights include the right of adaptation, right of reproduction, right of publication, right to make translations, etc.
    - Rights can be exercised only by the owner of copyright or by any other person who is duly licensed in this regard by the owner of copyright.
- **Section 17:** The author of a work shall be the first owner of the copyright.
- **Section 19:** Lays down the modes of assignment of copyright in India. Assignment can only be in writing and must specify the work, the period of assignment and the territory for which assignment is made.

1.4. Two Types of Rights

The Copyright Act, 1957 confers copyright protection in two forms: Economic rights and Moral rights.

Economic Rights

- Economic rights **allow right owners to derive financial reward** from the use of their works by others.
- The authors of copyright enjoy economic rights **under Section 14** of the Copyright Act. The rights are mainly, in respect of literary, dramatic and musical, other than computer programs, to reproduce the work in any material form.

Moral Rights

- Moral rights **allow authors and creators to take certain actions** to preserve and protect their link with their work.

- Moral rights of an author finds expression in **Section 57** of the Copyright Act, 1957. These are: **right of paternity, and right of integrity.**
- The right of paternity refers to a right of an author to claim authorship of work and a right to prevent all others from claiming authorship of his work.
- The right to integrity permits the author to restrain or claim damages in the event of any distortion, mutilation, modification or any other untoward act done to his work.

1.5. Exceptions To Infringement

The Copyright Act, 1957 provides for certain exceptions to infringement of copyright, **under Section 52.** The following acts shall not constitute an infringement of copyright, namely:

- A fair dealing with any work, not being a computer programme, for the purposes of:
    - private or personal use, including research;
    - criticism or review, whether of that work or of any other work;
    - the reporting of current events and current affairs, including the reporting of a lecture delivered in public.
- Transient or incidental storage of a work or performance purely in the technical process of electronic transmission or communication to the public.
- Reproduction of any work for the purpose of a judicial proceeding or for the purpose of a report of a judicial proceeding.
- Reproduction or publication of any work prepared by the Secretariat of a Legislature or, where the legislature consists of two Houses, by the Secretariat of either House of the Legislature, exclusively for the use of the members of that Legislature.
- Reproduction of any work in a certified copy made or supplied in accordance with any law for the time being in force.
- Reading or recitation in public of reasonable extracts from a published literary or dramatic work.
- Publication in a collection, mainly composed of non-copyright matter, bona fide intended for instructional use, and so described in the title and in any advertisement issued by or on behalf of the publisher, of short passages from published literary or dramatic works, not themselves published for such use in which copyright subsists.

1.6. Berne Convention and Copyright Act 1957

- **India is a signatory to the Berne Convention** for the Protection of Literary and Artistic Works, 1886.
- Being a signatory, India is obligated to give equal protection to the works originating not only in India but also outside India in any of the contracting states.
- An important principle of the Berne Convention is that the registration of copyright is not mandatory.
- In India too it is not mandatory for one to register a copyright for availing the protection of law. The Copyright Act 1957 also does not mandate registration.

1.7. Copyright (Amendment) Rules, 2021

- The amendments have been introduced with the objective of bringing the existing rules in parity with other relevant legislations.
- It aims to ensure smooth and flawless compliance by adopting electronic means as the primary mode of communication and working in the Copyright Office.

- In order to encourage accountability and transparency, new provisions have been introduced, to deal with the undistributed royalty amounts and use of electronic and traceable payment methods while collection and distribution of royalties.
- To reinforce transparency, the copyright societies will be required to draw up and make public an Annual Transparency Report for each financial year.
- The compliance requirements for registration of software works have been reduced, now the applicant has the liberty to file the first 10 and last 10 pages of source code, or the entire source code if less than 20 pages, with no blocked out or redacted portions.
- The time limit for the Central Government to respond to an application made before it for registration as a copyright society is extended to one hundred and eighty days, so that the application can be more comprehensively examined.

2. Geographical Indication

2.1. What is Geographical Indication (GI)?

- A geographical indication is a **sign used on goods that have a specific geographical origin** and possess qualities, reputation or characteristics that are essentially attributable to that place of origin (e.g. a town, region, or country).
- The use of a geographical indication may act as a certification that the product possesses certain qualities, is made according to traditional methods, or enjoys a certain reputation, due to its geographical origin.

2.2. Why Does the GI Need to be Recognized?

- Every region boasts of something unique and some local products are their claim to fame. This reputation of the region is not built in a day.
- These unique products are a combination of the best of man and nature and it has been carefully preserved and handed over for generations.
- In order to celebrate and recognise the unique identity connecting the products and places, the GI tag was developed.
- In many countries, the protection given to GIs by law is similar to the protection given to trademarks, and in particular, certification marks.
- Geographical indications law demands that the use of the GIs can be done only when the product originates from a particular area and/or meets certain standards.
- Sometimes these laws also stipulate that the product must meet certain quality tests that are administered by an association that owns the exclusive right to license or allow the use of the indication.

2.3. Legal position globally

- The WTO Agreement on TRIPS defines "geographical indications" as indications that identify a good as "originating in the territory of a Member, where a given quality, reputation or other characteristic of the good is essentially attributable to its geographic origin."
- In 1994, when negotiations on the WTO TRIPS were concluded, governments of all WTO member countries had agreed to set certain basic standards for the protection of GIs in all member countries.

- **Article 22** of the TRIPS Agreement says that all governments must provide legal opportunities in their own laws for the owner of a GI registered in that country to prevent the use of marks that mislead the public as to the geographical origin of the goods.
- **Article 23** of the TRIPS Agreement says that all governments must provide the owners of GI the right, under their laws, to prevent the use of a geographical indication identifying wines not originating in the place indicated by the geographical indication.
- Furthermore, the significance of protecting industrial property and geographical indications as integral components of intellectual property is acknowledged and emphasised in Articles 1(2) and 10 of the Paris Convention.

2.4. Legal position in India

- The Indian Parliament passed the **Geographical Indications of Goods (Registration and Protection) Act in December 1999** (became effective in September 2003) which aimed at providing a registration and also protection of GI of the goods in India.
- This Act is **administered by the Controller General of Patents, Designs and TradeMarks** (CGPDTM), who is also the Registrar of Geographical Indications.
    - **Note:** CGPDTM under DPIIT is entrusted with the responsibility of administering the laws relating to Patents, Designs, TradeMarks and Geographical Indications in India.
- Any established organisation or authority can apply for GI tag under the law.
- Under the Geographical Indications, persons who deal with production, processing, trading or dealing of agricultural goods, natural goods, making, manufacturing, trading or dealing of handicrafts or industrial goods, specific to the region are called the producers.
- Registration of the product under the GI facilitates better legal protection and the authorised user can exercise his right to use the tag effectively.
- The registration of GI is **valid for a period of 10 years** each which can be renewed from time to time. If the GI is not renewed then it will be removed from the register.
- A registered GI is a public property which belongs to the producers of the goods. It cannot be used for licensing, pledge, mortgage etc. After the demise of the authorised dealer, his right can be exercised by the successor.

2.5. Some examples from India

State	Product
Andhra Pradesh	Araku Valley Arabica Coffee
	Tirupati Laddu
	Etikoppaka Toys
	Udayagiri Wooden Carving
	Arunachal Orange

Arunachal Pradesh	Idu Mishmi Textiles
Assam	Muga Silk
	Karbi Anglong Ginger
	Joha Rice
Bihar	Shahi Litchi
	Madhubani Paintings
	Sikki Grass Products
	Maghai Paan
Chhattisgarh	Bastar Dhokra
	Bastar Iron Craft
Goa	Feni
Gujarat	Sankheda Furniture
	Gir Kesar Mango
	Kachchh Shawls
Himachal Pradesh	Kullu Shawl
	Kangra Tea
	Himachali Kala Zeera
	Mysore Silk
	Channapatna Toys & Dolls
	Udupi Sarees

Karnataka	Coorg Arabica Coffee
	Mysore Sandalwood oil
Kerala	Alleppey Coir
	Navara Rice
	Alleppey Green Cardamom
	Nilambur Teak
	Screw Pine Craft
Madhya Pradesh	Chanderi sarees
	Jhabua Kadaknath Black Chicken
	Ratlami Sev
Maharashtra	Solapur Chaddar
	Nashik Valley Wine
	Paithani Sarees and fabrics
	Kolhapur Jaggery
	Alphonso
Manipur	Chak-Hao
	Kachai Lemon
Mizoram	Mizo Chilli
	Pawndum
Nagaland	Naga Mircha

Odisha	Kotpad Handloom Fabric
	Konark Stone Carving
	Odisha Rasagola
Rajasthan	Kora Doria
	Molela Clay Work
	Bikaneri Bhujia
Tamil Nadu	Salem Fabric
	Arumbavur Wood Carvings
	Mahabalipuram Stone Sculpture
	Thanjavur Art Plate
	Kancheepuram Silk
Tripura	Tripura Queen pineapple
Telangana	Nirmal Toys and Craft
	Adilabad Dokra
	Cheriyal Paintings
Uttar Pradesh	Lucknow Chikan Craft
	Malihabadi Dussehri Mango
	Banaras Brocades and Sarees
	Kalanamak Rice
	Kannauj Perfume

	Chunar Balua Patthar
West Bengal	Darjeeling Tea
	Banglar Rasogolla
	Wooden Mask of Kushmandi

2.6. Significance of GI

- The GI tag is an indication which is definite to a geographical territory. It is used for agricultural, natural and manufactured goods.
- For a product to get a GI tag, the goods need to be produced or processed or prepared in that region. It is also essential that the product has a special quality or reputation.
- GI tag is beneficial because it confers legal protection to the Geographical Indications in India. This identity helps in preventing misuse of a registered GI.
- Moreover, the legal protection of GI boosts exports. GI tag not only helps the country's export market but also helps in promoting economic prosperity of the producers.

3. Protection of Plant Varieties and Farmers' Rights Act, 2001

3.1. Introduction

- The Government of India enacted the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act, 2001 to recognize the contributions of both commercial plant breeders and farmers in plant breeding activity. Rules for the same were notified in 2003.
- The law is in conformity with the International Union for the Protection of New Varieties of Plants (UPOV), 1978 and has sufficient provisions to protect the interests of public sector breeding institutions and the farmers.
- The Act also supports the TRIPS agreement. Under the TRIPS agreement, India was in obligation to introduce a system for protecting new plant variety.
- The agreement made it obligatory for a Member to provide protection to new plant varieties either through patent or an effective *sui generis* system or a combination of these two.

3.2. Why to Grant Plant Breeder's Rights?

- Protection is afforded to plant breeders **as an incentive for the development of new varieties of plants,** in order to provide sustainable progress in agriculture, horticulture and forestry.
- Improved varieties are a necessary, and very cost-effective, means of improving productivity, quality and marketability for farmers and growers.
- Breeding new varieties of plants requires a substantial investment in terms of skill, labor, material resources, money and time.
- The opportunity to obtain certain exclusive rights in respect of new with better varieties provides successful plant breeders a chance of recovering their costs and accumulating the funds necessary for further investment.

- In the absence of plant breeders' rights, those aims are more difficult to achieve since there is nothing to prevent others from multiplying the breeder's variety and selling it on a commercial scale.

3.3. Objectives of PPV & FR Act, 2001

- To stimulate investments for research and development both in the public and the private sectors for the developments of new plant varieties.
- To facilitate the growth of the seed industry in the country through domestic and foreign investment. This will ensure the availability of high quality seeds and planting material to Indian farmers.
- To recognize the role of farmers as cultivators and conservers and the contribution of traditional, rural and tribal communities to the country's agro biodiversity by rewarding them for their contribution through benefit sharing and protecting the traditional rights.

3.4. Varieties Registered under PPV & FR Act, 2001

- A new variety if it conforms to the criteria of novelty, distinctiveness, uniformity and stability.
- An extant variety if it conforms to criteria of distinctiveness, uniformity and stability.

3.5. Rights under PPV & FR Act, 2001

- **Breeders' Rights:** Exclusive rights to produce, sell, market, distribute, import or export the protected variety.
- **Researchers' Rights:** To use any of the registered varieties to conduct experiment or research.
- **Farmers' Rights:** Farmers variety can be registered as a breeder variety or extant variety. A farmer can save, use, sow, re-sow, exchange, share or sell his farm produce including seed of a variety protected under the Act.
    - Farmers are eligible for recognition and rewards, and for compensation as well.
    - Farmers shall not be liable to pay any fee in any proceeding before the Authority or Registrar or the Tribunal or the High Court under the Act.

3.6. Implementation of PPV & FR Act, 2001

- For the implementation of provisions of the Act, the Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare established the Protection of Plant Varieties and Farmers' Rights Authority on 11 November, 2005.
- The Chairperson is the Chief Executive of the Authority.
- The objective of the authority is to establish an effective system for protection of plant varieties, the rights of farmers and plant breeders and to encourage the development of new varieties of plants and facilitate the growth of the seed industry.
- The authority also works for the acceleration of agricultural development in the country and for stimulating investment for research and development both in the private and public sector for the development of new plant varieties.

4. National Intellectual Property Rights (IPR) Policy 2016

4.1. Introduction

- The National Intellectual Property Rights (IPR) Policy 2016 was adopted on 12 May, 2016 as a vision document to guide future development of IPRs in the country.
- The Policy recognises the abundance of creative and innovative energies that flow in India, and the need to channelize these energies towards a better future for all.
- The policy covers all forms of IP, seeks to create synergies between them and other agencies, and sets up an institutional mechanism for implementation and review.

4.2. Mission of the Policy

Stimulate a dynamic, vibrant and balanced intellectual property rights system in India to:

- Foster creativity and innovation and thereby, promote entrepreneurship and enhance socioeconomic and cultural development, and
- Focus on enhancing access to healthcare, food security and environmental protection, among other sectors of vital social, economic and technological importance.

4.3. Implementation

- The Department for Promotion of Industry and Internal Trade (DPIIT) under the Ministry of Commerce is the nodal department for IPR development in India and the CIPAM under DPIIT is the single point of reference for implementing the policy.

4.4. Objectives of the Policy

- **IPR Awareness-Outreach and Promotion:** To create public awareness about the economic, social and cultural benefits of IPRs among all sections of society.
- **Generation of IPRs:** To stimulate the generation of IPRs.
- **Legal and Legislative Framework:** To have strong and effective IPR laws, which balance the interests of rights owners with larger public interest.
- **Administration and Management:** To modernize and strengthen service oriented IPR administration.
- **Commercialization of IPR:** Get value for IPRs through commercialization.
- **Enforcement and Adjudication:** To strengthen the enforcement and adjudicatory mechanisms for combating IPR infringements.
- **Human Capital Development:** To strengthen and expand human resources, institutions and capacities for teaching, training, research and skill building in IPRs.

Scheme for IPR Awareness – Creative India; Innovative India

- Taking forward the National IPR Policy 2016, a 'Scheme for IPR Awareness – Creative India; Innovative India' was launched by Cell for IPR Promotion and Management (CIPAM).
- The duration of the scheme was for 3 Years (April 2017 – March 2020).
- Target of the scheme was to conduct IP awareness workshops/seminars in collaboration with industry organizations, academic institutions and other stakeholders across the country.
- It also proposed to undertake training programmes to create a resource pool of trainers who would conduct the IP Awareness workshops/seminars for the public, enforcement agencies and judiciary.

1. Cyber Security

- Cybersecurity is the practice of **protecting systems, networks, and programs from digital attacks.**
- These cyberattacks are usually aimed at accessing, changing, or destroying sensitive information; extorting money from users via ransomware; or interrupting normal business processes.

1.1. Concept of Cyber Threats

- Cyber threat is defined as any identified effort directed toward access to, exfiltration of, manipulation of, or impairment to the integrity, confidentiality, security, or availability of data, an application, or a federal system, without lawful authority.
- A cyber threat can be **unintentional and intentional, targeted or non-targeted,** and can come from a variety of sources, including foreign nations engaged in espionage and information warfare, criminals, hackers, virus writers, and disgruntled employees and contractors working within an organization.
- Unintentional threats can be caused by inattentive or untrained employees, software upgrades, maintenance procedures and equipment failures that inadvertently disrupt computer systems or corrupt data.
- Intentional threats include both targeted and nontargeted attacks.
    - A targeted attack is when a group or individual specifically attacks a critical infrastructure system.
    - A non-targeted attack occurs when the intended target of the attack is uncertain, such as when a virus, worm, or malware is released on the Internet with no specific target.
- Repeatedly identified as the **most worrisome threat is the "insider"** — someone legitimately authorized access to a system or network.

1.2. Types of Cyber Threats

- **Denial-of-service (DoS) and distributed denial-of-service (DDoS) attacks:** A denial-of-service attack overwhelms a system’s resources so that it cannot respond to service requests. A DDoS attack is also an attack on a system's resources, but it is launched from a large number of other host machines that are infected by malicious software controlled by the attacker.
- **Man-in-the-middle (MitM) attack:** A MitM attack occurs when a hacker inserts itself between the communications of a client and a server.
- **Phishing and spear phishing attacks:** Phishing attack is a type of email attack in which an attacker tries to find sensitive information of users in a fraudulent manner through electronic communication by pretending to be from a related trusted organization. Spear phishing targets specific organizations or individuals, and seeks unauthorized access to confidential data.
- **Drive-by attack:** Drive-by download attacks are a common method of spreading malware. Hackers look for insecure websites and plant a malicious script into HTTP or PHP code on one of the pages. This script might install malware directly onto the

computer of someone who visits the site, or it might redirect the victim to a site controlled by the hackers.

- **Password attack:** Brute-force password guessing means using a random approach by trying different passwords and hoping that one works.
- **SQL injection attack:** SQL injection has become a common issue with database-driven websites.
- **Cross-site scripting (XSS) attack:** XSS attacks use third-party web resources to inject malicious JavaScript into a website's database.
- **Eavesdropping attack:** It occurs through the interception of network traffic. By eavesdropping, an attacker can obtain passwords, credit card numbers and other confidential information that a user might be sending over the network.
- **Malware attack:** Malwares can be described as unwanted software that is installed in a system without consent. It can attach itself to legitimate code and propagate or replicate itself across the internet.
- **Ransomware:** Ransomware is a type of malware attack in which the attacker locks or encrypts the victim's data and threatens to publish or block access to data unless a ransom is paid.

1.3. Sources of Cyber Threats

- **Botnet operators:** Botnet operators use a network, or botnet, of compromised, remotely controlled systems to coordinate attacks and to distribute phishing schemes, spam, and malware attacks. The services of these networks are sometimes made available on underground markets.
- **Criminal groups:** Criminal groups seek to attack systems for monetary gain. Specifically, organized criminal groups use spam, phishing, and spyware/malware to commit identity theft and online fraud. International corporate spies and criminal organizations also pose a threat through their ability to conduct industrial espionage and large-scale monetary theft and to hire or develop hacker talent.
- **Foreign nation states:** Foreign intelligence services use cyber tools as part of their information gathering and espionage activities. Also, several nations are aggressively working to develop information warfare doctrine, programs, and capabilities. Such capabilities enable a single entity to have a significant and serious impact by disrupting the supply, communications, and economic infrastructures that support military power.
- **Hackers:** Hackers break into networks for revenge, stalking others, and monetary gain. While gaining unauthorized access once required a fair amount of skill or computer knowledge, hackers can now download attack scripts and protocols from the Internet and launch them against victim sites.
- **Hacktivists:** Those who make politically motivated attacks on publicly accessible web pages or e-mail servers. These groups and individuals overload e-mail servers and hack into websites to send a political message.
- **Insiders:** The disgruntled insider, working from within an organization, is a principal source of computer crimes. Insiders may not need a great deal of knowledge about computer intrusions because their knowledge of a victim system often allows them to gain unrestricted access to cause damage to the system or to steal system data. The insider threat also includes contractor personnel.

- **International corporate spies:** International corporate spies pose a threat through their ability to conduct economic and industrial espionage and large-scale monetary theft and to hire or develop hacker talent.
- **Phishers:** Individuals, or small groups, execute phishing schemes in an attempt to steal identities or information for monetary gain. Phishers may also use spam and spyware/malware to accomplish their objectives.
- **Spammers:** Individuals or organizations distribute unsolicited e-mail with hidden or false information in order to sell products, conduct phishing schemes, distribute spyware/malware, or attack organizations (i.e., denial of service attack).
- **Spyware/malware authors:** Individuals or organizations with malicious intent carry out attacks against users by producing and distributing spyware and malware. Several destructive computer viruses and worms have harmed files and hard drives, including the Melissa virus, the Explore.Zip worm, the CIH (Chernobyl) virus, Nimda worm, Code Red, Slammer worm, and Blaster worm.
- **Terrorists:** Terrorists conduct cyber attacks to destroy, infiltrate, or exploit critical infrastructure to threaten national security, compromise military equipment, disrupt the economy, and cause mass casualties.

2. Cyber Security Scenario in India

- In India, cybersecurity has become a top priority in recent years due to the growing number of cyber-attacks on Indian businesses and government institutions.
- In India, phishing attacks have been on the rise in recent years. One notable example is the 2017 phishing attack on the Reserve Bank of India that resulted in the theft of over $1 million.
- Malware attacks are also common in India. In 2016, the WannaCry ransomware attack hit several Indian organizations, including the Andhra Pradesh police force and Bharat Sanchar Nigam Limited (BSNL).
- India witnessed **13.91 Lakh cyber security incidents in 2022.** The numbers still do not give an entire picture of cyberattacks on the country as these statistics only include information reported to and tracked by the CERT-In.
- Despite these challenges, there are positive trends emerging in India when it comes to cybersecurity.
- The Indian government has taken several steps to improve the country's cybersecurity posture, including establishing a National Critical Information Infrastructure Protection Centre (NCIIPC) and creating a National Cyber Coordination Centre (NCCC).
- In addition, the government has launched various awareness campaigns to educate citizens about cybersecurity threats and how to protect themselves.
- Approaches like R&D, legal framework, security incidents, early warning and response, best security policy compliance & assurance, international cooperation and security training are also followed in India to secure Indian Cyber Space.

2.1. Information Technology (IT) Act, 2000

- The IT Act of 2000 was enacted by the Parliament of India and **administered by the Indian Computer Emergency Response Team** (CERT-In) to guide Indian cybersecurity legislation, institute data protection policies, and govern cybercrime.
- It also protects e-governance, e-banking, e-commerce, and the private sector, among many others.
- While India does not have an exclusive, unitary cybersecurity law, it uses the IT Act and multiple other sector-specific regulations to promote cybersecurity standards. It also provides a legal framework for critical information infrastructure in India.
- This Act was amended through the Information Technology (Amendment) Act, 2008. The amendments were enforced and rules of important sections were notified in October, 2009 which addresses the needs of National Cyber Security.
- The Amendment inter alia added provisions to the IT Act, 2000 to deal with new forms of cyber crimes like publicizing sexually explicit material in electronic form, video voyeurism and breach of confidentiality and leakage of data by intermediary and e-commerce frauds.
- The IT Act of 2008 applies to any individual, company, or organization (intermediaries) that uses computer resources, computer networks, or other information technology in India.

2.2. National Cyber Security Policy, 2013

- The Government of India on 1 July 2013 launched the National Cyber Security Policy 2013 with an aim **to protect information and build capabilities to prevent cyber attacks.**
- The policy is intended to cater for a broad spectrum of Information and Communications Technology users and providers including Government and non-Government entities.
- The National Cyber Security Policy 2013 is to safeguard both physical and business assets of the country.

Salient Features of the National Cyber Security Policy 2013

- The Policy outlines the roadmap for creation of a framework for comprehensive, collaborative and collective responsibility to deal with cyber security issues of the country.
- The policy lays out 14 objectives which include creation of a 5,00,000-strong professional, skilled workforce over the next five years through capacity building, skill development and training.
- The policy plans to create national and sectoral level 24×7 mechanisms for obtaining strategic information regarding threats to ICT infrastructure, creating scenarios for response, resolution and crisis management through effective, predictive, preventive, proactive response and recovery actions.
- The policy identifies eight different strategies for creating a secure cyber eco-system including the need for creating an assurance framework apart from encouraging open standards to facilitate interoperability and data exchange amongst different products or services.

Other Goals Include

- Creating a resilient and safe cyberspace for individuals, organizations, and the government.

- Creating frameworks, capabilities, and vulnerability management strategies for minimizing, faster prevention, or responding to cyber incidents and cyber threats.
- Encourage organizations to develop cybersecurity policies that align with strategic goals, business workflows, and general best practices.
- Simultaneously create institutional structures, people, processes, technology, and cooperation to minimize the damage caused by cybercrime.

2.3. Information Technology Rules

- The Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Rules, 2021 ('2021 Rules') were released by the Central Government in February 2021.
- The 2021 Rules have been passed **under Sections 69A(2), 79(2)(c) and 87** of the Information Technology Act, 2000.
- The 2021 Rules supersede the previously enacted Information Technology (Intermediary Guidelines) Rules 2011.
- The 2021 Rules were introduced to update the regulatory framework in order to empower the ordinary users of social media and place obligations on Social Media Intermediaries ('SMIs') and Significant Social Media Intermediaries ('SSMI') for a safe and trusted online environment.
- It places special emphasis on the protection of women and children from sexual offences on social media.

Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Amendment Rules, 2023 ('2023 Amendment')

- On April 6, 2023, the Ministry of Electronics and IT (MeitY) notified the Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Amendment Rules 2023 to amend the IT Rules 2021.
- This amendment authorises the central government to **designate a "fact check unit" to identify "fake or false or misleading" information in respect of any business** of the central government.
- Initially, this amendment only contained provisions for regulating online gaming companies. But later MeitY published a new draft that included "fact-checking powers."
- The fact check unit can scrutinize any online comments, news reports or opinions about government officials and ministries and then notify online intermediaries for its censorship.
- Such intermediaries not only include online social media companies but also service providers such as internet service providers and file hosting companies.
- If any intermediary fails to comply, they will be at risk of losing their **safe harbour status under Section 79 of the IT Act, 2000.**
    - Safe harbour provision states that "an intermediary shall not be liable for any third-party information, data, or communication link made available or hosted by him".

2.4. National Cyber Security Strategy 2020

- The National Cyber Security Strategy 2020 was formulated by the Office of National Cyber Security Coordinator at the National Security Council Secretariat in March 2021.
- The strategy aims to **improve cybersecurity audit quality** so organizations can conduct better reviews of their cybersecurity architecture and knowledge.

- The plan's main goal is to serve as the official guidance for stakeholders, policymakers, and corporate leaders to prevent cyber incidents, cyber terrorism, and espionage in cyberspace.
- It also calls for an index of cyber preparedness, and attendant monitoring of performance.

2.5. Reserve Bank of India Act, 2018

The Reserve Bank of India introduced the RBI Act in 2018, which details cybersecurity guidelines and frameworks for UCBs (urban co-operative banks) and payment operators. The RBI Act of 2018 aims to:

- Create standards that equalize security frameworks of banks and payment operators according to how they adapt to new technologies and digitalization.
- Mandate banks to create and present their cyber crisis management plans.
- Encourage banks to regularly schedule threat assessment audits.
- Help banks implement their own email domains with anti-phishing and anti-malware technology.
- All Indian banks must follow these guidelines to standardize frameworks for payment processing cybersecurity and combat the ever-increasing business complications in a digital environment.

2.6. Indian Computer Emergency Response Team (CERT-In)

- Made **official in 2004,** CERT-In is the national nodal agency set up **under Section 70B of the Information Technology Act, 2000** to respond to computer security incidents as and when they occur.
- CERT-In creates awareness on security issues through dissemination of information on its website and **operates 24x7 Incident Response Help Desk.**
- It provides Incident Prevention and Response services as well as Security Quality Management Service.
- CERT-In perform the following functions in the area of cyber security:
    - Collection, analysis and dissemination of Information on cyber incidents;
    - Forecast and alerts of cyber security incidents;
    - Emergency measures for handling cyber security incidents;
    - Coordination of cyber incident response activities;
    - Issue guidelines, advisories, vulnerability notes and whitepapers relating to information security, practices, procedures, prevention, response and reporting of cyber incidents; and
    - Such other functions relating to cyber security as may be prescribed.

2.7. National Critical Information Infrastructure Protection Center (NCIIPC)

- The National Critical Information Infrastructure Protection Center (NCIIPC) was **established on January 16, 2014,** by the Indian government, **under Section 70A of the IT Act, 2000**.
- Based in New Delhi, the NCIIPC was appointed as the national nodal agency in terms of Critical Information Infrastructure Protection.
- Additionally, the NCIIPC is regarded as a unit of the National Technical Research Organization (NTRO) and therefore comes under the Prime Minister's Office (PMO).

- NCIIPC is required to monitor and report national-level threats to critical information infrastructure. The critical sectors include:
    - Power and energy
    - Banking, financial services, and insurance
    - Telecommunication and information
    - Transportation
    - Government
    - Strategic and public enterprises
- NCIIPC successfully implemented several guidelines for policy guidance, knowledge sharing, and cybersecurity awareness for organizations to conduct preemptive measures of these important sectors, especially in power and energy.

2.8. Cyber Regulations Appellate Tribunal (CRAT)

- **Under the IT Act, 2000, Section 62,** the Central Government of India created the Cyber Regulations Appellate Tribunal (CRAT) as a chief governing body and authority for fact-finding, receiving cyber evidence, and examining witnesses.
- According to the Civil Court and Code of Civil Procedure, 1908, CRAT has the power to:
    - Receive evidence on affidavits.
    - Ensure that all electronic and cyber evidence and records are presented for court.
    - Enforce, summon, and issue regular commissions for examining witnesses, documents, and people under oath.
    - Review final decisions of the court to resolve incidents and cases.
    - Approve, dismiss, or declare the defaulter's applications as ex-parte.

3. Digital Personal Data Protection (DPDP) Act, 2023

- On August 11, 2023 the Digital Personal Data Protection Act, 2023 (the Act) received the assent of the President of India and was published in the Official Gazette.
- The DPDP Act is **India's first data protection Act,** and it establishes a framework for the processing of personal data in India.
- It provides for the processing of digital personal data in a manner that recognizes both the rights of the individuals to protect their personal data and the need to process such personal data for lawful purposes and for matters connected therewith or incidental thereto.
- The Act is concise and SARAL, that is, Simple, Accessible, Rational & Actionable Law, and used the word “she” instead of “he”, to acknowledge women in Parliamentary law-making.

Seven Principles

The Act is based on the following seven principles:

- The principle of consented, lawful and transparent use of personal data;
- The principle of purpose limitation (use of personal data only for the purpose specified at the time of obtaining consent of the Data Principal);
- The principle of data minimisation (collection of only as much personal data as is necessary to serve the specified purpose);

- The principle of data accuracy (ensuring data is correct and updated);
- The principle of storage limitation (storing data only till it is needed for the specified purpose);
- The principle of reasonable security safeguards; and
- The principle of accountability (through adjudication of data breaches and breaches of the provisions of the Bill and imposition of penalties for the breaches).

Salient Features of the Digital Personal Data Protection Act, 2023

Applicability

- The Act applies to the **processing of digital personal data within India** where such data is collected online, or collected offline and is digitized.
- It will also apply to the processing of personal data **outside India** if it is for offering goods or services in India. Personal data is defined as any data about an individual who is identifiable by or in relation to such data.

Consent

- Personal data may be processed only for a lawful purpose after obtaining the consent of the individual. **A notice must be given before seeking consent.**
- The notice should contain details about the personal data to be collected and the purpose of processing. Consent may be withdrawn at any point in time.
- Consent will **not be required for 'legitimate uses'** including:
    - specified purpose for which data has been provided by an individual voluntarily,
    - provision of benefit or service by the government,
    - medical emergency, and
    - employment.
- For individuals **below 18 years of age, consent will be provided by the parent or the legal guardian.**

Rights of data principal

- Data principal is an **individual whose data is being processed.** He/She will have the right to:
    - obtain information about processing,
    - seek correction and erasure of personal data,
    - nominate another person to exercise rights in the event of death or incapacity, and
    - grievance redressal.

Duties of Data Principals

- Data principals will have certain duties. They must not:
    - register a false or frivolous complaint, and
    - furnish any false particulars or impersonate another person in specified cases.
- Violation of duties will be punishable with a penalty of up to Rs 10,000.

Obligations of data fiduciaries

- Data fiduciary is the **entity determining the purpose and means of processing.** Data fiduciary must:
    - make reasonable efforts to ensure the accuracy and completeness of data,
    - build reasonable security safeguards to prevent a data breach,

    - inform the Data Protection Board of India and affected persons in the event of a breach, and
    - erase personal data as soon as the purpose has been met and retention is not necessary for legal purposes.
- In case of government entities, storage limitation and the right of the data principal to erasure will not apply.

Transfer of personal data outside India

- The Act allows transfer of personal data outside India, except to countries restricted by the central government through notification.

Exemptions

- Rights of the data principal and obligations of data fiduciaries (except data security) will not apply in specified cases. These include:
    - prevention and investigation of offences, and
    - enforcement of legal rights or claims.
- The central government may, by notification, exempt certain activities from the application of the Act. These include:
    - processing by government entities in the interest of the security of the state and public order, and
    - research, archiving, or statistical purposes.

Data Protection Board of India

- The central government will establish the Data Protection Board of India. Key functions of the Board include:
    - monitoring compliance and imposing penalties,
    - directing data fiduciaries to take necessary measures in the event of a data breach, and
    - hearing grievances made by affected persons.

Penalties

- The schedule to the Act specifies penalties for various offences such as up to:
    - Rs 200 crore for non-fulfilment of obligations for children, and
    - Rs 250 crore for failure to take security measures to prevent data breaches.

Key Issues

- Exemptions to data processing by the State on grounds such as national security may lead to data collection, processing, and retention beyond what is necessary. This may violate the fundamental right to privacy.
- The Act does not regulate risks of harms arising from processing of personal data.
- The Act does not grant the right to data portability and the right to be forgotten to the data principal.
- The Act allows transfer of personal data outside India, except to countries notified by the central government. This mechanism may not ensure adequate evaluation of data protection standards in the countries where transfer of personal data is allowed.
- The members of the Data Protection Board of India will be appointed for two years and will be eligible for re-appointment. The short term with scope for re-appointment may affect the independent functioning of the Board.

1. Internet of Things (IoT)

- The term Internet of Things refers to the collective network of connected devices and the technology that **facilitates communication between devices and the cloud,** as well as between the devices themselves.
- Basically, IoT integrates everyday “things” with the internet.

1.1. Working of IoT

- IoT systems work through the **real-time collection and exchange of data.** An IoT system has **three components: smart device, IoT application and a graphical user interface.**
- Smart device is a device, like a television, security camera, or exercise equipment that has been given **computing capabilities.** It collects data from its environment, user inputs, or usage patterns and communicates data over the internet to and from its IoT application.
- An IoT application is a **collection of services and software that integrates data received** from various IoT devices. It uses machine learning or artificial intelligence (AI) technology to analyze this data and make informed decisions.
- The decisions are communicated back to the IoT device and the IoT device then responds intelligently to inputs.
- The IoT device or fleet of devices can be managed through a graphical user interface.

1.2. Examples of IoT devices

Connected cars

- There are many ways vehicles, such as cars, can be connected to the internet. It can be through smart dashcams, infotainment systems, or even the vehicle's connected gateway.
- They collect data from the accelerator, brakes, speedometer, odometer, wheels, and fuel tanks to monitor both driver performance and vehicle health.

Connected homes

- Smart home devices are mainly focused on improving the efficiency and safety of the house, as well as improving home networking.
- Devices like smart outlets monitor electricity usage and smart thermostats provide better temperature control.
- Hydroponic systems can use IoT sensors to manage the garden while IoT smoke detectors can detect tobacco smoke.
- Home security systems like door locks, security cameras, and water leak detectors can detect and prevent threats, and send alerts to homeowners.

Smart cities

- IoT applications have made urban planning and infrastructure maintenance more efficient.
- IoT applications can be used for measuring air quality and radiation levels, reducing energy bills with smart lighting systems, detecting maintenance needs for critical infrastructures and increasing profits through efficient parking management.

Manufacturing

- IoT applications can predict machine failure before it happens, reducing production downtime.
- Wearables in helmets and wristbands, as well as computer vision cameras, are used to warn workers about potential hazards.

Logistics and transport

- Commercial and Industrial IoT devices can help with supply chain management, including inventory management, vendor relationships, fleet management, and scheduled maintenance.
- Shipping companies use Industrial IoT applications to keep track of assets and optimize fuel consumption on shipping routes.

1.3. Benefits of IoT

- Real-time resource visibility.
- Reduced costs.
- Improved operational efficiency.
- Data-driven insights for quick decision-making.
- End-to-end, remote monitoring and management of assets/resources.
- Real-time, predictive and prescriptive insights.
- Improve end-customer experience.

1. Blockchain Technology

- Blockchain technology is a **decentralized, distributed ledger that stores the record of ownership of digital assets.** Any data stored on blockchain is unable to be modified, making the technology a legitimate disruptor for industries like payments, cybersecurity and healthcare.
- A blockchain database stores data in blocks that are linked together in a chain. The data is chronologically consistent because **one cannot delete or modify the chain** without consensus from the network.

1.1. History of Blockchain

- The first concept of blockchain **dates back to 1991,** when the idea of a cryptographically secured chain of records, or blocks, was introduced by Stuart Haber and Wakefield Scott Stornetta.
- The year **2008** marked a pivotal point for blockchain, as **Satoshi Nakamoto** (a pseudonym for a person or group) gave the technology an established model and planned application.
- The first blockchain and **cryptocurrency officially launched in 2009** and the first successful Bitcoin transaction occurs between computer scientist Hal Finney and Satoshi Nakamoto.

1.2. Features of Blockchain Technology

- **Decentralization:** Transferring of control and decision making from a centralized entity to a distributed network.
- **Immutability:** No participant can tamper with a transaction once someone has recorded it to the shared ledger.
- **Consensus:** Blockchain establishes rules about participant consent for recording transactions. A person can record new transactions only when the majority of participants in the network give their consent.

1.3. Types of Blockchain Networks

Public Blockchains

- Public blockchains are **permissionless in nature, allow anyone to join,** and are **completely decentralized.**
- Public blockchains **allow all nodes** of the blockchain **to have equal rights** to access the blockchain, create new blocks of data, and validate blocks of data.
- People primarily use public blockchains to exchange and mine cryptocurrencies like Bitcoin, Ethereum, and Litecoin.

Private Blockchains

- **A single organization controls** private blockchains, also called **managed blockchains.** The authority determines who can be a member and what rights they have in the network.
- Private blockchains are **only partially decentralized** because public access to these blockchains is restricted.

Consortium Blockchains

- Consortium blockchains are **permissioned blockchains governed by a group** of organizations, rather than one entity.
- Consortium blockchains enjoy more decentralization than private blockchains, resulting in higher levels of security.
- However, setting up consortiums can be a fraught process as it requires cooperation between a number of organizations, which presents logistical challenges as well as potential antitrust risk.

Hybrid Blockchains

- Hybrid blockchains combine elements from both private and public networks. Companies can set up **private, permission-based systems alongside a public system.**
- In this way, they control access to specific data stored in the blockchain while keeping the rest of the data public. They use smart contracts to allow public members to check if private transactions have been completed.

1.4. How Does Blockchain Work?

Record the transaction

- The first step is to record the transaction. A blockchain transaction shows the movement of physical or digital assets from one party to another in the blockchain network.
- It is recorded as a data block and can include details like Who was involved in the transaction? What happened during the transaction? When did the transaction occur? etc.

Gain consensus

- Most participants on the distributed blockchain network must agree that the recorded transaction is valid.
- Depending on the type of network, rules of agreement can vary but are typically established at the start of the network.

Link the blocks

- Once the participants have reached a consensus, transactions on the blockchain are **written into blocks equivalent to the pages of a ledger book.**
- Along with the transactions, a **cryptographic hash** is also appended to the new block. The hash acts as a chain that links the blocks together.
- If the contents of the block are intentionally or unintentionally modified, the hash value changes, providing a way to detect data tampering.
- Thus, the blocks and chains link securely, and a person cannot edit them. Each additional block strengthens the verification of the previous block and therefore the entire blockchain.

Share the ledger

- This is the last stage. The system distributes the latest copy of the central ledger to all participants.

1.5. Applications of Blockchain Technology

Cryptocurrency

- Blockchain's most well-known use is in cryptocurrencies. Cryptocurrencies are digital currencies (or tokens), like Bitcoin, Ethereum or Litecoin, that can be used to buy goods and services.

- When people spend cryptocurrency, the transactions are recorded on a blockchain. The more people use cryptocurrency, the more widespread blockchain could become.

Banking

- Blockchain is used to process transactions in fiat currency, like dollars and euros. This could be faster than sending money through a bank or other financial institution as the transactions can be verified more quickly.

Asset Transfers

- Blockchain can also be used to record and transfer the ownership of different assets. This is very popular with digital assets like Non-fungible tokens (NFTs).

Executing Contracts

- Another blockchain innovation is self-executing contracts commonly called “smart contracts.” These digital contracts are enacted automatically once conditions are met.
- For instance, a payment for a good might be released instantly once the buyer and seller have met all specified parameters for a deal.

Supply Chain Monitoring

- With traditional data storage methods, it can be hard to trace the source of problems, like which vendor poor-quality goods came from.
- Storing this information on blockchain would make it easier to go back and monitor the supply chain.

Voting

- Blockchain voting would allow people to submit votes that could not be tampered with as well as would remove the need to have people manually collect and verify paper ballots.

Energy

- Energy companies use blockchain technology to create peer-to-peer energy trading platforms and streamline access to renewable energy.
- For instance, With blockchain-based crowdfunding initiatives, users can sponsor and own solar panels in communities that lack energy access. Sponsors might also receive rent for these communities once the solar panels are constructed.

Media and Entertainment

- Copyright verification is critical for the fair compensation of artists. It takes multiple transactions to record the sale or transfer of copyright content.
- Companies in media and entertainment use blockchain systems to manage this copyright data.

1.6. Advantages of Blockchain

- **Higher Accuracy of Transactions:** Because a blockchain transaction must be verified by multiple nodes, this can reduce error. If one node has a mistake in the database, the others would see it’s different and catch the error.
- **No Need for Intermediaries:** Using blockchain, two parties in a transaction can confirm and complete something without working through a third party. This saves time as well as the cost of paying for an intermediary like a bank.
- **Extra Security:** A decentralized network, like blockchain, makes it nearly impossible for someone to make fraudulent transactions, because to enter in forged transactions, they would need to hack every node and change every ledger.

- **More Efficient Transfers:** Since blockchains operate 24/7, people can make more efficient financial and asset transfers, especially internationally.

1.7. Disadvantages of Blockchain

- **High Energy Costs:** Having all the nodes working to verify transactions takes significantly more electricity than a single database or spreadsheet. Not only does this make blockchain-based transactions more expensive, but it also creates a large carbon burden on the environment.
- **Risk of Asset Loss:** Some digital assets are secured using a cryptographic key, like cryptocurrency in a blockchain wallet. If the owner of a digital asset loses the private cryptographic key that gives them access to their asset, currently there is no way to recover it, which means the asset is gone permanently.
- **Potential for Illegal Activity:** Blockchain's decentralization adds more privacy and confidentiality, which unfortunately makes it appealing to criminals. It's harder to track illicit transactions on blockchain than through bank transactions that are tied to a name.

1.8. Blockchain Development in India

- Blockchain adoption in India could reach a staggering **46% by 2026,** which indicates vast prospects to boost the local economy.
- The Ministry of Electronics and Information Technology (MeitY) has identified Blockchain Technology as one of the important research areas having application potential in different domains such as Governance, Banking & Finance, Cyber Security and so on.
- MeitY has supported a multi-institutional project titled **"Distributed Centre of Excellence in Blockchain Technology"** with C-DAC, Institute for Development & Research in Banking Technology (IDRBT), Hyderabad and Veermata Jijabai Technological Institute (VJTI), Mumbai as executing agencies.
    - As part of this initiative, agencies have carried out research on the use of Blockchain technology in various domains and developed Proof-of-Concept solutions.
- **Centre of Excellence** (CoE) in Blockchain technology was established by National Informatics Centre (NIC) in association with National Informatics Centre Services Incorporated (NICSI).
- The objectives of CoE are to accelerate adoption & deployment of Blockchain technology in Government, execute projects focussing on different use cases, pilot deployment, offer Blockchain-Platform as a service to ramp up the design and development of solutions, offer consultancy services and capacity building.
- NITI Aayog has also recognized Blockchain as a promising Technology enabling features such as decentralization, transparency and accountability.

National Strategy on Blockchain

- The 'National Strategy on Blockchain' as brought out by the Ministry of Electronics and Information Technology (MeitY) in December 2021, is the move in the direction towards enabling trusted digital platforms creating blockchain framework for the development of applications based on this technology.
- The document introduces Blockchain technology in simple terms, giving the international scene on its adoption, highlighting national initiatives, and projecting various directions in which developmental work needs to be done.

Vision

- To create trusted digital platforms through shared Blockchain infrastructure; promoting research and development, innovation, technology and application development; and facilitating state of the art, transparent, secure and trusted digital service delivery to citizens and businesses, thus making India a global leader in Blockchain Technology.

Objectives

- Create a trusted digital platform by evolving a national Blockchain infrastructure that can be used for development and deployment of applications supported with a sandbox for testing multiple Blockchain based solutions.
- Foster research & development in Blockchain technology to address challenges related to rapid application development & deployment, interoperability, scalability, security and privacy.
- Create and update an innovation roadmap for a trusted digital platform, addressing various challenges towards Blockchain technology adoption.
- Plan for production grade applications of national interest focusing on providing faster, secure, transparent, trusted and efficient delivery of services to the citizens and businesses.
- Encourage development of standards in the area of Blockchain technology.
- Identify the legal and policy requirements towards regulating Blockchain for offering services to citizens and businesses.
- Encourage multi stakeholder model in evolving national Blockchain infrastructure for offering citizen services thereby ensuring transparency, trust and provenance.
- Strengthen India's collaboration with global organizations and innovation and research centres working in the area of Blockchain technologies.
- Evolve a centralized planning and decentralized execution model for large scale adoption.
- Promote capacity building, skill development and innovation in Blockchain technology.

2. Cryptocurrency

- Cryptocurrencies are a **decentralized form of digital currency running on blockchain** technology used for executing transactions.
- Cryptocurrency received its name because it **uses encryption to verify transactions.** This means advanced coding is involved in storing and transmitting cryptocurrency data between wallets and to public ledgers.
- The **first cryptocurrency was Bitcoin,** which was founded in 2009 and remains the best known today. Other examples include Ethereum, Litecoin, Ripple, etc.
- Nodes are a network of contributors by which cryptocurrencies are managed. On the network, the **nodes perform a diversity of roles,** from storing to validating transactional data.
- Nodes overall **manage the database and validation** of the new transaction entries. The best part is that there is no single point of failure which means if one node breaks down it will have no impact on the blockchain ledger.

2.1. Origin of Bitcoin

- The origin of Bitcoin is unclear, as is who founded it.
- A person, or a group of people, who went by the identity of Satoshi Nakamoto are said to have conceptualized an accounting system in the aftermath of the 2008 financial crisis.
- Nakamoto published a **white paper about a peer-to-peer electronic cash system,** which would allow online payments to be sent directly from one party to another without going through a financial institution.

2.2. Working Mechanism of Bitcoin

- Bitcoin transactions are messages that state the movement of bitcoins from senders to receivers.
- Transactions are **digitally signed using cryptography** and sent to the entire Bitcoin network for verification.
- Transaction information is public and can be found on the digital ledger, i.e, the blockchain.
- The history of each and every Bitcoin transaction leads back to the point where the bitcoins were first produced or 'mined.'

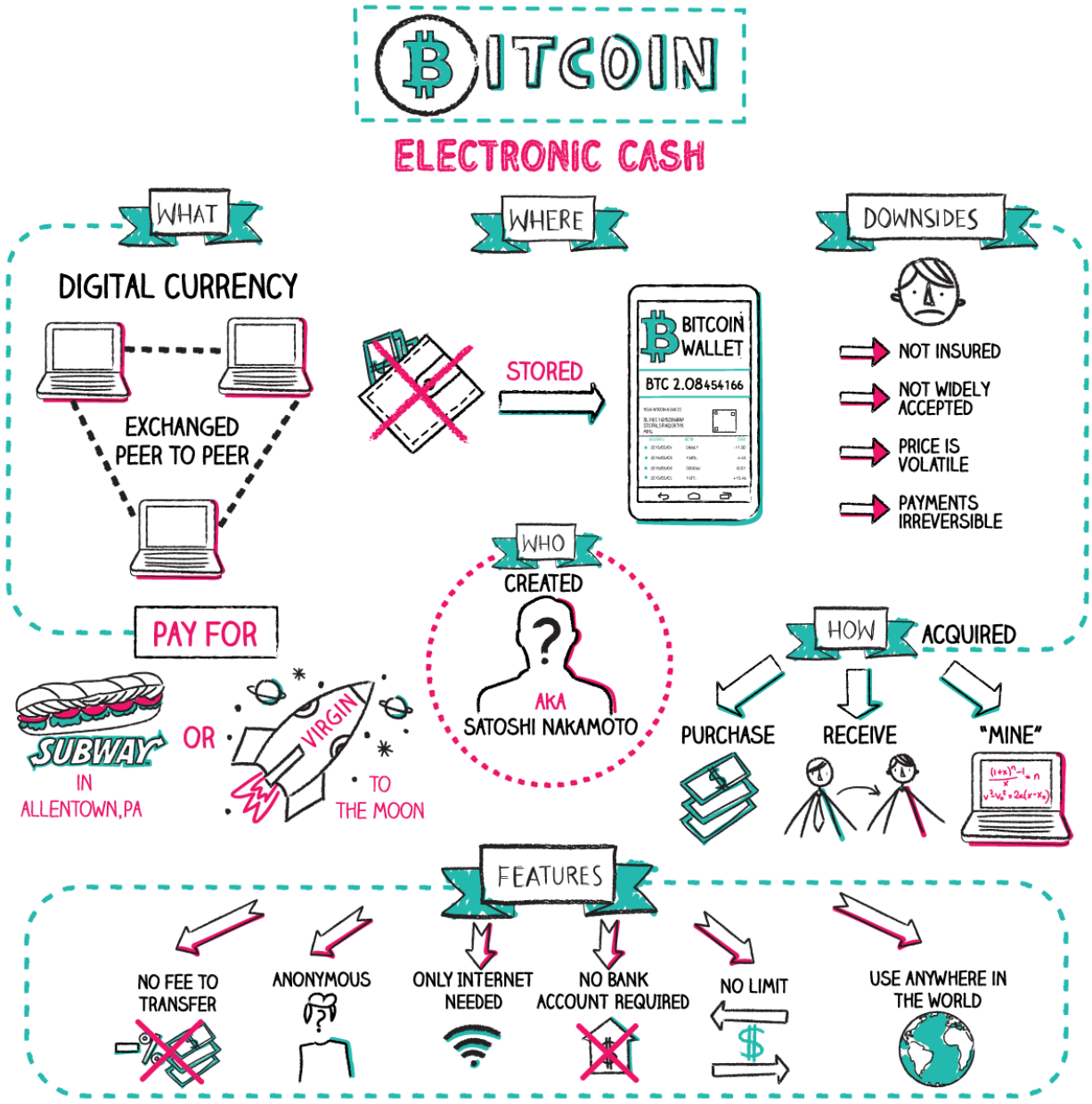


Figure.1. Features of Bitcoin

2.3. Advantages and Disadvantages of Cryptocurrency

Advantages

- Easier to transfer funds between parties
- Protection from inflation.
- Transactional Speed.
- Cost Effective Transactions.
- Decentralization.
- Self-governed and managed.
- Safe, secure and transparent
- Can be used to generate returns.
- Remittances are streamlined.

Disadvantages

- Transactions are pseudonymous.
- Pseudonymity allows for criminal uses.
- Expensive to participate in a network and earn.
- Off-chain security issues.
- Prices are very volatile.

2.4. Cryptocurrencies in India

- Cryptocurrencies as a payment medium are **not regulated or issued by any central authority** in India. There are no guidelines laid down for sorting disagreements while dealing with cryptocurrency.
- Despite uncertainty around the future of cryptocurrencies in India, investments in the unregulated digital asset, especially Bitcoin, has shown a breathtaking upward trend since 2020.

2013: RBI's First Circular Regarding Cryptocurrencies

- The Reserve Bank of India (RBI) issued a circular, warning users of the potential security-related risks pertaining to the use of virtual currencies in 2013.

2017-2018: RBI's Banking Ban on Cryptocurrencies

- A warning clarifying that virtual currencies are not a legal tender was issued by the RBI and the Ministry of Finance by the end of 2017.
- In March 2018, a draft scheme for banning virtual currencies was submitted by the Central Board of Digital Tax (CBDT) to the Ministry of Finance.
- Just about a month later the RBI came out with a circular restraining banks, Non Banking Finance Companies and payment system providers from dealing with virtual currencies and providing services to virtual currency exchanges.

March 2020: Supreme Court Strikes Down the Crypto Banking Ban

- On 4th of March 2020, the Supreme Court quashed the RBI's circular that declared the trading of such virtual currencies illegal, stating that since virtual currencies do not enjoy a status that is at par with conventional money, the RBI may only intervene in such matters if it impacts the monetary or economic system of the country adversely.
- This *de jure* means that cryptocurrencies are not illegal, however, still not recognized as legal tender.

2021: Announcement of Cryptocurrency and Regulation of Official Digital Currency Bill, 2021

- On January 29, 2021, the Indian government announced that it will introduce a Bill to create a sovereign digital currency and subsequently put a blanket ban on private cryptocurrencies.
- In November 2021, the Standing Committee on Finance, met the Blockchain and Crypto Assets Council (BACC) and other cryptocurrency representatives and concluded that cryptocurrencies should not be banned but regulated.

2022: Tax on Cryptocurrency

- In the Union Budget 2022, the Finance Minister presented a tax regime for virtual or digital assets that include cryptocurrencies.
- Cryptocurrency investors are required to report the calculated profits and losses as a part of their income.

- A 30% tax will be charged on the earnings from the transfer of digital assets that include cryptocurrencies, NFTs, etc.

2023: Prevention of Money Laundering Act

- The Centre via a notification dated March 7, 2023, has brought digital assets and fiat currencies, virtual digital assets (cryptocurrencies) and such other digital assets, their trading, safekeeping and related financial services under the ambit of the Prevention of Money Laundering Act, 2002.

3. Non-Fungible Tokens (NFTs)

- An NFT is a **digital asset** that can come in the form of art, music, in-game items, videos, and more. They are **bought and sold online**, frequently **with cryptocurrency,** and they are generally encoded with the same underlying software as many cryptocurrencies.

3.1. Difference Between NFT and Cryptocurrency

- NFT is generally built using the same kind of programming as cryptocurrency, like Bitcoin or Ethereum, but that's where the similarity ends.
- Physical money and cryptocurrencies are "fungible," meaning they can be traded or exchanged for one another. They're also equal in value like one Bitcoin is always equal to another Bitcoin. Cryptocurrency's fungibility makes it a trusted means of conducting transactions on the blockchain.
- Whereas, NFT has a digital signature that makes it impossible for NFTs to be exchanged for or equal to one another (hence, non-fungible).

3.2. Features of NFT

- NFTs exist on a blockchain, which is a distributed public ledger that records transactions.
- An NFT is **created, or "minted" from digital objects** that represent both tangible and intangible items, including graphic art, videos and sports highlights, collectibles, music, etc.
- NFTs can have only one owner at a time, and their use of blockchain technology makes it easy to verify ownership and transfer tokens between owners.
- The creator can also store specific information in an NFT's metadata. For instance, artists can sign their artwork by including their signature in the file.

3.3. Creation of NFT

- A non-fungible token is **created by an artist, creator, or license-holder** through a process called minting.
- Minting is a process that **involves signing a blockchain transaction** that outlines the fundamental token details, which is then broadcasted to the blockchain to trigger a smart contract function which creates the token and assigns it to its owner.
- Under the hood, a non-fungible token consists of a unique token identifier, or token ID, which is mapped to an owner identifier and stored inside a smart contract.
- When the owner of a given token ID wishes to transfer it to another user, it is easy to verify ownership and reassign the token to a new owner.

3.4. Smart Contract

- A smart contract is **code** that is **executed** deterministically **in the context of a blockchain network;** each participant in the network verifies the state-changing operations that a smart contract's code makes.
- Smart contracts are the primary means by which developers can create and manage tokens on a blockchain.
- Smart contracts can store small amounts of data in common data structures, which is a critical component of tokenization use cases that map token identifiers to owner identifiers to track who owns which token.

Introduction

- **Definition of Quantum Computing**: Quantum computing is a type of computation that takes advantage of the quantum mechanical properties of particles to perform operations on data at a scale that is not feasible with traditional computers.
- **Historical Background**: The concept of quantum computing originated in the early 1980s with Richard Feynman and Yuri Manin proposing the idea of a machine that operates on quantum mechanical principles.
- **Significance**: Quantum computers promise to solve complex problems significantly faster than classical computers, especially in fields such as cryptography, material science, and complex system simulation.

Principles of Quantum Computing

Superposition

- **Concept**: Superposition refers to the quantum phenomenon where particles exist in multiple states at once, enabling a quantum computer to perform many calculations simultaneously.
- **Applications**: This principle finds significant application in parallel computing and cryptography.

Quantum Bits (Qubits)

- **Definition**: Unlike classical bits that can be either 0 or 1, a quantum bit (qubit) can exist in a state corresponding to both 0 and 1 simultaneously, due to the principle of superposition.
- **Manipulation**: Utilizing the principle of superposition, a quantum bit (qubit) can simultaneously exist in states of 1 and 0, allowing it to perform multiple calculations at once. This phenomenon, described as cooperation between parallel universes, exponentially increases computational power with the addition of each qubit, revolutionizing computational capabilities.

Entanglement

- **Concept**: Quantum entanglement is a physical phenomenon where the state of one particle instantly influences the state of another, no matter the distance separating them.
- **Applications**: Entanglement is exploited in quantum computing for complex operations and algorithms, such as quantum teleportation and quantum key distribution.

Quantum Computing Algorithms

Shor's Algorithm

- **Purpose**: Developed by Peter Shor in 1994, this algorithm can factor large numbers exponentially faster than the best-known algorithms running on a classical computer.

- **Significance**: This algorithm threatens current cryptographic techniques, as it can potentially crack encryption codes much quicker.

Grover's Algorithm

- **Purpose**: Devised by Lov Grover in 1996, it's designed for searching an unsorted database.
- **Efficiency**: It can perform these tasks considerably faster than any classical algorithm.

Current Developments and Future Prospects

- **Research and Development**: Many nations and corporations are investing heavily in research and development to build scalable and reliable quantum computers (e.g. Google, IBM, Alibaba, Amazon etc.). As of now, IBM has the leadership in this space.
    - In November 2022, IBM unveiled its new 433-qubit Osprey chip, which is currently the world's most powerful quantum processor.
    - IBM has more than 20 quantum computers available on its open-source quantum toolkit Qiskit.
    - IBM offers free access to some quantum machines, while paying clients like startups and scholars can lease more powerful ones remotely.
    - IBM has a roadmap to launch a 1,121-qubit processor in the current year 2023.
    - By 2025, IBM plans to surpass 4,000 qubits by creating modular quantum circuits that connect multiple processor chips in the same computer.
- **Potential Applications**: Quantum computing has potential applications in numerous fields including medicine for drug discovery, finance for portfolio optimization, and logistics for route optimization etc.
- **India's Initiative**: In India, significant strides are being made in the field, with the government launching the Quantum Computing Applications Lab in collaboration with AWS, aiming to boost quantum computing research and development in the country.

Application areas

Quantum computing stands as a rapidly progressing field with the potential to influence various domains significantly. Here are the key areas where quantum computing is anticipated to make a substantial impact:

1. **Artificial Intelligence**

   Quantum computing can potentially foster advancements in deep learning, enhancing the understanding of quantum mechanics. Simultaneously, matured quantum computers may excel in data pattern recognition, surpassing traditional computers.

2. **Energy Storage**

   The field may contribute to the creation of batteries with enhanced efficiency and longevity.

3. **Agricultural Advancements**

   Quantum computers might play a role in formulating cleaner fertilization methods.

4. **Cybersecurity**

   The application of quantum computing is foreseen to reinforce cybersecurity protocols.

5. **Pharmaceutical Innovations**

   The advent of quantum computing can be a catalyst in the revolution of drug development, allowing the simulation of molecular-level quantum mechanics.

6. **Materials Science**

   Quantum computers have the potential to aid in the discovery of novel electronic materials.

7. **Financial Analysis**

   Quantum computing is poised to refine financial modeling, facilitating more accurate predictions.

8. **Renewable Energy**

   The technology might enhance methods for solar energy capture.

9. **Urban Planning**

   Quantum computers could streamline traffic flow management, reducing congestion and fostering more efficient transportation systems.

10. **Meteorology and Environmental Science**

    Quantum computing can enhance weather forecast accuracy and be a vital tool in climate change studies.

Concerns

1. **Security Risks**: The significant computing power of quantum computers poses a threat to existing cryptographic systems, potentially rendering them obsolete. This could compromise the security of sensitive information, including communications, financial transactions, and military defenses.
2. **Race for Technological Dominance**: The development of quantum computing has become a race between nations, particularly China and the United States, as they strive to gain a competitive edge in this disruptive technology.
3. **Impact on Industries**: Quantum computing has the potential to disrupt various industries, affecting traditional computing, cryptography, logistics, finance, and more.

4. **Ethical Considerations**: Quantum computing raises ethical questions related to privacy, data security, and the potential for misuse. Safeguarding personal and sensitive information becomes even more critical as the computing power of quantum computers advances.
5. **Economic Disparities**: The development and deployment of quantum computing technologies may lead to economic disparities between countries and industries. Access to quantum computing resources and expertise may become a determining factor in economic competitiveness.

Need for New Regulations

The rapid advancement of quantum computing necessitates the development of new regulations and policies to address potential risks and ensure responsible use. Establishing guidelines for data protection, encryption standards, and international cooperation becomes crucial.

Skill Gap and Talent Acquisition

Quantum computing requires specialized knowledge and skills. The demand for experts in quantum physics, computer science, and related fields is likely to increase. Bridging the skill gap and attracting top talent will be essential for the successful development and adoption of quantum computing.

Notes on Information and Communication Technology and Computing

Different Generations of Wireless Communication

Wireless telephones **started with 0G** (zero generation) systems, which became available after World War II. Mobile telephones were usually mounted in cars or trucks, briefcase models were also made. Technologies used in 0G systems included MTS (Mobile Telephone System), IMTS (Improved Mobile Telephone Service), AMTS (Advanced Mobile Telephone System) etc.

Generations	Details	Advantages	Limitations
1G	**In 1979,** the first cellular system in the world became operational **by Nippon Telephone and Telegraph (NTT) in Tokyo, Japan.** First-generation mobile systems used analog transmission for speech services. In a few years, cellular communication spread to other parts of the world too – reaching Europe in 1981 and the USA in 1982.	Use of multiple cell sites. Ability to transfer calls from one site to the next site. Allowed voice calls in one country.	Poor quality of voice. Poor life of battery. Size of the phone was very large. No security. Capacity was limited. Poor handoff reliability.
2G	Second generation of mobile telecommunication was **launched in Finland in 1991.** It was **based on the GSM** (Group Special Mobile) standard. It enables data transmission like text messaging (SMS - Short Message Service), transfer of photos or pictures (MMS-Multimedia Messaging Service), but not videos. The family of this technology includes 2.5G and 2.75G. **2.5G** stands for "second and a half generation." It is a 2G-systems that have implemented **General**	Text messages, image messages, SMS and MMS are all possible. Signals are digitally encoded, which increases speech quality and lowers line noise. Improved Spectrum Efficiency, Enhanced security, better quality and capacity. Voice and data service. Framework cap has been increased, as well as network coverage.	Unable to handle complex data such as video. Requires strong digital signals.

	Packet Radio Service (GPRS). **2.75G** is also called **"Enhanced Data rates for GSM Evolution".** It allows the clear and fast transmission of data and information.		
3G	The third generation was first **released in the early 2000s.** 3G technologies enable network operators to offer users a wider range of more advanced services. Services include wide area wireless voice telephony, video calls, and broadband wireless data, all in a mobile environment. The family of this technology includes 3.5G and 3.75G. **3.5G** is also called **High-Speed Downlink Packet Access.** It provides a smooth evolutionary path for 3G networks allowing for higher data transfer speeds. **3.75G** is also called high **speed uplink packet access** (HSUPA). It is an enhanced form of the 3rd G network that includes **high speed packet access plus** (HSPA+).	Streaming audio and video has been improved. Several times faster data transmission. Can deliver speeds of up to 3Mbps. Multimedia applications such as video and photography are supported. Higher-speed, web WAP browsing and more security. Broadband with Large Capacity. Global Positioning System, mobile television, phone calls, and live video conferencing are examples of value added services.	Costly. Requirement of high bandwidth. Expensive 3G phones. Size of cell phones was large.
4G	4G wireless systems are a packet switched wireless system with wide area coverage and high throughput. It is designed to be cost effective and to provide high spectral efficiency. The 4G wireless uses the technique of **Orthogonal Frequency Division Multiplexing** (OFDM), **Ultra Wide Radio Band** (UWB) and millimeter wireless. 4G refers to all-IP packet-switched networks, mobile ultra-broadband (gigabit speed) access and multi-carrier transmission. The word **"MAGIC"** also refers to 4G wireless technology which stands for Mobile multimedia, Any-where, Global mobility support, Integrated wireless solution and Customized services.	High Speed, more security, high capacity. Access to the internet, streaming media, and video conferencing with ease. Exceptional spectral efficiency. Provide any type of service to users at any time and in any place. High quality of service and low cost per bit.	Uses more battery. Difficult to implement. Expensive equipment is required.
5G	In 5th Generation wireless	Data transmission is	Obstructions

	systems, customers benefit from ultra-fast internet and multimedia experiences. 5G technology transmits data using millimeter waves and unlicensed spectrum to achieve higher data rates. 5G performance targets high data rate, reduced latency, energy saving, cost reduction, higher system capacity, and massive device connectivity. Machine to machine communication can be possible in 5G. It performs Internet of Things (IoT) for smart home and smart city, connected cars etc.	faster than in previous generations. Global connectivity and service portability are provided by 5G technology. Wide broadcasting bandwidth up to Gigabit, supporting approximately 75,000 simultaneous connections. Large phone memory, quick dialing, and audio/video clarity. A high-speed, high-capacity system that allows for large-scale data broadcasting at Gbps.	can impact connectivity. Weakening of gadget batteries. Cybersecurity. Lack of encryption. Upload speeds do not match download speeds.

Visible Light Communication (VLC)

- VLC is a wireless technology that **relies on optical intensity modulation** and is potentially a game changer for internet-of-things (IoT) connectivity.
- It enables **high-speed transmission of data with visible light.** This data is transmitted by modulating the intensity of light given off by a light source.
- It is a preferred communication technique because of its high bandwidth and immunity to interference from electromagnetic sources.
- VLC uses wavelengths between 380 nm to 750 nm (i.e. 430 THz to 790 THz) for communication.

Architecture of VLC Systems

- A VLC system is composed of **two parts: the transmitter and the receiver.**
- Light emitted from a LED light (transmitter) through rapid light modulation is received by a receiving device, which is then translated into usable data.
- This can then be separated into three layers:
    - the **physical layer,** which basically dictates the relationship between the device and the medium,
    - the **MAC layer,** which points the data received and processed to the direction in which they need to go, and
    - the **application layer.**

Applications of VLC

Li-Fi

- Li-Fi or **'Light Fidelity'** is a **wireless optical networking** technology that makes use of LED lights to communicate and transmit data between devices wirelessly.
- It is analogous to Wi-Fi, which uses radio frequency for communication.
- **LED lights form the basis** of a wireless network whereas Li-Fi enables the transmission of data **by modulating the intensity of these LED lights.**
- A photo sensor receives modulated light which is then demodulated into electronic form.

Vehicle to vehicle communication

- VLC can be used for vehicular communication due to the presence of the vehicle lights and the existing traffic light infrastructure.
- The high priority applications indicated by the Vehicle Safety Communications Project include cooperative forward collision warning, pre-crash sensing, emergency electronic brake lights, lane change warning, stop sign movement assistant, left turn assistant, traffic signal violation warning and curve speed warning.

Underwater communication

- RF waves do not travel well in sea water because of its good conductivity. Therefore, VLC communication should be used in underwater communication networks.
- The **Un Tethered Remotely Operated Vehicle** (UTROV) is another application of the VLC in underwater communication.
- The different jobs that can be performed using UTROV include observatory maintenance of the oceans and deployment opportunities from the ships.

Information displaying signboards

- Signboards are often made from an array of LEDs which in turn are modulated to convey information in airports, bus stops and other places where the broadcasting of data is necessary.

Healthcare Industry

- The use of Wi-Fi can interfere with medical devices such as MRI (magnetic resonance imaging) and even treatment of patients.

- Li-Fi, on the other hand, offers a feasible opportunity where visible light communication can enable data transfer in such EMI (Electromagnetic Interference) sensitive environments. It can further aid in robotic treatment and laparoscopy.

Power Plants and Other Sensitive Areas

- Sensitive areas like Power Plants need fast digital communication to monitor grid-integrity and demand. Nuclear Power Plants, instead, need to monitor core temperature and send it across quickly.
- Wi-Fi can negatively affect sensitive areas because of its radiation; however, the implementation of Li-Fi in such areas can provide a safer and faster measure.

Educational Institutes

- Universities and schools need to have uninterrupted internet access for a plethora of reasons.
- By installing LED lights, universities and schools can not only save energy cost but also provide high-speed internet access. Li-Fi can completely replace Wi-Fi in educational institutes.

Entertainment and Advertisement Industry

- A single LED light can be used for transmission and reception as well as providing the visualization to entertain kids.
- Another use of VLC could be in the advertising industry, where large billboards made of LEDs are used for advertisement.

Advantages of VLC communication

- **Supports larger bandwidth:** Hence overcome bandwidth limitation of RF communication.
- **Secure communication:** VLC based data communication can not be intercepted by any one from the other room. It provides secured communication unlike RF communication.
- **Power efficient:** VLC source is used for both illumination and communication, it has low power consumption.
- **EM radiation:** Light based communication, hence, not affected due to EM radiation from RF systems.
- **Health and installation:** It does not have any health risks to human beings and is easy to install.

Disadvantages of VLC communication

- Interference issues from other ambient light sources.
- Supports short coverage range.
- Challenges to integrate with the WiFi system.
- Other drawbacks include atmospheric absorption, shadowing, beam dispersion etc.

Types of Web

- **Web 1.0:** Refers to the early days of the dial-up Internet when websites and web pages were static, and their primary purpose was to share information.
- **Web 2.0:** Characterized by social media platforms, blogs, wikis, and other user-generated content platforms delivered over the internet.
- **Web 3.0:** A version of the internet that focuses on **intelligent automation, context-aware applications, and enhanced privacy and security measures.**
    - This new technological dimension believes in leveraging the power of Artificial Intelligence, machine learning, and the latest technologies like blockchain to solve the problems of the present-day online ecosystem.
    - With Web 3.0, the data generated by disparate and increasingly powerful computing resources, including mobile phones, desktops, appliances, vehicles, and sensors, will be sold by users through decentralized data networks, ensuring that users retain ownership control.

Optical Fibre

- Optical fibre is a data transmission method that **makes use of light pulses** traveling down a long fibre, often constructed of plastic or glass.
- The **total internal reflection of light** is used in the fibre optic cable.

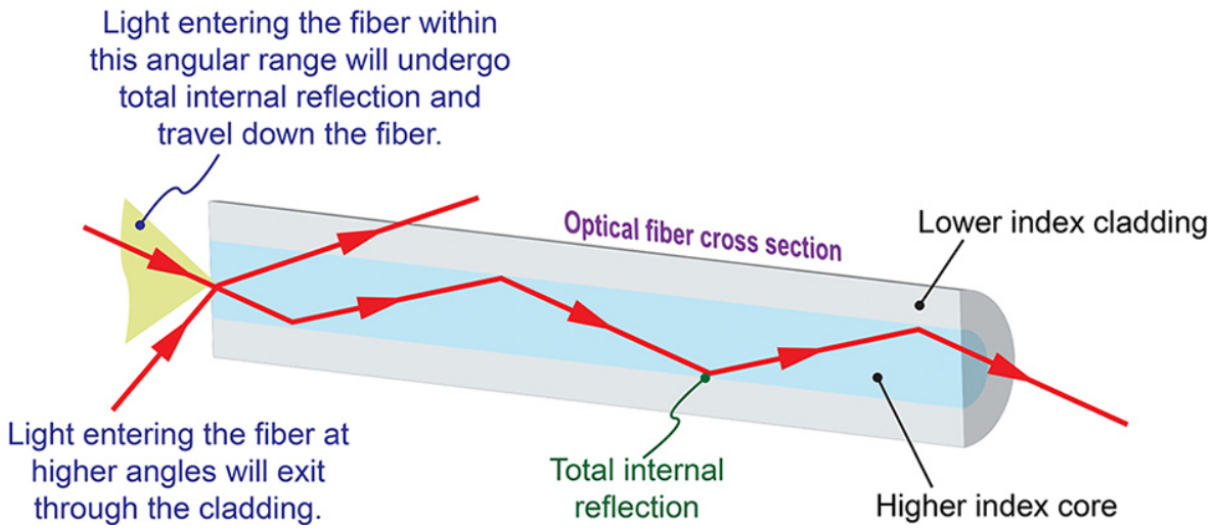


Figure.1. Operation of an Optical Fibre

Structure of Optical Fibre

- The **core, cladding, and outer coating** are all components of an optical fibre. While glass and plastic are commonly utilised, various materials can be used based on the desired transmission spectrum.
- The section of the fibre that transmits light is called the core.
- The material used for cladding often has a **lower refractive index than the core** (usually about 1 percent lower).
- Because of the index difference, total internal reflection occurs at the index border along the length of the fibre, preventing light from escaping through the sidewalls.

Applications of Optical Fibre

- **Medical Industry:** to view internal body parts by inserting into hollow spaces in the body.
- **Communication:** It increases the speed and accuracy of the transmission data. Compared to copper wires, fibre optics cables are lighter, more flexible and carry more data.
- **Defence:** data transmission in high-level data security fields of military and aerospace applications.
- **Industries:** for imaging in hard-to-reach places.
- **Broadcasting:** to transmit high-definition television signals which have greater bandwidth and speed.
- **Lighting and Decorations:** in festivals or homes.
- **Mechanical Inspections:** to detect damages and faults which are at hard-to-reach places.

BharatNet

- National Optical Fibre Network (NOFN) was **launched in October 2011** and was renamed as Bharat Net Project in 2015.
- The project is being executed by a **Special Purpose Vehicle (SPV) namely Bharat Broadband Network Limited** (BBNL), which was incorporated on February 25, 2012 under Indian Companies Act, 1956 with an authorized capital of Rs 1000 crore.

- The entire project is being funded by the **Universal Service Obligation Fund** (USOF), which was set up for improving telecom services in rural and remote areas of the country.
- The project is a **Centre-State collaborative project,** with the states contributing free Rights of Way for establishing the Optical Fibre Network.
- Non-discriminatory access to the NOFN was provided to all the service providers like Telecom Service Providers (TSPs), Cable TV operators and content providers to launch various services in rural areas.

Aim of BharatNet

- **To connect all the 2,50,000 Gram panchayats** in the country and **provide 100 Mbps connectivity** to all gram panchayats.
    - To achieve this, the existing unused fibres (dark fibre) of public sector undertakings (PSUs) (BSNL, Railtel and Power Grid) were utilised and incremental fibre was laid to connect to Gram Panchayats wherever necessary.
- To facilitate the delivery of e-governance, e-health, e-education, e-banking, Internet and other services to rural India.

Three-phase implementation

- **First Phase:** Provide one lakh gram panchayats with broadband connectivity by laying underground optic fibre cable (OFC) lines by December 2017.
- **Second Phase:** Provide connectivity to all the gram panchayats in the country using an optimal mix of underground fibre, fibre over power lines, radio and satellite media. It was to be completed by March 2019.
- **Third Phase:** From 2019 to 2023, a state-of-the-art, future-proof network, including fibre between districts and blocks, with ring topology to provide redundancy would be created.

Recent Development

- The Union Cabinet in August 2023 has approved an allotment of ₹1,39,579 crore for the next phase of BharatNet to make 5G network available to remote areas of the country.
- According to government sources, around 1.94 lakh villages have been connected at present and the rest of the villages are expected to be connected in the next 2.5 years.

National Broadband Mission

- The Ministry of Communications has launched the 'National Broadband Mission' (NBM), on **December 17, 2019, to facilitate universal and equitable access to broadband services** across the country, especially in rural and remote areas.
- It aimed to provide broadband access to all villages by 2022.
- It involves laying an incremental **30 lakh route km of Optical Fiber Cable** (OFC) and an increase in tower density from 0.42 to 1 tower per thousand of the population by 2024.

Vision of the National Broadband Mission

- To enable fast track growth of digital communications infrastructure, bridge the digital divide for digital empowerment and inclusion, provide affordable and universal access to broadband for all.

Objectives of the National Broadband Mission

- To address policy and regulatory changes required to accelerate the expansion and creation of digital infrastructure and services.
- Creation of a digital fiber map of the Digital Communications network and infrastructure, including Optical Fiber Cables and Towers, across the country.
- Work with all stakeholders including the concerned Ministries/ Departments/ Agencies, and the Ministry of Finance, for enabling investments for the Mission.
- Work with the Department of Space, to make available adequate resources required for extending connectivity to far flung areas of the country through satellite media.
- To encourage and promote adoption of innovative technologies for proliferation of broadband especially by the domestic industry.
- Seek cooperation from concerned stakeholders by developing innovative implementation models for Right of Way (RoW).
- To work with States/UTs for having consistent policies pertaining to expansion of digital infrastructure including for RoW approvals required for laying of OFC.
- To develop a Broadband Readiness Index (BRI) to measure the availability of digital communications infrastructure and conducive policy ecosystem within a State/UT.
- Promote direct and indirect employment as a result of development of Digital Communications infrastructure across the country and through the digital economy.

Progress of the National Broadband Mission (As of June 2022)

- **Broadband Connectivity to Villages:** Under the BharatNet Project 1,77,550 Gram Panchayats (GPs) have been made service ready till June 2022.
- **Availability of Broadband Speeds (Mbps):** Telecom Regulatory Authority of India (TRAI) has been obtaining Crowd-sourced data about download and upload speed for different service providers through TRAI My speed App. It is envisaged to achieve broadband speeds up to 50 Mbps by 2024-25.
- **Fiberization (Lakh Kms) Cumulative:** Total Optical Fibre Cable (OFC) laid is approximately 34.62 Lakh Km as on June 2022. It is envisaged to be increased up to 50 Lakh Km by 2024-25.
- **Towers (in Lakhs) Cumulative:** 7.23 Lakh towers have been installed up to June 2022. It is envisaged to increase up to 15 Lakh towers by 2024-25.
- **Fiberization of Telecom Towers/ Base Transceiver Station (BTS) (%) Cumulative:** Approximately 35.11% of Telecom Towers/ BTSs are fiberized as of June 2022. It is envisaged to be increased up to 70% by 2024-25.
- **Mapping of Fiber Cumulative:** 10 Lakh Route KMs of Optical Fibre Cable laid by the PSUs is mapped on the PM GatiShakti NMP Portal.

Recent Development

- The government has revised the definition of broadband connectivity in February 2023.

- The Centre has specified a **higher minimum download speed of 2 Mbps** (megabits per second). Earlier, the definition notified by the Telecom Department in July 2013 had benchmarked it to 512 kbps (kilobits per second) as minimum download speed.
- As of June, 2023, India had about **861.47 million broadband subscribers**.
- Top five service providers constituted 98.37 per cent market share of the total broadband subscribers at the end of June 2023.
- India's top-5 service providers are- Reliance Jio Infocomm Ltd (447.75 million), Bharti Airtel (248.06 million), Vodafone Idea (124.90 million), BSNL (24.59 million) and Atria Convergence (2.16 million).

Cloud Computing

- Cloud computing is the **delivery of computing services**—including servers, storage, databases, networking, software, analytics, and intelligence—over the Internet ("the cloud") to offer faster innovation, flexible resources, and economies of scale.
- Rather than keeping files on a proprietary hard drive or local storage device, cloud-based storage makes it possible to save them to a remote database.
- As long as an electronic device has access to the web, it has access to the data and the software programs to run it.

Operation of Cloud Computing

The salient features of cloud computing are as follows:

- **On-demand:** Computing services sold on demand generally by the minute or the hour.
- **Elastic:** A user can have as much or as little of a service as they want at any given time.
- **Fully managed by the provider:** The consumer requires nothing but a personal computer and internet connection.
- **Data-intensive:** The focus is on data rather than computation.
- **Scalability:** Cloud computing has the ability to scale-up or scale-down in order to meet a user's needs.

Types of Cloud Computing

Public cloud

- Public clouds are **owned and operated by third-party cloud service providers,** which deliver computing resources like servers and storage over the internet. Examples include Amazon Web Services, Microsoft Azure, etc.

Private cloud

- A private cloud refers to cloud computing resources **used exclusively by a single business or organization.** The services and infrastructure are maintained on a private network.
- It can be physically located on the company's onsite datacenter. Some companies also pay third-party service providers to host their private cloud.

Hybrid cloud

- Hybrid clouds combine public and private clouds, bound together by technology that allows data and applications to be shared between them.
- By allowing **data and applications to move between private and public clouds,** hybrid cloud provides businesses greater flexibility and more deployment options and helps optimize existing infrastructure, security, and compliance.

Types of Cloud Computing Services

Infrastructure as a Service (IaaS)

- The most basic category of cloud computing services.
- With IaaS, a **user can rent IT infrastructure**—servers and virtual machines (VMs), storage, networks, operating systems—from a cloud provider **on a pay-as-you-go basis.**

Platform as a Service (PaaS)

- Platform as a service (PaaS) refers to cloud computing services that supply an **on-demand environment** for developing, testing, delivering, and managing software applications.
- PaaS is designed to make it easier for developers **to quickly create web or mobile apps,** without worrying about setting up or managing the underlying infrastructure of servers, storage, network, and databases needed for development.

Software as a service (SaaS)

- Software as a service (SaaS) is a method for delivering software applications over the internet, on demand and typically on a subscription basis.
- With SaaS, cloud providers **host and manage the software application and underlying infrastructure,** and handle any maintenance, like software upgrades and security patching.
- Users connect to the application over the internet, usually with a web browser on their phone, tablet, or PC.

Serverless computing

- Overlapping with PaaS, serverless computing focuses on building app functionality without spending time continually managing the servers and infrastructure required to do so.
- The cloud provider handles the setup, capacity planning, and server management.

Advantages of Cloud Computing

- Cloud computing services **minimize IT requirements and physical storage,** which helps small businesses cut significant business costs.
- Most cloud services are paid on a subscription basis, so capital expenditure is reduced.
- Cloud computing is also much **faster and easier to deploy,** so there are fewer start-up costs.
- Moving the business data to the cloud can make disaster recovery possible i.e., retrieving data in case of a hardware compromise.
- For many businesses, moving to the cloud enhances opportunities for collaboration between employees.
- It allows team members to work from anywhere.
- The cloud centralizes the data, meaning that the owner, employees and clients can access the company data from any location with internet access.
- Cloud computing **reduces a company's carbon footprint** by minimizing energy consumption and carbon emissions by more than 30%.

Limitations

- For cloud-based services, **consistent internet connection** is important.
- While the upfront or capital cost for the cloud-based server is very low , the cloud **server requires a significant amount to be paid each month** to maintain both servers as well as data.
- Companies with highly sensitive data may need their own IT department to keep data secure because when the data is stored in the cloud, the company is trusting a third party to keep it safe.

Cloud Storage

- Cloud storage is a cloud computing model that enables **storing data and files on the internet through a cloud computing provider** that a person can access either through the public internet or a dedicated private network connection.

Importance of Cloud Storage

Cost effectiveness

- With cloud storage, there is no hardware to purchase, no storage to provision, and no extra capital being used for business spikes.
- A person can add or remove storage capacity on demand, quickly change performance and retention characteristics, and only pay for storage that is actually used.

Increased agility

- With cloud storage, resources are only a click away. This results in an increase in agility of an organization.

Faster deployment

- Cloud storage services allow IT to quickly deliver the exact amount of storage needed, whenever and wherever it's needed.
- A developer can focus on solving complex application problems instead of having to manage storage systems.

Efficient data management

- By using cloud storage lifecycle management policies, users can perform powerful information management tasks including automated tiering or locking down data in support of compliance requirements.

Virtually unlimited scalability

- Cloud storage delivers virtually unlimited storage capacity. This removes the constraints of on-premises storage capacity.
- Users can efficiently scale cloud storage up and down as required for analytics, data lakes, backups, or cloud native applications.

Repair and recover

- Cloud storage services are designed to handle concurrent device failure by quickly detecting and repairing any lost redundancy.
- It can further protect data by using versioning and replication tools to more easily recover from both unintended user actions or application failures.

Limitations

Internet Dependency

- One can always save files while offline and access them later. However, an internet connection will be required for the update and sync.

Security and Privacy

- Confidential data must be given over to a third-party organization in order to be stored in the cloud. One must therefore have complete faith in the cloud vendor.

Costs

- There are additional costs for uploading and downloading files from the cloud. These can quickly add up if a user is trying to access lots of files often.

Limitations on Control

- After the user moves data to the cloud, the vendor is now in charge of it. This implies that users must rely on the vendors to maintain their services in a safe, stable, up-and-running, and fully functional manner. This limits the influence on data safety.

Cloud Computing in India

Cloud Computing and Data Centres

- The size of the digital population in India and the growth trajectory of the digital economy necessitates a strong growth of Data Centres.
- A Data Centre is a **dedicated secure space within a centralized location** where computing and networking equipment is concentrated for the purpose of collecting, storing, processing, distributing or allowing access to large amounts of data.
- Cloud Service providers host their IT infrastructure in Data Centres to provide the Cloud Computing services to the end users.
- In the Union Budget 2022-23, the Union Minister for Finance and Corporate Affairs proposed that the Data Centres (along with Energy Storage Systems) would be included in the harmonized list of infrastructure.

Need for Data Centre

- Need for Data Centre infrastructure in India is necessitated by the data localization provisions of the Digital Personal Data Protection Act, 2023 and for protection of the digital sovereignty of the country in an increasingly connected world.
- As per various estimates, India has around 499 MW installed power capacity for Data Centres (till December 2022).
- The Ministry of Electronics & Information Technology also proposed a draft Data Centre Policy in 2020 with the vision of:
    - Making India a Global Data Centre hub,
    - Promoting investment in the sector,
    - Propelling digital economy growth,
    - Enabling the provisioning of trusted hosting infrastructure, and
    - Facilitating state of the art service delivery to citizens.

Growth of Data Centre in India

As per the draft Data Centre Policy 2020, for the long-term growth of the Data Centre sector in the country, it is critical to create a congenial, competitive and sustainable operating environment for the businesses. Some of the key policy thrust areas in this direction include:

- Availability of uninterrupted, clean and cost-effective electricity for Data Centres remains as one of the most important considerations for the Data Centre sector.
- MeitY to work with the Department of Telecommunications (DoT) to facilitate robust and cost-effective connectivity backhaul.
- Data Centres to be declared as an Essential Service under “The Essential Services Maintenance Act, 1968 (ESMA)”.
- Recognize Data Centres as a separate category under the National Building Code.
- Setting-up of Data Centre Economic Zones.
- Promote indigenous technology development, research and capacity building.

GI Cloud Initiative - MeghRaj

- In order to utilize and harness the benefits of Cloud Computing, Government of India has embarked upon an ambitious initiative - "GI Cloud" which has been named as 'MeghRaj' in **February 2014.**
- This initiative is to implement various components including governance mechanisms to ensure proliferation of Cloud in the government.
- The focus of this initiative is to **accelerate delivery of e-services** in the country while optimizing ICT spending of the Government.
- The architectural vision of GI Cloud encompasses a set of discrete cloud computing environments spread across multiple locations, built on existing or new (augmented) infrastructure, following a set of common protocols, guidelines and standards issued by the Government of India.

- The National Informatics Centre (NIC) is providing **National Cloud services** under the initiative MeghRaj. The services offered are Platform as a Service (PaaS), Infrastructure as a Service (IaaS), Software as a Services (SaaS), Container as a Services (NCCaaS), Artificial Intelligence as a Service, Application Performance Management (APM) Service, Resource Monitoring as a Service, etc.

Advantages of MeghRaj

- Optimum utilization of existing infrastructure.
- Any software made available by any government department in India can be made available to other departments as well without additional costs.
- It provides a single point for maintaining Information & Communication Technology (ICT) infrastructure in India.
- According to the demands from the citizens of India, infrastructure of the government can be increased accordingly.
- Efficient service delivery.
- A security framework for the entire GI Cloud will lead to less environmental complexity and less potential vulnerability.
- Increased user mobility.
- Reduced effort in managing technology.
- Ease of first time IT solution deployment.
- Cost reduction.
- It prescribes the standards around interoperability, integration, security, data security and portability etc.

DigiLocker

- DigiLocker is a flagship initiative of the Ministry of Electronics & Information Technology (MeitY) as **part of the Digital India Programme.**
- **Launched in 2015,** the program **aims to make India go paperless** while providing a secure document access platform on a public cloud.
- It intends to provide citizens with 'Digital Empowerment' by allowing them to access authentic digital documents through a Digital Document Wallet.
- The stored documents can also be shared and verified through DigiLocker.

Three key layers

- The Government is aiming for the digital transformation with a philosophy 'Minimum Government and Maximum Governance', and it has identified three key layers- i) Cashless layer, ii) Paperless Layer and iii) Presenceless Layer.
- Cashless layer is taken care of by National Payments Corporations of India (NPCI) through the Digital Cashless transfer.
- Presenceless layer has been achieved by UIDAI.
- Paperless Layer has been addressed by DigiLocker addressing the eKYC, design and verification process.

Benefits to Citizens

- Important Documents Anytime, Anywhere.
- Authentic documents that are legally equal to originals.
- Citizen's consent is required for the exchange of digital documents.
- Faster service Delivery in the areas of Government Benefits, Employment, Financial Inclusion, Education and Health.

Benefits to Agencies

- **Reduced Administrative Overhead:** Aims towards paperless governance. It saves administrative costs by reducing the usage of paper and shortening the verification process.
- Trusted issued documents are provided as part of the digital transformation.
- Issued documents are retrieved in real-time from the issuing agency using DigiLocker.

Special Features and Achievements Under DigiLocker

- A total of Rs 452 crore documents have been made available to citizens.
- DigiLocker systems can be extremely useful in the event of a disaster. A successful example was demonstrated in the case of Kerala Flood, in which the IT department issued digital certificates to Kerala citizens during the Floods.
- Students in various states have access to more than 40 crore Educational Documents from school boards and higher education institutions.
- Digital DL/ RC (Driving Licence/Certificate of Registration) are made available to people.

Cyber Security

- Cybersecurity is the practice of **protecting systems, networks, and programs from digital attacks.**
- These cyberattacks are usually aimed at accessing, changing, or destroying sensitive information; extorting money from users via ransomware; or interrupting normal business processes.

Concept of Cyber Threats

- Cyber threat is defined as any identified effort directed toward access to, exfiltration of, manipulation of, or impairment to the integrity, confidentiality, security, or availability of data, an application, or a federal system, without lawful authority.
- A cyber threat can be **unintentional and intentional, targeted or non-targeted,** and can come from a variety of sources, including foreign nations engaged in espionage and information warfare, criminals, hackers, virus writers, and disgruntled employees and contractors working within an organization.
- Unintentional threats can be caused by inattentive or untrained employees, software upgrades, maintenance procedures and equipment failures that inadvertently disrupt computer systems or corrupt data.
- Intentional threats include both targeted and nontargeted attacks.
    - A targeted attack is when a group or individual specifically attacks a critical infrastructure system.
    - A non-targeted attack occurs when the intended target of the attack is uncertain, such as when a virus, worm, or malware is released on the Internet with no specific target.
- Repeatedly identified as the **most worrisome threat is the "insider"** — someone legitimately authorized access to a system or network.

Types of Cyber Threats

- **Denial-of-service (DoS) and distributed denial-of-service (DDoS) attacks:** A denial-of-service attack overwhelms a system's resources so that it cannot respond to service requests. A DDoS attack is also an attack on a system's resources, but it is launched from a large number of other host machines that are infected by malicious software controlled by the attacker.
- **Man-in-the-middle (MitM) attack:** A MitM attack occurs when a hacker inserts itself between the communications of a client and a server.
- **Phishing and spear phishing attacks:** Phishing attack is a type of email attack in which an attacker tries to find sensitive information of users in a fraudulent manner through electronic communication by pretending to be from a related trusted organization. Spear phishing targets specific organizations or individuals, and seeks unauthorized access to confidential data.
- **Drive-by attack:** Drive-by download attacks are a common method of spreading malware. Hackers look for insecure websites and plant a malicious script into HTTP or PHP code on one of the pages. This script might install malware directly onto the computer of someone who visits the site, or it might redirect the victim to a site controlled by the hackers.
- **Password attack:** Brute-force password guessing means using a random approach by trying different passwords and hoping that one works.
- **SQL injection attack:** SQL injection has become a common issue with database-driven websites.
- **Cross-site scripting (XSS) attack:** XSS attacks use third-party web resources to inject malicious JavaScript into a website's database.

- **Eavesdropping attack:** It occurs through the interception of network traffic. By eavesdropping, an attacker can obtain passwords, credit card numbers and other confidential information that a user might be sending over the network.
- **Malware attack:** Malwares can be described as unwanted software that is installed in a system without consent. It can attach itself to legitimate code and propagate or replicate itself across the internet.
- **Ransomware:** Ransomware is a type of malware attack in which the attacker locks or encrypts the victim's data and threatens to publish or block access to data unless a ransom is paid.

Sources of Cyber Threats

- **Botnet operators:** Botnet operators use a network, or botnet, of compromised, remotely controlled systems to coordinate attacks and to distribute phishing schemes, spam, and malware attacks. The services of these networks are sometimes made available on underground markets.
- **Criminal groups:** Criminal groups seek to attack systems for monetary gain. Specifically, organized criminal groups use spam, phishing, and spyware/malware to commit identity theft and online fraud. International corporate spies and criminal organizations also pose a threat through their ability to conduct industrial espionage and large-scale monetary theft and to hire or develop hacker talent.
- **Foreign nation states:** Foreign intelligence services use cyber tools as part of their information gathering and espionage activities. Also, several nations are aggressively working to develop information warfare doctrine, programs, and capabilities. Such capabilities enable a single entity to have a significant and serious impact by disrupting the supply, communications, and economic infrastructures that support military power.
- **Hackers:** Hackers break into networks for revenge, stalking others, and monetary gain. While gaining unauthorized access once required a fair amount of skill or computer knowledge, hackers can now download attack scripts and protocols from the Internet and launch them against victim sites.
- **Hacktivists:** Those who make politically motivated attacks on publicly accessible web pages or e-mail servers. These groups and individuals overload e-mail servers and hack into websites to send a political message.
- **Insiders:** The disgruntled insider, working from within an organization, is a principal source of computer crimes. Insiders may not need a great deal of knowledge about computer intrusions because their knowledge of a victim system often allows them to gain unrestricted access to cause damage to the system or to steal system data. The insider threat also includes contractor personnel.
- **International corporate spies:** International corporate spies pose a threat through their ability to conduct economic and industrial espionage and large-scale monetary theft and to hire or develop hacker talent.
- **Phishers:** Individuals, or small groups, execute phishing schemes in an attempt to steal identities or information for monetary gain. Phishers may also use spam and spyware/malware to accomplish their objectives.
- **Spammers:** Individuals or organizations distribute unsolicited e-mail with hidden or false information in order to sell products, conduct phishing schemes, distribute spyware/malware, or attack organizations (i.e., denial of service attack).
- **Spyware/malware authors:** Individuals or organizations with malicious intent carry out attacks against users by producing and distributing spyware and malware. Several destructive computer viruses and worms have harmed files and hard drives, including the Melissa virus, the Explore.Zip worm, the CIH (Chernobyl) virus, Nimda worm, Code Red, Slammer worm, and Blaster worm.

- **Terrorists:** Terrorists conduct cyber attacks to destroy, infiltrate, or exploit critical infrastructure to threaten national security, compromise military equipment, disrupt the economy, and cause mass casualties.

Cyber Security Scenario in India

- In India, cybersecurity has become a top priority in recent years due to the growing number of cyber-attacks on Indian businesses and government institutions.
- In India, phishing attacks have been on the rise in recent years. One notable example is the 2017 phishing attack on the Reserve Bank of India that resulted in the theft of over $1 million.
- Malware attacks are also common in India. In 2016, the WannaCry ransomware attack hit several Indian organizations, including the Andhra Pradesh police force and Bharat Sanchar Nigam Limited (BSNL).
- India witnessed **13.91 Lakh cyber security incidents in 2022.** The numbers still do not give an entire picture of cyberattacks on the country as these statistics only include information reported to and tracked by the CERT-In.
- Despite these challenges, there are positive trends emerging in India when it comes to cybersecurity.
- The Indian government has taken several steps to improve the country's cybersecurity posture, including establishing a National Critical Information Infrastructure Protection Centre (NCIIPC) and creating a National Cyber Coordination Centre (NCCC).
- In addition, the government has launched various awareness campaigns to educate citizens about cybersecurity threats and how to protect themselves.
- Approaches like R&D, legal framework, security incidents, early warning and response, best security policy compliance & assurance, international cooperation and security training are also followed in India to secure Indian Cyber Space.

Information Technology (IT) Act, 2000

- The IT Act of 2000 was enacted by the Parliament of India and **administered by the Indian Computer Emergency Response Team** (CERT-In) to guide Indian cybersecurity legislation, institute data protection policies, and govern cybercrime.
- It also protects e-governance, e-banking, e-commerce, and the private sector, among many others.
- While India does not have an exclusive, unitary cybersecurity law, it uses the IT Act and multiple other sector-specific regulations to promote cybersecurity standards. It also provides a legal framework for critical information infrastructure in India.
- This Act was amended through the Information Technology (Amendment) Act, 2008. The amendments were enforced and rules of important sections were notified in October, 2009 which addresses the needs of National Cyber Security.
- The Amendment inter alia added provisions to the IT Act, 2000 to deal with new forms of cyber crimes like publicizing sexually explicit material in electronic form, video voyeurism and breach of confidentiality and leakage of data by intermediary and e-commerce frauds.
- The IT Act of 2008 applies to any individual, company, or organization (intermediaries) that uses computer resources, computer networks, or other information technology in India.

National Cyber Security Policy, 2013

- The Government of India on 1 July 2013 launched the National Cyber Security Policy 2013 with an aim **to protect information and build capabilities to prevent cyber attacks.**

- The policy is intended to cater for a broad spectrum of Information and Communications Technology users and providers including Government and non-Government entities.
- The National Cyber Security Policy 2013 is to safeguard both physical and business assets of the country.

Salient Features of the National Cyber Security Policy 2013

- The Policy outlines the roadmap for creation of a framework for comprehensive, collaborative and collective responsibility to deal with cyber security issues of the country.
- The policy lays out 14 objectives which include creation of a 5,00,000-strong professional, skilled workforce over the next five years through capacity building, skill development and training.
- The policy plans to create national and sectoral level 24×7 mechanisms for obtaining strategic information regarding threats to ICT infrastructure, creating scenarios for response, resolution and crisis management through effective, predictive, preventive, proactive response and recovery actions.
- The policy identifies eight different strategies for creating a secure cyber eco-system including the need for creating an assurance framework apart from encouraging open standards to facilitate interoperability and data exchange amongst different products or services.

Other Goals Include

- Creating a resilient and safe cyberspace for individuals, organizations, and the government.
- Creating frameworks, capabilities, and vulnerability management strategies for minimizing, faster prevention, or responding to cyber incidents and cyber threats.
- Encourage organizations to develop cybersecurity policies that align with strategic goals, business workflows, and general best practices.
- Simultaneously create institutional structures, people, processes, technology, and cooperation to minimize the damage caused by cybercrime.

Information Technology Rules

- The Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Rules, 2021 ('2021 Rules') were released by the Central Government in February 2021.
- The 2021 Rules have been passed **under Sections 69A(2), 79(2)(c) and 87** of the Information Technology Act, 2000.
- The 2021 Rules supersede the previously enacted Information Technology (Intermediary Guidelines) Rules 2011.
- The 2021 Rules were introduced to update the regulatory framework in order to empower the ordinary users of social media and place obligations on Social Media Intermediaries ('SMIs') and Significant Social Media Intermediaries ('SSMI') for a safe and trusted online environment.
- It places special emphasis on the protection of women and children from sexual offences on social media.

Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Amendment Rules, 2023 ('2023 Amendment')

- On April 6, 2023, the Ministry of Electronics and IT (MeitY) notified the Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Amendment Rules 2023 to amend the IT Rules 2021.
- This amendment authorises the central government to **designate a "fact check unit" to identify "fake or false or misleading" information in respect of any business** of the central government.

- Initially, this amendment only contained provisions for regulating online gaming companies. But later MeitY published a new draft that included "fact-checking powers."
- The fact check unit can scrutinize any online comments, news reports or opinions about government officials and ministries and then notify online intermediaries for its censorship.
- Such intermediaries not only include online social media companies but also service providers such as internet service providers and file hosting companies.
- If any intermediary fails to comply, they will be at risk of losing their **safe harbour status under Section 79 of the IT Act, 2000.**
    - Safe harbour provision states that "an intermediary shall not be liable for any third-party information, data, or communication link made available or hosted by him".

National Cyber Security Strategy 2020

- The National Cyber Security Strategy 2020 was formulated by the Office of National Cyber Security Coordinator at the National Security Council Secretariat in March 2021.
- The strategy aims to **improve cybersecurity audit quality** so organizations can conduct better reviews of their cybersecurity architecture and knowledge.
- The plan's main goal is to serve as the official guidance for stakeholders, policymakers, and corporate leaders to prevent cyber incidents, cyber terrorism, and espionage in cyberspace.
- It also calls for an index of cyber preparedness, and attendant monitoring of performance.

Reserve Bank of India Act, 2018

The Reserve Bank of India introduced the RBI Act in 2018, which details cybersecurity guidelines and frameworks for UCBs (urban co-operative banks) and payment operators. The RBI Act of 2018 aims to:

- Create standards that equalize security frameworks of banks and payment operators according to how they adapt to new technologies and digitalization.
- Mandate banks to create and present their cyber crisis management plans.
- Encourage banks to regularly schedule threat assessment audits.
- Help banks implement their own email domains with anti-phishing and anti-malware technology.
- All Indian banks must follow these guidelines to standardize frameworks for payment processing cybersecurity and combat the ever-increasing business complications in a digital environment.

Indian Computer Emergency Response Team (CERT-In)

- Made **official in 2004,** CERT-In is the national nodal agency set up **under Section 70B of the Information Technology Act, 2000** to respond to computer security incidents as and when they occur.
- CERT-In creates awareness on security issues through dissemination of information on its website and **operates 24x7 Incident Response Help Desk.**
- It provides Incident Prevention and Response services as well as Security Quality Management Service.
- CERT-In perform the following functions in the area of cyber security:
    - Collection, analysis and dissemination of Information on cyber incidents;
    - Forecast and alerts of cyber security incidents;
    - Emergency measures for handling cyber security incidents;
    - Coordination of cyber incident response activities;

    - Issue guidelines, advisories, vulnerability notes and whitepapers relating to information security, practices, procedures, prevention, response and reporting of cyber incidents; and
    - Such other functions relating to cyber security as may be prescribed.

National Critical Information Infrastructure Protection Center (NCIIPC)

- The National Critical Information Infrastructure Protection Center (NCIIPC) was **established on January 16, 2014,** by the Indian government, **under Section 70A of the IT Act, 2000**.
- Based in New Delhi, the NCIIPC was appointed as the national nodal agency in terms of Critical Information Infrastructure Protection.
- Additionally, the NCIIPC is regarded as a unit of the National Technical Research Organization (NTRO) and therefore comes under the Prime Minister's Office (PMO).
- NCIIPC is required to monitor and report national-level threats to critical information infrastructure. The critical sectors include:
    - Power and energy
    - Banking, financial services, and insurance
    - Telecommunication and information
    - Transportation
    - Government
    - Strategic and public enterprises
- NCIIPC successfully implemented several guidelines for policy guidance, knowledge sharing, and cybersecurity awareness for organizations to conduct preemptive measures of these important sectors, especially in power and energy.

Digital Personal Data Protection (DPDP) Act, 2023

- On August 11, 2023 the Digital Personal Data Protection Act, 2023 (the Act) received the assent of the President of India and was published in the Official Gazette.
- The DPDP Act is **India's first data protection Act,** and it establishes a framework for the processing of personal data in India.
- It provides for the processing of digital personal data in a manner that recognizes both the rights of the individuals to protect their personal data and the need to process such personal data for lawful purposes and for matters connected therewith or incidental thereto.
- The Act is concise and SARAL, that is, Simple, Accessible, Rational & Actionable Law, and used the word “she” instead of “he”, to acknowledge women in Parliamentary law-making.

Seven Principles

The Act is based on the following seven principles:

- The principle of consented, lawful and transparent use of personal data;
- The principle of purpose limitation (use of personal data only for the purpose specified at the time of obtaining consent of the Data Principal);
- The principle of data minimisation (collection of only as much personal data as is necessary to serve the specified purpose);
- The principle of data accuracy (ensuring data is correct and updated);
- The principle of storage limitation (storing data only till it is needed for the specified purpose);
- The principle of reasonable security safeguards; and
- The principle of accountability (through adjudication of data breaches and breaches of the provisions of the Bill and imposition of penalties for the breaches).

Internet of Things (IoT)

- The term Internet of Things refers to the collective network of connected devices and the technology that **facilitates communication between devices and the cloud,** as well as between the devices themselves.
- Basically, IoT integrates everyday “things” with the internet.

Working of IoT

- IoT systems work through the **real-time collection and exchange of data.** An IoT system has **three components: smart device, IoT application and a graphical user interface.**
- Smart device is a device, like a television, security camera, or exercise equipment that has been given **computing capabilities.** It collects data from its environment, user inputs, or usage patterns and communicates data over the internet to and from its IoT application.
- An IoT application is a **collection of services and software that integrates data received** from various IoT devices. It uses machine learning or artificial intelligence (AI) technology to analyze this data and make informed decisions.
- The decisions are communicated back to the IoT device and the IoT device then responds intelligently to inputs.
- The IoT device or fleet of devices can be managed through a graphical user interface.

Examples of IoT devices

Connected cars

- There are many ways vehicles, such as cars, can be connected to the internet. It can be through smart dashcams, infotainment systems, or even the vehicle's connected gateway.
- They collect data from the accelerator, brakes, speedometer, odometer, wheels, and fuel tanks to monitor both driver performance and vehicle health.

Connected homes

- Smart home devices are mainly focused on improving the efficiency and safety of the house, as well as improving home networking.
- Devices like smart outlets monitor electricity usage and smart thermostats provide better temperature control.
- Hydroponic systems can use IoT sensors to manage the garden while IoT smoke detectors can detect tobacco smoke.
- Home security systems like door locks, security cameras, and water leak detectors can detect and prevent threats, and send alerts to homeowners.

Smart cities

- IoT applications have made urban planning and infrastructure maintenance more efficient.
- IoT applications can be used for measuring air quality and radiation levels, reducing energy bills with smart lighting systems, detecting maintenance needs for critical infrastructures and increasing profits through efficient parking management.

Manufacturing

- IoT applications can predict machine failure before it happens, reducing production downtime.
- Wearables in helmets and wristbands, as well as computer vision cameras, are used to warn workers about potential hazards.

Logistics and transport

- Commercial and Industrial IoT devices can help with supply chain management, including inventory management, vendor relationships, fleet management, and scheduled maintenance.

- Shipping companies use Industrial IoT applications to keep track of assets and optimize fuel consumption on shipping routes.

Benefits of IoT

- Real-time resource visibility.
- Reduced costs.
- Improved operational efficiency.
- Data-driven insights for quick decision-making.
- End-to-end, remote monitoring and management of assets/resources.
- Real-time, predictive and prescriptive insights.
- Improve end-customer experience.

Big Data

- By definition, Big Data is data whose scale, diversity, and complexity require new architecture, techniques, algorithms, and analytics to manage it and extract value and hidden knowledge from it. Big Data is characterized by 6Vs:
    - **Volume:** amount of data from myriad sources.
    - **Variety:** types of data: structured, semi-structured, unstructured.
    - **Velocity:** speed at which big data is generated.
    - **Veracity:** degree to which big data can be trusted.
    - **Value:** business value of the data collected.
    - **Variability:** ways in which big data can be used and formatted.

Applications of Big Data

Governance

- Prevent cyber-attacks
- Enhance security systems
- Detect card-related fraud cases
- Predict criminal activities
- Improving the quality of education
- Disaster Management

Retail/Consumer

- Market based analysis
- Supply chain management and analytics
- Behaviour based targeting
- Market and consumer segmentation

Medical and Health

- Clinical trials data analysis
- Disease pattern analysis
- Campaign and sales program optimization
- Patient care quality and program analysis
- Medical device and pharmacy supply chain management
- Drug discovery and development analysis

Economy

- To manage financial data
- To capture the production, price statistics, and calculate the resultant GDP
- Evade risks and minimize losses for financial firms
- Catching hold of tax evaders
- Deregistration of shell companies
- Preventing money laundering and curbing terrorism financing

Finances and Fraud Services

- Compliance and regulatory reporting
- Risk analysis and management
- Fraud detection and security analysis
- Credit risk and scoring
- Trade surveillance
- High speed arbitrage trading

Web and Digital Media

- Large scale clickstream analysis
- Ad targeting, forecasting and optimization
- Social graph analysis and profile segmentation

Agriculture and Food

- Seed Selection
- Geo-Tagging to keep the track record of agricultural assets
- Weather Forecasting
- Effective water management
- Food Processing
- Identification of Crop Diseases

Telecommunications

- Revenue assurance and price optimization
- Call detail record analysis
- Network performance
- Mobile user location analysis

Government Initiatives and Interventions in India

- **National Data & Analytics Platform (NDAP):** NITI Aayog launched the National Data & Analytics Platform (NDAP) in May 2022. The platform uses cutting-edge methods to link diverse datasets from across the government and enables the use of several types of data at once. As of Feb 2023, NDAP hosts 885 datasets from across 15 sectors and 46 Ministries.
- **Big Data Management Policy:** It was drafted by CAG for auditing large chunks of data generated by the public sector in the states and the union territories.
- **National Data Warehouse on Official Statistics:** The Ministry of Statistics and Programme Implementation has proposed to establish a National Data Warehouse on Official Statistics with a view to leveraging big data analytical tools to further improve the quality of macro-economic aggregates.
- Use of Direct Benefit Transfer in MGNREGA (Mahatma Gandhi National Rural Employment Guarantee Act), Aadhaar for authentication and availing welfare scheme, Smart City Mission, Digital India, BHIM app etc. are important government initiatives that are using Big Data for achieving good governance in the country.