

Antrix Corporation, Bangalore is ISRO's commercial arm.

Difference between air-space and space

- Air space is controlled by individual country. Space is Global common.
- Air space is used for air transport.

1. ORBITS AND SATELLITES

- An orbit is a regular, repeating path that one object in space takes around another one. An object in an orbit is called a satellite. – NASA.
- Planets, comets, asteroids and other objects in the solar system orbit the sun.
- After having lived out their useful lives, satellites become **space debris**.
- Most of the objects orbiting the sun move along or close to an imaginary flat surface. This imaginary surface is called **ecliptic plane**.
- An orbit has a **balance of two forces**: **Centripetal force** (due to satellite's **velocity**) and earth's **gravitation force**. An artificial satellite is always falling towards earth. But, it does not fall down due to the balance of these two forces.

1.1 Type of satellites

- **Natural satellite**: like Earth or moon. Many planets have moons orbiting them.
- **Man-made satellite**: like International Space Station. In 1957, Soviet Union launched the world's first artificial satellite, **Sputnik 1**.
- **Communication satellites**: all INSATs (Except INSAT 3D), GSAT, EDUSAT.
- **Navigation satellites (7)**: IRNSS
- **Space science satellites (2)**: MOM, ASTROSAT
- **Earth observation satellites (12)**: INSAT 3D and all others.

1.2 Types of orbits

Polar Orbit

- It has an inclination of 90° to the equator. In a polar orbit, a satellite passes above both the north and south poles.
- This allows the satellite to **observe every part of the Earth**. But, a location **cannot** be under **continuous surveillance**.
- Hence, polar orbit is suitable for **earth mapping** satellites, **weather satellites**, **communication** satellites, **remote sensing** satellites, **reconnaissance** or **spy** satellites and **surveillance** satellites.
- Satellite is **launched from higher latitude**.

Sun Synchronous Orbit or Sun Synchronous Polar Orbit (SSO or SSPO)

- This is a **special case of polar orbit**.
- This orbit allows a satellite to **pass over a spot on the Earth at the same time of day**.
- The satellite is **always at the same angle to the Sun**. Since there are 365 days in a year and 360 degrees in a circle, the satellite has to **shift its orbit by one degree per day** (approximately).
- These are **Low Earth Orbit**.
- This orbit can place a satellite in **constant sunlight**, which allows the solar panels to work continually.
- Advantage: A location can be under **continuous surveillance**.

1. SPACE TECHNOLOGY	1
Difference between air-space and space	1
1. ORBITS AND SATELLITES.....	1
2. SATELLITE LAUNCH VEHICLES	2
3. SPACE PROBE	3
4. RELATED CURRENT AFFAIRS	4
2. DEFENCE TECHNOLOGY	10
1. INDIAN MISSILE PROGRAMME.....	10
2. SUBMARINE FLEET	11
3. SURFACE FLEET: NAVAL SHIPS	11
4. AIR FLEET.....	13
5. INTERNATIONAL DEFENCE ARCHITECTURE.....	14
3. NUCLEAR TECHNOLOGY	17
1. NUCLEAR MATERIALS	17
2. THE URANIUM ENRICHMENT PROGRAMME	17
3. NUCLEAR REACTORS IN INDIA	17
4. THREE STAGE NUCLEAR PROGRAMME	18
5. NUCLEAR WEAPONS.....	19
6. NUCLEAR TRIAD	19
7. INDIAN NUCLEAR DOCTRINE	19
8. RADIOISOTOPES.....	19
9. LARGE HADRON COLLIDER (LHC).....	20
10. NUCLEAR ACCIDENTS	20
11. INTERNATIONAL NUCLEAR ARCHITECTURE	21
4. BIOLOGY AND BIOTECHNOLOGY	22
1. Cell.....	22
2. Stem Cells	24
3. Genetics.....	25
4. Virus.....	28
5. DNA technology	30
6. Important definitions	33
7. Five Kingdom Classification.....	33
8. Biotechnology	35
9. Gene Therapy	36
10. GM CROPS.....	38
5. NANOTECHNOLOGY	39
Applications of Nanotechnology.....	39
Nanotechnology in India	39
Challenges	39
6. CYBER SECURITY	41
Definitions.....	41
Need for Cyber Security	41
Cyber attackers and their motives	41
Recent cyber attacks.....	41
Challenges	41
Institutional Actions by Governments.....	41
Legislative Actions by governments	42
International efforts	42
Way Forward.....	42
Conclusion	42
7. INTELLECTUAL PROPERTY RIGHTS	44
7.1 Organisations related to IPR.....	44
7.2 TYPES OF IPR	44
7.3 ISSUES RELATED TO IPRS.....	45
7.4 IPR RELATED CURRENT AFFAIRS.....	45

1. SPACE TECHNOLOGY

Indian Space Programme was started in early 60s by Pt. Jawaharlal Nehru and Vikram Sarabhai under the DAE.

Indian Space Research Organization (ISRO) was established in 1969.

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Equatorial orbit

- It is an orbit that lies close to the equatorial plane. Such an orbit has an inclination near 0° .
- A satellite must be launched from a place close to the equator. E.g. French Guiana, Thumba.
- Launches directly into equatorial orbit **eliminate the need for costly adjustments to a spacecraft's trajectory.**

Thumba Equatorial Rocket Launching Station (TERLS) at VSSC

- Very close to magnetic equator of the Earth, making it ideal to conduct atmospheric research.
- One of the farthest points from Pakistan and China.

Geosynchronous orbit (GSO) or Earth Synchronous orbit

- It has a period of revolution equal to period of rotation of earth, one sidereal day. It is synchronized with the Earth's rotation.
- Satellites are typically launched in an eastward direction. A circular geosynchronous orbit is 35,786 km above the Earth's surface.
- The orbit is tilted with respect to the plane of the equator.
- An object in geosynchronous orbit returns to exactly the same position in the sky after one sidereal day.

Notes: **solar day:** the time between successive noons. It is 24 hours for earth.

Sidereal day: the time in which Earth rotates once around its axis 360 degrees. It is ~ 4 minutes shorter than solar day. (23 hours, 56 minutes, 4 seconds).

Geostationary orbit or geosynchronous equatorial orbit (GEO)

- It is a special case of geosynchronous orbit, which has a **circular orbit in Earth's equatorial plane**.
- A geostationary orbit is a particular type of equatorial orbit.
- A circular geosynchronous orbit is **35,786 km** above Earth's equator. It yields an **orbital period of 24 hours**.
- The satellite has **very high Speed**, so that its orbit matches the Earth's rotation.
- An object in such an orbit **appears motionless**, looks like **fixed in the sky** to ground observers or to its **footprint**.
- Application: **Communications** satellites and **weather** satellites. E.g. **IRNSS**: Three satellites are in geostationary orbit over the Indian Ocean.

Geosynchronous or Geostationary Transfer Orbit (GTO)

- It is a **highly elliptical Earth orbit** with elliptical orbit used to transfer between two circular orbits of different radii. It has an apogee (high point) of 35,784 km.
- A **high thrust launch vehicle** helps to **escape Earth's atmosphere and to maximize total mass**.

Low Earth Orbit (LEO)

- It is placed near to the Earth at an altitude of 2,000 km.
- **Application:** All **crewed space stations** to date, and majority of the satellites, are in LEO. The **International Space Station** is in LEO.
- **Gaganyaan, 2022** will be the first human spaceflight mission of India.

Medium Earth orbit (MEO)

- A region of space above low Earth orbit and below geosynchronous orbit.
- The most common altitude is approximately 20,000 kilometres. It yields an orbital period of 12 hours.

- **Application:** navigation satellites with global coverage. E.g. **Global Positioning System (GPS), USA. Glonass, Russia. Galileo, EU. BeiDou, China.**

Note: If the satellite is in a **polar, sun-synchronous, or equatorial orbit**, its orbital altitude may be **medium or low**.

High Earth orbit

- Its altitude is above that of a geosynchronous orbit i.e. 35,786 kilometres.
- The orbital periods are greater than 24 hours.

2. SATELLITE LAUNCH VEHICLES

Payload

- It is the carrying capacity of an aircraft or launch vehicle, usually measured in terms of weight.

Fuel and Oxidiser

- **PS2:** Vikas engine, Earth storable liquid rocket engine, UDMH (Fuel) + N2O4 (Oxidiser)
- **PS3:** Solid fuel = HTPB.
- **PS4:** 2 engines, MMH + MON

Engine

Principle: Based on Newton's Third Law of Motion.

- Jet engines and rocket engines work on the same principle.
- **Jet engines** get the oxygen to burn fuel from the air. These have two openings -an intake and an exhaust nozzle.
- **Rockets carry their own oxygen**, which allows them to operate in space. These have one opening -an exhaust nozzle.

Vikas Engine

- The Vikas (from initials of VIKram Ambalal Sarabhai)
- It is a family of **liquid fuelled rocket engines**.

Kaveri Engine

- It is a **jet engine. (Not for space)**
- Originally intended for **HAL Tejas**.
- Failed to satisfy the technical requirements.

Cryo-engine

- It uses a **cryogenic fuel and oxidizer**. i.e. its fuel and oxidizer are **gases liquefied** and stored at **very low temperatures**.
- **liquid hydrogen (LH2) fuel and the liquid oxygen (LOX) (liquid H₂ + O₂)**
- The C25 is powered by CE-20, India's largest cryogenic engine, designed and developed by the Liquid Propulsion Systems Centre.
- **India is among six nations** — apart from the US, Russia, France, Japan and China — to possess cryogenic engine technology.

Strap-on Motors

- Along with the solid rocket motor core of the first stage, strap-ons these are required to extract maximum thrust out of the initial stages.
- **PSLV:** In PSLV-XL and PSLV-G, there are HTPB based **solid** Strap-on motors. There are no strap-on motors in PSLV-CA (core alone version).
- **GSLV:** There are 4 **liquid** strap-on motors, powered by one **Vikas engine** each.

PSLV: Polar Satellite Launch Vehicle

- Before the advent of PSLV in 1993, launching a satellite into sun-synchronous orbits service was commercially available **only from Russia**.
- It was developed to launch **earth observation satellites**. E.g. **Indian Remote Sensing (IRS) satellites** into **sun-synchronous orbits**.
- PSLV is an **expendable medium-lift launch vehicle**.

Capacity

- It can launch up to 1,750 kg payload to **Sun-Synchronous polar orbits (600 km approx)**.
- It is also used to launch a payload with **lower lift-off mass** up to 1400 Kg into **Geostationary Transfer Orbit (GTO)**. It ultimately launches a satellite into Geosynchronous and Geostationary orbits. E.g. for **IRNSS**.

Stages

- Four stages, alternating solid and liquid stages.**
- PS1:** It is a **Solid fuel (HTPB)** powered stage. It provides the launcher the high thrust that is required for lift off. PSLV-G and PSLV-XL are Strap-on versions.
- PS2:** It is **earth storable liquid fuel** powered stage. **Vikas engine** is used.
- PS3:** It is a **Solid fuel** powered stage, which provides high thrust after the atmospheric phase of the launch.
- PS4:** It is a **Solid fuel (MMH + MON)** powered stage. 2 engines are used. The purpose of this stage is **to correct the trajectory**.

Some notable payloads launched by PSLV

- India's **first lunar probe Chandrayaan-1**, India's **first interplanetary mission Mangalyaan** and India's **first space observatory Astrosat**, India's indigenous navigation system **IRNSS** etc.

GSLV: Geosynchronous Satellite Launch Vehicle

- GSLV is designed mainly to deliver the **communication satellites** to the **Geosynchronous Transfer Orbit (GTO)**.
- GSLV Mark II (GSLV Mk II):** It is a three stage **medium lift launch vehicle**. (First Flight: 2001). It uses **CE-7.5, India's first cryo engine**.
- GSLV Mk-III:** It is a three stage **heavy lift launch vehicle** with an indigenous cryogenic upper stage engine (C25).

It has two solid fuel strap-on engines in first stage. It uses **CE20, India's largest cryogenic engine**.
It will be the launch vehicle for **Gaganyaan to LEO**.

Capacity

- GSLV Mk-II:** It can launch up to 2,500 kg payload to **GTO** (Geosynchronous Transfer Orbit) and up to **5,000 kg to LEO** (low earth orbit).
- GSLV Mk-III:** It has been designed to carry heavier communication satellites weighing up to **4000 kg to GTO, and 8,000 kg to LEO**.

Stages

- Stage 1:** The first stage of GSLV is **derived from the PS1 of PSLV**. Strap-ons are required to extract maximum thrust out of the initial stages.
- Stage 2:** The second stage was **derived from the PS2 of PSLV**, where the **Vikas engine** has proved its reliability.

- Stage 3: Cryogenic Upper Stage (CUS- Mk II, C25-Mk III):** It imparts a high velocity to the payload to achieve **escape velocity**.

Some notable payloads launched by GSLV

- Communication satellites of INSAT class, EDUSAT and GSAT** (all in Geostationary orbits)

Problem: All INSATs were launched from outside India.

Reusable launch vehicle

A few companies are developing reusable launch systems intended to cut costs. Such as the **SpaceX Falcon 9**.

3. SPACE PROBE

It is a robotic spacecraft that **does not orbit Earth**, but **explores into outer space, orbits or lands on other planetary bodies**. E.g. Moon or Mars.

Space Probes by NASA

- Cassini-Huygens:** (NASA+ESA) To study Saturn, along with its ringed system and moons. In 2017, the probe was de-orbited and burned up in Saturn's atmosphere.
- New Horizons:** First probe **Pluto**.
- Dawn:** First spacecraft to visit proto-planet (4 Vesta). Currently orbiting **Ceres**. **Ceres is the largest object in the asteroid belt** that lies between the orbits of Mars and Jupiter.
- Mars Climate Orbiter, Mars Polar Lander:** planet Mars.
- Juno:** planet Jupiter.
- Messenger:** planet Mercury.
- Pioneer 10 and 11, Voyager 1 and 2:** Interstellar probes: Beyond the Solar System.
- Apollo 11:** the first crewed mission of USA to land on the Moon (1969).
- Themis:** to study auroras.

Other space probes

- Luna 2:** Russia. First man-made object to reach the surface of the Moon (1959).
- Selene:** Japanese lunar orbiter.
- Chang'e 4, 2019:** first soft landing on the far side of the Moon [Chang'e: Chinese Moon goddess]

Chandrayaan-1, 2008-2009

- It was India's first lunar probe. It made India the **fourth country** to place its flag on the Moon.
- Launched from PSLV-XL C11 rocket, from SDSC, Sriharikota.
- The probe struck near Shackleton crater, known as **Jawahar Point**.
- It stopped working in 2009 due to failure of the star sensors and poor thermal shielding. In 2016, NASA used ground-based radar systems to relocate it in its lunar orbit.

Chandrayaan-2, July-2019

- It will be India's second lunar exploration mission, and is to be launched from GSLV Mk III.
- If successful, Chandrayaan-2 will be the **India's first mission** to land near the **lunar south-pole**. Earlier Chang'e 4 has landed here.
- Chandrayaan-2 will make India the 4th country to **soft-land** on the moon, only after US, USSR and China. **Soft-landing** prevents damaging vehicle.

- It has three modules namely Orbiter, Lander (**Vikram**) & Rover (**Pragyan**). The rover data will be relayed through Chandrayaan-2 orbiter.

ASTROSAT, 2015

- AstroSat is **India's first dedicated multi wavelength space observatory**. (space telescope).
- It was launched from PSLV-XL vehicle at SDSC, with a lift-off mass of **1500 kg** into a **near-Earth, equatorial orbit**.
- It is an **IRS-class satellite** (Indian Remote Sensing).
- A number of space agencies** have become successful to send a space observatory.

Mangalyaan or Mars Orbiter Mission (MOM)

- It is orbiting Mars since 2014. It is "technology demonstrator" for interplanetary mission.
- It is **India's first interplanetary mission**. ISRO became fourth space agency to reach Mars, after Roscosmos (Russia), NASA (USA), and the European Space Agency.
- India became the **first nation to do so in first attempt**, and is the **first Asian nation to reach Mars orbit**.
- The lifted-off from Satish Dhawan Space Centre using a PSLV C25 rocket in 2013.
- The total cost of the mission was ₹450 Crore, the least-expensive Mars mission to date.

Aditya L1, 2019

It is India's first solar mission.

It will be placed in a halo orbit around a vantage point in space known as **L1 Lagrange point**. The Aditya-L1 mission will be inserted in a halo orbit around the L1, which is about 1.5 million km from the Earth.

The 1,500 kg class satellite, carries a total of seven payloads, including the **main payload- Visible Emission Line Coronagraph (VLEC)**.

Objective:

- First satellite to study the magnetic field of the sun's corona.
- To study that why the **deeper layer of the sun (photosphere)** is at much lower temperature than the **corona**.
- To study space weather, solar wind, etc. to Pluto.

Lagrange point

- It is a point of equilibrium where **combined gravitational forces** of two bodies **equal the centrifugal force** felt by much smaller body. For example, Earth and sun.
- The sun can be viewed sun without any occultation or eclipses.

Gaganyaan Mission

It will be first Indian human spaceflight mission into the space by **2022**.

- It will use **GSLV Mk-III**.
- Experiments are already done and are successful. such as Space Capsule Recovery Experiment (**SRE-2007**), Crew module Atmospheric Reentry Experiment (**CARE-2014**).
- ISRO also recently unveiled a **space capsule** (crew module) and **Space suit prototype**.
- Aim:** development of newer technologies, increased understanding of human body functioning, understanding of effects of microgravity and cosmic radiation on bioorganisms etc.

- Will be implemented by **ISRO Human Space Flight Centre (HSFC), Bengaluru**.

4. RELATED CURRENT AFFAIRS

Anti-satellite (ASAT) missile

- ASATs are **space weapons designed to destroy satellites** for strategic military purposes.
- India recently became the fourth country**, only next to the United States, Russia, and China, to successfully demonstrate this capability.
- Mission Shakti:** In March 2019, India destroyed a "live satellite" in **Low Earth orbit**. Developed by **DRDO**, It was launched from **Integrated Test Range (ITR) in Chandipur, Odisha** and targeted **Microsat-R**.
- Indian ASAT program utilized technologies from Indian Anti-Ballistic missiles defence system. **Prithvi Air Defence (PAD)** is India's first exo atmospheric interceptor, similar to **THAAD**, an American anti-missile system.
- No ASAT system has yet been utilised in warfare.

IRNSS or NAVIC

- Indian Regional Navigation Satellite System or NAVigation with Indian Constellation.
- Rationale to develop:** American Global Positioning System (GPS) refused to provide services during the Kargil War in 1999.
- It provides real-time positioning and timing services.
- It covers India and a region extending 1,500 km around it.
- The system at present consists of a constellation of seven satellites, with two additional satellites on ground as stand-by. There are plans to expand these from 7 to 11.
- Three satellites will be in geostationary orbit and four in geosynchronous orbit.
- News Context:** India's IRNSS is now part of Worldwide Radio Navigation System (WWRNS).
- India became 4th country** to have its **independent regional navigation satellite system recognized by International Maritime Organisation (IMO)** as a part of WWRNS.
- Other 3 are:** US's GPS, Russia's GLONASS, China's BeiDou.

Web Mapping Service

- It is the process of using the maps delivered by geographic information systems (GIS) in World Wide Web (Online).
- It allows users to explore 2D and 3D representation of the Earth surface. e.g. **Google earth**, **Wikimapia**, **Bhuvan**.
- Bhuvan browser** is specifically tailored to view India, offering the highest resolution in the region.

Outer Space Treaty, 1967

- Treaty on principles governing the activities of states in the exploration and use of outer space.
- India is a signatory.

Laser Interferometer Space Antenna (LISA) mission

- It is led by the **European Space Agency** to detect and measure **gravitational waves**, the tiny ripples in the fabric of space-time.

- LISA would be the first dedicated space-based gravitational wave detector.

GSAT-11

- It is the heaviest satellite built by ISRO. It weighs around 5855 Kg, double the size of biggest satellite built till now.
- It was launched into circular geo-stationary orbit from French Guiana by Ariane-V Rocket of Arianespace (a joint venture of Airbus and Safran).
- It will provide country's Internet Broadband from space to untouched areas at throughput data rate of 16 gbps. It is part of ISRO's high-throughput communication satellite (HTS) fleet.
- It carries 40 transponders in Ku (32)/ Ka (8) Band. For the First time use of Ka-Band is introduced in India.

ISRO's most powerful launcher **GSLV-Mk III** can launch satellite weighing up to 4000 kg only to GTO.

Ku vs Ka Band

- Ku band ranges between 12-18 GHz while Ka Band ranges from 26.5-40 GHz.
- It is difficult to build hardware and software for Ka Band Transponders. Most satellites today use Ku Band Transponders.

CMS- 01

- News Context:** ISRO launched India's 42nd communication satellite CMS-01.
- It will provide services in Extended-C Band of frequency spectrum.
- Its coverage includes: Indian mainland, Andaman-Nicobar, Lakshadweep.
- It will be 1st in a new series of communication satellites by India after GSAT and INSAT series.

Joint Lunar Polar Exploration Mission (JAXA)

- News Context:** Details of JLPE mission were released by Japan Aerospace Exploration Agency (JAXA).
- It was conceptualized by JAXA and ISRO in 2017 to put a lander and a rover on Moon's surface.
- It would last for 6 months and will target a sunlit region near Moon's South Pole.
- Rover will observe areas, where water may present.
- If it detects H₂, rover will mine the surface to collect samples.

Objectives:

- To understand distribution, conditions, other parameters of water resources at moon's South Pole.
- To determine resources for sustainable space exploration activities in future.

Moon's South Pole:

- Its craters have been untouched by sunlight for billions of years.
- Its permanently shadowed craters are estimated to hold nearly 100 million tons of water.
- It's a suitable stop for future space exploration.
- It has traces of H₂, Ammonia, Methane, Sodium, Mercury, Silver.

Space Remote Sensing Policy, 2020 (SpaceRS Policy, 2020)

- It encourages stakeholders to participate in space based remote sensing activities to commercialize space technology.

- Earlier Remote sensing data policy (RSDP), 2011 was more restrictive and provides less opportunities to service providers.
- Objective:**
 - To Promote Indian Industries to carry out space based remote sensing activities within and outside India.

Remote Sensing

- It is a process of detecting and monitoring physical characteristics of an area/object.
- It is done by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft).
- Application of space based remote sensing includes:**
 - Identifying and mapping Natural Resources, Disaster management.
 - Agriculture, Rural and urban development, Weather and climate etc.
- Some Eg:**
 - Cameras on satellites and airplanes take images of large areas on Earth's surface.
 - Sonar systems on ships can be used to create images of ocean floor without needing to travel to ocean bottom.

Indian National Space Promotion and Authorization Centre (In-Space)

- News Context:** Government has created IN-Space to boost private sector participation in entire range of space activities.
- It is a new entity of Department of Space with its own chairperson and board.
- It will regulate and promote:**
 - Building of routine satellites.
 - Rockets and Commercial launch services through Indian industry and startups.
- It will act as an interface between ISRO and private parties.
- It will assess how best to utilise India's space resources and increase space-based activities.
- It will function autonomously and parallel to ISRO.
- Note:** It is 2nd space organisation created by Government in last 2 years.
 - 1st was New Space India Limited (NSIL).

New Space India Limited, 2019

- It was founded by Department of Space to bridge gap between ISRO and private sector.
 - It is to facilitate transfer of ISRO technologies to industry.
- It is Government owned company.
- Note:** It will not replace ANTRIX.

India's 1st In-Orbit Space Debris Monitoring and Tracking System

- It will provide global real-time earth coverage.
- It will deploy:**
 - Nano Satellites in Low Earth Orbit.
 - Space-based air surveillance payload for accurate tracking of both aircraft and space objects.
- News Context:** Digantara, (India's 1st air and space surveillance company) has developed India's 1st in-orbit Space debris monitoring and tracking system.

Space Debris

- It encompasses both natural (meteoroid) and artificial (man-made) particles.
- Meteoroids are in orbit about sun.
 - While most artificial debris is in orbit.
- There are no international space laws to clean up debris in Low Earth Orbit.

Himalayan Chandra Telescope (HCT)

- It is an optical-infrared telescope to study solar system bodies and star formation in external galaxies.
- It is installed at Indian Astronomical Observatory (IAO), Ladakh.
- It is named after India-born Nobel laureate Subrahmanyam Chandrasekhar.
- News Context: HCT completed 20 years of its operation.

India's 2nd Rocket Launch Pad

- It is setup in Thoothukudi, Tamil Nadu.
- It will have 1 launch pad exclusively for small satellite launch vehicles (SSLV).
- At present, India has 1 rocket port at Sriharikota (Andhra Pradesh) with 2 launch pads.

Sonic Boom

- It is a thunder-like noise heard on ground when an aircraft or other type of aerospace vehicle flies overhead faster than speed of sound (Supersonic).
- If source of sound keeps moving slower than speed of sound itself, this source remains nested within sound waves that are travelling in all directions.
- When an aircraft travels at supersonic speed, field of sound waves moves to rear of the craft.
- News Context: It was heard in Bengaluru, during Indian Air Force test flight.

Nasa's Heliophysics Missions

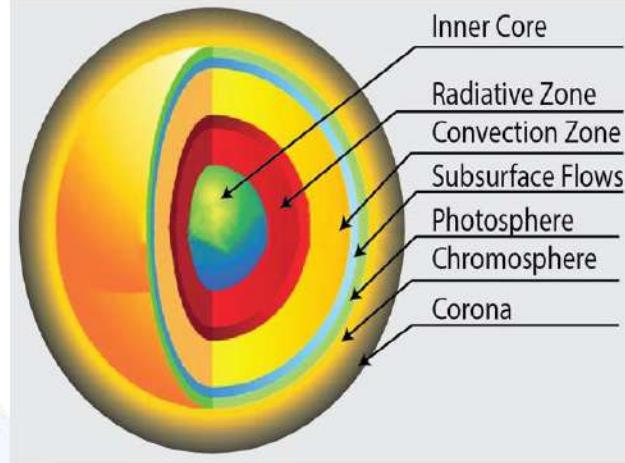
- News Context: NASA approved 2 Heliophysics Missions to Explore Sun, Earth's Aurora.
- It will explore Sun and system that drives space weather near Earth.
- It will help scientists to understand Sun and Earth as an interconnected system.

Extreme Ultraviolet High-Throughput Spectroscopic Telescope (EUVST) Mission (Solar-C):

- It is a solar telescope to study how Sun's atmosphere releases solar wind and drives eruptions of solar material.
- It is led by Japan Aerospace Exploration Agency.
- Solar wind is created by outward expansion of plasma (a collection of charged particles) from the Sun's corona (outermost atmosphere).
- Solar winds can disrupt communications, navigation systems, satellites.

Electrojet Zeeman Imaging Explorer (EZIE) Mission:

- It will study electric currents in Earth's atmosphere linking aurora to Earth's magnetosphere.
- Magnetosphere is region of space surrounding Earth.
 - Where dominant magnetic field is magnetic field of Earth, rather than of interplanetary space.
- Magnetosphere is formed by interaction of solar wind with Earth's magnetic field.
- Other solar missions: European Space Agency's Solar Orbiter.

LAYERING OF THE SUN

Auroras

- They are caused by interaction of energetic particles (electrons and protons) of solar wind with atoms of upper atmosphere.
- It occurs primarily in high latitudes of both hemispheres.
- In Northern Hemisphere, they are called: Aurora borealis, aurora Polaris (Northern Lights).
- In Southern Hemisphere: Aurora australis (Southern Lights).

Fifth State of Matter

- News Context: NASA observed 5th state of matter in space for 1st time as part of Bose Einstein Condensates (BEC) Experiments.
- Existence of BEC, is also known as 5th state of matter.
- It was predicted by Albert Einstein and Indian mathematician Satyendra Nath Bose in early 1920s.
- Other 4 states of matter: Solids, Liquids, Gases, Plasma.
- BEC is a super cooled gas that no longer behaves as individual atoms and particles.
 - But rather an entity in a single quantum state.
- They are formed when atoms of certain elements are cooled to near absolute zero (0 Kelvin, minus 273.15 Celsius).
 - When they reach that temperature, atoms become a single entity with quantum properties.
 - Wherein each particle also functions as a wave of matter.
- They are extremely fragile and slightest interaction with external world is enough to warm them past their condensation threshold.
- This makes it nearly impossible for scientists to study them on Earth.
 - Where gravity interferes with magnetic fields required to hold them in place for observation.

Plasma: 4th State of Matter

- It is like a Gas but comprised of positive ions and free electrons with little or no overall electric charge.
 - Because of presence of charged ions, it is highly electrically conductive and responds strongly to magnetic and electric fields (unlike gas).
- They have no fixed shape or volume, and are less dense than solids or liquids.
- It is most common state of matter in Universe comprising more than 99% of our visible universe.
- It occurs naturally in sun, core of stars, quasars, X-ray beam emitting pulsars and supernovas.
- On Earth, Plasma naturally occurs in flames, Lightening, Auroras.

Saturn's Tilt Caused by Its Moons

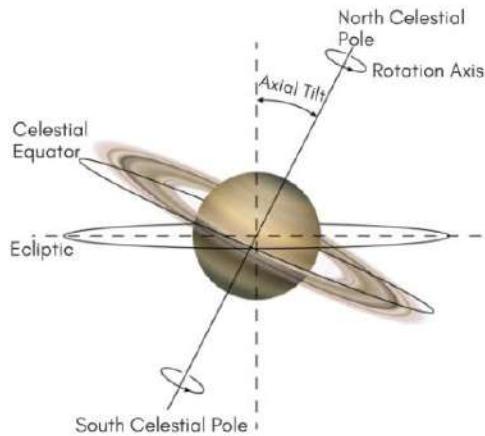
- News Context: Saturn's axial tilt is caused by gravitational pull of Saturn's moons.
 - As they migrate away from their host planet.
- They also predict that planet will keep tilting in future for a few billion years.

Saturn's Tilt

- Its axis is tilted by 26.73 degrees with respect to its orbit around the Sun.
 - Which is like Earth's 23.5-degree tilt.
- This means that, like Earth, Saturn experiences seasons.
 - Earth's tilt is due to energetic collisions between 'planetesimals'.
 - Which eventually coalesced to form planets.
- Planetesimal: It is one of a class of bodies that are theorized to have coalesced to form Earth and the other planets after condensing from concentrations of diffuse matter early in history of the solar system.

Missions to Saturn:

Axial Tilt of Saturn



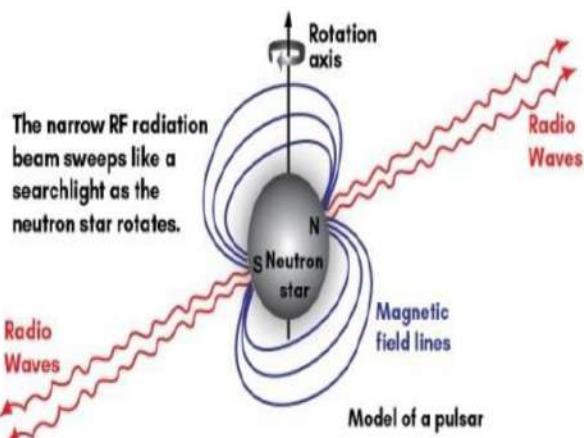
- Pioneer 11, launched by NASA: 1st spacecraft to study Saturn up close.
 - It ended in 1995.
- Voyager 1 and 2: Launched by NASA.
 - It is to conduct close-up studies of Jupiter and Saturn, Saturn's rings, larger moons of 2 planets.

Exoplanets

- They are planets, that orbit around stars other than Sun.
- They are very hard to see directly with telescopes.
 - As they are hidden by bright glare of stars they orbit.
- Some of exoplanets discovered so far:
- Super earth: It is an exoplanet that is similar to size of Earth.
 - But with more mass than Earth and less than a larger planet like Uranus or Neptune.
- Kepler-1649c: It is Earth-size exoplanet, which is 300 light-years away.
- K2-18b: It is more than 8 times mass of Earth.
 - it orbits a red dwarf star 124 light-years away from Earth in Leo constellation.
- WASP-76b: It is 640 light-years from earth.
- Fomalhaut B: It is one of 1st exoplanets ever discovered.
 - It was recently confirmed as a cloud of dust and not an exoplanet.
- News Context: A potential radio signal was collected for 1st time from an exoplanet system about 51 light-years away from our solar system.
- Observing an exoplanet's magnetic field helps astronomers as:
 - Decipher a planet's interior and atmospheric properties, Physics of star-planet interactions.

Pulsars

- They are rapidly rotating neutron stars that emit radio-frequency pulses.
- They are highly magnetic.
- They have magnetic fields that range from 100 million times to 1 quadrillion (a million billion) times stronger than Earth's.
- They can radiate light in multiple wavelengths, from radio waves all the way up to gamma-rays, the most energetic form of light in the universe.
- Radio beam waves emitted by a pulsar may not pass-through field of view of an Earth-based telescope, preventing astronomers from seeing it.
- Scientists use pulsars to study extreme states of matter, gravitational waves, search for planets beyond Earth's solar system, measure cosmic distances.

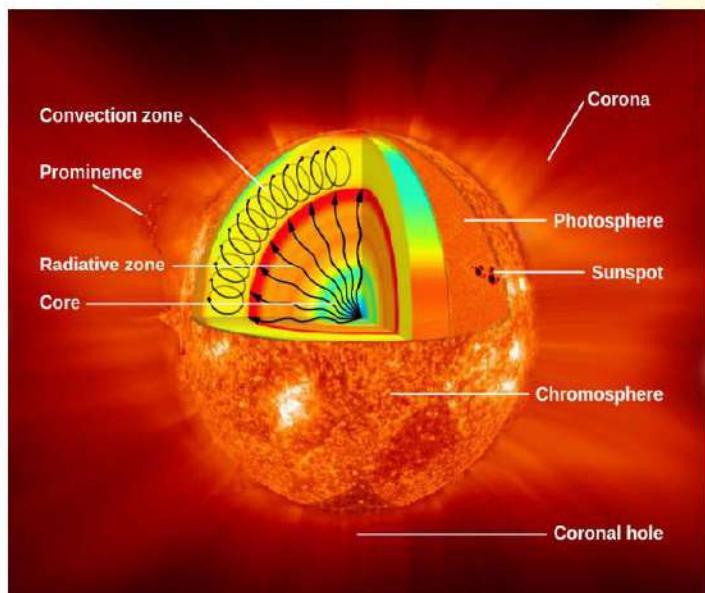


Neutron Stars and Magnetars

- **Neutron stars:** They are formed when a massive star runs out of fuel and collapses.
 - Core of star collapses, crushing together every proton, electron into a neutron.
 - If core of collapsing star is between about 1-3 solar masses.
 - These newly created neutrons can stop collapse, leaving behind a neutron star.
- **Note:** Stars with higher masses will continue to collapse into stellar-mass black holes.
- **Magnetar:** It is another type of neutron star.
 - In a typical neutron star, magnetic field is trillions of times that of Earth's magnetic field.
 - However, in a magnetar, magnetic field is another 1000 times stronger.

Magnetic Field of Sun's Corona

- News Context: Global magnetic field of Sun's corona was measured for 1st time.
- Corona is outermost layer of Sun's atmosphere, consisting of hot, diffuse, highly ionized plasma.
- Sun's magnetic field governs many aspects of Sun's behavior.
 - Such as 11-year solar cycle, solar eruptions etc.
- Till now, solar magnetic fields were measured only at Sun's surface (photosphere).
- Magnetic field information of whole atmosphere of sun is required to understand interplay between solar plasma and magnetic field.
- Researchers used a technique known as coronal seismology or magneto seismology to measure coronal magnetic field.
- This method uses magnetic waves.
 - That are observed to travel along with magnetic fields.



Mars 2020, NASA

- Rover will seek signs of ancient life and collect rock, soil samples for possible return to Earth.
- Rover is equipped with specialized equipment to collect data.
 - To analyze weather conditions to help for future human missions.
 - To produce O₂ from CO₂ rich atmosphere.
- The mission also includes Ingenuity Mars Helicopter.
- Ingenuity will be 1st aircraft to attempt controlled flight on another planet.

Artemis Accords for Responsible Space Exploration

- Artemis Accords are a series of bilateral agreements between NASA and its international partners that want to cooperate on Artemis program.
- Artemis is NASA's moon mission under which it will land 1st woman and next man on Moon by 2024.
- It is established to create common set of principles to govern civil exploration and use of outer space at times.
 - When numerous countries and private sector players conducting missions and operations in cislunar space (space between earth and moon).
- Agreement includes various norms such as:
 - Transparency, peaceful exploration, Interoperability of systems.
 - Registration of Space Objects, Orbital Debris & Spacecraft Disposal etc.
- Accord is based on Outer Space Treaty of 1967.
 - That was created to ensure fairness and peaceful relationships at a time, when humans were 1st exploring final frontier.
- Note: France, Japan, Australia, Canada have already shown their support.
 - India has not clarified its stand yet.

Antarctic Impulsive Transient Antenna (ANITA)

- ANITA instrument is a radio telescope.
 - It detects ultra-high energy cosmic-ray neutrinos from a scientific balloon flying over continent of Antarctica.
- A neutrino is a subatomic particle that is very similar to an electron.
 - But it has no electrical charge and a very small mass.
- They are one of most abundant particles in universe.
- ANITA is 1st NASA observatory for neutrinos of any kind.

Astrophysics Stratospheric Telescope for High Spectral Resolution Observations at Submillimeter wavelengths (ASTHROS), NASA

- It is NASA's new mission to send a telescope, on a football stadium-sized balloon, high into stratosphere to observe wavelengths of light invisible from Earth.
- Mission will try to find answers about formation of giant stars in galaxy.
- It will be launched in 2023 from Antarctica.

OSIRIS-Rex (Origins Spectral Interpretation Resource Identification Security – Regolith Explorer), NASA, 2016

- It is a **spacecraft**, that will travel to near-Earth asteroid, called Bennu.
- It will bring sample back to Earth for study.
- Its 1st sample collection attempt was in 2020.
- It will help scientists investigate how:
 - Planets formed, Life began, improve understanding of asteroids.

Chang'e 5, China

- This mission recently returned to Earth, loaded with moon rocks.
- It was for 1st since Soviet Union's Luna 24 mission in 1976.
- China is 3rd country to have retrieved lunar samples after USA and Russia.
- This mission collected material in an area north of Mons Rümker (Oceanus Procellarum or Ocean of Storms).
 - Which is a vast, unexplored lava plain.

Ariel (Atmospheric Remote-Sensing Infrared Exoplanet Large-survey) Space Mission, European Space Agency

- It is a space telescope to be launched in 2029.
- Consortium comprises more than 50 institutes from 17 European countries.
- It will perform a large-scale survey of over a thousand exoplanets in 4 Years.
- It will study nature, Formation, Evolution of Exoplanets.

Hayabusa 2, Japan, 2014

- It is on 6 years mission to study asteroid Ryugu and to collect samples to bring to Earth for analysis.
- News Context: It landed in Australia.
- Ryugu is a carbonaceous near-Earth asteroid.
- Mission is to find about origins of solar system and where molecules like water came from.

Hope Mission, UAE

- Spacecraft Amal (Hope) is launched which is Arab world's 1st mission to Mars.
- It is UAE's 4th space mission and 1st interplanetary mission.
- It will orbit Mars to study Martian atmosphere and its interaction with outer space and solar winds.

Solar Orbiter, 2020

- It is an international collaboration of ESA and NASA, to study Sun.
- It has completed its 1st close pass of Sun.
- It is nearest probe with sensors facing Sun (77 million kms away from Sun) and closest with cameras.
 - That can capture our closest star at extreme proximity.

BepiColombo

- It is a joint mission of ESA and Japan Aerospace Exploration Agency (JAXA).
- It is 1st European mission to Mercury and is 1st to send 2 spacecraft to make complementary measurements of Mercury.
- It consists of 2 individual orbiters:
 - ESA's Mercury Planetary Orbiter (MPO).

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- JAXA's Mercury Magnetospheric Orbiter (MMO, or 'Mio').
- Recently, it successfully completed its 1st flyby of Venus.

Other Projects

Stardust 1.0

- It was launched from Loring Commerce Centre, USA.
- It becomes 1st commercial space launch powered by biofuel.
- Rocket is manufactured by BluShift, an aerospace company based in Maine.
- These rockets will help to launch small satellites called Cubesats into space.

New Shepard, Blue Origin, USA

- It is reusable suborbital rocket system.
- It is designed to take astronauts and research payloads past Karman line (Internationally recognized Boundary of Space).

Thirty Meter Telescope (TMT Project)

- It will allow seeing deeper into space and observing cosmic objects with unprecedented sensitivity.
- It is a joint venture of 5 countries: India, Canada, USA, China, Japan.
- Installed at: Mauna Kea in Hawaii.

Starlink

- It is a network of satellites being built by SpaceX.
- It will deliver high speed broadband internet, where access unreliable and expensive.
- It operates at 550km above Earth's surface in low Earth orbit
- Note: Conventional internet satellites are positioned at over 35,000km.

Asteroid 16 Psyche

- It is one of most massive objects in asteroid belt in our solar system.
- It orbits between Mars and Jupiter
- Note: Asteroids, sometimes called minor planets, are rocky, airless remnants left over from early formation of solar system.
- 16 Psyche could be made entirely of metal.

Geminid Meteor Shower

- It occurs every year around 2nd week of December.
- Note: Meteor is a meteoroid that enters Earth's atmosphere.
 - Meteoroids are objects in space that range in size from dust grains to small asteroids.
- They are created by tiny bits of rocky debris shed from a small asteroid named 3200 Phaethon.
 - Which was discovered in 1983.
- Phaethon loops around Sun every 1.4 years in an orbit that approaches Sun closer than any other known asteroid.

2. DEFENCE TECHNOLOGY

2.1. INDIAN MISSILE PROGRAMME

2.1.1. Types of Missiles

1. Ballistic missile: Full flight is not powered. It has a **ballistic trajectory** (parabolic type) for most of the flight path.

2. Cruize missile: Full flight is powered (self-propelled). It is a self-propelled **guided vehicle**. It sustains flight through aerodynamic lift for most of its flight path.

It flies **within earth's atmosphere** and use **jet engine technology**.

Types: [Note: speed of sound=1 Mach]

- Subsonic cruise missile: 0.8 Mach speed.
- Supersonic cruise missile: 2-3 Mach speed.
- Hypersonic cruise missile: > 5 Mach speed.

Concepts related to missiles

1. Newer version of missiles and rockets use **solid fuel**. It is compact, and energy dense, hence the mission/rocket has longer range.
2. **Range:** Land based missiles have longer range than air based version. Submarine versions have least range.
3. A **tactical ballistic missile (TBM)** is also known as **battlefield range ballistic missile (BRBM)**. It is designed for short-range battlefield use. Typically, range: < 300 km..

Note: Ramjet engine

It uses the engine's forward motion at supersonic speed to compress incoming air without a compressor.

It differs from conventional rocket propellant whose formulation is approximately 20% fuel and 80% oxidizer. It has **100% fuel and obtains oxidizer from air**.

It results **four times the specific impulse** (the product of thrust and time divided by propellant weight). Hence it propels the missile at high supersonic speeds (> 2 Mach).

2.1.2. IGMDP (INTEGRATED GUIDED MISSILE DEVELOPMENT PROGRAMME)

Envisioned by Dr. Kalam (1983), developed by DRDO.

Prithvi

- **Surface-to-surface (SSM)**, nuclear capable, ballistic missile.
- **Short range:** Prithvi I: land version (150 km), Prithvi II: air version (350 km), Prithvi III (or Dhanush): naval variant (150 km).
- **Fuel:** Liquid, now solid.

Agni

- Surface-to-surface missile (SSM), nuclear capable, ballistic missile.
- **Agni 5-ICBM:** Inter-continental Ballistic Missile
- **Agni 6:** Can also be launched **from submarine** along with land based launchers.
- **Range:** Short, intermediate, medium, Inter-continental (long). (range ~ version*1000)
- **Fuel:** Solid
- **High accuracy Navigation System:** Ring Laser Gyro based Inertial Navigation System (RINS) and Micro Navigation System (MINS).
- Work in progress for Multiple Independently Targetable Re-entry Vehicles (**MIRV**) for the Agni-V.

Trishul

- Short range Surface-to-Air missile (SAM).

- It can be used against low Low-level attacking missiles.
- **Fuel:** Solid.

Akash

- Supersonic, medium range Surface-to-Air missile (SAM).
- Can attack **multiple targets** simultaneously.
- Range: 30 km, can carry approx. 50 kg warhead.
- **News Context:** Cabinet approved export of Akash missile systems to friendly countries.
- Note: Akash-NG (New generation) Missile is to intercept high manoeuvring low Radar Cross Section aerial threats.

Nag (Prosperina)

- 'Fire and forget' anti-tank guided missile (ATGM).
- It is India's 3rd generation, anti-tank guided missile.
- **Range:** 500 m- 20km.
- **HELINA:** helicopter-launched NAG. It can be fired from Dhruv and Rudra helicopters.
- **Stand-off Anti-tank (SANT) missile** is an upgraded version of Helicopter Launched Nag (HeliNa) missile.
- **NAMICA:** land based version. It is operated from the BPM-2 career vehicle.

2.1.3. CRUIZE MISSILES

BrahMos

Short Range (290 km), **Supersonic cruise missile**.

- It is developed jointly by **India and Russia**. Named after **Brahmaputra** and **Moskva** rivers.
- It can be launched from Land, Air, Submarine and Ships.
- It is the world's **fastest anti-ship cruise missile**.
- **First stage:** solid propellant booster
- **Second stage:** liquid-fueled ramjet Engine.
- As India became member of the Missile Technology Control Regime (MTCR) in 2016, the range could be increased to **600 km (medium range)**.
- **News Context:** Range of new land-attack version is extended to 400 km from 290 km.
 - Speed is maintained at 2.8 Mach.

Nirbhay

Long range, **subsonic** designed and developed by DRDO.

- Capable of both carrying conventional and nuclear warheads.
- **First stage:** solid propellant booster
- **Second stage:** liquid-fueled Turbofan Engine

* In India, all other missiles are Supersonic.

Astra

It is an **Active Radar Homing**; Beyond Visual Range Air-to-Air Missile (**BVR-AAM**).

- It is the first air-to-air missile developed by India at DRDO.
- **Supersonic speed:** Mach 4.5+,
- Propellant used is HTPB (solid-fuel).

Note: Active radar homing (ARH) is a missile guidance method in which a missile contains a radar transceiver

Shaurya

- It is a **medium range, canister launched, hypersonic, surface-to-surface tactical missile**.
 - **Canister Based System:** It is stored and operated from specially designed compartments.
- Developed by DRDO.

- It is a land-based parallel of submarine launched K-15 missile.

2.1.4. K FAMILY OF MISSILES

- These are named after Dr. Kalam, and are version of Agni.
- These are Submarine Launched Ballistic Missiles (SLBM).
- It is a classified project, also known as "Black Project" of DRDO.
- It is part of India's nuclear triad, and will provide retaliatory second strike capabilities.

K-4: Intermediate-range under development by DRDO. It is to be integrated with Arihant class submarine.

Sagarika or K-15 missile is the short range, SLBM version of Shaurya missile. It is to be integrated with Arihant class submarine.

2.1.5. OTHER MISSILES

Surya ICBM

- It is an inter-continental ballistic missile, with range more than 10,000 km.

Barak 8

- It is an Indian-Israeli supersonic, long range surface-to-air missile (LRSAM). It is naval version, and boosts Naval Air Defense System.
- MRSAM is land version of LRSAM. It can attack multiple aerial targets. Range > 50 km.
- Barak-8 can simultaneous engage multiple targets.

S-400 Missile

- It is Russia's 4th generation of long-range surface-to-air missile system.
- It is capable of firing 3 types of missiles to create a layered defense.
- It can engage all types of aerial targets including:
 - Aircraft, Unmanned aerial vehicles (UAV).
 - Ballistic and cruise missiles within range of 400km, at an altitude of upto 30km.

2.1.6 BALLISTIC MISSILE DEFENCE PROGRAMME

The two-tiered shield should be able to intercept any incoming ballistic missile launched from 5,000 km.

1. Prithvi Air Defence (PAD) or Pradyumna Ballistic Missile

Interceptor: to intercept incoming ballistic missiles outside the atmosphere (exo-atmospheric, 80 km altitude)

It is a two stage system. Fuel: first stage – Solid, second stage – Liquid.

2. Advanced Air Defence (AAD) or Ashwin Ballistic Missile

Interceptor: to intercept incoming ballistic missiles in the endo-atmosphere (30 km).

AAD is a single-stage, solid-fuelled missile.

2.2. SUBMARINE FLEET

A submarine is a watercraft capable of independent operation underwater.

The 30 years Indian Submarine Programme (2000-2030) aims to build 24 submarines: 18 conventional and 6 nuclear powered (SSNs).

2.2.1 CONVENTIONAL SUBMARINES

Diesel-electric powered.

Sindhу class

- Kilo-class Class, From Russia

Synopsis IAS

207, Apsara Arcade, Karolbagh delhi-5

- Name of these submarines starts from Sindhу e.g. INS Sindhu, INS Sindhu, INS Sindhu, INS Sindhu sank in dock.

Shishumar class

- German attack submarines.

Scorpène-class

- Jointly developed by France and Spain.
- It has diesel propulsion and an additional air-independent propulsion (AIP) system.

Kalvari-class submarine is the Indian version.

- Six submarines under this class: INS Kalvari, Khanderi, Karanj, Vela, Vagir, Vagsheer.
- INS Kalvari is also known as Tiger Shark (or S50).
- Developed under Project 75 or P 75 of the Indian Navy.
- **Kalvari class of submarines** design is a class of diesel-electric attack submarines.
 - It is based on Scorpène class of submarines with technology transfer from France.

2.2.2 NUCLEAR SUBMARINE

Nuclear powered.

Akula Class

- It is a Russian nuclear-powered Attack Submarine (SSN).
- Example: INS Chakra.

Arihant Class

- It is a nuclear-powered ballistic missile submarine (SSBN). It can also launch missiles.
- INS Arihant (SSBN 80) is the lead ship of this class.
- INS Arighat (or INS Aridhaman) is the second Arihant-class submarine.

2.2.3 PROJECT 75 India or P-75I

- It is follow-on of the Project 75. It is part of a 30 year Indian Submarine Programme.
- Under this project, the Indian Navy intends to acquire 24 (earlier 6) conventional submarines.
- An advanced Air-independent propulsion (AIP) system will enable submarines to stay submerged for longer duration.

Recently the Defence Acquisition Council approved indigenous construction of 24 (earlier 6) Project 75(I) submarines under strategic partnership model.

Note: Strategic Partnership (SP) Model

- It was recommended by Dhirendra Singh Committee and was introduced by Defence Procurement Procedure 2016.
- An Indian private company would be selected in each segment which would tie up with shortlisted global Original Equipment Manufacturer (OEM) to manufacture in India under technology transfer.
- This model has 4 segments: Submarines, Single engine fighter aircraft, Helicopters, armoured carriers/ battle tanks.
- A 49% FDI cap has been kept.

2.3. SURFACE FLEET: NAVAL SHIPS

Mostly made by Garden Reach Shipbuilders & Engineers Ltd. (GRSE), Kolkata and by Mazagon Dock Limited (MDL), Mumbai. Stealth ship is a non-detectable ship.

Types

- Aircraft carrier

- An aircraft carrier is a warship that serves as a dynamic seagoing airbase.
- It is equipped with a **full-length flight deck**.
- Typically, it is the **capital ship of a naval fleet**.
- It allows a navy to project air power worldwide without depending on local air bases.
- By its **diplomatic and tactical power**, the aircraft carrier is the **centerpiece of modern combat fleets**.
- Destroyer:** It is a fast and maneuverable warship intended to **defend larger vessels** in a fleet.
- Frigates:** it is a naval vessel **intermediate** between corvettes and destroyers.
 - Significant role in Indian naval history.
 - Maratha Navy and East India Company used them.
- A **corvette** is a **small** warship.
- A **patrol vessel** is a **relatively small** vessel.
- Torpedo recovery vessel:** They are intended to recover torpedoes and mines.

Fast Patrol Vessel (FPV) ICGS Kanaklata Barua

- It is **5th** and **last** in a series of FPV built by Garden Reach Shipbuilders and Engineers Ltd.
- Other 4 are:** ICGS Priyadarshini (named after Indira Gandhi).
 - ICGS Annie Besant, ICGS Kamala Devi (after Kamala Devi Chattopadhyay).
 - ICGS Amrit Kaur (Named after a teenage freedom fighter of Assam of Quit India Movement).
- These FPVs are **upgraded versions of inshore patrol vessels**.
- It is suited for:** Patrolling, Maritime surveillance, Anti-smuggling.
 - Anti-poaching operations, Fishery protection, Rescue and Search missions.

2.3.1 Aircraft carriers

Aircraft launch and recovery systems

1. STOBAR system (Short Take-Off but Arrested Recovery)

- A system used for the launch and recovery of aircraft from the deck of an aircraft carrier.
- Combines elements of both: Short take-off and vertical landing (**STOVL**) and Catapult-assisted take-off but arrested recovery (**CATOBAR**).

2. EMALS system (Electromagnetic Aircraft Launch System)

- The system launches aircraft by a **catapult employing a linear induction motor** rather than the conventional steam piston.
- Used to launch **heavy aircrafts**.

AIRCRAFT CAREERS OF INDIA

INS Virat, Centaur-class, UK

- It was part of **UK Royal Navy** as **HMS Hermes**.
- It was recently decommissioned.
- News Context:** It will be scrapped at ship breaking yard at Alang (World's biggest) in Gujarat.
- Note: It was used in **Op Parakram**, post terrorist attack on Parliament (2001-02)

INS Vikramaditya: Kiev-class, Russia

- STOBAR system.
- Largest in India.
- It India's only active aircraft carrier.

INS Vikrant, Majestic class, UK

Synopsis IAS

207, Apsara Arcade, Karolbagh delhi-5

- Used in 1971 war.
- commissioned as the first aircraft carrier of the Indian Navy.
- recently decommissioned.
- It is India's 1st domestically built aircraft carrier.
- It operates a ski-jump assisted Short Take-off Arrested Recovery (STOBAR) launch systems for launching aircraft.
 - It is capable of accommodating MiG 29K fighter jets and helicopters.

INS Vikrant (IAC-1)

- STOBAR system.
- India's 1st Indigenous Aircraft Carrier (IAC-1)**

INS Vishal (IAC-2)

- EMALS CATOBAR** system.
- Nuclear propulsion.
- It Will be India's 2nd Indigenous Aircraft Carrier (IAC-2) to be built in India after INS Vikrant (IAC-1).

2.3.2 Destroyers

Rajput class destroyers (Soviet Kashin-class)

- These are **GMDs** (guided missile destroyers)
- INS Rajput, INS Rana, INS Ranveer, INS Ranvijay.

Delhi-class destroyers (Project 15)

- These are **GMDs** (guided missile destroyers)
- Indeginous.
- INS Delhi, INS Mysore, INS Mumbai.

Kolkata class destroyers (Project 15A)

- These are **stealth GMDs** (guided missile destroyers)
- follow-on of the Project 15 Delhi-class destroyers.
- The class comprises three ships – INS Kolkata, INS Kochi and INS Chennai.

Visakhapatnam class destroyers (Project 15B)

- These are stealth guided missile destroyers (GMD)
- Improved version of the Kolkata-class.: enhanced stealth characteristics.
- Under construction.
- It comprises four ships – INS Visakhapatnam, INS Mormugao, INS Imphal and INS Porbandar.

2.3.3 Frigates

Godavari-class frigates (Project 16)

- Guided-missile frigates.**
- First significant indigenous warship.**

Shivalik class frigates (Project 17)

- These are the **first stealth warships** built in India.

Talwar class frigates, Russian

- These are guided missile frigates.
- Part of Western Naval Command.
- INS Tarkash

Project 17A

- It is a **total of 7 ships (guided missile frigates)**.
- They are being built with enhanced stealth features, advanced indigenous weapon, sensor fit etc.
- Note: Indian Navy's 2nd Project 17A Frigate 'Himgiri' was launched.

2.3.4 Corvette

Kamorta-class corvette (Project 28)

- Anti-submarine warfare corvettes.**
- This project is a leap forward for **indigenization**.

- INS Kamorta, INS Kadmat, INS Kiltan, INS Kavaratti
- INS Kilatan**

- India's first major warship to have a superstructure of carbon fibre composite material.
- Hence, it has improved stealth features, lower weight and maintenance costs.
- It is well equipped to fight in Nuclear, Biological and Chemical (NBC) warfare.

INS Kavaratti

- It is **commissioned in Indian Navy**.
- It is last of 4 **indigenously built Anti-Submarine Warfare (ASW)** stealth corvettes built under Project 28 (Kamorta class).
- It joins 3 other ships of same class namely: INS Kamorta, INS Kadmat, INS Kiltan.
- It has equipment and systems to **fight in Nuclear, Biological, Chemical warfare conditions**.

2.3.5 Patrol vessel

Car Nicobar class patrol vessel

- High-speed.
- First water jet-propelled vessels of Indian Navy.
- Patrol, anti-piracy and rescue operations in India's exclusive economic zone.
- Their production started after the **2008 Mumbai attacks**.

INS Tarmugli (Car Nicobar class)

- These are highly maneuverable Water Jet Fast Attack Craft (WJFAC).
- Sister ships: INS Tarmugli, INS Tillanchang, INS Tilayu, INS Tarasa.

2.3.6 Torpedo recovery vessel

INS Astradharanini

- Torpedo launch and recovery vessel.
- Indigenously designed and built.
- Part of Eastern Naval Command.

Supersonic Missile Assisted Release of Torpedo (SMART)

- It is a **Torpedo System for Anti-Submarine Warfare (ASW)** operations far beyond Torpedo range.
- Range:** over 600 km.
- Note:** Torpedo is a **weapon consisting of a self-propelled, self-guided, cigar-shaped underwater projectile**.
 - It carries a **conventional or nuclear warhead**.

Varunastra

- It is a **ship launched, heavy weight, electrically propelled anti-submarine torpedo**.
- It can **target quiet submarines, both in deep and shallow waters**.
- Range:** 40 km, **Speed Travel:** Upto 70 km, **Depth:** 400 meters.

2.4. AIR FLEET

MiG 21

- The Mikoyan-Gurevich MiG-21 is a Soviet designed supersonic jet fighter and interceptor.
- Interceptor:** a fast aircraft for stopping or repelling hostile aircraft.
- Wing Commander Abhinandan Varthaman.**

Rafale Jet

- The Dassault Rafale is a French twin-engine, multirole, canard delta wing, fighter aircraft.

Sukhoi Su-30MKI

- It is a twin-engine, multirole, all-weather, long-range fighter.
- It is developed by Russia's Sukhoi and built by India's Hindustan Aeronautics Limited (HAL)
- Used in Balakot airstrike.

Mirrage 2000

- The Dassault Mirage 2000 is a French single-engine, multirole, fourth-generation jet fighter.
- Used in Balakot airstrike.

Popeye

- It is an Israeli air-to-surface missile.
- Used by Mirage 2000 in Balakot airstrike.

SPICE-2000

- It is a, Israeli GPS-guided kit for converting air-droppable unguided bombs into precision guided bombs.
- SPICE: Smart, Precise Impact, Cost-Effective.
- Used by Mirage 2000 in Balakot airstrike.

Netra and Phalcon

- These are surveillance aircrafts or Airborne Early Warning and Control System (AEWACS).
- Netra is a made by DRDO. Phalcon is Israeli.
- Used in Balakot airstrike.

Ilyushin Il-78

- It is a Russian aerial refueling tanker.
- Used in Balakot airstrike.

IAI Heron UAV

- It is an Israeli Medium Altitude Long Endurance (MALE) Unmanned Aerial Vehicle (UAV).
- Used in Balakot airstrike.

Balakot airstrike, 2019

- On 26 February 2019, the Indian air force conducted airstrikes at Balakot, crossing the de facto border deep within Pakistan as a retaliation to the Pulwama attack.
- India characterized it to be a non-military and preemptive strike directed against a terrorist training camp of Jaish-e-Mohammed, and causing the deaths of a "large number" of terrorists.
- First time since the Indo-Pak war of 1971 warplanes of either country crossed the LOC.

Light Combat Aircraft (LCA) 'Tejas'

- It is an indigenous single-engine, multirole, delta wing, single seat, supersonic, light fighter jet.
- It is world's smallest and lightest supersonic fighter aircraft in its class.
- 'Flying Daggers' 45: IAF squadron of LCA.
- Jointly developed by Aeronautical Development Agency (ADA) and HAL.
- It can carry out mid-air refueling.
- It has limited strike capability of 400-km and can be used for close air-to-ground operations.

Note: 1. Sukhoi- 30MKIs or Rafale have deep strike capability into enemy territory due to their long range.

Note: 2. HF-24 Marut is the first indigenous fighter.

Chinook Helicopters

- The Boeing CH-47 Chinook is an American twin-engined, multi-role, vertical-lift platform, tandem rotor, heavy-lift helicopter.
- India received Chinooks recently.
- Can be used for disaster relief and boost to infrastructure development along India's borders.

2.5. INTERNATIONAL DEFENCE ARCHITECTURE

There are a number of international protocols to prevent development, use and proliferation of **weapons of mass destruction** (WMD). It can be a nuclear, radiological, chemical, biological or any other weapon that can kill and bring significant harm.

5.1 Multilateral Export Control Regime (MECR)

There are currently four such regimes:

Australia Group (AG), 1985

- Controls the spread of **chemical and biological weapons**.
- Australia Group Common Control List:** It includes compounds that are not prohibited for export under CWC but can be used in the manufacture of chemical weapons.
- To strengthen export control: "**no-undercut**" requirement and "**catch-all**" provision.
- The first provision stated that **any member of the group considering making an export to another state that had already been denied an export by any other member of the group must first consult with that member state before approving the export.**
- The second, "**catch-all**" provision, which **requires member states to halt all exports that could be used by importers in chemical or biological weapons programs, regardless of whether the export is on the group's control lists.**
- Its formation was prompted by Iraq's use of chemical weapons during the Iran-Iraq War (1980-1988).
- Secretariat:** managed by Australia. Members meet every year in **Paris**.
- It is an informal group of countries.
- India is a member. China is not a member.**

Missile Technology Control Regime (MTCR), 1987

- A multilateral export control regime; established by G7 countries.
- An **informal and voluntary** partnership among 35 countries to prevent the **proliferation of missile and unmanned aerial vehicle technology** capable of carrying above 500 kg payload for more than 300 km.
- Since its establishment, the MTCR has been successful in helping to slow or stop several ballistic missile programs.
- The MTCR is not a treaty and does not impose any legally binding obligations on Partners (members)
- India is a member. China is not a member.**

Wassenaar Arrangement, 1996

- In Wassenaar, the Netherlands, near The Hague. Secretariat: **Vienna**, Austria.
- Arrangement on export controls for **conventional arms and dual-use goods and technologies**.
- It is the **successor to the COCOM** (Cold War-era Coordinating Committee for Multilateral Export Controls).
- SCOMET list:** Special Chemicals, Organisms, Materials, Equipment and Technologies. In India,

Direktorat General of Foreign Trade (DGFT) prepares it under **Foreign Trade Policy, 2015**.

- Not legally binding.**

- India is a member. China is not a member.**

Note: **Dual use goods** are used both for civilian and military purposes.

Nuclear Suppliers Group (NSG)

- It seeks to **prevent nuclear proliferation** by controlling the export of materials, equipment and technology.
- Founded in response to the Indian nuclear test in May 1974.
- Zanger Committee or Nuclear Exporters Committee:** It maintains **Zanger Trigger List**. It is a list of equipments which can be exported only under International Atomic Energy Agency (IAEA) safeguards.
- India is not a member. China is a member.**

5.2 Other conventions

Hague Conventions of 1899 and 1907

- Among the first formal statements of the laws of war and war crimes.

Geneva Convention, 1949

- Negotiated in the aftermath of the World War II.
- Extensively **defined the basic rights** of wartime prisoners, established protections for the wounded and sick, and established protections for the civilians in and around a war-zone.

Geneva Protocol (1925)

- It prohibits use, but not possession or development of chemical and biological weapons.
- India is a signatory.**

Biological Weapons Convention (BWC), 1972

- An arms control treaty that outlaws production, stockpiling and use of biological weapons and their precursors.
- It is supplement to the 1925 Geneva Protocol.
- Biological weapons are **living organisms or replicating entities** (viruses, which are not universally considered "alive") that reproduce or replicate within their host victims.
- It is legally binding. India is a signatory.**

Chemical Weapons Convention (CWC), 1997

- An arms control treaty that outlaws the production, stockpiling, and use of chemical weapons and their precursors.
- It is supplement to the 1925 Geneva Protocol and was adopted in **UN Conference on Disarmament, 1992**.
- Chemical weapons:** Asphyxiating, Poisonous or other Gases, all analogous liquids, materials or devices.
- About 97% of the world's declared stockpile of chemical weapons had been destroyed.
- India has destroyed all its chemical weapon storage.**
- Administered by the Organisation for the Prohibition of Chemical Weapons (**OPCW**), The Hague, Netherlands.
- It is legally binding. India is a signatory.**

Antarctic Treaty System (ATS), 1961

- For the purposes of the treaty, Antarctica is defined as the lands and ice shelves south of 60°S. The treaty **bans military activity**.
- Secretariat:** Buenos Aires, Argentina.
- India is not a signatory, but has consultative status.**

Seabed Arms Control Treaty, 1971

- Prohibits the emplacement of nuclear weapons or "weapons of mass destruction" on the ocean floor beyond a 12-mile coastal zone.
- **India** is a signatory.

Hague Code of Conduct (HCOC), 2002

- It is an arrangement to prevent the proliferation of ballistic missiles.
- The HCOC does not ban ballistic missiles, but it does call for restraint in their production, testing, and export.
- It is the only normative instrument to verify the spread of ballistic missiles.
- **India** is a member. **China** is not a member.

Shangri-La Dialogue (IISS Asia Security Summit)

- It is a "Track One" inter-governmental security forum held annually by the International Institute for Strategic Studies (IISS), an independent think tank.
- It is attended by defense ministers, military chiefs etc. of 28 Asia-Pacific states.
- The forum gets its name from the Shangri-La Hotel in Singapore.

Raisina Dialogue

- It is annual conference held in New Delhi, envisioned to be India's flagship conference of geopolitics and geo-economics.
- The conference is held jointly by Ministry of External Affairs and the Observer Research Foundation (ORF), an independent think tank based in India.
- The conference is organized like the Shangri-La Dialogue in Singapore.

Chao-phraya Dialogue

- It is an Indo-Pak Track-II initiative jointly undertaken by the Jinnah Institute and Australia India Institute.

Coastal Radar Network

- India to set up coastal radar stations in Maldives, Myanmar, Thailand, Bangladesh.
- Note: China's coastal radar is already set up in Mauritius, Seychelles, Sri Lanka.

Integration is being done on mainly 2 platforms:

- Indian Navy's Information Management and Analysis Centre (IMAC), Gurugram
 - It was set up after 26/11 Mumbai terror attacks.
 - It is nodal agency for maritime data fusion.
 - It is jointly operated by: Navy and Coast Guard.
 - It monitors maritime traffic in India's area of interest.
 - It focuses on ships passing through Indian Ocean Region.
 - It tracks only non-military or commercial ships, known as white shipping.
- Note: Military ships (Grey Hull Ships) are tracked by Directorate of Naval Operations.

- Navy's Information Fusion Centre for Indian Ocean Region (IFC-IOR), Gurugram
 - It promotes Maritime Domain Awareness.
 - It is hub of maritime security information in IOR through white shipping exchange agreements.

- It is jointly administered by: Indian Navy and Indian Coast Guard.

Digital Ocean

- It is a data platform to provide ocean data related services at one place.
- It is developed by Indian National Centre for Ocean Information Services (INCOIS) of Earth Science Ministry.
- INCOIS provides ocean information and advisory services for:
 - Fishing Zone advisories, Ocean State Forecast, Weather, Forecast.
 - High wave alerts, Tsunami early warnings, etc.
- It is unit of Earth System Science Organization (ESSO).

Bioterrorism

- It is a planned and deliberate use of microorganisms such as: Bacteria, viruses to spread life-threatening diseases.

It is classified as categories A, B, and C.

- Category A: High-priority agents that pose a risk to national security.
 - As it be transmitted from person to person resulting in high mortality rates.
 - Eg. Anthrax by Bacillus anthracis, botulism by Clostridium botulinum toxin.
 - Plague by Yersinia pestis etc.
- Category B: It is 2nd highest priority agents including:
 - Brucellosis (Brucella species), Glanders (Burkholderia mallei) etc.
- Category C: It includes emerging pathogens that could be engineered for mass dissemination in future.
 - Eg. Infectious diseases such as Nipah and Hanta virus etc.

Existing measures to counter Bioterrorism in India

- Epidemic Diseases Act of 1897.
- National Disaster Management Authority (NDMA):
 - It is specifically trained to deal with chemical, biological, radiological, nuclear (CBRN) threats.
- Integrated Disease Surveillance Project (IDSP):
 - It was started with World bank.
 - It is to strengthen decentralized laboratory-based IT enabled disease surveillance system for epidemic prone diseases.
- International Health Regulations (Revised), 2007:
 - It is to ensure, outbreaks and public health emergencies of international concern are detected and investigated more rapidly.

Initiatives at International Level

- Biological Weapons Convention:
 - It is 1st multilateral disarmament treaty to ban development, production, stockpiling of Bacteriological (Biological) and Toxin Weapons.
- INTERPOL Bioterrorism Prevention Unit:
 - It is a law enforcement agency against deliberate use of bacteria, viruses or biological toxins.
- Cartagena Protocol on Biosafety:

- It is to ensure safe handling, transport and use of living modified organisms (LMOs) resulting from modern biotechnology.

2.6. Military Exercise

Indian Army Exercises

- **UK:** Ajaya, Warrior, **USA:** Yudh, Abhyas
- **France:** Shakti, **China:** Hand in Hand.
- **Russia:** Indra (Tri-serine exercise), **Oman:** Al -Nagah
- **Multi-National: Force 18**
- 18 ASEAN Plus countries, China, USA, Japan, Russia, South Korea.
- **Singapore:** Bold Kurukshtera
 - **Indonesia:** Garuda Shakti, Thailand: Maitree, Cobra Gold
- **Kazakhstan:** Prabal Dostyk, **Nepal:** Surya Kiran.
- **Bangladesh:** Sampriti, **Sri Lanka:** Mitra Shakti.

Routine Exercise

- **Sagar Kawach:** Joint efforts by **Odisha and West Bengal.**
 - Indian Navy, Indian Coast Guard, Odisha Police, Local Fishermen, Forest Department, Port Marine Department.
- **Shatru Jeet.**
- **Jalrahat (Disaster Management).**

Indian Navy Exercises

- **UK:** Konkan, **USA + Japan:** Malabar
- **France:** Varun, **Russia:** Indra, Oman: Naseem Al-Bahr
- **Singapore:** Simbex, **Indonesia:** CORPAT (Co-ordinated Patrol)
- **Thailand:** CORPAT (Co-ordinated Patrol), **Myanmar:** IMCOR (India Myanmar Co-ordinated Patrol).

Multinational Navy Exercises

- **ADMM Plus:** ASEAN+ Countries.
- **DIMDEX:** Doha International Maritime defense exhibition.
 - 22 Participants and 6 Observers.
- **RIMPEC:** off Hawaii, largest multilateral naval exercise, every 2nd year (Pacific Ocean)
- **Sagarmatha:** Exercise between Nepal and China (Not India).

Indian Airforce Exercise

UK: Indradhanush, **France:** Garuda, **Russia:** Indra

USA: Red-Flag, Cope-India

Multinational Airforce Exercise

Blue Flag (Israeli Exercise): USA, UK, France etc.

Singapore: Sindex, **Thailand:** Siam Bharat.

UAE: Desert Eagle, **Oman:** Eastern Bridge.

Routine Exercise

- Danx (Defence of Andaman and Nicobar Islands Exercise)
- Gagan Shakti: Indo French.
- Iron First, Pralay Shyam.

Misc.

- **INS Tarini:** All Women crew (circumnavigate the globe)
- **INS Mahadevi:** All Women crew (went Mauritius, cope town)
- **INS Tarmugli:** Highly maneuverable fast Attack craft
- **P 8-I Aircraft:** Maritime Reconnaissance Aircraft

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3. NUCLEAR TECHNOLOGY

INDIAN NUCLEAR PROGRAMME

"No power is costlier than no power". – **Dr. Homi J. Bhabha**
The Indian nuclear programme was started way back in 1948 with the establishment of **Atomic Energy Commission (AEC)**. The AEC was established through a presidential order and government resolution.

Department of Atomic Energy is an independent department under Government of India. The **Atomic Energy Regulatory Board (AERB)** ensures the safe use of ionizing radiation and nuclear energy.

Indian Nuclear program aims to develop nuclear energy for **peaceful purposes**. India is self-reliant and one of the global nuclear powers.

1. NUCLEAR MATERIALS

Neutron source

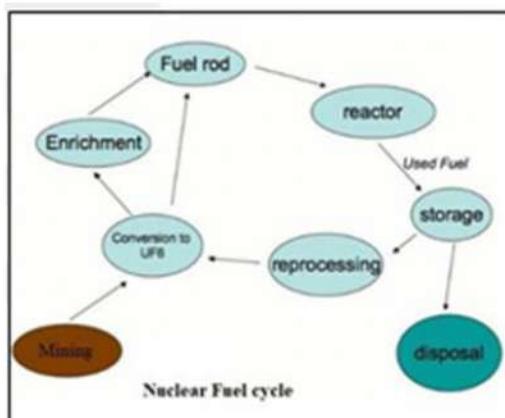
- It is a material to generate neutrons, especially to start the chain fission reaction.
- E.g. Beryllium, Deuterium.
- Neutron energy** may be classified as (a) slow or thermal neutrons, and (b) fast neutrons.

Moderator

- It is used to reduce the speed of fast neutrons to turn them into slow or thermal neutrons.
- Thermal neutrons are capable of sustaining a nuclear chain reaction involving uranium-235.
- Commonly used moderators: **Light water** (H_2O , 75% reactors), **Heavy Water** (D_2O , 5% reactors), **solid graphite** (20% reactors), **Beryllium** in some experimental reactors. **Hydrocarbons**.

Nuclear fuel

- Fissile material:** It is capable of sustaining a nuclear fission chain reaction. E.g. **Uranium-233, 235 and Plutonium-239**. Fissile material can sustain a chain reaction with **thermal neutrons**.
- Fertile material:** It is not itself fissionable by thermal neutrons, but can be converted into a fissile material by neutron absorption and subsequent nuclei conversions. E.g. transmutation of **U-238** into **Pu-239, Th-232** into **U-233**.
- Nuclear fuels have the highest energy density.



Coolants

- Extracts heat from reactor core and transfer it to electrical generators and turbines.
- Commonly used coolants: **Water, Heavy water,**

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Sodium for Fast Breeder Reactors, Lead, Helium for Gas cooled Reactors

Control rods

- Used to control the fission rate by absorbing many neutrons without fissioning themselves.
- Commonly used control rods: **boron, cadmium silver, indium etc.**

Other nuclear materials

- Zircaloy** tubes used as cladding Material, to bundle together the fuel pellets.
- Helium gas:** to fill the fuel cladding gap to improve heat conduction from the fuel to the cladding.

Waste disposal

- Spent nuclear fuel (SNF) is highly radioactive.
- One of the most politically divisive aspects related to nuclear.
- Mainly stored at individual reactor sites, and in deep geological trenches.
- Mounting bombs for future generations.

Reprocessing

- Originally, reprocessing was used solely to extract **fissionable plutonium** for producing nuclear weapons.
- The **reprocessed uranium** can in principle also be re-used as fuel.
- It is necessary to reprocess the fertile material from a reactor to remove those neutron poisons.
- Reprocessing presents a **proliferation concern**.

2. THE URANIUM ENRICHMENT PROGRAMME

Rationale

- Natural uranium has 99.3% U-238 isotope, with only 0.7% U-235. **U-235 is fissile** with thermal neutrons, and **U-238 is fertile**.
- PHWRs use natural uranium**, but require heavy water. Their efficiency is lesser.
- LWRs use **enriched uranium with light water**. These are more **efficient**.
- Weapon grade** uranium requires 90% or more fissile material.

Enrichment

- By enrichment process, the percent composition of uranium-235 is increased in natural uranium through the **process of isotope separation**.
- In India, enrichment is carried out by **gas centrifuge technology**.
- Manhattan Project** of USA, undertaken during World War II, produced first nuclear weapons.
- International Atomic Energy Agency (IAEA)** controls enriched uranium supplies and processes. The **Indian uranium enrichment facility is not under IAEA safeguards**.

3. NUCLEAR REACTORS IN INDIA

India has 22 nuclear power plants in operation having a total installed capacity of **6,780 MW**.

Research Reactors

These are not intended for power generation.

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- Apsara:** It was 1 MW capacity reactor. She was the first atomic reactor in Asia.
- Cirus (Canada-India-Reactor):** it was a 40 MW reactor intended mainly for radioisotopes.
- Zerlina:** zero energy.
- Dhruva, 1984:** It produces radio isotopes. It is the first completely indigenous reactor.
- Purnima:** Plutonium Reactor
- Kamini:** Kalpakkam prototype FBR

Except Kamini, all other research reactors are at BARC, Trombay.

Pressurized Heavy Water Reactor (PHWR)

- The primary coolant (heavy water) is kept under pressure, allowing it to be heated to higher temperatures without boiling.
- Heavy water creates enhanced neutron economy, allowing to operate **without enriched fuel**.

Fuel: Natural uranium (UO_2). **Moderator:** Heavy Water (D_2O). **Coolant:** Heavy Water (D_2O)

Light Water Reactors (LWR)

Types of LWRs: Pressurized Water Reactor (PWR), Boiling Water Reactor (BWR), and Water-Water Energetic Reactor (VVER or WWER)

- Ordinary water creates low neutron economy, hence **enriched fuel** is required.

Fuel: Enriched uranium (UO_2). **Moderator:** Water (H_2O).

Coolant: Water (H_2O)

Fast Breeder Reactor (FBR)

- A breeder reactor **generates more fissile material than it consumes**.
- These reactors **create new fissile fuel** by irradiation of a fertile material. **Uranium-238 and Thorium-232** are such fertile materials.
- These are known as Fast breeder reactor (FBR) because they **use fast or unmoderated neutrons**.

Fuel: Mixed Oxide (MOX) fuel: U-Pu Oxide). **Moderator:** n.a. **Coolant:** Sodium. **Control rod:** Boron Carbide.

Thermal Breeder Reactor

- It uses **thermal-spectrum or moderated neutrons**. It is under conceptual stage.
- It breeds fissile uranium-233 from thorium-232 (**Thorium fuel cycle**).
- Fuel: thorium.

Advanced Heavy Water Reactor (AHWR)

- The AHWR is the next generation PHWR.
- It is similar to PHWR in pressure tubes and calandria tubes. However, the tubes' orientation in the AHWR is vertical, unlike that of the PHWR.

Fuel: thorium and low enriched uranium (LEU) (80-20%).

Moderator: heavy water. **Coolant:** boiling light water.

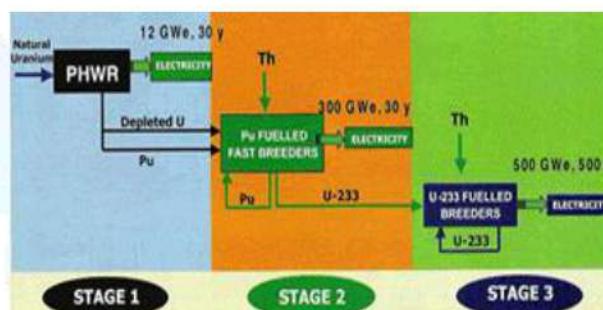
4. THREE STAGE NUCLEAR PROGRAMME

It was envisioned by **Homi Bhabha** in the 1950s to secure the country's long term energy independence.

Objective: enabling the **thorium reserves of India** to be utilized in meeting the country's energy requirements.

Thorium

- India has **25% of world thorium reserves** but only 1-2% global uranium reserve.
- The **Indo-US Nuclear Deal** and the NSG waiver ended more than three decades of international isolation of the Indian civil nuclear programme. However, thorium could provide **self-sufficiency with efficiency**.
- Thorium itself is not a fissile material**. Instead, it must be **transformed into fissile U-233**.
- The first two stages are intended to generate sufficient fissile material from India's limited uranium resources.



Stage 1: PHWR

- Natural **uranium** fuelled PHWRs produce electricity and plutonium-239 as by-product.
- Natural uranium contains only 0.7% fissile isotope U-235 and 99.3% fertile U-238.
- Fertile U-238** is converted in a reactor core into **fissile isotope plutonium-239**.
$$\text{U-238} \rightarrow \text{Plutonium-239} + \text{Heat}$$
- PHWRs are a natural choice because **uranium enrichment facility is not required**. Rather, it is easier to create a heavy water facility.
- Most of the existing Indian nuclear power base is composed of first stage PHWRs.

Stage 2: FBR

- FBRs would use **mixed oxide (MOX) fuel** consisted of natural uranium and plutonium-239.
- Plutonium-239 is recovered by **reprocessing spent fuel** from the first stage.
- Electricity generation:** plutonium-239 undergoes fission to produce energy.
- Breeding of fuel:** The 99.3% uranium-238 present in natural uranium transmutes to additional plutonium-239.
- Once the inventory of plutonium-239 is built up, **thorium can be introduced** as a blanket material in the reactor and **transmuted to uranium- 233** for use in the third stage.
- India's first **Prototype Fast Breeder Reactor at Kalpakkam** attained criticality in 2018.

Challenge: In Bhabha's 1958 papers on thorium, estimated doubling time was 5-6 years for breeding U-233 in the Th-

U233 cycle. This estimate has now been revised to at least 3-4 decades of commercial operation of FBR.

Stage 3: Thorium Based Reactors

- A thermal breeder reactor (TBR) is under design and development at BARC.
- After initial fuelling, a TBR could in principle be refuelled only with naturally occurring thorium. It breeds thorium-232 into uranium- 233 in a self-sustaining series.

However, full exploitation of India's domestic thorium reserves is unlikely to occur before 2050.

Parallel approaches

- There is a long delay before direct thorium utilisation in the three-stage programme.
- Hence, the country is now looking at alternate reactor designs, which allow more direct use of thorium.
- Options under consideration: Advanced Heavy Water Reactor (AHWR), Accelerator Driven Systems (ADS), and Compact High Temperature Reactor (CHTR).

5. NUCLEAR WEAPONS

First-generation nuclear weapon

- These are the conventional nuclear bombs, based on fission reaction.
- It was used by the United States against Japan in Second World War in 1945. This convincingly concluded the war.

Thermonuclear or fusion weapon: second-generation nuclear weapon

- These are also called as hydrogen bombs.
- It is based on from a combination of fission and fusion reactions.
- Primary stage: Nuclear fission (U-235 or Pu-239 fuel). A fusion explosion provides necessary temperature of approx. one hundred million Kelvins for fusion initiation.
- Secondary stage: nuclear fusion. It uses thermonuclear fuel like heavy hydrogen isotopes deuterium and tritium.
- The first thermonuclear test was carried out by the United States in 1952 during cold war.

6. NUCLEAR TRIAD

- A nuclear triad is a three-pronged three components of atomic weapons delivery structure, consisting of: land, submarines and aircrafts.
- Land-based intercontinental ballistic missiles (ICBMs); Submarine-launched ballistic missiles (SLBMs), and strategic bombers.
- India's nuclear triad consists of Agni and Prithivi missiles for Army, INS Arihat for Navy, and Sukhoi-30MKI and Mirage-2000 for Airforce.
- It reduces the possibility of first-strike attack or Pre-emptive nuclear strike. It also increases the second-strike capability in respond to a nuclear attack with powerful nuclear retaliation.

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7. INDIAN NUCLEAR DOCTRINE

1. Maintaining a minimum credible deterrence.
2. No First Use policy: nuclear weapons to be used only "in retaliation against a nuclear attack on Indian territory or on Indian forces anywhere".
3. Nuclear retaliation to a first strike will be "massive" and designed to inflict "unacceptable damage".
4. No use of nuclear weapons against non-nuclear weapon states. However, in the event of a major attack against India, or Indian forces anywhere, by biological or chemical weapons, India retains the option of retaliating with nuclear weapons.
5. Nuclear retaliatory attacks to be authorized only by civilian political leadership through the Nuclear Command Authority.

Note: Pakistan subscribes to full spectrum deterrence. USA and Russia virtually follow mutually assured deterrence (MAD).

Nuclear Command Authority

- Political Council: it is the sole body, which can authorize using nuclear weapons. It is represented by the civilian leadership. As the first among equals, the Prime Minister will symbolically have his finger on the nuclear button.
- Executive Council chaired by the National Security Adviser to the Prime Minister, will provide inputs for decision making.
- There is absolute political control over nuclear decision making in India.

Strategic Forces Command

- It functions below the executive council.
- A Commander-in-chief, SFC is responsible for the overall operational control of the nuclear forces. It is the custodian of all nuclear weapons and delivery systems.
- The command is rotational among three services - Air Force, Army and Navy.

8. RADIOISOTOPES

These are unstable isotopes of an element and thus radioactive. For example, Iodine-131, Molybdenum-99, Chromium-51, Phosphorus-32 (P-32) etc.

Applications of radioisotopes

Agriculture

- BARC has developed various high yielding crop varieties e.g. groundnut, pulses, rice etc.
- Commercial cultivation: BARC has developed green manure crop Sesbania rostrata.

Medical Science

- Powerful diagnostic tools: radioisotopes are used as non-invasive tracers in biological substances. E.g. Technetium-99m
- Radiation medicine centre at BARC, Mumbai is involved in R&D for nuclear medicines.
- BhabhaTron: Uses cobalt-60 for Cancer therapy.
- Radiopharmaceuticals: Cobalt 60 & Arsenic-74:

thyroid disorders and cancer. Iodine-131: thyroid disorders. Coronary stents coated with P-32.

- **Digital imaging:** Positron Emission Tomography (PET) is precise radioisotope imaging technique.

Food processing

- Food is exposed to ionising radiation.
- Radioisotopes used: Cobalt-60, X-rays, high energy electrons.
- It kills bacteria and other microbes. Thus, it increases shelf life of food items.
- It breaks chemical bonds and thus destroys enzymes needed for the cellular functions.
- **The Prevention of Food Adulteration Act, 1994** was amended to provide irradiation for spices, potatoes, onions and other tubers.

Water desalination

- BARC has developed a number of desalination technologies for providing potable water.
- These are based on multistage flash evaporation, reverse osmosis and low temperature evaporation.

Industry

- Irradiation, quality control and testing, material strength checking etc.

9. LARGE HADRON COLLIDER (LHC)

- It is world's largest and most powerful particle collider and the largest machine in the world.
- It is in a tunnel of 27 km circumference and 175 meters depth at the France-Switzerland border near Geneva.
- It was made by the European Organization for Nuclear Research (CERN) with worldwide collaboration.
- It tests the predictions of different theories of particle physics, including measuring the properties of the Higgs boson.
- It also searches for the large family of new particles predicted by supersymmetric theories.
- It works to resolve other unsolved questions of physics.

Higgs Boson

- In the Standard Model of particle physics, the Higgs boson (God Particle) is an elementary particle- a scalar boson, with zero spin, no electric charge and no colour charge. It is very unstable, decays into other particles immediately.
- It is produced by the quantum excitation of the Higgs field.
- Higgs field is a quantum field responsible for giving particles their masses. All Quantum fields have a fundamental particle associated with them. Higgs Boson is associated with Higgs field.
- Its existence was confirmed in 2012 by the ATLAS and CMS particle detection experiments at LHC.
- Its discovery validates the standard model essentially correct. It is the only elementary particle predicted by the Standard Model that has not yet been observed by particle physics.

- **Higgs mechanism** is explained by the Higgs Boson. This mechanism explains why elementary particles have mass.
- Peter Higgs and Francois Englert were awarded the 2013 Nobel Prize in Physics.

10. NUCLEAR ACCIDENTS

Three Mile Island accident, USA- 1979

- **Incident:** partial meltdown of the reactor.
- **Reason:** large amounts of nuclear reactor coolant to escape. It was a loss-of-coolant accident (LOCA) due to inadequate training and human factors.
- The accident crystallized anti-nuclear safety concerns among activists and the general public. It resulted in new regulations for the nuclear industry.

Chernobyl disaster, Ukraine- 1986

- It was a major nuclear accident in which a reactor core is damaged and significant amounts of radioactive isotopes are released.
- **Reasons:** Inherent reactor design flaws and poor management control
- **Incident:** Water flashed into steam. It generated a destructive steam explosion and a subsequent open-air graphite fire.
- **Impact:** Deaths, radiation induced cancer, genetic disorders etc.

- **World Association of Nuclear Operators (WANO)** was established in 1989 at London after it. It is an international NGO of nuclear power plant operators, dedicated to nuclear safety.

The Fukushima and Chernobyl disasters and the only two to be rated Level 7 event classification of the International Nuclear Event Scale.

Madras Atomic Power Station (MAPS)

Unlike Fukushima, after the Tunami event, MAPS was marked safe.

- **Reason:** Inherent safety features.
- The reactor draws water from the sea for cooling. As soon as the water level rises, seawater pumps trip. The moment it trips the operator knows that something is wrong and he trips the reactors.

Mayapuri radiological accident, 2010

- **Reason:** A unused research irradiator (cobalt- 60 source) at by Delhi University was sold to a scrap metal dealer in Mayapuri.
- One fragment was taken by a person in his wallet, as it was very illuminating.
- The event was rated level 4 out of 7 on the International Nuclear Events Scal

Fukushima Daiichi nuclear disaster, 2011

- **Reason:** initiated primarily by the tsunami following earthquake. The plant operator did not meet basic safety requirements such as risk assessment, preparing for containing collateral damage, and developing evacuation plans.

- Incident:** Immediately after the earthquake, the active reactors automatically shut down sustained fission reactions. However, the tsunami disabled the emergency generators operating the cooling pumps. The insufficient cooling led to three nuclear meltdowns, hydrogen-air explosions, and the release of radioactive material.

11. INTERNATIONAL NUCLEAR ARCHITECTURE

International Atomic Energy Agency (IAEA)

- Promotes peaceful use of nuclear energy, and inhibits its use for military purposes.
- It serves as an intergovernmental forum for scientific and technical co-operation in the peaceful use of nuclear technology.
- It is established through international treaty **IAEA Statute independently of the United Nations**. **However**, it reports to the United Nations.
- The IAEA has its headquarters in Vienna, Austria.
- India is a member.**

Nuclear Suppliers Group (NSG)

- Topic is covered in International Defence Architecture.

Partial Test Ban Treaty (PTBT), 1963

- In 1954, Pt. Nehru made the first call for a “standstill agreement” on nuclear testing.
- PTBT banned nuclear weapon tests in atmosphere, outer space and under water, except underground.
- India was not a signatory.

Non-Proliferation Treaty (NPT), 1970

- To prevent the spread of nuclear weapons and technology, to promote cooperation in the peaceful uses of nuclear energy, and to further the goal of achieving nuclear disarmament.
- The treaty defines NWS and NNWS members.
- NWS (Nuclear Weapon States):** Those who conducted a nuclear test before 1 January 1967. These are **P-5 countries**.
- NNWS (Non-Nuclear Weapon States):** Those who are not NWS.
- Opened for signature in 1968, the treaty entered into force in 1970.
- NPT Parties met in 1995 and **extended it indefinitely**.
- North Korea, withdrawal** in 2003.
- India**, Israel, Pakistan and South Sudan are not its members. North Korea withdrew from it. **India's argument:** Unequal treatment.
- The treaty is reviewed every five years in **Review Conferences**.

Comprehensive Nuclear-Test-Ban Treaty (CTBT), 1996

- Bans all nuclear explosions, for both civilian and military purposes, in all environments.
- Adopted by UNGA on September 1996 but has not entered into force as eight specific states have not ratified the treaty.

- The treaty will enter into force 180 days after the 44 states listed in Annex 2 of the treaty have ratified it.
- Annex 2 states:** states that participated in the CTBT's negotiations between 1994 and 1996 and possessed nuclear power reactors or research reactors at that time.
- As of 2016, eight Annex 2 states have not ratified the treaty: China, Egypt, Iran, Israel and the United States have signed but not ratified. **India**, North Korea and Pakistan have **not signed**.

Treaty on the Prohibition of Nuclear Weapons (TPNW), 2017

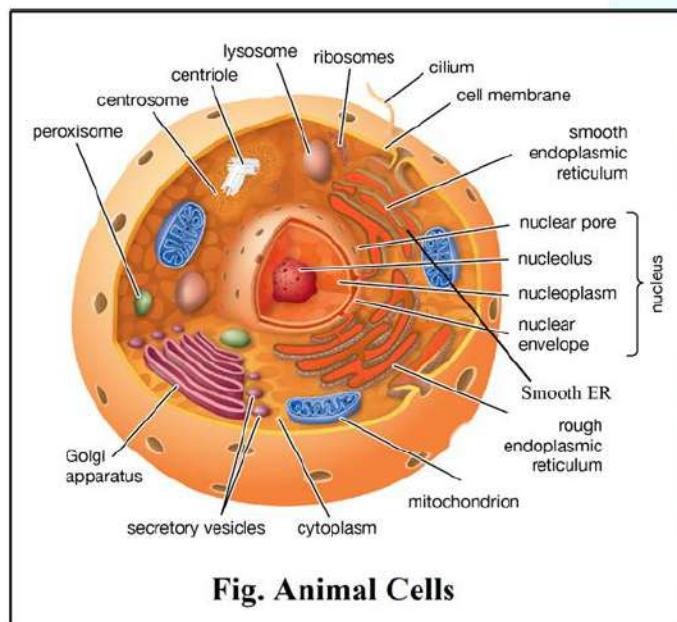
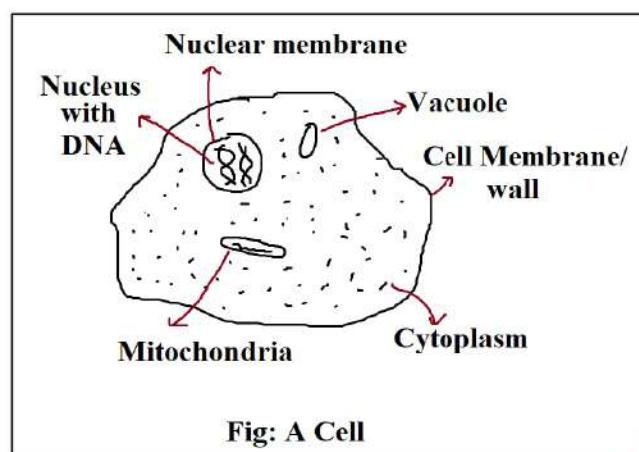
- Also known as **Nuclear Weapon Ban Treaty**.
- It is **first legally binding international agreement** to comprehensively **prohibit** nuclear weapons, and their total elimination.
- It provides for a **time-bound framework** for negotiations leading to **verified and irreversible elimination**.
- In order to come into effect, signature and ratification by at least 50 countries is required.
- No nuclear nation expressed support for a ban treaty. North Korea was the only nuclear state to vote for initiating ban negotiations.

4. BIOLOGY AND BIOTECHNOLOGY

1. Cell

- It is the smallest structural and functional unit of a living organism.
- It is the building block of life.

1.1 Structure of a cell



1. Cell membrane or plasma membrane

- It surrounds the cytoplasm of a cell.

2. Genetic material

- Two different kinds of genetic material exist: **deoxyribonucleic acid (DNA)** and **ribonucleic acid (RNA)**.
- Cells use **DNA for long-term information storage**. The biological information is encoded in the DNA sequence.
- **RNA** is used for information transport (e.g., mRNA) and enzymatic functions (e.g., ribosomal RNA).

Gene therapy

- It is designed to introduce genetic material into cells to compensate for abnormal genes or to make a beneficial protein.

3. Cytoplasm

It is a thick solution that fills each cell and is enclosed by the cell membrane.

4. Nucleus

The cell nucleus contains all the cell's genome, except a small fraction of mitochondrial DNA.

It is organized as **multiple long linear DNA molecules** in a complex with a large variety of proteins, such as histones, to form **chromosomes**.

5. Cell wall

It acts to protect the cell mechanically and chemically from its environment.

- Plant cell walls are primarily made up of **cellulose**,
- Fungi cell walls are made up of **chitin**,
- Bacteria cell walls are made up of **peptidoglycan**.

6. Organelle

- It is a specialized subunit within a cell that has a specific function.

Important Organelle:

(a) Mitochondria: powerhouse of the cell.

- These are sites of **cellular respiration** which releases energy.
 - Some portion is used to form **energy rich compound ATP** (Adenosine Triphosphate)
- It is absent in **bacteria** and the **red blood cells of mammals and higher animals**.

(b) Chloroplasts: conduct photosynthesis.

In a cell, other than nucleus, **Mitochondria and Chloroplast** contains DNA.

(c) Vacuole: These are storage bubbles in cells.

- Stores food, nutrients etc.
- Stores waste products so the rest of the cell is protected from contamination.

(d) Golgi apparatus: It is the cell's post office.

- It is also involved in the **transport of lipids**, and in the **creation of lysosomes**.
- **Secretion** is its major function. It collects **Synthetic products** of the cell (e.g. **Protein, hormones, and enzymes**); and secretes into the **cytoplasm**.

(e) Lysosome

- It contains **digestive enzymes**.
- They break down excess or worn-out cell parts.
- They may be used to destroy invading viruses and bacteria.

(f) Centrosome: They are made from two centrioles.

Function:

- It is the main place where **cell microtubules** are organized.
- provide structure for the cell.
- It regulates the cell division cycle.

Centriole

- To help with **cell division (mitosis)** in animal cells.
- Centrioles are **microtubule rings**.
- The centrioles are **found in pairs**. They move towards the poles (opposite ends) of the nucleus when it is time for cell division.

(g) Peroxisomes

- Two functions
 - **Break down fatty acids**- used for forming membranes and as fuel for respiration
 - **Making water**: Transfer **hydrogen** to oxygen
 $\rightarrow \text{H}_2\text{O}_2 \rightarrow \text{H}_2\text{O}$.

(h) Endoplasmic reticulum (ER)

- A continuous membrane system with a series of flattened sacs.
- Smooth ER: role in both lipid and phospholipid metabolism
- Rough ER: consists of ribosome, which does protein synthesis.
 - They bind messenger RNA and transfer RNA to synthesize polypeptides, lipids and proteins.

1.2 Type of cells

Prokaryotic cells and Eukaryotic cells

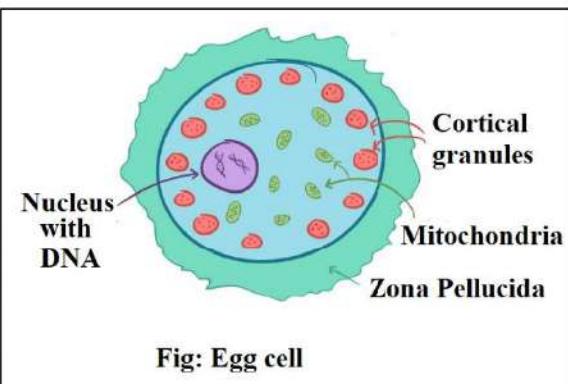
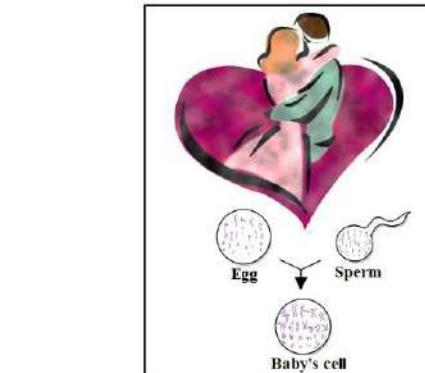
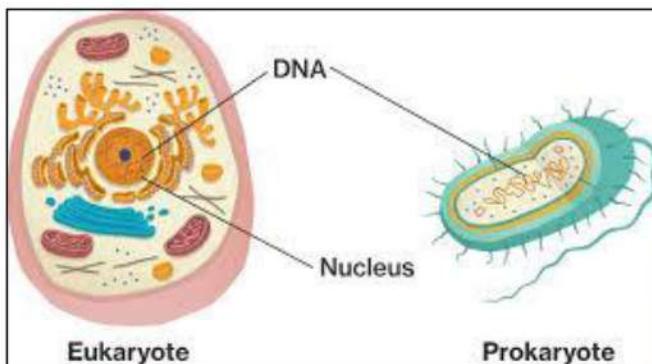


Fig: Egg cell

	Prokaryotic cells	Eukaryotic cells
Nucleus	Do not contain	Contain
Single/ multi celled	single-celled organisms	Can be both
Organelles	No	Yes
Examples	Bacteria and archaea. * Prokaryotic cells were the first form of life on Earth.	Plants, animals, fungi, slime moulds, protozoa, algae etc.
Genetic material	Organized in a simple circular bacterial chromosome in the nucleoid region of the cytoplasm.	Divided into different, linear molecules called chromosomes inside a discrete nucleus.

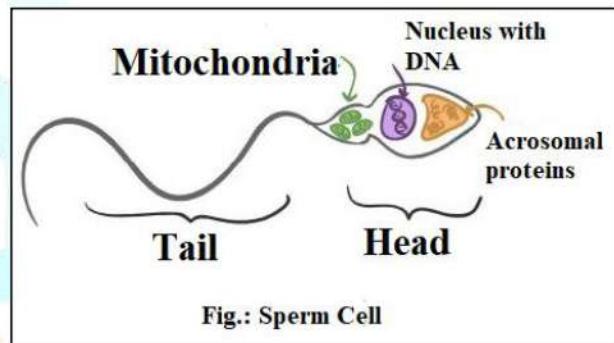


Fig.: Sperm Cell

	Egg	Sperm
Numbers	1 per menstrual cycle.	300 million per ejaculation
size	Largest diameter cell in human body. (0.12 mm)	50 μm long. 10,000 times smaller than the egg.
Ploidy	Haploid. Meiosis II uncompleted	Haploid, with 23 chromosomes.
Mitochondria	100 to 200,000	75-100
Special feature	cortical granules: enzyme packet within the cell. Mitochondria: in the cell.	Acrosome: enzyme packet in the head. Tail: for propulsion. Mitochondria: in middle.

Note: -cyte: A suffix denoting a cell.

(b) Important somatic cells

1. Red Blood Cells (Erythrocytes)

- Formed in the red bone marrow, by stem cells.

Function:

- To carry oxygen from the lungs to the body tissues.

Theoretically, it is possible to transform either of the cells.

(a) Egg and Sperm cells

- These combine to form an embryo.

- To carry carbon dioxide as a waste product, away from the tissues and back to the lungs.
- Hemoglobin (Hgb) is an important protein in RBCs that carries oxygen.

2. White Blood Cells (Leukocytes)

- These have a nucleus, but do not contain haemoglobin.
- Produced in the bone marrow by stem cells.
- Found throughout the body, including the blood and lymphatic organs.

Function:

- The cells of the immune system.
- Protects the body against both infectious disease and foreign invaders.

3. Platelets (Thrombocytes)

- Platelets have no cell nucleus. They are fragments of cytoplasm.
- Derived from the bone marrow.
- Platelets are found only in mammals.

Function: initiating a blood clot (hemostasis). **Not Homeostasis**

4. Liver cells (Hepatocytes or Hepatic cells)

Function:

- Digestion:** Protein synthesis and storage, Transformation of carbohydrates
- Synthesis of cholesterol and bile**
 - Bile is a mixture of water, bile salts, and the pigments.
 - Bile helps in the digestion and absorption of fats.

5. Lymphocytes

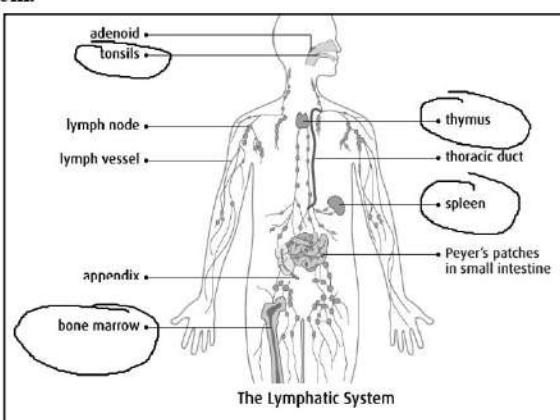
- Produced in bone marrow.
- Migrate to secondary lymphoid organs like Peyer's patches, spleen, tonsils, lymph nodes, appendix, etc.

Note

1. Lymphatic or lymphoid system

- Latin word lympha = the deity of fresh water
- The large network of vessels through which lymph drains towards the heart; and from the tissues into the blood.
- Unlike the circulatory system, the lymphatic system is not a closed system.

Function: it is part of the circulatory system and the immune system.



2. Bone marrow

- It is the spongy tissue inside some bones. Eg. hip and thigh bones.
- It manufactures bone marrow stem cells and other substances, which in turn produce blood cells.

Synopsis IAS

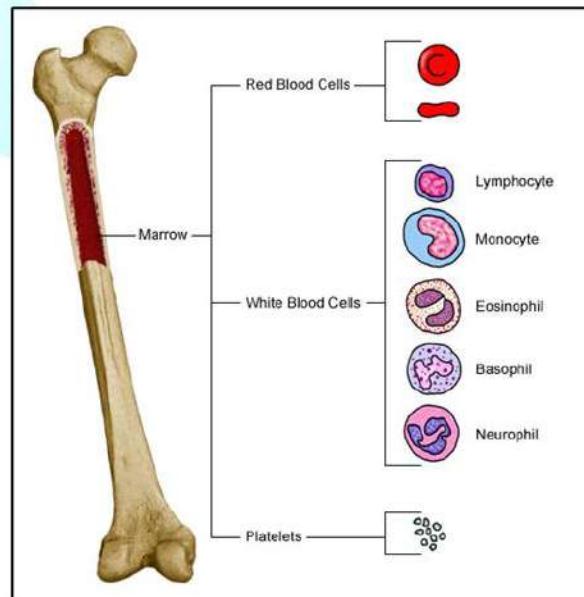
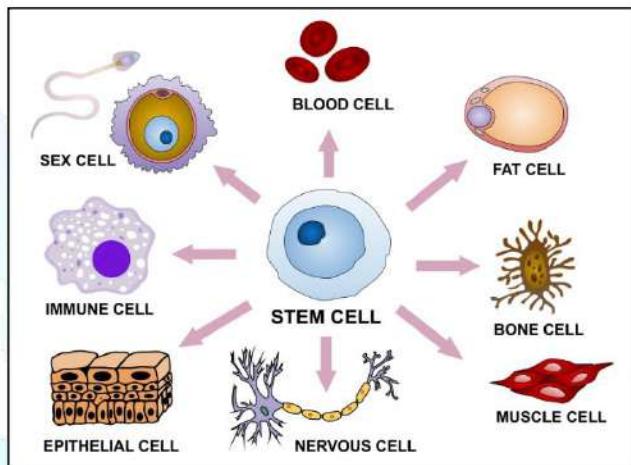
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- Hematopoietic Stem Cells (HSCs)** are the stem cells that give rise to other **blood cells**. This process is called **haematopoiesis**.

2. Stem Cells

- Stem cells are **special human cells** that have the ability to develop into many different cell types, from muscle cells to brain cells.
- Stem cells are cells that can **differentiate into other types of cells**.
- In multicellular organisms, stem cells are undifferentiated or partially differentiated cells.

Note: Cellular differentiation is the process in which a cell changes from one cell type to another.



- These have **capability of self-renewal** to produce more same type stem cells.
- Usually, the cell changes to a **more specialized type**.
- Differentiation occurs **numerous times** during the **development of a multicellular organism**.
 - Such organism changes from a simple zygote to a complex system of tissues and cell types.
- Stem cells also have the ability to repair damaged tissues.
- Researchers believe that **stem cell-based therapies** may soon be used to treat many ailments. Eg. paralysis and Alzheimer's disease.

2.1 Types of stem cells

Stem cells are divided into two main forms:

- **Embryonic stem cells:** These come from embryos.
- **Adult stem cells:** These come from adult tissue.

Both types of stem cells are generally **characterized by their potency**. **Cell potency** is a cell's ability to differentiate into other cell types.

1. Embryonic stem cells

- These come from unused embryos resulting from an **in vitro fertilization procedure** and that are **donated to science**.
- The embryonic stem cells are **pluripotent**. It means that they can turn into **more than one type of cell**.

Pluripotent Stem Cells (PSCs)

- These have the ability to differentiate into almost all cell types, and to undergo self-renewal.
- These are derived from human embryos.

2. Adult stem cells: There are two types of adult stem cells.

(a) Cells from fully developed tissues

- Eg. cells from the brain, skin, and bone marrow.
- There are only small numbers of stem cells in these tissues.
- They are more **likely to generate only certain types of cells**.
- Eg. a stem cell derived from the liver will **only generate more liver cells**.

(b) Induced Pluripotent Stem Cells (iPSCs)

- These are **adult stem cells**, that have been **manipulated in a laboratory to take on the pluripotent characteristics of embryonic stem cells**.
 - i.e. iPSCs are **body cells (somatic cells)** which have been **reprogrammed to function like embryonic stem cells**.
 - These are a **type of artificial pluripotent stem cell**, derived from a **non-pluripotent cell**.
- These **don't appear to be clinically different from embryonic stem cells**.
- **Method:** by inducing a "forced" expression of certain genes and transcription factors.
- Eg. iPSCs from skin or blood cells.
- **Hence**, the iPSCs play a role in sidestepping the controversial use of killing the embryos while harvesting the stem cells. They are capable of forming any cell types of the body.

2.2 Stem Cell Therapy

Principle: Stem cells are extracted from bone marrow or other body tissues. It is implanted back into the body to cure diseases.

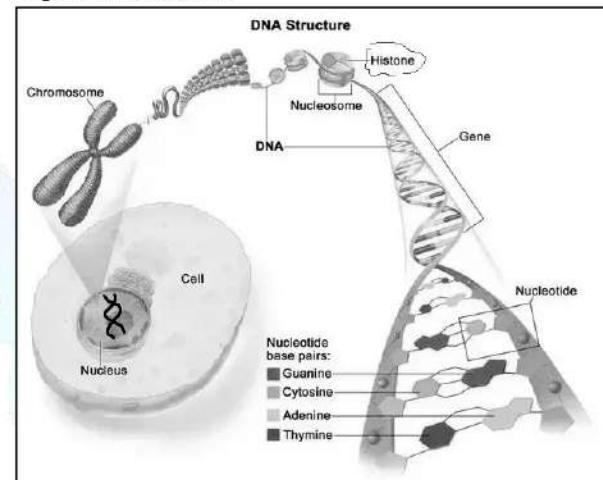
- The **only stem cells** currently used to treat disease are **hematopoietic stem cells (HSCs)**.
 - These are the **blood cell-forming adult stem cells** found in **bone marrow**.
- These cells are used in procedures like **bone marrow transplants**. It helps cancer patients produce new **blood cells**.
 - Their own **hematopoietic stem cells** have been killed by radiation therapy and chemotherapy.
- They may also be used to treat **Fanconi anemia**, a **blood disorder** that causes the body's bone marrow to fail.

Significance of stem cell therapy

- Stem cells offer new potentials for treating diseases like diabetes, Retinitis pigmentosa, heart diseases, cancer etc.
- To identify birth defects causes.
- To study how an organism develops from a single cell and how healthy cells replace damaged cells in adult organisms.
- These cells can be used for testing of new drugs and new therapies.

3. Genetics

Important definitions



Chromosomes

- A threadlike structure of **nucleic acids (DNA)**, carrying **genetic information** in the form of genes.
- DNA is made up of **23 pairs of chromosomes**. It provides instructions for building entire organism and the proteins.

Genes

- Genes are segments of DNA. It is contained within Chromosomes.
- **Gene therapy** is designed to introduce genetic material into cells to compensate for abnormal genes.

Genome

- A genome is the **genetic material** of an organism. It consists of **DNA (or RNA in RNA viruses)**.
- It is the **haploid set of chromosomes**.

Haploid	Diploid
A cell having half the usual number of chromosomes.	A cell that has paired chromosomes, one from each parent.
Eg. sex cells. They contain a single set of chromosomes. ($n = 23$)	Eg. all body cells (other than sex cells). These have 23 pairs of chromosomes. ($2n = 46$)

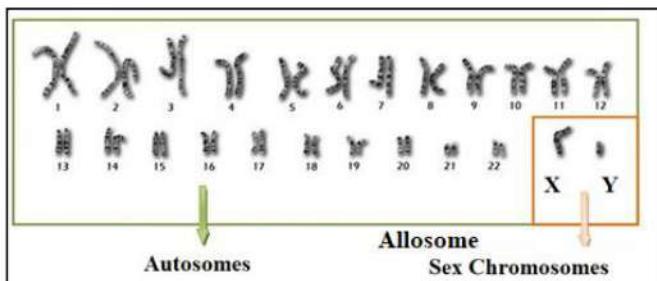
Heredity

- Also known as **biological inheritance**.
- The passing on of traits from parents to their offspring.

Sex chromosome

- In female – XX
- In male – XY
- Males play a major role in sex determining of offspring due to Y chromosomes.

- Males are at a greater risk of inheriting an X linked mutation, because males only have one X chromosome.
- Males have no spare normal chromosome to override the mutated chromosome.

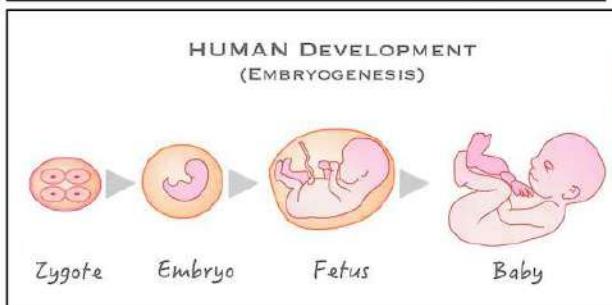
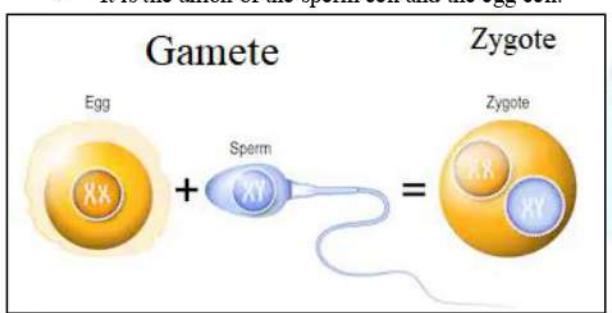


Gamete

- A mature male or female germ cell which is able to unite to form a zygote.

Zygote or fertilized ovum

- It is the union of the sperm cell and the egg cell.



3.1 Genetic material

The hereditary material must be capable of

- Replication
- Storage of information
- Transmission of information
- Expression of information and
- Regulation of gene expression.

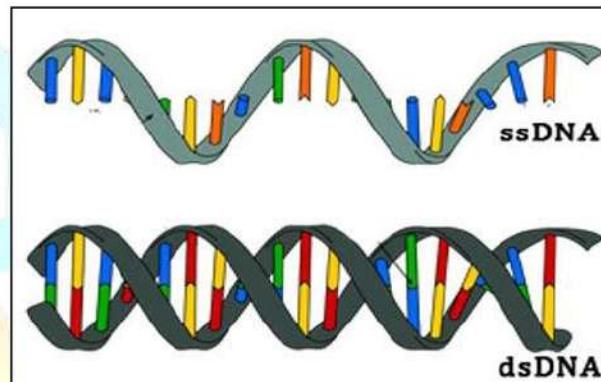
Types of genetic material

- There are two different kinds of genetic material: deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).
- These are important nucleic acid present inside the cell.

Differences between DNA and RNA

	DNA	RNA
Molecule	Double stranded	Single stranded

Sugar	Deoxyribose sugar.	Ribose sugar.
Bases	A, T, C, G	A, U, C, G
Complementary base to adenine (A)	Thymine (T).	Uracil (U).
Location	Mainly found in nucleus.	Located in the cytoplasm, mainly in the ribosomes.
Types	Nuclear DNA, mtDNA	mRNA, rRNA, tRNA
Function	Only 1 function: To carry genetic information.	Different functions.
Growth	Can self replicate itself. DNA is vulnerable to damage by ultraviolet light.	Can't self replicate itself. RNA is synthesized on a DNA template. RNA is more resistant to damage from UV light than DNA.



Structure of Nucleic acid

In 1953, James Watson and Francis Crick were awarded the Nobel Prize for working out the structure of DNA.

A Nucleic acid is a polynucleotide macromolecule.

- Nucleoside = base + sugar. (s -- Sugar)
- Nucleotide = nucleoside + phosphate.

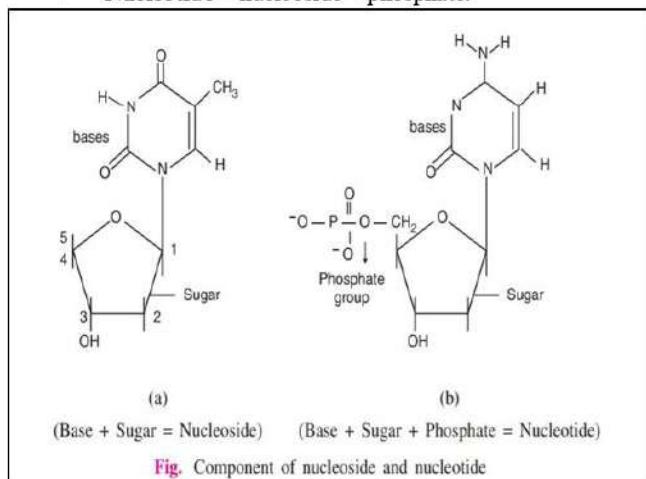


Fig. Component of nucleoside and nucleotide

Nucleotides consist of 3 components:

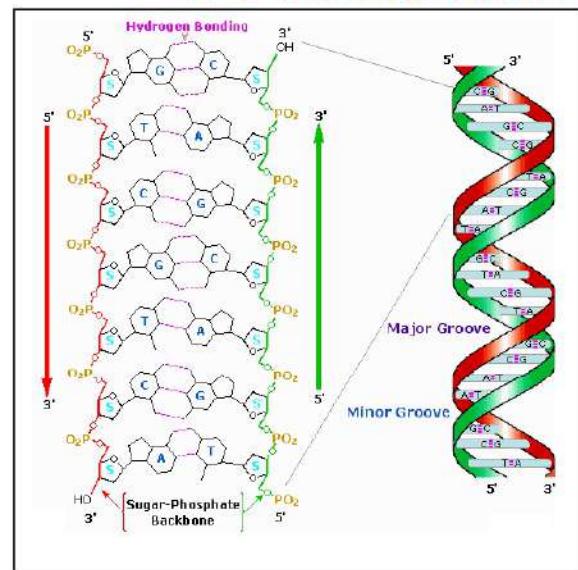
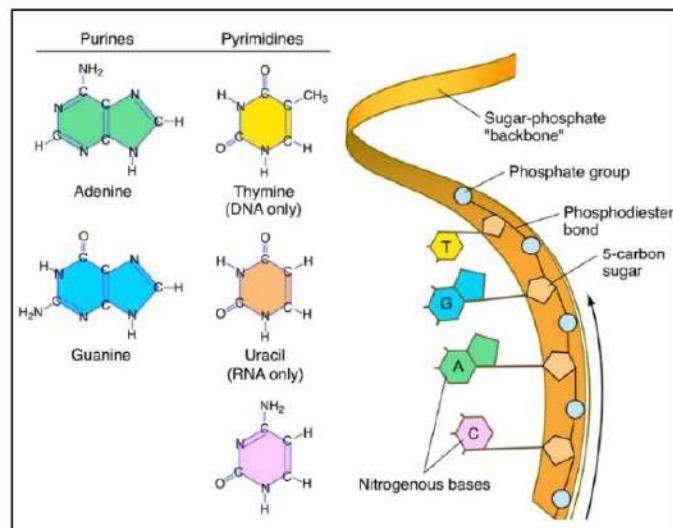
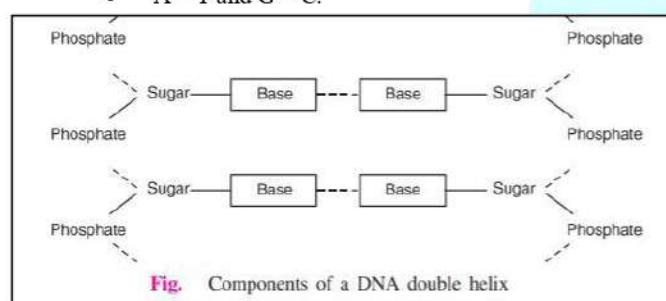
1. **5-carbon sugar or pentose sugar:** deoxyribose in DNA, and ribose in RNA.
2. **Phosphate (PO₄):** positioned on the sugar.
3. **Nitrogenous Bases:** Human DNA consists of about 3 billion bases. More than 99% of these bases are same in all people.
Genetic information is conveyed using the nitrogenous bases.
 - . **Purine bases:** Adenine (A), and Guanine (G).
 - a. **Pyrimidine bases:** Thymine (T) or Uracil (U); and Cytosine (C).
 - o Thymine (T) in DNA or Uracil (U) in RNA.
 - o Uracil is an unmethylated form of thymine.

Important facts:

- The backbone of the helix is made of sugar and phosphate.
- Nitrogenous bases are linked to the sugar.
- Thymine (T) / uracil (U) binds to adenine (A) via two hydrogen bonds.
- In the DNA helix, a complete helical turn occurs after 34 Å.

Chargaff's rule

- Base pairing is very specific as per Chargaff's rule.
- A purine base always pairs with a pyrimidine base.
 - o A always pairs with T.
 - o G always pairs with C.
 - o These pairs of bases are called complementary bases.
- Purines (A + G) = pyrimidines (T + C).
- A = T and G = C.



3.2 Types of DNA and RNA

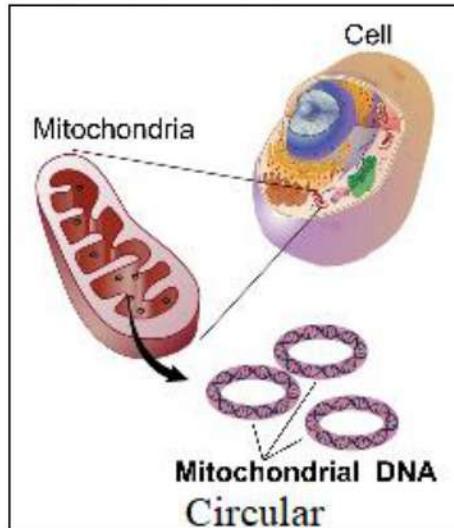
Types of DNA

1. Chromosomal DNA

- It is any DNA that is found in the chromosomes.
- a. in eukaryotic organisms: **Nuclear DNA**
 - Most DNA is located in the cell nucleus.
 - It contains more than 20,000 genes.
- b. in prokaryotic organisms: **Nucleoid DNA**
 - Prokaryotic organisms do not possess a membrane bound nucleus
 - The nucleoid is an irregularly shaped region within the prokaryote cell that contains most of the genetic material or **main chromosome**.

2. Extrachromosomal DNA

- It is any DNA that is found off the chromosomes.
- a. In prokaryotes
 - Outside the nucleoid region as circular or linear plasmids.
- b. In Eukaryotic plants:
 - Eukaryotic Chloroplasts DNA and plastids DNA
- c. in eukaryotic cells: **mitochondrion DNA (mt DNA):**
 - Small amount of DNA can be found in Mitochondria.
 - It contains 37 genes.
 - **mtDNA is inherited from mother.**
 - **mtDNA evolves faster** than nuclear genetic markers, it represents a mainstay of **evolutionary biology**.
 - It has become **important in anthropology and biogeography**.
 - o It is useful to trace **geographic distribution** of genetic variations, **migration** and other pattern of gene flow.
 - The **mtDNA can have mutations** that can lead to serious diseases.
 - o It can cause **infertility** for women carrying defective mitochondria.
 - o **The mtDNA dysfunctioning** leads to certain disorders like diabetes, respiratory disorders, Huntington's disease, Parkinson's disease, Alzheimer's disease etc.



Note: Mitochondria also performs several other cellular activities. It helps to regulate the **self-destruction of cells (apoptosis)**. Apoptosis is necessary for production of substances such as **cholesterol** and **heme** (a component of haemoglobin).

Types of RNA

1. mRNA or messenger RNA

- Functions: To carry information, from DNA to site of protein synthesis in the cytoplasm.
- Cellular organisms use it to convey genetic information that directs synthesis of specific proteins.
- Many viruses encode their genetic information using an RNA genome.

Transcriptome

- Set of all messenger RNA (mRNA) in one cell.

2. Transfer RNA (tRNA) or soluble RNA

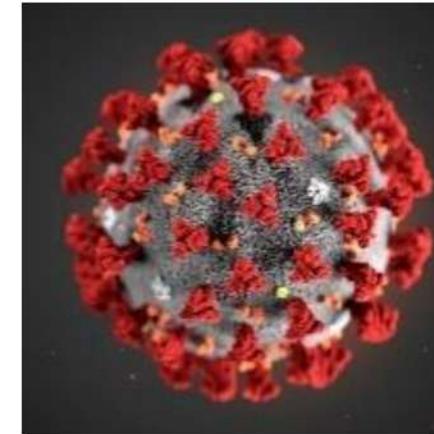
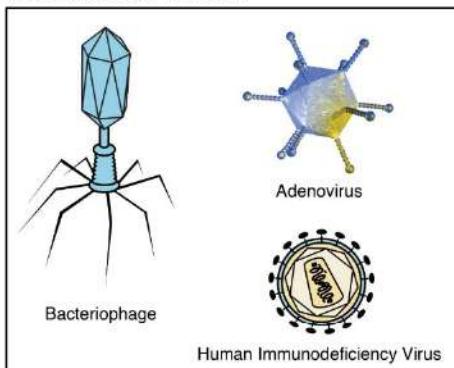
- Functions: To transfers the amino acids to the ribosome during protein synthesis

3. Ribosomal RNA (rRNA)

- Functions: Enzymatic functions.
- tRNA molecules deliver amino acids to the ribosome. Here, rRNA then links amino acids together to form coded proteins.

4. Virus

- A virus is a **submicroscopic infectious agent** that **replicates only inside the living cells**.
- Viruses occupy the twilight zone that separates the 'living' from the 'non-living'.
- They **do not have a cellular organization**.
- They contain only one type of nucleic acid, either **DNA or RNA** but never both.



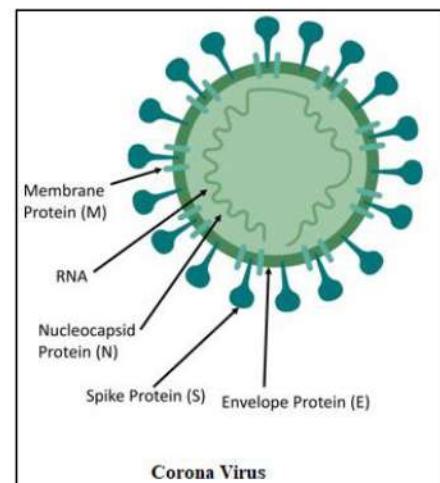
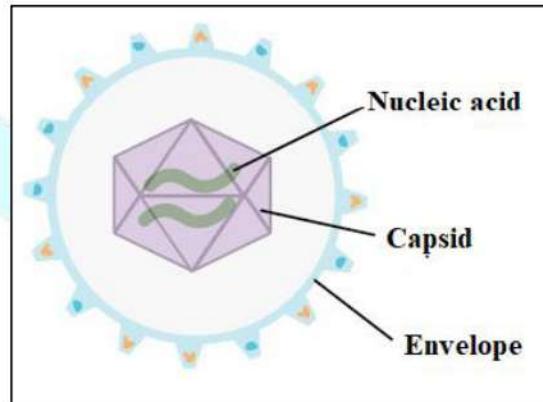
Morphology of Viruses

Structure, shape and symmetry:

- Virus = Protein coat (**capsid**) + genetic material (DNA/RNA)
- Virion = The extracellular infectious virus particle.
- Viroid = consisting only of nucleic acid without a protein coat.

Protein coat/ shell

- Arranged symmetrically.
- capsid + nucleic acid = **nucleocapsid**.
- Enveloped or non-enveloped.
- The chemical units of the capsid are **polypeptide molecules**.



Medical importance of viruses

- Viruses can infect all types of life forms, from animals and plants to microorganisms, including bacteria and archaea.
- Wide range of human diseases: range from minor ailments to terrifying diseases.
- Eg. common cold, chicken pox, measles, rabies and AIDS.

4.1 Baltimore classification of viruses

David Baltimore grouped viruses into families. (**Group I to VII**). Basis of division

- Type of genome (DNA, RNA, single-stranded (ss), double-stranded (ds), etc.) and
- Method of replication.**

DNA Virus	RNA Virus
A virus that has DNA as its genetic material.	A virus that has RNA as its genetic material.
It replicates using DNA polymerase.	It replicates using RNA polymerase.
Group I or II Eg. Adenoviruses, Poxviruses	Group III, IV or V

Group IV virus (+ssRNA virus)

- Eg. Coronaviruses, Zika virus.

Note: **Aedes aegypti**

- It is a vector (means carrier of pathogens)
- A mosquito that can spread dengue, chikungunya, Zika, yellow fever viruses etc.
- A **vector** is an organism that **does not cause disease itself**; but spreads infection by conveying pathogens.

Group VI virus:

- Single strand RNA virus with DNA intermediate in life-cycle.
- Eg. **Retroviruses**. **HIV** is a retrovirus. It carries single-stranded RNA.
- A **retrovirus** is a type of RNA virus that **inserts a copy of its genome into the DNA of a host cell that it invades**, thus changing the genome of that cell.

Group VII virus:

- Double-stranded DNA viruses that replicate through a single-stranded RNA.
- They are **not considered DNA viruses**.
- Eg. Hepatitis B.

Diseases	dsDNA-RT viruses	Vaccine
Hepatitis B	Hepatitis B virus (HBV)	Hepatitis B vaccine

DNA Viruses

Diseases	DNA viruses	Vaccine

Differences between bacteria and viruses

	Bacteria	Viruses
Definition	Single celled microbes	Set of proteins and genetic material
Cell	Single cell	Absent
Size	Large	Much smaller
DNA & RNA	Both are present	Only one
Ribosomes	Present	Absent
Growth on inanimate (non-living)	Yes	No
Reproduction	Binary fission	* Cannot reproduce by themselves * Infects a cell to copy itself
Sensitivity to antibacterial antibiotics	Yes	No
Impact	* Both positive and negative. * Trillions of bacteria in human body	* Mostly negative impact.

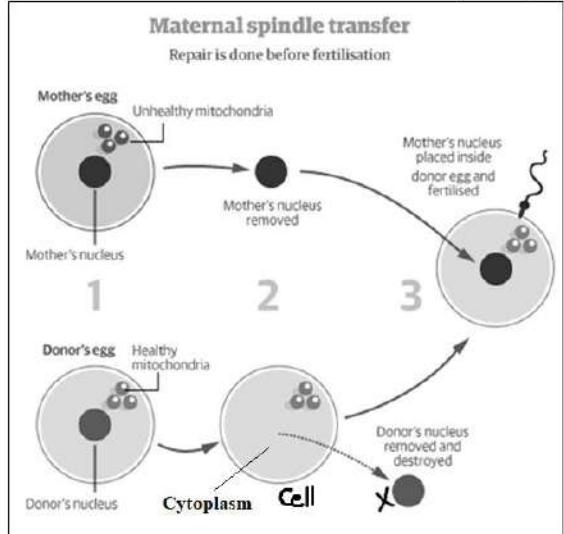
Chickenpox or varicella (eradicated)	varicella zoster virus (VZV)	Varicella
Smallpox (eradicated)	Variola virus	Smallpox
Herpes simplex	herpes simplex virus	No vaccine

RNA Viruses

Diseases	RNA viruses	Vaccine
COVID-19	SARS coronavirus (SARS-CoV-2)	No vaccine
SARS (severe acute respiratory syndrome)	SARS coronavirus (SARS-CoV-1)	No vaccine
Rabies	Rabies virus, Lyssa virus	Rabies vaccine
Common cold		
Influenza Eg. swine flu, bird flu	swine flu virus bird flu virus	swine flu vaccine no bird flu vaccine
Ebola virus disease	Ebola virus	Ebola vaccine
Hepatitis C	Hepatitis C virus (HCV)	No vaccine
Hepatitis E	Hepatitis E virus (HEV)	HEV 239
Polio (Poliomyelitis)	Polio virus	Polio vaccine
Measles	Measles virus	Measles vaccine. Most successful
Foot-and-mouth disease	FMD virus	FMD vaccine

5. DNA technology

- Also known as Recombinant-DNA (rDNA) technology.



- It is the technology, where genetic material from one organism is artificially introduced into the genome of another organism.
- Recombinant DNA (rDNA) molecules** are DNA molecules formed by laboratory methods of genetic recombination.
- Examples:** DNA cloning, DNA sequencing, Polymerase chain reaction, Gel electrophoresis.

5.1 Polymerase chain reaction (PCR)
Polymerase

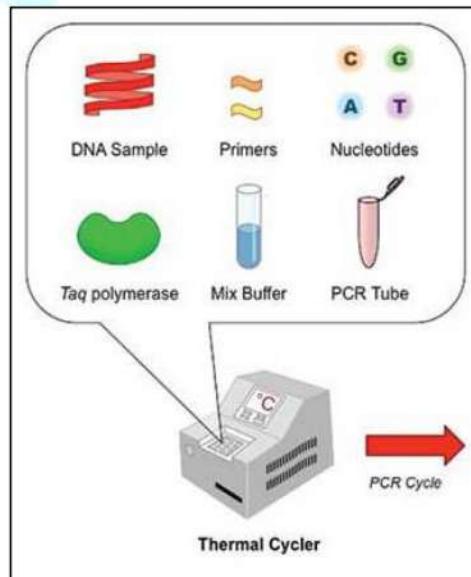
- A polymerase is an enzyme that synthesizes long chains of polymers or nucleic acids.
- DNA polymerase is the enzyme responsible for DNA replication or making a copy of its molecule.
- Synthesis of RNA is done by RNA polymerase enzyme, using DNA as a template, a process known as transcription. (प्रतिलेखन)

Taq polymerase

- It is a thermostable DNA polymerase enzyme.
- Found from *Thermus aquaticus* bacterium, which lives in hot springs.
- It is heat tolerant with the optimum temperature activity being 75-80 °C.

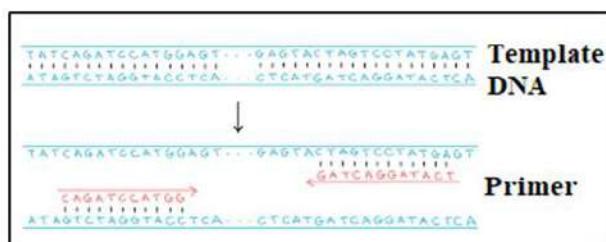
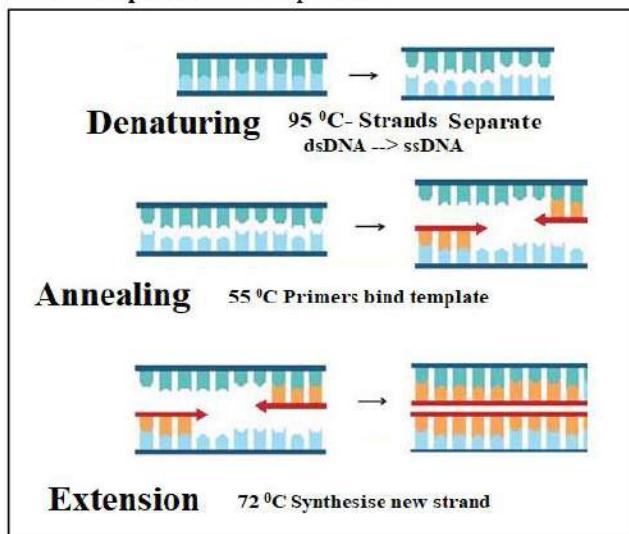
a. DNA PCR

- In this technique, DNA polymerase enzyme is used repeatedly for making many copies of a small fragment of DNA.
- It allows scientists to take a very small sample of DNA and amplify it to a large enough amount to study.
- PCR was invented in 1983 by the American biochemist Kary Mullis.


Steps of Thermal cycle

- Denaturing:** Heating; DNA breaks up into two strands.
- Annealing:** Primers are added and the DNA is cooled.
 - Primers are short single strand DNA fragments
- Extension:** DNA polymerase is added.
 - in its presence, two single strands (ssDNA) acquire complementary strands.

- Hence, two molecules of the DNA are formed.
- 4. Amplification:** multiplication

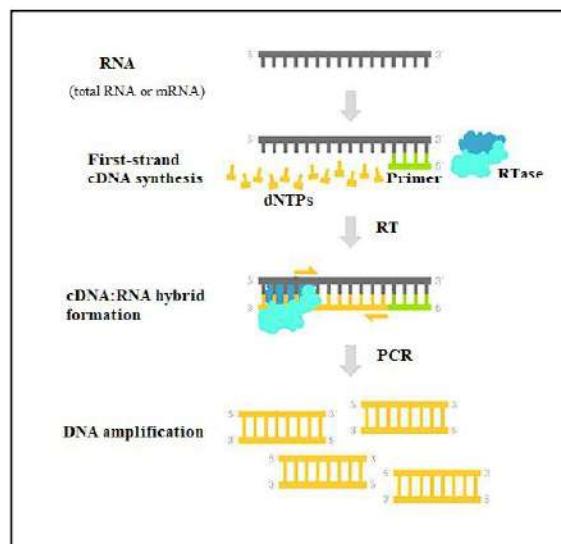


b. RNA PCR

- This is not direct PCR.
- It is done by **Reverse transcription polymerase chain reaction (RT-PCR)**
- A **reverse transcriptase (RT)** is an enzyme used to generate complementary DNA (cDNA) from an RNA template.
- Applications:** gene expression analysis, RNAi validation, pathogen detection, genetic testing, and disease research etc.

Real-time PCR or quantitative PCR (qPCR)

- It monitors the amplification of a targeted DNA molecule during the PCR (i.e., in real time); and not in the end, as in conventional PCR.



Steps

- Transcribe:** (लिखना) RNA is first transcribed into complementary DNA (**cDNA**) by reverse transcriptase; either from total RNA or from messenger RNA.
- Hybrid:** Combining reverse transcription of RNA into DNA.
- Amplification of DNA:** using polymerase chain reaction (PCR).

5.2 DNA Fingerprinting Technology

- DNA Fingerprinting** is a chemical test that shows the genetic makeup of a person or other living things.
- It is highly accurate technology. Blood, bones, hair with root, saliva, semen, and teeth are used to study DNA.

Uses

- To ascertain the **identity of a person from the DNA sample**
- To establish **biological relationships between individuals**.
- To strengthen the **justice delivery system**.
- To increase the **conviction rate**.
- Cross matching between persons who are **reported missing**.
- It can identify dead bodies.

Challenges

- Informed consent** is required for collection of samples. Eg. from the witness to the criminal, people looking for their lost relatives etc.
- DNA test results could be altered and misused.
- It could be used for breach of privacy.

5.3 Mitochondrial Replacement Therapy (MRT) or mitochondrial donation

- It is a **special form of in vitro fertilisation**, in which the baby's **mitochondrial DNA comes from a third party**.
- It is used when **mothers carry genes for mitochondrial diseases**.
- The therapy is approved in United Kingdom.

Types

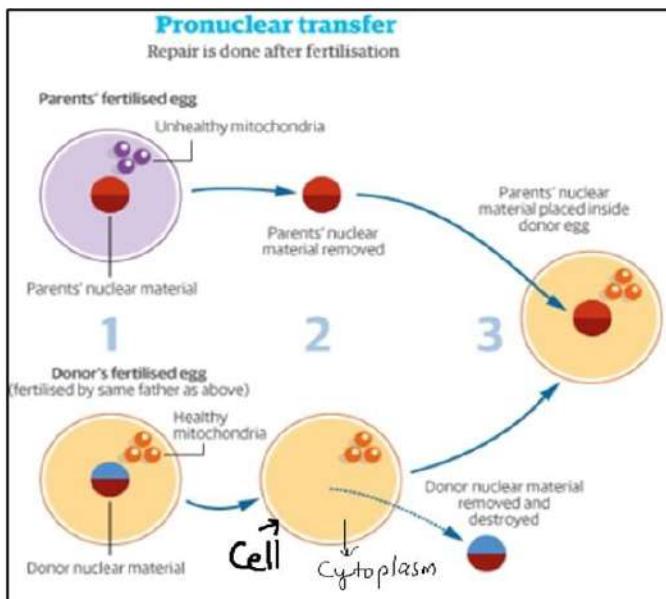
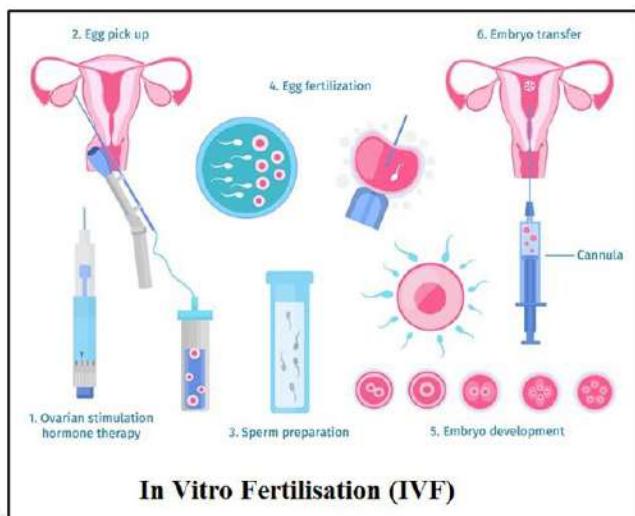
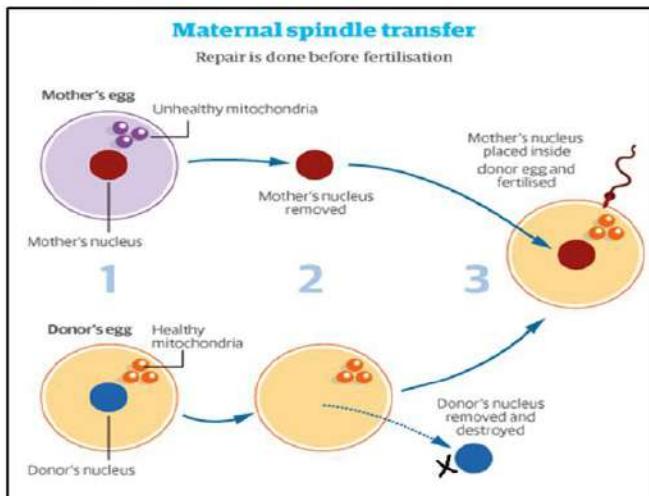
The MRT can be done by two methods for **cloning**.

1. Pronuclear Transfer

Steps

- First, mother's eggs with abnormal mitochondria and the donated egg with normal mitochondria are fertilised with sperm.
- Then the pronuclei from the normal mitochondria are destroyed and the pronucleus from zygote of the abnormal mitochondria is transferred to the emptied zygote.
- After this, the embryo with normal mitochondria and maternal and paternal genome is transferred to the uterus.

3. This gamete or embryo is transferred into vagina (the reproductive tract of a woman) to obtain a pregnancy.



2. Spindle Transfer

Steps

- The spindle and associated chromosomes from the normal mitochondria are removed and destroyed.
- mother's eggs/abnormal mitochondria are transferred to the emptied donor egg.
- The reconstituted egg is fertilised with sperm from father and the embryo with normal mitochondria and maternal and paternal genomes is transferred to the uterus.

5.4 Assisted Reproduction Technology

- In ART, the sperms and/or the eggs are handled outside the human body.
- ART includes all fertility treatments in which both eggs and embryos are handled.
- Eg. In Vitro Fertilisation (IVF). It is the most common form of ART.

Types

a. In Vitro Fertilisation (IVF)

Steps

- The eggs are surgically removed from a woman's ovaries.
- These eggs are mixed with sperms to make gamete or embryo.

b. Surrogacy

- It is an ART process, where an intending couple commissions a surrogate mother to bear their child.
- Pregnancy is achieved through in vitro fertilization (IVF).

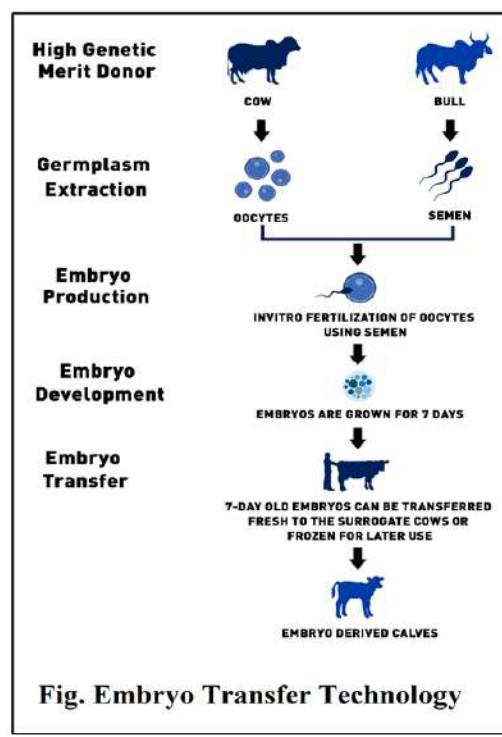
c. Embryo Transfer Technology (ETT)

The embryo or zygote is collected from a donor female with higher genetic merit and transferred to a recipient surrogate for rest of the pregnancy.

It is being used for development and conservation of indigenous breeds in:

- Rashtriya Gokul Mission;
- National Mission on Bovine Productivity;
- National Dairy Plan-I and
- Breed Improvement Institutes.

Indigenous Cow Breeds such as Sahiwal, Gir, Red Sindhi, Ongole, Deoni and Vechur will be the recipient surrogates.



5.5 Three Parents Baby

Three-parent baby is a human offspring produced from the **genetic material of one man and two women** using assisted reproductive technologies, and specifically mitochondrial replacement technologies.

Process involved:

1. Assisted reproductive technologies. Eg. IVF
2. Mitochondrial Replacement therapy (MRT)
 - o It is used to replace mother's faulty Mitochondrial DNA with healthy Mitochondria from a donor woman during IVF process.
 - o The child will have **nuclear DNA from the couple, and mitochondrial DNA from the donor woman**.

- Hence, such baby gets the name- "three-parent" baby. However, the child is still **conceived from two parents**.
- The donor's mitochondria contribute just **37 genes to the child**, compared with more than 20,000 from the parents. It is **negligible**, and far less than one would gain from a **blood transfusion or organ transplant**.
- **No other characteristics** in terms of intelligence, eye colour, hair colour, height etc. are changed.
- **UK became the first country** to have officially approved procedures to create "three-parent" babies.

Issues involved in ART and TPB

- **Lack of regulation.**
- Approx. 50% IVF cycles in India are by unorganized clinics.
- There is **lack of experience** leading to **unethical practices**.
- **lack of ART penetration:** Only 1% infertile population comes forward for evaluation; and less than half of these are prescribed treatment.
- **Safety Issues:** Long term evolutionary consequences on the heredity and future generations are unknown.
- **Religious Grounds:** Human replacing the God.
 - o **Objections are mostly raised with pro-nuclear transfer technique** which involves creating and **destroying a fertilised egg** to treat another embryo.
- **Ethical Issues:** It can be misused to get "genetically modified" or "designer" babies.
- It could potentially lead to **gender selection and sex discrimination against women** in society.

Way Forward

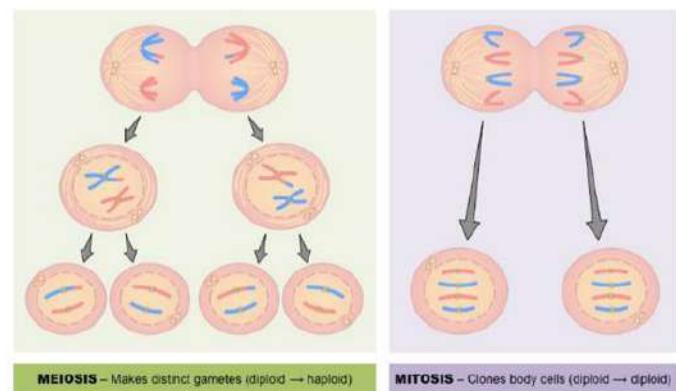
- ART techniques should be administered in a regulated environment.
- It should be used to prevent fatal diseases.
- Ensuring that it is not misused, and only the needy ones get access to it.

6. Important definitions

Mitosis and meiosis

- These are two types of cell division.

Meiosis	Mitosis
It is the type of cell division that creates egg and sperm cells.	A cell duplicates all of its contents, including its chromosomes, and splits to form two identical daughter cells.
Makes distinct gametes (diploid → haploid)	Clones body cells (diploid → diploid)



Hormones

- A hormone is any member of a **class of signaling molecules**, produced by **glands** in multicellular organisms.
- These are transported by the circulatory system to target distant organs to regulate physiology and behavior.
- Hormones are our body's chemical messengers.
- They work slowly, over time, and affect many different processes, including Growth and development.

Cellulose

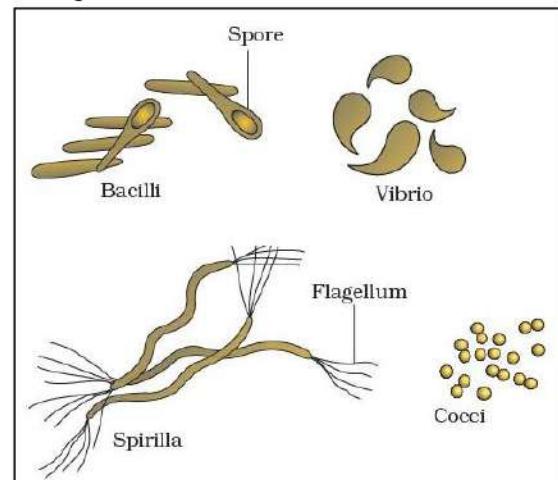
- It is a molecule, consisting of carbon, hydrogen and oxygen atoms.
- It is the main substance in the walls of plant cells.
- It helps plants to remain stiff and upright.
- Humans cannot digest cellulose, but it is important in the diet as fibre.

7. Five Kingdom Classification

- Given by R.H. Whittaker (1969)
- Main criteria: cell structure, body organisation, mode of nutrition, reproduction and phylogenetic relationships.
- Viruses did **not find a place in classification** since they are **not considered truly 'living'**.
- Living organisms are those who have a **cell**.

a) Kingdom Monera (Bacteria)

- **Bacteria** are its sole members.
- They are the most abundant micro-organisms. Bacteria occur almost everywhere.
- Eg. soil bacteria



- Can live in **extreme habitats** such as hot springs, deserts, snow and deep oceans.

- Many of them live in or on other organisms as parasites.
- Some of them are autotrophic. They may be photosynthetic autotrophic or chemosynthetic autotrophic.
- Majority of them are heterotrophs.

b) Kingdom Protista

- All single-celled eukaryotes are placed under Protista, but the boundaries of this kingdom are not well defined.
- What may be 'a photosynthetic protistan' to one biologist may be 'a plant' to another.
- Eg. Chrysophytes, Dinoflagellates, Euglenoids, Slime moulds and Protozoans.
- Members of Protista are primarily aquatic.
- This kingdom forms a link with the others dealing with plants, animals and fungi.

Reproduction: asexually and sexually by a process involving cell fusion and zygote formation.

c) Kingdom Fungi

- The fungi constitute a unique kingdom of heterotrophic organisms.
- Fungi are cosmopolitan and occur in air, water, soil and on animals and plants.
- Prefer to grow in warm and humid places.
- Great diversity in morphology. Eg. fungi on a moist bread; common mushroom (toadstools)
- Reproduction: by vegetative means – fragmentation, fission and budding.
 - Asexual reproduction and Sexual reproduction both.
- Except for yeasts which are unicellular, fungi are filamentous.
 - Their bodies consist of long, thread-like structures called hyphae.
 - Filamentous: means thin in diameter; resembling a thread.

Types

- Most fungi are heterotrophic. They absorb soluble organic matter from dead substrates, and hence are called saprophytes.
- Parasites: Those depend on plants & animals.
- Can also live as symbionts
 - In association with algae as lichens
 - With roots of higher plants as mycorrhiza.

Importance

- Some unicellular fungi are used to make bread and beer. e.g. yeast.
- Some fungi cause diseases in plants and animals. Eg. wheat rust-causing Puccinia.
- Some are the source of antibiotics. e.g. Penicillium. (Multicellular)
- We keep food in the refrigerator to prevent it from bacterial or fungal infections.

d) Kingdom Plantae

It includes all eukaryotic chlorophyll-containing organisms. Commonly, these are called plants.

- A few members are partially heterotrophic. eg.
 - Insectivorous plants: Bladderwort and Venus fly trap.

- Parasite: Cuscuta
- Eg. algae, bryophytes, pteridophytes, gymnosperms and angiosperms.
- The plant cells have an eukaryotic structure, with prominent chloroplasts and cell wall mainly made of cellulose.

e) Kingdom Animalia

This kingdom is characterised by heterotrophic eukaryotic organisms, that are multicellular and their cells lack cell walls.

- Directly / indirectly depend on plants for food.
- They digest their food in an internal cavity.
- They store food reserves as glycogen or fat.
- Their mode of nutrition is holozoic – by ingestion of food.
- They follow a definite growth pattern.
- Higher forms show elaborate sensory and neuromotor mechanism.
- Most of them are capable of locomotion.
- **Reproduction:** The sexual reproduction is by copulation of male and female, followed by embryological development.

7.1 Viruses, Viroids, Prions and Lichens

In the five kingdom classification of Whittaker there is no mention of lichens; and some acellular organisms like viruses, viroids and prions.

Virus

- A virus is a submicroscopic infectious agent that replicates only inside the living cells.
- Viruses occupy the twilight zone that separates the 'living' from the 'non-living'.
- They do not have a cellular organization.
- They contain only one type of nucleic acid, either DNA or RNA but never both.

Viroids

- It is an infectious agent, smaller than viruses, hence named as viroid.
- It is a free RNA. Its RNA is of low molecular weight.
- It lacks the protein coat found in viruses.
- It caused potato spindle tuber disease.

Prions

- It is an agent consisting of abnormally folded protein, transmitting infectious neurological diseases.
- This agent is similar in size to viruses.
- Disease examples:
 - Bovine Spongiform Encephalopathy (BSE) or mad cow disease
 - Its analogous variant Cr–Jacob disease (CJD) in humans.

Lichens

- Lichens are symbiotic associations between algae and fungi.
- The algal component is autotrophic, and is known as phycobiont. Algae prepare food for fungi.
- The fungal component is heterotrophic and is known as mycobiont. Fungi provide shelter and absorb mineral nutrients and water for its partner.
- Lichens are very good pollution indicators. They do not grow in polluted areas.

8. Biotechnology

Biotechnology is any technological application that uses biological systems, living organisms, or derivatives thereof, to make products or processes". (UN Convention on Biological Diversity)

It is a **multidisciplinary** science.

Globally, biotechnology industry is expected to witness the fastest growth. The important contributing factors are

- a) Wide range of applications, specially medical and pharmaceutical products.
- b) Protection of the intellectual property rights worldwide, including legislation and enforcement.

Applications of Biotechnology

1. Green biotechnology or Agriculture biotechnology

- **High Yielding Variety (HYV) seeds:** These are created by genetic modification or selective breeding of plants. HYV seeds have contributed radically to improve the global food security.
- **GM crops** like BT brinjal, GM Mustard.
- **Bio-fortification** to enhance the nutritional value: E.g. "Chhattisgarh Zinc Rice-1".
- **Pest control:** by changing the genetic make-up of the pest **by mutations**.
- **Manufacturing and bio-processing:** using plants for manufacturing detergents, paints, lubricants and plastics etc.
- **Bio-fertilisers:** converts atm. N₂ into a form absorbable by crops easily. E.g. **Blue-green algae (Cyanobacteria)** is a bio-fertiliser for rice.

2. Animal Biotechnology

- It works to improve the **productivity of livestock**, to develop affordable new generation vaccines and to **diagnose** a plethora of animal diseases.
- **Embryo Transfer Technology** is one such technology which has been developed in India.
- These varieties **adapt** easily to new environment and are **disease resist**. They follow **Darwin's theory** of 'survival of the fittest'.

3. Blue biotechnology or Marine Biotechnology

- It works to develop diagnostics and vaccines, new feed, fish nutrition, breeding and reproduction etc.
- In aquaculture, aquatic organisms are grown in culture and used for food, fuel, cosmetics, pharmaceuticals etc.
- Department of Biotechnology runs **Aquaculture & Marine Biotechnology program** to support R&D.

4. Red biotechnology or Medical Biotechnology

- **Antibiotics:** Antibiotic is a substance produced by a microorganism such as **bacteria or fungi** which inhibits the growth of another microorganism. In 1928, Alexander Fleming discovered it.
- Examples:** **Fungus Penicillium notatum** is used to produce penicillin to treat bacterial infections. **Penicillin** is a **narrow spectrum antibiotic**, which is used against few bacteria. Broad spectrum antibiotics can be used against more than one kind of bacterium.
- **Vaccines:** can be made from **attenuated disease causing bacteria** (first generation vaccines) or by **genetic engineering or recombinant DNA technology** (second generation vaccines) or synthesised from **chemicals** (third generation vaccines).
- **Important target areas:** infectious and chronic diseases, vaccines and diagnostics, human genetics and genome

analysis, stem cell research and regenerative medicines etc.

- **Pharmacogenomics** helps to analyse the effect of genetic mark-up on individual's response to drugs.
- **Gene therapy** involves correction of genetic disorders. It delivers a normal gene into the individual or embryo to compensate for the non-functional gene.

5. White biotechnology or industrial biotechnology

- Mass production of biodegradable plastics, vegetable oil, biofuels cheese, yoghurt, and alcohol etc.
- **Fermentation:** It is a process by which carbohydrates such as sugar are converted into alcohol **using yeast**. Wine is obtained by fermentation of grapes. The left over yeast is a good animal feed and a rich source of vitamins.
- **Important microorganisms (Microbes):** yeasts (fungi), moulds (fungi), bacteria, filamentous bacteria (actinomycetes)

6. Environment

- **Bioremediation:** It is a waste management technique, in which microorganisms (bacteria, fungi and enzymes etc.) are used to consume and break down pollutants.
- E.g. **Oil Zappers bacteria** to control **oil spills** on sea. **Pseudomonas** is the oil eating bacteria.

7. Bioenergy

- **Biogas:** from cow dung and organic waste.
- **Bioethanol:** from Maize
- **Biodiesel:** from Jatropha, Pongamia, Sunflowers. (**Lipid content rich**), grown in arid regions.
- **Microbial fuel cell or biological fuel cell** drives electric current by using bacteria.
- **BIO-FUELS: G1, G2, G3, G4** (class notes)

8. Bioinformatics or gold biotechnology

- It is an interdisciplinary field that addresses biological problems using computational techniques and data management.
- **Transcriptome:** Set of all messenger RNA (mRNA) in one cell.

Major Developments in the Field of Biotechnology

Stem Cell Therapy, DNA Technology, Assisted Reproduction Technology, Three Parents Baby, Gene Therapy, GM Crops etc.

Biotechnology Sector in India

- **Department of Biotechnology (DBT)**, Ministry of Science and Technology is the nodal agency. It aims to promote large scale use of Biotechnology, support R&D and manufacturing in Biology etc.
- Biotechnology is one of the **sunrise sectors** in India, with a Compound Annual Growth Rate (**CAGR**) of **20%**.
- India holds **2% global share of Biotech Industry**. Indian is among the 12 top biotech destinations in the world, and 2nd in Asia after China.
- The government has set-up a target of USD 100 Billion by 2025.
- Biotech Sector in India is **highly dominated by Pharmaceutical Sector** with 60% share.

Key drivers of the growth:

- **National IPR Policy** to speed up IPR filings.
- **National Biotechnology Development Strategy 2015-2020:** It aims to establish India as a world-class bio-manufacturing hub.

- Inclusion in higher education and research:** at national level universities, IITs, and IISERs etc.
- Establishment of biotech parks through PPPs.**
- FDI policy:** 100% FDI in medical devices, up to 100% FDI for Brownfield/Green Projects.
- Biotechnology is one of the 25 sectors under the 'Make in India' programme.
- Cost-effective manufacturing.
- Support for biotech startups:** Establishment of BIRAC, new Bio-clusters, technology transfer offices, Biotech Equity Fund (BIRAC AcE Fund) etc. BIRAC empowers biotech startups and SMEs through funding, mentoring, and infrastructure support.

DNA Technology (Use and Application) Regulation Bill, 2019

- DNA data banks, Laboratories and Regulatory Board** will be set up.
- It will help to maintain national database for victim identification, suspects in cases, undertrials, missing persons and unidentified human remains.
- DNA data will only be used for identification of the person and not for "any other purpose".
- Leaking of DNA profile** will be punishable with 3 years of prison with fine.
- News Context:** Opposition indicated towards the misuse of this bill. As:
 - The concern over privacy violations.
- Deoxyribonucleic Acid (DNA) & Ribonucleic Acid (RNA):**
 - They are 2 main types of nucleic acids responsible for storage and reading of genetic information.

mRNA Vaccine

- News Context:** India's 1st indigenous mRNA vaccine got nod for human trial.
- Unlike a normal vaccine, RNA vaccines work by introducing an mRNA sequence.
 - Which is coded for a disease specific antigen.
- Once produced within body, the antigen is recognised by immune system, preparing it to fight real thing.
- mRNA vaccines teach our cells how to make a protein that triggers an immune response inside our bodies.
- That immune response, which produces antibodies, is what protects us from getting infected.
- mRNA vaccines can be delivered using a number of methods:**
 - Needle-syringe injections or needle-free into skin.
 - Injection into blood, muscle, lymph node or directly into organs.
 - Via a nasal spray.
- There are different types of mRNA vaccine like:**
 - Non-replicating mRNA, in vivo self-replicating mRNA.
 - In vitro dendritic cell non-replicating mRNA vaccine etc.

Conventional Vaccines (traditional Vaccines)

- It requires refrigeration.**
- It Includes:**
 - Live attenuated vaccines, inactivated pathogens (Killed Vaccines).

- Viral-vectorized vaccines, Subunit, Toxoid, Conjugate vaccines.

- It exposes body to proteins made by a virus or bacteria.**
- They are often made by using weakened or inactive versions of that virus or bacteria.

Gene based Vaccines

- They contain 2 types of Vaccine:** DNA and RNA vaccines.
- Instead of injecting a weakened form of a virus or bacteria into body:**
 - DNA and RNA vaccines** use part of virus' own genes to stimulate an immune response.
- In other words, **they carry genetic instructions for host's cells** to make antigens.
- Both DNA and RNA vaccines deliver message to cell** to create desired protein.
 - So, immune system creates a response against this protein.
- They can be stored at room temperature.
- They are more stable than conventional vaccines in warm climates. (If kept dry and/or sterile at pH8).

9. Gene Therapy

Gene therapy is designed to introduce genetic material into cells to compensate for abnormal genes or to make a beneficial protein.

Genome editing

- or gene editing technologies allow genetic material to be added, removed, or altered at targeted locations in the genome.
- However, this technique is still in its infancy stage. The technique remains risky and is still largely unregulated.

Mechanism

- A gene is inserted through a genetically engineered carrier known as **vector, retro virus**.
- The retro-virus can be programmed to carry a gene or a DNA that will overwrite the mutation.

Some important gene therapies

1. Somatic cell gene therapy

- The somatic cell therapy is relatively safer as it is **not passed on to the future generations**.
- However, the somatic cell gene therapy is **short-lived**. Most tissues cells ultimately die and replaced by new ones.
- Therefore, **repeated treatments are required** to maintain the therapeutic effect.

2. Germ line cells gene therapy

- Germline editing** is a genome editing technology. This requires the insertion of the gene into the reproductive tissue of the patient.
- It results in **permanent changes** that are passed to subsequent generations. It edits the DNA of egg and sperm or the embryo itself. Hence, it offers **hereditarily permanent therapeutic effect**.
- However, a malfunctioning during treatment can lead to undesirable changes in the whole human gene pool.

3. CRISPR-Cas9

- Clustered Regularly Interspaced Short Palindromic Repeats and CRISPR-associated protein 9 (**CRISPR-Cas9**) is a **genome editing technology**.

- It was adapted from a naturally occurring genome editing system in bacteria.
- It is faster, cheaper, more accurate, and more efficient than other existing genome editing methods.

4. Yescarta therapy

- **Yescarta (axicabtagene ciloleucel) therapy** is a treatment for large B-cell lymphoma (blood cancer), that has failed conventional treatment such as chemotherapy.
- It is a CD19-directed genetically modified chimeric antigen receptor T-Cell (**CAR-Ts**) therapy.
- It turns body cells into a “**living drug**” that targets and kills cancer cells.
- U.S. Food and Drug Administration (**USFDA**) recently approved it as **Orphan Drug**. Hence, financial incentives are given to encourage manufacturers.

Living Drug: Genetically modified cells that are infused into body, continue multiplying to fight disease for months and years. Hence, these immunotherapy treatments are called **living drugs**. E.g. in **CAR-Ts therapy**.

Orphan Drug: It is intended to treat rare diseases only. Hence, sponsors are reluctant to develop them under usual marketing conditions.

Application of Gene Therapy

- **Enhancement genetic engineering:** insertion of a gene to 'enhance' a known characteristic.
- **Eugenetic genetic engineering:** insertion of a gene to alter or 'improve' complex human traits; for example, intelligence.
- **Health:** to treat diseases such as cancer, AIDS, sickle cell anaemia, haemophilia B, large B-cell lymphoma etc.

Issues with Gene Therapy

1. Immune response: The main function of the immune system is to attack and expel the invaders. It may expel the inserted gene.

2. Insertional mutagenesis: The faulty targeting of DNA in the genome may become counterproductive. For example, if the DNA is integrated in a tumour suppressor gene, it could induce a tumour.

3. Ethical concerns: Human acting Gods. The gene therapy may turn mankind into commodity.

Also, some questions raise ethical debates. Like, deciding what is normal and what is a disability? And, whether the disability is a disease?

4. Equal Access to treatment: The gene therapy has high cost and has limited application. E.g. the cost of yescarta therapy is 4Lakh USD.

5. Low incentive to pharmaceutical industry: Presently, it treats only the rarest of rare diseases. These orphan drugs are of little interest of profit generating MNCs.

6. Regulating Body: There is no regulating body for standardization and harmonization.

7. Uncontrolled clinical trials: There are no standard norms for clinical trials.

8. Transfer of diseases: The technology should be restricted to the diseases for which there is no effective diagnosis available.

Human Genome Project (HGP)

HGP aims to map the genes and the DNA sequence of human. It was the largest international collaborative biological project.

HGP-read & HGP-write

- The **HGP-read** aimed to read and decipher the human genome using chemicals and instruments.
- **HGP-write** aims to write complete set of human genes with sophisticated bioengineering tools.

Potential Benefits for Healthcare

- **Communicable disease:** Technologies, vaccine and drugs etc. developed through HGP-write will be universally applicable to all organisms. These will counter malaria, dengue and chikungunya etc.
- **Non-Communicable diseases:** HGP will help us fight the non-communicable diseases like cancer by constructing specific chromosomes.
- **Organ growth and transplant:** HGP-write has the potential to grow human organs and thus solve the **ethical issue** of human donors.
- **Stem cells:** it will revolutionize the use of stem cells by using **induced pluripotent stem cells (iPSCs)** to create an ‘Ultra safe’ human cell line.

Evaluation

Along with identifying all of the approximately 20,000–25,000 genes in the human genome, the project also created ethical and legal and IPR concerns.

One of the main concerns was related to issues in **hiring of employees and health insurance** because of a health concern indicated by someone's genes.

Earth Genome Project (EGP)

- It aims to sequence, catalogue, and characterize the genomes of **every eukaryotic biodiversity** on Earth over a period of 10 years.
- The EGP project will help to create a detailed genetic sequence and reveal evolutionary connections that will make up the Digital Library of life.
- **World Economic Forum** is also collaborating with EGP through its Fourth Industrial Revolution.

Genome Sequencing

- A genome is an organism's complete set of DNA.
- It includes all chromosomes, which houses the DNA, and genes.
- Each genome contains all information needed to build and maintain that organism.
- Genome can be understood through process described as sequencing.
- Genome sequencing means deciphering exact order of base pairs in an individual.

IndiGen Programme

- It is to **undertake whole genome sequencing of Indian individuals** representing diverse ethnic groups from India.
- **Funded by: CSIR India** (R&D organization under Science and Technology Ministry).
- It creates a **pilot dataset to enable genetic epidemiology of carrier genetic diseases** towards enabling affordable carrier screening approaches.

Significance of Project:

- **Understanding Epidemiology** of genetic diseases to enable cost effective genetic tests.
- **Carrier screening:** Determining chances of having a child with genetic disorders.
- **Pharmacogenetic** (study of how genes affect a person's response to drugs) tests to prevent adverse drug reactions.

- Understanding genetic diversity on a population scale.

Human Genome Project (HGP), 1990-03

- It was international research effort to determine DNA sequence of entire human genome.
- It gave us ability to read nature's complete genetic blueprint for building a human being.
- It was coordinated by:
 - National Institutes of Health, USA.
 - Department of Energy, USA.

Biopesticides

- They are **formulated form of active ingredients based on microorganisms** such as:
 - Bacteria, Viruses, Fungi, Nematodes or Naturally occurring substances.
 - Including plant extracts and semi chemicals (e.g. insect pheromones).
- Advantages of using Biopesticides:**
 - Less toxic than conventional pesticides.
 - Affect only target pest and closely related organisms (not overall ecosystem).
 - Effective in small quantities and decompose quickly etc.

National Biomedical Resource Indigenization Consortium (NBRIC)

- It is hosted and led by Centre for Cellular and Molecular Platforms.
- It aims to be a nation-wide Public Private Partnership for convergence of:
 - Research, Product resources and services towards developing reagents.
 - Diagnostics, Vaccines, Therapeutics for COVID-19 across India.
- It is a 'Make in India' initiative for Biomedical research and innovative products, to promote import substitution and exports.
- News Context: It was constituted by Department of Biotechnology, Science and Technology Ministry.

BBX11

- It is a newly identified gene that facilitates in greening of plants by regulating levels of protochlorophyllide.
- Protochlorophyllide is an intermediate in the biosynthesis of chlorophyll.
- Synthesis of chlorophyll in plants is a lengthy, multi-step process.
 - It is required for growth of plants.
- To facilitate quick synthesis of chlorophyll, plants make a precursor of chlorophyll called 'protochlorophyllide' in dark.

10. GM CROPS

Genetically modified crops are cultivated from genetically engineered seeds to increase yields or tolerance to pests.

Examples

- GM Mustard:** DU. created by inserting a soil bacterium for self-pollinating.
- BT brinjal/GM brinjal:** created by inserting a crystal protein gene (Cry1Ac) from the soil bacterium Bacillus thuringiensis (BT gene) into the genome of a brinjal. To make it pest-resistant.

- Bt Maize/ GM Maize/ Mon 863:** created by inserting a crystal protein gene (Cry3Bb1) from the soil bacterium Bacillus thuringiensis into the genome of a maize. To make it pest-resistant.
- Bt cotton:** pest resistant.
- GM rice/Golden rice:** to produce a fortified food for Vitamin A.

Issues

Safety issues:

- There is a scientific consensus that GM foods have no greater risk than conventional food. However, each GM food needs to be tested on a case-by-case basis.
- There are ongoing public concerns and movements by NGOs related to food safety, labelling, regulation, environmental impact etc.

IPR vs. ethical issues:

- Seeds are sometimes terminator seeds. Some Plant Variety rights (PBRs) are owned by large MNCs, which are driven by sole profit motive.
- Recently, PepsiCo India filed a lawsuit against potato farmers in Gujarat for allegedly growing a variety protected under the Plant Variety Protection rights.
- There are contrasting ideological differences about Plants as Intellectual Property.

Legal issues:

- These vary worldwide, ranging from banning, to different degrees of regulation etc.
- The first GM labelling requirements for food products were introduced by the European Union (EU) in 1997.
- There are no regulations in India till now. In India, a Supreme Court moratorium has been in place for cultivation of GM food crops.

GM food imports in India require approvals under

- Environment Protection Act, 1986:** It covers environmental impacts of the food products.
- Food Safety and Standards Act, 2006:** It assesses the food's impact on human health.

Major initiatives undertaken by FSSAI

- Food Safety on Wheels** (mobile food lab units).
- Centralised lab management system called **InfolNet (Indian Food Laboratory Network)**.
- Food safety index** launched by FSSAI

India needs a regulatory mechanism for GM foods.

Notes

1. Food Safety and Standards Authority of India

- FSSAI was established under FSS Act, 2006 under **Ministry of Health & Family Welfare**.
- It lays down scientific food standards, regulates manufacture, distribution, sale and import etc.
- To ensure availability of safe and wholesome food for human consumption.

2. Genetic Engineering Appraisal Committee

- GEAC works under the aegis of MoEFCC.
- It is responsible for appraisal of proposals relating to release of genetically engineered (GE) products into the environment including **experimental field trials**.
- It is responsible for appraisal of activities involving use of **hazardous microorganisms and recombinants** in research and industrial production from the environmental angle.

5. NANOTECHNOLOGY

- Nanotechnology deals in the physical size range of 1-100 nanometres (nm).
- It studies physical phenomena, develops new devices and material structures at nano scale.
- At this scale the materials follow the **laws of quantum physics**. The general **properties behave in a different manner**. These include physical, chemical, electrical, biological and optical properties.

Applications of Nanotechnology

Nanotechnology is a **multidisciplinary science**. Hence, its broad-spectrum deals with agriculture, energy, electronics, medicines, healthcare, textile etc.

1. Medical field

- Disease Diagnosis:** Nano medicine and Nano scale diagnostic devices are more efficient. These can detect cancer, bacterial and viral infection.
- Drug Delivery:** The targeted drug delivery helps in lowering overall drug consumption and side effects.
- Nanorobots:** **Nanorobotics** is a technique of creating machine at microscopic scale. These Nano size robots can **navigate the human body, transport molecules, and communicate with physician** by miniature sensors.
- Superbugs & anti-microbial resistance:** Nanotechnology could effectively control antibiotic-resistant bacteria.
- Cancer Diagnosis and Treatment:** Gold Nano-cells locate and eliminate cancer cell. Nano cells targets cancer cell by **tagging antibodies to the cell surface**.
- Tissue Engineering:** Nanotechnology can repair damaged tissue by using biodegradable polymers. **Polycaprolactone** is such a polymer. It is coated with collagen to promote the wound healing.

2. Energy

- Photovoltaic cells and organic light-emitting devices based on quantum dots.
- Carbon nanotubes for solar cells.**
- Carbon nanotubes for novel hydrogen storage systems.**
- Nanocatalysts for hydrogen generation.**

3. Defence

- Precision guiding tools for snipers.
- To **detect sensors devices**.
- Possible supplement to traditional weaponry for **close combat situations**.

4. Agriculture

- Antimicrobial nanoemulsion** is used in the food processing industry. It can be used for **decontamination, packaging etc.**
 - An emulsion is a mixture of two or more liquids that are normally immiscible.
- Nano biosensors** are used to detect **antigen and pathogen contamination**. Nano biosensors are also used for **remote sensing devices required for precision farming**.
- Anti-bacterial products** such as **nano silver** are used as **preservatives**.
- Nano Bio-indicators** can detect the bio magnification of pesticides and fertilizers. Hence, the soil health can be maintained.

- Bio-conjugated nanoparticles** (encapsulation) are used for slow release of nutrients and water. Hence, agricultural efficiency and productivity could be enhanced.
- Nanogels** are used for pests control. Hassle-free gel-based carriers are used.

5. Water treatment

- Nanomembranes** for water purification, desalination etc.
- Nanosensors** for the detection of contaminants.
- Nanoporous zeolites, nanoporous polymers, and attapulgite clays** for water purification
- Magnetic nanoparticles** for water treatment and remediation.

6. Construction

- Nanomolecular structures** for more robust concrete.
- Heat-resistant nanomaterials** to block UV and IR.
- Self-cleaning surfaces** (e.g., windows, mirrors, toilets) with **bioactive coatings**.

Nanotechnology in India

- The **9th Five-Year Plan** mentioned for setting up national facilities and core groups to promote research in frontier areas of S&T.
- These included **superconductivity, robotics, neurosciences and carbon and nano materials**.
- In **2007 Nano Mission** was launched by the DST.
 - To foster, promote and develop all aspects of nanoscience and nanotechnology, which have the potential to benefit the country.
- India ranks third in the number of researches in the field of nanotechnology after China and USA.
- The global nanotechnology industry would require about two million professionals from 2015 onwards (ASSOCHAM and TechSci Research study).
- India is expected to contribute about **25% professionals**.

Challenges

- Health and environmental issues:** Potential risk due to the size of the nano particles.
- Ethical issues:** Nanotechnology may be used in warfare, to invade people's privacy etc.
- Effect on developing countries:** It would further marginalise the global demand for their products.
- Human Resource issues:** A developing country such as India may struggle to find quality human resource; especially in such an emerging field which requires cutting edge research.
- Governance issues:** As nanotechnology is multidisciplinary and interdisciplinary science. Hence, coordination is a major challenge.

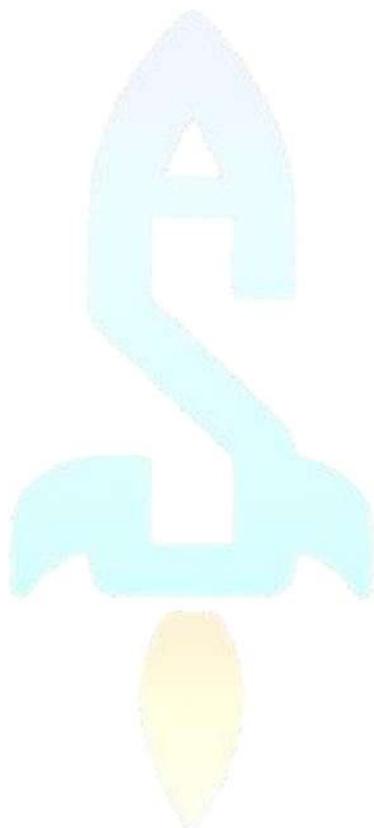
Gold Nanoparticles (GNPs)

- They are **biocompatible, have high surface area, more stability, non-toxic**.
- They are melted at much lower temperatures (300 °C) than bulk gold (1064 °C).
- News Context:** National Centre for Polar and Ocean Research and Goa University has successfully synthesized GNPs using psychrotolerant Antarctic bacteria.
- Advantages of GNPs:**
 - Greater solar radiation **absorbing ability**.
 - Unique **optical properties**.

- Useful in electronics industry.

Nanomicelles

- They are **globe-like structures** with a **hydrophilic outer shell** and a **hydrophobic interior**.
- This **dual property makes them perfect carrier** for **delivering drug molecules**.
- **Advantage:** Low toxicity, ability to minimize drug degradation.
 - Ability to permeate tissues easily for drug delivery, Lower adverse drug side effects.
- **News Context:** It is found that Nanomicelles can be used for **Cancer treatment**.



6. CYBER SECURITY

Definitions

- **Cyberspace**
 - A **global domain** within the information environment consisting of the **interdependent network of information technology infrastructures**, including the Internet, telecommunications networks, computer systems, and embedded processors and controllers.
 - Cyberspace is the **connected Internet Ecosystem**.
- **Cyber security: Securing the cyberspace** from attack, damage, misuse and economic espionage.
- **Cyber Attack**
 - It is a **malicious and deliberate** attempt by an individual or organization to breach the information system of another individual or organization.
 - There are **majorly 8 types** of cyber attacks namely, malware, phishing, ransomware, denial of service, man in the middle, cryptojacking, SQL injection and zero-day exploits.

Need for Cyber Security

- ‘**Digital India**’ is high on Government’s priority.
- India ranks **3rd** in terms of the highest number of **internet users** in the world after USA and China.
- India was ranked among the **top five countries** to be affected by cybercrime.
- Information Technology (IT) has **become a part of life** today with applications like **e-learning, smart cities, e-records, online transactions etc.**
- Cyber Intrusions and Attacks have **increased dramatically over the last decade**, exposing sensitive information about,
 - **Individuals:** Photos, videos and other personal information. Leading to **Cyber Bullying**.
 - **Business:** Competitive information (such as patents or original work); Employees'/customers' private data.
 - **Government:** Critical infrastructure and confidential data.
- **Huge economic cost** (around \$4.5 billion) of these attacks.

Cyber attackers and their motives

- **Cyber Criminals:** Seeking commercial benefits through hacking banks software, **phishing and ransomware**.
- **Cyber Terrorists:** Attacking **critical infrastructure** like nuclear facilities, power grids etc with a purpose of taking political advantage. Using internet to brainwash and recruit terrorists.
- **Cyber Espionage:** IT malware (e.g. Virus, Trojan, Worm, etc) is used to obtain **corporate, military or/and intelligence data**.
- **Cyber Hacktivists:** Hacking of sites and servers to propagate some message or campaign.

Recent cyber attacks

- Attack on administrative block **Kudankulam nuclear power plant** (India’s largest nuclear power plant) in October, 2019. It was a **Malware attack**.
- **WannaCry, SapoShhi and Petya:** Ransomwares which used Denial of Service method to extort money to return the valuable data.

- **Cosmos Bank cyber attack:** In Pune, hackers’ gang siphoned off around Rs 95 crore.
- **Sim swap scam.**
- **Hack attack on Indian healthcare websites** in 2019.
- Attempt to hack **Aadhar data** in 2018.
- **STUXNET malware** used by the USA and Israel to cripple Iran’s nuclear programme.

Challenges

- Cyberspace has **inherent vulnerabilities** that cannot be removed.
- **Data Colonisation:** All **major tech companies** take out data of Indian users and store it in **servers abroad** which makes it difficult for our law enforcement agencies to stop its **misuse** in the form **influencing national politics, radicalization, etc.**
- **Attack technology** is usually a step **ahead of defence technology**.
- **Lack of awareness (digital illiteracy) and adaptability** towards new technologies for Cyber security.
- **Lack of Cyber security infrastructure and specialists.**
- **Cyber warfare:** Increased use of cyberspace by **State and Non-State actors** (like terrorists) to fulfil geopolitical, geo-economics and ideological objectives.
- **Cyber devices:** Substandard, import dependence and lack of uniform safety standards. **Saposhi malware** is a result of substandard devices only.
- **Anonymity of criminal:** Generally, criminals operate from some **far flung and inaccessible area** to dodge security agencies, e.g. around **80% of cyber crimes in India** are committed from **Jamtara (Jharkhand)**.
- **Underreporting of cyber crimes:** Only **10%** reporting due to fear of loss of reputation.

Institutional Actions by Governments

- **CyberDome Project**
 - Initiative of Kerala Police.
 - It is a public private partnership initiative which pools the resources of various stakeholders to augment the capacity to address the ever growing challenges to cyber security.
- **Cyber Surakshit Bharat Initiative:** It was launched in 2018 with an aim to spread **awareness** about cybercrime and **building capacity** for safety measures across all government departments.
- **National Cyber security Coordination Centre (NCCC):** In 2017, the NCCC was developed. Its mandate is to **scan internet traffic** and to detect cyber threats in **real-time**.
- **Cyber Swachhta Kendra**
 - In 2017, this platform was introduced for **internet users to clean their computers and devices** by wiping out viruses and malware.
 - It was launched by **CERT-fin** (Financial Sector arm of CERT-in).
- Improving the **public key infrastructure (PKI):** It is a technology for authenticating users and devices in the digital world.
- **National Critical Information Infrastructure Protection Centre (NCIIPC)**
 - To battle cyber security threats in **strategic areas** like nuclear installations, defence, etc.

- It is under direct control of National Security Advisor (NSA) in PMO.
- **Cyber and Information Security (CIS) Division:** To tackle cyber threats, child pornography and online stalking.

Legislative Actions by governments

Information Technology Act, 2000

- It regulates use of
 - Computers, computer systems, computer networks
 - Electronic data and information
- Following mentioned are declared as offences under this Act:
 - **Tampering** with computer source documents
 - **Hacking** with computer system
 - **Act of cyber terrorism**
 - **Cheating** using cyberspace

National Cyber Security Policy 2013

It has following **4 broad objectives** through which it ultimately aims to make cyberspace safe:-

1. **Infrastructure protection:** By creating National Critical Information Infrastructure Protection Centre (NCIIPC).
2. **Enhance capability of people**
 - Human Resource Development through **education and training** programs to build capacity.
 - Create a **trained cyber workforce** of 500,000.
3. **Reduce vulnerabilities**
 - Promoting **research and development** to build **indigenous** cyber security technology.
 - **Incentivizing businesses** for adopting safe practices.
4. **Damage response:** Indian Computer Emergency Response Team (CERT-in) functions as the nodal agency for coordination of all cyber security efforts, **emergency responses, and crisis management.**

International efforts

Budapest Convention on Cybercrime

- It seeks to tackle **cybercrimes** (like infringements of copyright, computer-related fraud, child pornography, etc) by **harmonizing national laws**, improving **investigative techniques**, and increasing **cooperation** among nations.
- It came into force on 1 July 2004.
- **India is not a signatory to this convention** because it is
 - Drafted by developed nations without consulting other countries
 - Threat to individual rights and sovereignty of nations
 - Complex, lengthy and inefficient.

International Telecommunication Union (ITU)

- Specialised agency within the **United Nations** which plays a leading role in the **standardization and development of telecommunications** and cyber security issues.

Global Centre for Cyber security

- Launched by the **World Economic Forum (WEF)**

- To serve as **laboratory and early-warning think tank** for future cyber security scenarios.

Global Conference on Cyber Space (GCCS)

- Global event where World leaders, policymakers, industry experts, think tanks, cyber wizards etc **gather to deliberate** on issues and challenges for optimal use of cyberspace.
- In last conference (in 2017), the **theme** was – “**Cyber4All: A secure and Inclusive Cyberspace for Sustainable Development.**”

Way Forward

- **Ensure coordination** at
 - International, national, state levels and so on
 - Along various sectors (e.g. PPP coordination for cyber security)
- **Real-time intelligence** gathering and sharing.
- Periodical ‘**Backup of Data**’ can help tackle ransomwares.
- **Updation of Cyber Security Policy** to keep pace with fast changing nature of cyber attacks and ensure **stringent cyber security standards.**
- **Use of Artificial Intelligence (AI):** For predicting and precisely identifying cyber attacks.
- More states should make initiatives like **CyberDome or State level CERT.**
- **Cyber deterrence:** A fine balance of offensive and defensive should be ensured by India to ensure appropriate deterrence.
- **Capacity building, awareness and digital literacy.**
- **Establishing cyber insurance framework:** Presently it is in its nascent stage.
- **Dedicated fund** for cyber security.
- **Increased global cooperation**
 - Russia has called for more inclusive version of Budapest Convention to which developing and under developed Nations should be made part of.
 - India too should have proactive participation and accommodative stance to reach to a uniform and guiding Law for global cyberspace governance.

Conclusion

Stephane Nappo (Cyber security expert) said, “**Cyber Security is much more than a matter of IT.**” Therefore, a holistic and all encompassing approach is needed to keep cyberspaces safe as the situations like pandemic are giving us cues that the future will be online.

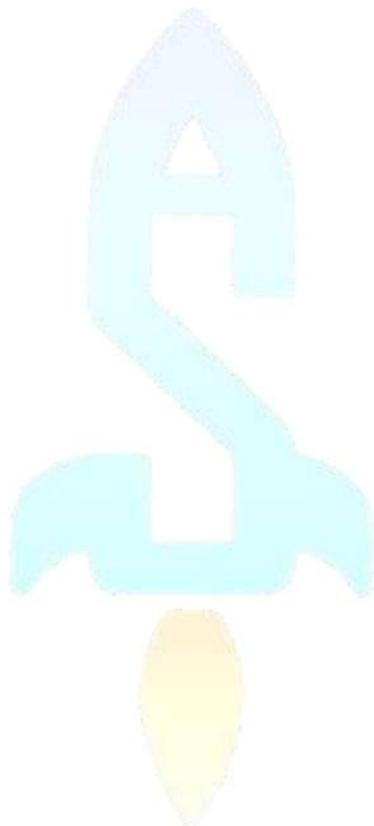
NIC-CERT (body National Information Centre-Computer Emergency Response Team)

- **News Context:** Government inaugurated it to prevent and predict cyber-attacks on government utilities.
- It is a **dedicated body to detect, prevent, mitigate impact of cyberattacks.**
- It is done by **monitoring data across the NIC platform.**
- It includes **communication between Government and citizens.**

Cyber-Security Index

- It is released by **International Telecommunication Union (ITU).**
- Outcomes:

- only about **half of all countries** have **cybersecurity strategy** o are in process.
- **Top 3 most committed countries to cybersecurity:** Singapore, USA, Malaysia.
- **Note: India** is listed in '**Maturing**' category.
 - **International Telecommunication Union (ITU) HQ:** Geneva, Switzerland.



7. INTELLECTUAL PROPERTY RIGHTS

Intellectual property (IP) refers to creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commerce. - WIPO

WIPO administers these two conventions:

- **Paris Convention** for the protection of Industrial Property (1883) and
- **Berne Convention** for the Protection of Literary and Artistic Works (1886)

IPRs are outlined in Article 27 of Universal Declaration of Human Rights.

7.1 Organisations related to IPR

World Intellectual Property Organisation (WIPO)

India is a member.

Cell for IPR Promotion and Management (CIPAM)

- It works under the aegis of **DPIIT (erstwhile DIPP)** to ensure effective implementation of the National IPR Policy.
- Department for Promotion of Industry and Internal Trade
- It has launched **SIPRA**: "Scheme for IPR Awareness".
- **Aiming geographical and demographical inclusion**: Simplifying and streamlining of IP processes, furthering IPR awareness, commercialization and enforcement, coordinating with stakeholders etc.

International Intellectual Property Index (IPI).

- Global Innovation Policy Centre (GIPC) of US Chambers of Commerce.
- India has been ranked 44 out of 50 countries up from 43 out of 45 in 5th edition.
- India has achieved highest improvement. 25% (8.75 out of 35) to 30% (12.03 out of 40).

WTO- TRIPS

- **Agreement on Trade-Related Aspects of Intellectual Property Rights (or TRIPS Agreement)**
- It sets down minimum standards for intellectual property protection.
- It was negotiated at **Uruguay Round** of the General Agreement on Tariffs and Trade (GATT) between 1989 and 1990.
- **Doha Declaration on the TRIPS Agreement and Public Health** was adopted by the WTO Ministerial Conference, 2001. It reaffirmed flexibility of TRIPS for better access to essential medicines.
- **India is an active member** and represents the voice of the third world.

7.2 TYPES OF IPR

Patent

A patent is granted for an **invention** which is a **new product or process** that meets conditions of **novelty, non-obviousness** and **industrial use**. In India, Patents are governed by the **Patent Act, 1970**. It was amended in 2005 to make it TRIPS compliant.

Trademark

A trademark is a mark capable of being represented graphically, which is capable of distinguishing the goods or services of one undertaking from those of other undertakings. Trade marks in India are governed by **Trade Marks Act, 1999**, amended in 2010. Trade

Mark Rules, 2017 provides for ease of filing trademarks, rationalised trademark fee etc. Modalities for determining well-known trademarks has been introduced for the first time.

Copyright

Copyright is a right given by the law to creators of **literary, dramatic, musical and artistic works and producers of cinematograph films and sound recordings**. This right allows its creator the rights of reproduction, communication to the public, adaptation and translation of the work. Copyrights in India are governed by the **Copyright Act, 1957**.

Industrial Design

An industrial design consists of the creation of a shape, configuration or composition of pattern or color, or combination of pattern and color in three-dimensional form containing aesthetic value. Designs in India are governed by the **Designs Act, 2000**.

Geographical Indications (GI)

- It is a sign used on a natural or manufactured good indicating its geographical locality.
- It is a collective right.
- **GI are protected Sui Generis** means of its own kind/genus.
- Geographical Indicators in India are governed by the **Geographical Indications Act, 1999**. Controller General of Patents, Designs and Trade Marks, administers the act. It is complaint with the **WTO TRIPS** (Agreement on Trade-Related Aspects of Intellectual Property Rights).
- GI is also covered under **Paris Convention for Protection of Industrial Property**.

Plant breeders' rights or plant variety rights (PBR or PVR)

These are intellectual property rights (IPRs) granted to the breeder of a modified variety of a plant.

Breeder gets **exclusive rights** for culture, harvesting methods and marketing for a number of years.

It is governed by International Convention for the Protection of New Varieties of Plants or UPOV Convention, 1961.

In India, it is governed by the **Protection of Plant Varieties and Farmers' Rights Act, 2001**.

The **WTO TRIPS Agreement** requires members to provide protection for plant varieties. Most countries do it through UPOV Convention-compliant legislation. **Indian law has been rejected** by the UPOV Council due to not meeting the requirements of the treaty.

Utility Model

- It is just like a Patent.
- It also protects inventions/innovations but for a shorter period.
- **Main difference between Patent and Utility Model is that:**
 - Requirements for granting a Utility Model are less stringent than for Patents.
- **Term of protection for utility models is shorter than for patents**, (usually between 6-15 years).

Trade Secrets

- They are **IP rights on confidential information**.
 - Which may be sold or licensed.
 - Eg: Formulae, Recipes, Pattern, Technique, Compilation.
 - Method, Program, Process, Device or Product Mechanism.

- It remains valid if, one does not discover it independently.

7.3 ISSUES RELATED TO IPRs

Secondary Patents or Patent Evergreening

Secondary Patent refers to the various ways wherein the patent holders attempts to exploit the loopholes in patent laws.

Section 3(d): when a medicine is merely a variant of a known substance, Section 3(d) necessitates a demonstration of improvement in its therapeutic efficacy. The provision also bars patents for new uses and new properties of known substances.

Compulsory Licensing

Compulsory licensing is when a government allows someone else to produce a patented product or process without the consent of the patent owner or plans to use the patent-protected invention itself. WTO

It is defined in the National Manufacturing Policy and Section 84 of Indian Patents Act.

TRIPS PLUS

- It seeks to reduce the flexibilities in TRIPS.
- Since the developed countries own most of the new upcoming technologies, they advocate TRIPS-Plus provisions
- The creation of anti-circumvention laws to protect Digital Rights Management systems under WIPO Treaty, 1996 is example of it.
- It seeks to restrict the compulsory licenses (CL)

Gene Patenting

Myrid genetics

Patent exclusivity

Bioprospecting and Biopiracy

These are the IPR issues related to Biodiversity.

Bioprospecting or Biodiversity prospecting is the process is the systematic search for information in nature, incorporating indigenous knowledge. These resources can be important for pharmaceuticals, agriculture, bioremediation, and nanotechnology etc.

Bioprospecting may involve biopiracy. **Biopiracy** is the exploitative appropriation of indigenous forms of knowledge for commercial purpose. It can include:

1. Exploitative use of indigenous forms of knowledge.
2. Patenting of already widely used natural resources, such as plant varieties.
3. Unlawful sharing of benefits by the patent holder and deprivation of indigenous communities.

Examples of biopiracy

1. **Basmati rice patent case:** In 2000, a US corporation RiceTec attempted to patent certain hybrids of basmati rice. Indian government intervened several claims of the patent were invalidated.
2. **Neem patent case:** A European patent was claimed in 1994 on methods of controlling fungal infections using extracts of the neem tree. In 2000 the patent was successfully opposed on the basis that the fungicidal activity of neem extract had long been known in Indian traditional medicine.

7.4 IPR RELATED CURRENT AFFAIRS

National IPR Policy, 2016

The new IPR policy introduced with a slogan of "Creative India, Innovative India".

Features:

- It is completely compliant with the WTO's agreement on Trade Related aspects of IPRs (TRIPS).
- Department of industrial policy and promotion (DIPP) is the nodal agency.
- The policy will be renewed every five years in consultation with all the stakeholders.
- The policy retains the Compulsory Licensing (CL) provision in spite of the EU and US objections terming it as inconsistent with WTO's TRIPS agreement.
- The policy suggests incentives such as tax benefits and fee waivers to encourage R&D and IP creation to strengthen the Make In India/Start-up/Digital India initiatives.
- The Policy promotes 'utility patents' with lower compliance burden and shorter period of protection, for mechanical innovations. It is to protect 'small inventions' developed especially in the informal / unorganised sectors.

SIPRA: "Scheme for IPR Awareness".

- It is launched by CIPAM (Cell for IPR Promotion and Management).

IPR Nani

It is a mascot for awareness generation.

IPRISM

- = IPR quiz competition for students.
- By CIPAM + ... +...
- For Indian residents only.

Patent Pooling

- According to World Intellectual Property Organisation (WIPO), patent pools are defined as:
 - An agreement made between 2 or more patent holders for licensing their patents to one another or any 3rd party to share their intellectual property rights.
- Generally, patents pools are made for complex technologies.
- Note: 'Sewing Machine Combination' of 1856 is considered as 1st modern patent pool in USA.
 - Patent pooling structures were discussed and considered in response to:
 - SARS outbreak of 2002-03, H5N1 influenza outbreak of 2005.
 - H1N1 influenza pandemic of 2009.

International steps towards patent pooling:

- COVID-19 Technology Access Pool (CTAP) (hosted by WHO).
- Global Initiative to Sharing of All Influenza Data (GISaid):
 - It promotes rapid sharing of data from all influenza viruses and coronavirus.
- Medicines Patent Pool (MPP):
 - It has facilitated development of generic drugs for HIV, TB, Hepatitis C, allowing them to be sold at an affordable price.
 - It is a UN backed public health organisation.
- Trade Related Intellectual Property Regime (TRIPS):

- It allows countries to grant compulsory licences to companies to produce a patented product at times of emergencies.
- **Nagoya Protocol under Convention on Biodiversity (CBD):**
 - Article 2 (e) includes genetic sequence information that forms bases for all ongoing research and development on Covid treatment and prevention.

India and Patent Pooling:

- In India, it has been focused to have solutions for affordable health care.
- **Indian Patents Act (IPA), 1970:**
 - It does not render for any provisions related to formation of patent pools or any guidelines for same.
 - But at same time, it neither restrain for creation or formation of patent pools.
 - Under this, Government can set up patent pool by acquiring inventions and patents.
- **Note:** However, in India, patent pooling is viewed as restrictive practice by Competition Act, 2002, which are anticompetitive in nature.

Patent (Amendment) Rules, 2020

- It provides new format for patentees and licensees to disclose extent to which they have commercially worked.
- By way of Amended Rules, certain amendments are made to **Form 27** ("New Form 27").
- **Form 27:** It is form prescribed for patentees and licensees to furnish statements regarding working of their patent in India.
- It is mandatory under (Indian) Patents Act, 1970 for every patentee and every licensee:
 - To file a statement as to extent of commercial working of a granted patent in Indian territory.
- It must now be furnished in respect of every financial year within **6 months** from expiry of every financial year. (Earlier, it was **within 3 months**)
- There will be **one form for multiple patents**.

8. Award and Miscellaneous

Nobel Prize in Chemistry

- News Context:** It was awarded to Emmanuelle Charpentier and Jennifer A. Doudna.
 - For discovering Clusters of Regularly Interspaced Short Palindromic Repeats CRISPR-Cas9 genetic scissors.
 - Which allows scientists to ‘cut-paste’ inside a genetic sequence.

Clusters of Regularly Interspaced Short Palindromic Repeats (CRISPR):

- They are specific segments in bacterial DNA.
 - That contain palindromic repeats interspersed with pieces of DNA (called spacer), that bacteria snip off from attacking viruses.
- Cas9:** It is a CRISPR-associated (Cas) endonuclease, or enzyme, that acts as ‘Molecular Scissors’ to cut DNA at a location specified by a guide RNA.
- CRISPR-Cas9:** It is a unique genome editing technology.
- It enables geneticists and medical researchers to edit parts of genome by removing, adding, altering sections of DNA sequence.

Genome Editing

- It is a technology that gives scientists ability to change an organism's DNA.
- This allows genetic material to be added, removed, altered at locations in genome.
- It is a 3-stage complex mechanism of unwinding, cleaving, rewinding of DNA to bring desirable changes in genome of any living beings.
 - Cleaving of DNA** includes editing of genes (cut paste of the DNA).
 - Other genome editing systems include TALENs and Zinc-Finger Nucleases.

Nobel Prize in Medicine

- News Context:** Awarded to Harvey Alter, Charles Rice, Michael Houghton for discovering Hepatitis C virus (HCV).

Hepatitis C virus (HCV):

- It is a blood-borne virus and causes Hepatitis C disease which affects liver.
- It happens through transfusions of:
 - HCV-contaminated blood and blood products.
 - Contaminated injections during medical procedures.
 - Through injection drug use.
 - Sexual transmission is also possible but is much less common.
- Note:** It is also a major cause of liver cancer.
- No vaccine is available for HCV yet.

Nobel Prize in Physics

- News Context:** Awarded to Roger Penrose, Reinhard Genzel, Andrea Ghez.
 - For further understanding of black holes, most ‘Enigmatic’ objects in universe.
- Black hole formation** is a robust prediction of general theory of relativity.

- Roger Penrose proved that Black Holes hide a singularity in which all the known laws of nature cease.
- He proves that black holes are a direct consequence of Albert Einstein’s general theory of relativity.

Black Hole:

- It is a place in space where gravity pulls so much that even light cannot get out.
- Gravity is so strong because matter has been squeezed into a tiny space.
- This can happen when a big star is dying.
 - Our sun will never turn into a black hole as it is not big enough to make a black hole.
- At center of a black hole is a gravitational singularity.
- Note: In 2019 scientists got 1st optical image of a black hole through Event Horizon Telescope.
- Sagittarius A* is 2nd black hole whose photographs were captured by Event Horizon Telescope project.

General Theory of Relativity

- It was proposed by Albert Einstein in 1915.
- It’s a theory of gravity whose basic idea is that instead of being an invisible force that attracts objects to one another.
- Gravity is a curving or warping of space.
- The more massive an object, more it warps space around it.
 - Eg: Sun is massive enough to warp space across our solar system (a bit like way a heavy ball resting on a rubber sheet warps the sheet).
- As a result, Earth and other planets move in curved paths (orbits) around it.
- This warping also affects measurements of time.

International Thermonuclear Experimental Reactor (ITER), 1985

- It is an experimental fusion reactor facility under construction in Cadarache, France.
- It aims to prove feasibility of nuclear fusion as a future source of energy.
- It is to build world’s largest tokamak through an international collaboration.
- ITER will be 1st fusion device to produce net energy.
- ITER Members: China, EU, India, Japan, Korea, Russia, USA (35 nations).
 - India joined it in 2005.

Nuclear Fission

- It is splitting of a heavy, unstable nucleus into 2 lighter nuclei.
 - Which releases a tremendous amount of energy.
- Uranium and plutonium are most used for fission reactors.
- Energy produced is lesser than that in nuclear fusion.
- Fission reactors produce highly radioactive fission products.
- Additional neutrons released in fission reaction can initiate a chain reaction.
 - Which sustains fission reactions for longer durations.

Nuclear Fusion

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- It is a process where 2 light nuclei combine together releasing vast amounts of energy.
- Atoms of Tritium and Deuterium (isotopes of H₂) are used in fusion reactors.
- Energy released is several times greater than fission.
- Fusion reactors produce no high activity/long-lived radioactive waste.
 - Burnt fuel in a fusion reactor is helium, an inert gas.
- Due to tremendous amount of pressure and temperature needed to join nuclei together.**
 - Fusion reactions are difficult to sustain for long periods of time.**

Hyperloop

- It is a **high-speed train** that travels in a near-vacuum tube.
- It is considered **5th mode of transportation**.
- Other 4 includes:** Railways, Roadways, Airways, Waterways.
- Hyperloop aims to remove 2 things that slow down regular vehicles:** Friction and Air resistance.
- For Friction, Pod Hovers above its track, like a magnetic levitation train and tube is used to reduce air resistance.
- Reduced air resistance allows capsule inside tube to reach speeds of more than 1000 km/h thereby drastically reducing travel times.
- News Context:** Virgin hyperloop became 1st company to conduct a human test of technology.

Chemosynthesis (Carbon Fixation)

- It is a process through which bacteria or other living organisms derive energy from reactions involving inorganic chemicals typically in absence of sunlight.
- Through this **inorganic carbon is converted to organic compounds** by living organisms and stored as form of energy.
- It has **profound impact on production and cycling of greenhouse gases** such as CO₂, Methane, Nitrous Oxide.
- News Context:** Chemosynthesis Aids Microbes Survival.
- Scientists discovered that microbes across globe could live on air by feeding off H₂, CO₂, Carbon Monoxide to survive extreme conditions.

Photosynthesis vs Chemosynthesis

- Photosynthesis:** it occurs in plants and some bacteria, wherever there is enough sunlight.
 - Photosynthetic organisms use Sun's energy to turn CO₂ and water into sugar and O₂.
- Chemosynthesis:** It is use of energy released by chemical reactions (instead of sun's energy) to produce food.

Winter Diesel

- It is a **specialised fuel introduced by IOC**.
- It is **specifically for high altitude and low-temperature regions** such as Ladakh.
 - Where ordinary diesel can become unusable.
- It contains additives to maintain lower viscosity.
- It can be used in temperatures as low as -30°C.

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- Higher cetane rating-an indicator of combustion speed of diesel and compression needed for ignition.**
- Lower sulphur content**, which would lead to lower deposits in engines and better performance.
- It has a **low pour point** (Temperature below which liquid loses its flow characteristics) of -33° Celsius.
- Note: Unlike regular diesel, it is free from paraffin wax.

Lab Grown Meat (cultured Meat)

- News Context:** Singapore approved sale of a lab-grown meat product, for 1st time in world.
- In lab-grown meat scientists use **Animal's stem cells** to create meat rather than slaughtering animals.
- Stem cells are building blocks of cells and tissues.**
 - By feeding them amino acids and carbohydrates, muscle cells will be multiplied and grown in lab.
- Once **muscle fibers start growing**, it results in an artificially created meat.
 - That resembles actual meat in terms of appearance, texture, nutrient profile.
- It is different from plant-based meat.**
 - As latter is made from plant sources such as soya or pea protein.
- While cultured meat is grown directly from cells in a laboratory.**

National Science Technology and Innovation Policy (STIP)

News Context: Draft of 5th National Science Technology and Innovation Policy (STIP) was released by Science and Technology department.

Objective:

- To identify and address strengths and weaknesses of Indian Science, Technology, Innovation ecosystem.
- To catalyse socio-economic development of country.

Vision:

- To achieve technological self-reliance position.
 - To double number of Full-Time Equivalent researchers, Gross Domestic Expenditure on R&D (GERD), private sector contribution to GERD every 5 years.

Superconductivity

- Superconductivity consists of 2 key elements:
- Zero Electrical Resistance:** Flow of electrical current encounters some degree of resistance.
- A bit like how air resistance pushes back on a moving object.
 - Eg: Higher the conductivity of a material, less electrical resistance it has, and current can flow more freely.
- Meissner effect:** It is **expulsion of a magnetic field** from interior of a material during its transition to superconducting state.
 - When it is cooled below critical temperature.
- News Context:** For the 1st Time, Physicists have Achieved Superconductivity at Room Temperature.
 - For the 1st time, physicists have achieved resistance-free flow of an electrical current in a material at room temperature of 15 degrees Celsius (59 degrees Fahrenheit).

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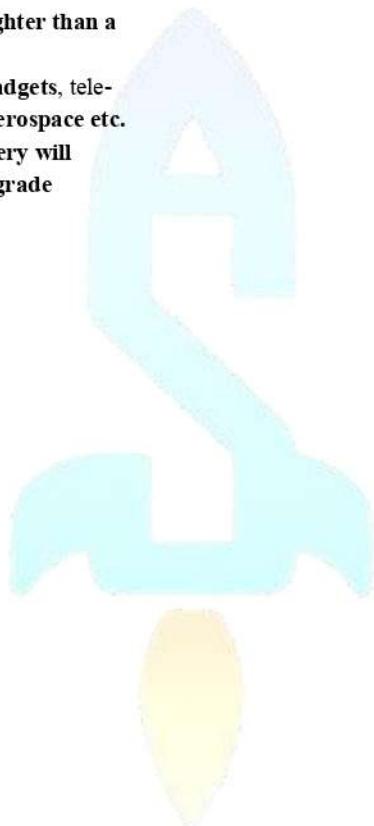
- Material used is a combination of: Carbon, Sulphur, Hydrogen.

Lithium

- It is an **alkali metal and lightest of solid elements**.
 - It is soft, white, and lustrous.
- It is **found in minerals and ores like**: Petalite, Lepidolite amblygonite etc.
- **Reserves: South America's 'Lithium Triangle'**.
 - It is an area encompassing parts of **Chile, Argentina, Bolivia** (Largest reserves of Lithium in World).
- **Note: Australia is largest producer.**

Lithium-Ion battery

- **They are rechargeable batteries with:**
 - High Voltage Capacity, High energy density, Long life cycle, High storage characteristics.
- **Lithium-ion batteries are smaller and lighter than a NiCad (Nickel Cadmium) battery.**
- **It finds wide applications in electronic gadgets, telecommunications, Industrial applications, aerospace etc.**
- **News Context: India's 1st Lithium refinery will process Lithium ore to produce battery grade material will be set up in Gujarat.**



5G

- It is a wireless communication technology using radio waves or radio frequency (RF) energy to transmit and receive data.
- D10 Club**
 - UK approached USA to create a 5G club of 10 democracies.
 - Members: G7 countries (UK, USA, Italy, Germany, France, Japan, Canada), Australia, South Korea, India.
 - It aims to create alternative suppliers of 5G equipment and other technologies to avoid relying on China.

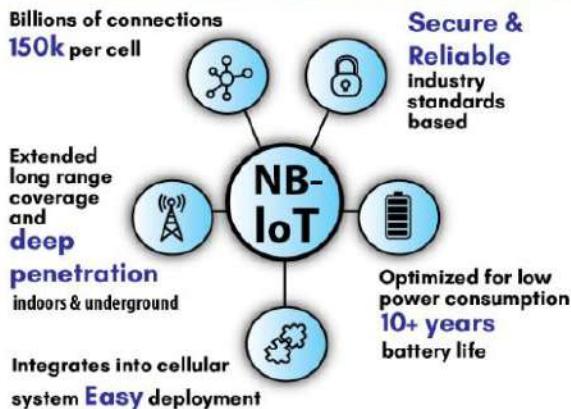
5G Hackathon

- It is shortlists India focused cutting edge ideas that can be converted into workable 5G products and solutions.
- Organized by: Telecommunications Department.
- Note: 2G and 3G mobile networks relied on microwave wireless backhaul to connect cell sites with the nearest switching center.
- 4G LTE introduced IP-based connectivity, replacing copper- or microwave-based cell sites with optical fibre.
- 5G deployment is based on optical fibre infrastructure.
- Steps taken
 - BharatNet programme: It plans to link 2.5 lakh gram panchayats through optical fibre network.
 - National Digital Communications Policy 2018.

Narrow Band Internet of Things (NB-IoT)

- It is a wireless communication standard for IoT belonging to category of low-power wide area networks (LPWAN).
- IoT refers to physical devices around world, that are now connected to internet, all collecting, sharing data.
 - Eg: A light bulb that can be switched on using a smartphone app is an IoT device.
- However, it doesn't necessarily have to be connected to internet.

Benefits of NB-IoT



- It can also be a network of things.

- It enables to connect devices that need small amounts of data, low bandwidth, long battery life.
- It doesn't operate in licensed LTE construct, Instead, it works in one of 3 ways:
 - Independently.
 - In unused 200-kHz bands that have previously been used for GSM (Global System for Mobile Communications).
 - On LTE base stations allocating a resource block to NB-IoT operations or in their guard bands.
- News Context:** BSNL with Skylotech India, announced world's 1st satellite-based NB-IoT network in India.

Prime Minister Wi-Fi Access Network Interface (PMWANI)

It aims to elevate wireless internet connectivity in country.

It will be operated by different players such as:

Public Data Office (PDO), Public Data Office Aggregator (PDOA), App Provider, Central Registry.

Public network will be set up by PDOAs to provide Wi-Fi service through PDOs spread throughout country.

- A PDOA buys bulk bandwidth from licenced telcos/ISPs and re-sells it to multiple PDOs.
 - It is to ensure latter can offer Wi-Fi connectivity to customers.
- This nationwide network of public Wi-Fi hotspots is termed PDOs after public call office (PCO) concept rolled out by Government.
 - It is to set up a nationwide network of landline public pay-phones.

Wi-Fi

- It is a wireless networking technology that allows devices such as:
 - Computers (laptops and desktops), mobile devices (smart phones and wearables).
 - Other equipment (printers and video cameras) to interface with Internet.
- It is commonly called a wireless LAN (local area network).
- Wireless network is operating 3 essential elements:
 - Radio Signals, Antenna, Router.
- Radio waves are keys that make Wi-Fi networking possible.
- Mobile data works essentially same way as Wi-Fi.
- Biggest difference is that signal comes through your mobile service provider rather than ISP (Internet service provider).

Dark Net (Dark Web)

- It is that part of Internet, which is neither accessible through traditional search engines like Google.
 - Nor is it accessible by normal browsers like Chrome or Safari.
- It uses non-standard communication protocols.
 - Which makes it inaccessible to internet service providers (ISPs) or Government.
- Dark Net content is encrypted and requires specific browser such as:
 - TOR (The Onion Ring) browser to access those pages.
- It is only a part of Deep Web that is a broader concept.

- Which includes sites that are protected by passwords.
- Eg: A person's bank statements which are available online but will not be pulled up in generalized Internet searches.
- Only difference is that Deep Web is accessible, Dark Net is deliberately hidden.

Surface Web: Part of internet available to public and searchable on standard search engines.

TOR (The Onion Ring)

- It was developed in mid-90s by US Naval Research laboratory employees to protect US intelligence communications online.
- It is termed so as traffic from browser creates several layers like those of an Onion before reaching destination site.
- In other words, unlike normal surfing, computer does not connect directly to server.
 - Where website is located.
- Instead, a whole series of servers are involved in connection to create greatest possible anonymity.

Supercomputers

- It is a computer with a high level of performance as compared to a general-purpose computer.
- Performance of a supercomputer is measured in floating-point operations per second (FLOPS).
- Other Indian Super Computers:
 - Param Shiva: India's 1st Supercomputer.
 - Pratyush: Located in Indian Institute of Meteorology.
 - Mihir: Located in National Centre for Medium Range Weather Forecasting.
- Note: World Fastest Supercomputer is Fugaku of Japan with speed of 415 Peta-Flops.

FLOPS (Floating-point Operations per Second)

- It is a common benchmark measurement for rating speed of microprocessors.
- 1 MegaFLOPS: Equal to 1 million FLOPS.
- 1 GigaFLOPS: Equal to 1 billion FLOPS.
- 1 TeraFLOPS: Equal to 1 trillion FLOPS.
- 1 PetaFLOPS: It can be measured as 1,000 teraflops.

National Supercomputing Mission (NSM), 2015

- It is to empower national academic and R&D institutions by installing a vast supercomputing grid.
- Under NSM, Param Shivay: 1st supercomputer was assembled indigenously and is installed in IIT (BHU).
 - Param Shakti and Param Brahma: Installed at IIT-Kharagpur and IISER, Pune.

Quantum Key Distribution (QKD)

- It is a technique that allows for secure distribution of keys to be used for encrypting and decrypting messages.
- In traditional cryptography, security is based on that an adversary is unable to solve a certain mathematical problem.
- In QKD, security is achieved through laws of quantum physics.
- 2 such most important laws are: Superposition and Entanglement.

- **Superposition:** It means that each quantum bit (basic unit of information in a quantum computer) can represent both a 1 and a 0 at same time.
- In quantum entanglement, subatomic particles become 'entangled' (linked) in such a way that:
 - Any change in one disturbs other even if both are at opposite ends of universe.
- **Quantum Satellite** serves as source of pairs of entangled photons, twinned light particles.
 - Whose properties remain intertwined no matter how far apart they are.
- **News Context:** A satellite-based communication between 2 ground stations was activated by entangled-based quantum key distribution (QKD).
 - This was achieved by Micius (Quantum Experiments at Space Scale), World's 1st quantum-enabled satellite.
 - Micius was launched by China in 2016.

Quantum Technology

- It seeks to harness laws of quantum physics.
 - Which describes behaviour of matter and energy at atomic and subatomic level.
- This is unlike classical physics, in which an object can exist in one place at one time.
 - Eg: Classical computers operate using binary physical state, meaning its operations are based on 1 or 0.
- Quantum principles will be used for engineering solutions to extremely complex problems.
 - Like in: Computing, Communications, Sensing, Chemistry, Cryptography.

3D Printing (Additive Manufacturing)

- It constructs a 3-dimensional object from a digital 3D model or a computer-aided design (CAD) model by adding material layer by layer.
- Addition of material can happen in multiple ways: Power deposition, Resin curing, Filament fusing.
- Deposition and Solidification are controlled by computer to create a 3-dimensional object.
- These objects can be of almost any shape or geometry.
- 3D printing is opposite of subtractive manufacturing.
 - Which is cutting out / hollowing out a piece of metal or plastic with for instance a milling machine.
- It allows creation of lighter, more complex designs.
 - That are too difficult or too expensive to build using traditional dies, molds, milling, machining.
- **News Context:** IT Ministry is planning a 3D printing policy.
 - Policy will develop a conducive ecosystem for design, development, deployment of 3D printing.
 - It would promote 3D printing on an industrial scale.
 - It will help domestic companies overcome technical and economic barriers.

Non-Personal Data (NPD)

- News Context: Draft report on NPD Governance Framework was released to invite feedbacks by Kris Gopalakrishnan committee.
- NPD is any set of data which does not contain personally identifiable information.
- In essence means that no individual or living person can be identified by looking at such data.
- It includes data sets aggregated and collected by various mobile apps, websites, devices.
- Difference from personal data:
 - Unlike personal data, which contains explicit information about a person's personal details.
 - NPD is more likely to be in an anonymized form.
- Anonymous data is initially personal data but is later made anonymous.
- It is to extent that individual specific events are no longer identifiable.

Classifications of NPD:

- Public NPD: All data collected by Government such as census, data collected on total tax receipts.
 - Or any information collected during execution of all publicly funded works is kept under umbrella of public NPD.
- All NPD collected by Government is confidential like:
 - Land records, public health information, vehicle registration shall not constitute Public Non-Personal Data.
- Community NPD: Any data identifiers about a set of people.
 - Who have either same geographic location, religion, job, or other common social interests.
 - Eg: Metadata (set of data that gives information about other data) collected by ride-hailing apps, telecom companies, electricity distribution companies.
- Private NPD: Those which are produced by individuals.
 - Which can be derived from application of proprietary software or knowledge.
- It is further sub-classified into: Sensitive and Critical NPD.

Some key stakeholders mentioned in draft report:

- Data principals: Natural persons, Entities and communities to whom NPD (prior to anonymization or aggregation) relates.
- Data custodians: entities which undertake collection, storage and processing of NPD.
- Data businesses: Horizontal category of businesses involved in data collection and processing.

2d-Electron Gas(2DEG)

- It is an electron gas with ultra-high mobility, which can speed up transfer of quantum information and signal from one part of a device to another.
 - It increases data storage and memory.
- Strong spin-orbit coupling and relativistic nature of electrons in 2DEG resulted in Rashba field.

- Rashba effect consists of splitting of spin-bands in an electronic system, might play a key role in spintronic devices.
- Produced by: Institute of Nano Science and Technology.

Pai

- It is launched by National Payment Corporation of India (NPCI).
- It is an AI based chatbot, to create awareness around NPCI's products like FASTag, RuPay, UPI, AePS on a real time basis.
- NPCI is umbrella organisation for operating retail payments and settlement systems in India.
- It is an initiative of RBI and Indian Banks' Association under Payment and Settlement Systems Act, 2007.

Project Loon

- It is a network of stratospheric balloons designed to bring Internet connectivity to rural and remote communities worldwide.
- It is a project under a Google subsidiary.
- Helium filled balloons are launched at altitudes of 20 km above the zone where airplanes fly.
- Balloons can then act as cell towers to receive and transmit signals.

Blockchain technology

- It is a specific type of data structure which can be used to transact across nodes or participants.
- Ownership rights are recorded in cryptographically stored and linked blocks.
 - Which contain records of ownership of assets among participants that can remain anonymous.
- Blockchains are open, distributed ledger that can chronologically record transactions between 2 or more parties in real time.
- Prerequisite for each subsequent transaction to be added to ledger is respective consensus of network participants (called nodes).
 - Thereby creating a continuous mechanism of control regarding manipulation, errors, and data quality.
- It has key characteristics of decentralization, persistency, anonymity, auditability.
 - With these traits, blockchain can greatly save cost and improve efficiency.
- It has various applications like in field of banking, capital markets, cybers security, healthcare, agriculture, telecom, governance etc.
- News Context: National Informatics Centre (NIC) has set up Centre of Excellence (CoE) in Blockchain Technology in Bengaluru.

Artificial Intelligence

- It is ability of machines to perform tasks like:
- thinking, Perceiving, learning, problem solving, Decision making in real time without constant supervision.

Various steps taken towards regulation of AI

- OECD Principles on AI: adopted by 42 countries including OECD members and non-members.

- National Strategy for AI:** NITI Aayog identified 5 areas where AI can be useful.
- Center of Excellence in AI by National Informatics Centre (NIC).**
- AI for crop cutting and yield estimation under PM Fasal Bima Yoajana.

Edge Computing

- It enables data to be analysed, processed, transferred at edge of a network.
- It means, data is analysed locally, closer to where it is stored, in real-time without latency.
- Basic difference between edge computing and cloud computing lies in where data processing takes place.
- Cloud Computing:** It means storing and accessing data and programs over Internet instead of your computer's hard drive.
- Existing Internet of Things (IoT) systems perform all their computations in cloud using data centres.
- Edge Computing:** It manages massive amounts of data generated by IoT devices by storing and processing data locally.

Benefits of edge computing

- It offers high speed, reduced latency & better reliability.
 - Which allows for quicker data processing and content delivery.
- It offers better security by distributing processing, storage, applications across a wide range of devices and data centers.
 - Which makes it difficult for any single disruption to take down network.

Data Localization

- It is a concept that personal data of a country's residents should be processed and stored in that country.
- It may restrict flow entirely or allow for conditional data sharing or data mirroring (in which only a copy has to be stored in country)
- It will aid countries asserting sovereignty in digital domain, ensure informational security.

Personal Data Protection Bill, 2019

- Personal data (data that can identify an individual):** Bill talks about various types of personal data, such as:
- Sensitive personal Data:** Finances, Health, Sex life, Sexual orientation, Biometric, Genetics, transgender status etc.
- Critical Personal Data:** Military or National security.
- General Personal Data:** Other than sensitive and critical personal data.
- Obligations of data fiduciary (An entity or individual who collects and decides means and purpose of processing personal data):**
- Personal data can be processed only for specific, clear, lawful purpose.
- All data fiduciaries must undertake certain transparency and accountability measures such as:**
 - Implementing security safeguards.
 - Instituting grievance redressal mechanisms to address complaints of individuals.
- Rights of data principal** (Individual whose data is being collected and processed):

These include right to:

- Obtain confirmation from fiduciary on whether their personal data has been processed:
 - Restrict continuing disclosure of their personal data by a fiduciary.
 - If it is no longer necessary or consent is withdrawn.
- It also includes right to be forgotten.
 - Which allows users to erase their personal data published online.
 - To give freedom to ask entities such as Facebook and Twitter to delete any data they do not want in public domain.
- Grounds for processing personal data:** Bill allows processing of data by fiduciaries only if consent is provided by individual.
- However, personal data can be processed without consent.**
- These include:**
 - If required by State for providing benefits to individual
 - Legal proceedings
 - To respond to a medical emergency
- Data Protection Authority:** Bill sets it up. It may:
 - Take steps to protect interests of individuals.
 - Prevent misuse of personal data.
 - Ensure compliance with the Bill.

Biometrics

- They are physical or behavioral human characteristics that can be used to digitally identify a person to grant access to systems, devices, data.
- Each of these identifiers is considered unique to individual.
- They may be used in combination to ensure greater accuracy of identification.

Biometrics can be divided into 3 main categories of characteristics:

- Biological:** DNA blood
- Morphological (form and structure of organisms):**
 - Shape of hand, palms, fingerprints, vein patterns, face, iris, vein, pattern in retina, voice, ear.
- Behavioral:** Walking, Handwritten Signatures, Keyboard Strokes.
- News Context:** India became 1st country to issue Biometric Seafarer Identity Document (BSID), capturing facial bio-metric data of seafarers.
- BSID** has dimensions of a smart ID card.
- It introduces modern security features like an embedded biometric chip.**
 - Optical security features such as micro prints/micro texts and Unique Guilloche pattern.
- New card is in confirmation of Convention No. 185 of International Labour Organisation on BSID.
- India ratified the Convention in 2015.

RFID Technology

- It is an electronic tag that can exchange data with an RFID reader through radio waves.

- In this, an antenna broadcasts energy to tag, which in turn returns modulated energy back in form of back-scatter.
- It is faster connection, and operational range is about 100m.
- RFID tag typically sends out information hence only one-way information.
- News Context:**
 - Indian Railways takes up RFID project.
 - It aims to automatically and accurately track and trace rolling stock to improve their safety and reliability.

Broadband Readiness Index (BRI)

- Telecom Department and Indian Council for Research on International Economic Relations (ICRIER) signed a MoU to develop a BRI for Indian States and UTs.
- It appraises condition of underlying digital infrastructure and related factors at State/UT level.
 - Which will be conducted annually until 2022.
- BRI consists of 2 parts.**
 - Part I:** It focuses on infrastructure development based on measurement of 9 parameters like state policy, towers, number of fibres etc.
 - Part II:** It consists of demand side parameters which will be captured through primary surveys.

Tech-Sagar

- It is an online portal for India's technological capability.
- Launched by: National Cyber Security Coordinator's office and Data Security Council (DSCI).
- It will list business and research entities from IT industry, startups, academia, individual researchers.

KP-Bot

- It is India's 1st RoboCop.
- Kerala became 1st police department to use it (SI-ranked) for police work.

Net Neutrality

- Basic principles are that nobody owns internet.
- It is free and open to all.
- Internet Service Providers (ISPs) must treat all internet traffic equally without any regard to the type, origin, destination of content or means of its transmission.
- According to TRAI:** Any form of discrimination or interference in treatment of content.
 - It includes practices like blocking, degrading, slowing down, granting preferential speeds, treatment to any content is prohibited.

Other recommendations include:

- Specialized Service:** They are exempted from neutrality framework such as tele-surgery, Voice over Internet Protocol (VoIP), IPTV services etc.
- Content delivery Network (CDN) platform:**
 - It should not be included within scope of any restrictions on nondiscriminatory treatment.
- News Context:** Telecom Commission, highest decision-making body in Department of Telecom approves net neutrality recommended by TRAI last year.

Inclusive Internet Index:

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- Prepared by:** Economist Intelligence Unit.
- It is based on 4 categories:**
 - Accessibility (Network Coverage), Affordability (pricing).
 - Relevance (availability of local-language content).
 - Readiness (capability to access internet).

National Digital Literacy Mission (NDLM)

- It was launched under Digital India to transform India into a digitally empowered society and economy.
- Under this, beneficiaries undergo a 20-hour training programme in using computers.
- Pradhan Mantri Gramin Digital Saksharta Abhiyan' (PMGDISHA), 2017**
 - It was to make 6 crore rural households digitally literate by March 2019.

Cryptocurrency

- It is a type of digital currency that uses cryptography for security and anticounterfeiting measures.
- It is normally not issued by any central authority, making it immune to government interference or manipulation.
- Control of each cryptocurrency works through distributed ledger technology called blockchain.
 - Eg: Bitcoin, Ethereum, Ripple etc.

Cyber-Physical System (CPS)

- It is an interdisciplinary field that deals with deployment of computer-based systems that do things in physical world.
- It integrates sensing, computation, control, networking into physical objects and infrastructure, connecting them to the Internet and to each other.
 - Eg: Smart Grid Networks, Smart Transportation System.
 - Enterprise Cloud Infrastructure, Utility Service Infrastructure for Smart Cities, etc.
- It is associated with technologies like:**
 - AI, Internet of Things (IoT), Machine Learning.
 - Deep Learning, Big Data Analytics, Robotics, Quantum Computing.
 - Quantum Communication, Quantum Key Distribution.
 - Data Science & Predictive analytics etc.

Paris Call

- News Context:** Paris Call for Trust and Security in Cyberspace was commenced at UNESCO.
- It is to develop common principles for securing cyberspace.
- Participants:** 190 signatures, 30 Private Sector, 50 member nations.
- Note:** India, USA, China, Russia did not sign agreement.

GravityRat Malware

- News Context:** Maharashtra Cybercrime department reports this.
- 'RAT' in the name stands for Remote Access Trojan.
 - Which is a program capable of being controlled remotely and difficult to trace.
- Malware, (Malicious Software):** It is any program or file that is harmful to a computer user.

- It includes **computer viruses, worms, Trojan horses, spyware.**

Bots

they are software programs created to automatically perform specific operations.

Some bots are created for relatively harmless purposes.

Eg: Video gaming, Internet auctions, Online contests, etc.

Ransomware

- It is a **form of malware that essentially holds a computer system captive while demanding a ransom.**
- Malware restricts user access to computer either by encrypting files on hard drive or locking down system.
- It displays messages that are intended to force user to pay malware creator to remove restrictions and regain access to their computer.

Spyware

It is a **type of malware that functions by spying on user activity without their knowledge.**

It spreads by **exploiting software vulnerabilities**, bundling itself with legitimate software, or in Trojans.

Trojan Horse

It is a **type of malware that disguises itself as a normal file or program to trick users into downloading and installing malware.**

It can give a malicious party remote access to an infected computer.

Virus

- It is a **form of malware that can copy itself and spreading to other computers.**
- **It can be used to:**
 - Steal information, Harm host computers and networks.
 - Create Botnets, Steal money, Render advertisements.

Worm

- They are among most **common types of malware.**
- They spread over computer networks by **exploiting operating system vulnerabilities.**
- Worms typically cause harm to their host networks by **consuming bandwidth and overloading web servers.**
- Worms often spread by sending mass emails with infected attachments to users' contacts.

Big Data

- **It is a large volume of data: Both structured and unstructured beyond ability of commonly used software tools to:**
 - Capture, Curate, Manage, Process data within a tolerable elapsed time.
- It can be **analyzed for insights that lead to better decisions** and strategic business moves.
- **Big data is characterized by 4Vs:** Variety, Volume Velocity and Value.
 - **2 more concepts have been added:** Variability and Complexity
- **Note:** Interesting insights from big data can be got using data mining.
- **Note:** Justice B.N. Srikrishna Committee came out with a white paper on Data Protection Framework for India.

- Earlier in 2016, CAG finalized a **Big Data Management Policy** to make itself future ready.

Data Mining (Knowledge Discovery in Data (KDD))

- It is a **process used to extract usable data from a larger set of any raw data.**
- It is **done by analyzing data patterns** in large **batches** of data using one or more software.
- It involves **effective data collection, warehousing, computer processing.**
- It uses **mathematical algorithms for segmenting data and evaluating probability** of future events.

Cloud Storage

- It is a **service model in which data is:**
 - Maintained, Managed, backed up remotely, made available to users over a network or cloud services platform (typically Internet).
- It also involves **on-demand delivery of:**
 - Compute power, Applications, IT resources.
- **Digilocker Service:** It enables Indian citizens to store certain official documents on cloud.

Project Brainwave

- It is launched by **Microsoft.**
- It is a **deep learning acceleration platform for real-time AI.**
- It uses **massive field-programmable gate array (FPGA)** infrastructure.

Deep Learning:

- It is a **subset of machine learning.**
- Which utilizes **hierarchical level of artificial neural networks to process unstructured data.**
- Neural networks are a set of algorithms, modeled loosely after human brain.
- That are designed to recognize patterns.
- **Hierarchical neural network** is an **artificial Neural Network (ANN)** with multiple hidden layers between input and output layers.

Humanoid Robot

- Its **overall appearance based on human body.**
- **Features of Humanoid Robots:**
 - Self-maintenance, Autonomous learning.
 - Avoiding harmful situations to people, property, and itself.
 - Safe interacting with human beings and environment.
- **Note:** Humanoid Robot Sophia became world's 1st robot citizen.
 - As **Saudi Arabia granted citizenship to her to promote AI.**
- **Other Eg:** Unplugged (USA), Asimo (Japan).
 - Icub (Cognitive Universal Body by European university).
 - Poppy (france), Lexy & Tess (Germany), Actroid-Sit (Japan) etc.

Bharat Net Project (National Optical Fibre Network), 2011

- It provides broadband connectivity to 2.5 lakh Gram Panchayats.
- It is implemented by a special purpose vehicle (SPV) named Bharat Broadband Network Ltd (BBNL) set up under Companies Act.

- It is funded through Universal Service Obligation Fund (USOF).

Free Space Optical Communication (FSO)

- It is an optical communication technology in which data is transmitted by propagation of light in free space allowing optical connectivity.
- Working of FSO is like OFC (optical fiber cable) networks.
 - But only difference is that optical beams are sent through free air or vacuum instead of glass fiber.
- It is a Line of Sight (LOS) technology.
- It consists of an optical transceiver at both ends to provide full duplex (bidirectional) capability.
- It can send up to 1.25 Gbps of data, voice, and video communications simultaneously through the air.
- Advantages:** Low initial investment.
 - Flexible network that delivers better speed than broadband.
 - Security due to line-of-sight operation etc.

Light-Fidelity (LiFi)

- It is a high speed wireless communications through light emitting diodes (LEDs).
- It uses both visible and near-visible light for free space communication.
- It is not strictly a line-of-sight technology i.e. data rate is not dependent on line of sight but on signal quality at device.

Tarang Sanchar Portal

- It is launched by Telecom Department.
- It allows people to track radiation emitted from mobile towers within a locality.
- It empowers consumers to know about towers working in a particular area.
 - And whether they are compliant to Electromagnetic field (EMF) emission norms defined by Government.

Mobile tower emissions rules in India are 10 times more stringent than global norms.

Radiation

- Energy emitted from a source is generally referred to as radiation.
- There are 2 types of radiation:
 - Ionizing radiation:** It is radiation with enough energy to cause chemical changes by breaking chemical bonds.
 - It
 - Molecule with a net positive charge. results in formation of 2 charged particles or ions:
 - Free electron with a negative charge.
 - This effect can cause damage to living tissue.
 - Eg: Heat or light from Sun, microwaves from an oven.
 - X rays from an X-ray tube, Gamma rays from radioactive elements.

Non-ionizing Radiation:

- The radiation in part of electromagnetic spectrum.
 - Where there is insufficient energy to cause ionization.
 - But may have enough energy to excite molecules and atoms causing them to vibrate faster.

- Eg: It includes electric and magnetic fields, radio waves, microwaves, infrared, ultraviolet, visible radiation.

Aquila

- It is part of Facebook's Connectivity Lab.
- It is a department which is creating new technologies including aircrafts, satellites, wireless communication systems.
- Facebook is trying to bring internet access to areas where internet connectivity is bad or non-existent.
- Free Basics (internet.org):** Pared down version of internet in poor areas.
- Note: Google's parent company Alphabet Inc. has also invested to provide internet access to underserved areas through Project Loon.
- News Context:** Facebook successfully completed its 1st test flight of its solar powered internet drone Aquila.

Augmented Reality

- It is a computer technology that:
 - Functions on computer vision-based recognition algorithms to augment sound, video, graphics on real world objects, using your device's camera.
- It layers digital enhancements to enrich an existing real life setting by appealing to senses.

Sunway Taihulight

- It is a new Chinese supercomputer that can make 93 quadrillions calculations per second.
- Developed by: National Research Centre of Parallel Computer Engineering and Technology (NRCPC).
- It is twice as fast as Tianhe-2 (previous fastest supercomputer) of China.

QR code (Quick Response code)

- It is a 2 dimensional (matrix) machine-readable bar code.
 - It is made up of black and white square.
- This code can be read by the camera of a smartphone.
- It is capable of 360 degrees (omnidirectional), high speed reading.
- It can store up to 7089 digits as compared to conventional bar codes which can store max 20 digits.
- It carries information both horizontally and vertically.
 - It has error correction capability and data stored in it can be restored even if it is partially damaged or dirty.

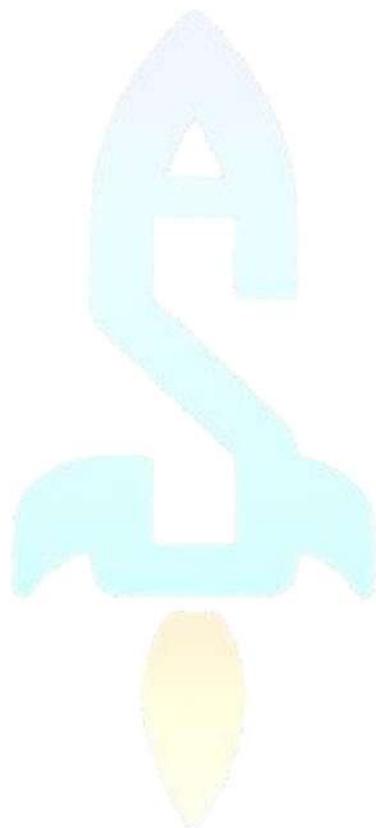
Bharat QR Code:

- It is developed jointly by:
 - National Payments Corporation of India (NPCL).
 - Visa, MasterCard, American Express under instructions RBI.
- It eliminates the need of using card swiping machines for digital payments.

Millimeter Wave Technology

- Facebook plans to bring internet to new areas without need to dig holes, install towers, stretch expensive wire lines across planet.
- They are smaller in wavelength than radio waves that transmit cell phone and Wi-Fi signals.

- Since they are not as widely used as others.
- Facebook will now use it to send much larger about of data.
- Only challenge would be higher power consumption by millimeter wave setup relative to the radio wave technology.



10. Health & Food

Trans fat (Trans Fatty Acids)

- They are unsaturated fatty acids that come from either natural or industrial sources:
- Naturally occurring trans-fat: Dairy and Meat products.
- **Industrial Trans-fat:** It is an industrial process that adds hydrogen to vegetable oil converting liquid into a solid.
 - Which results in '**Partially Hydrogenated' oil (PHO).**
- Industrially Trans-fats are found in hardened vegetable fats. Such as:
 - Ghee (clarified butter).
 - They are often present in snack foods, baked goods, fried foods.
- Manufacturers often use them for longer shelf life and are cheaper than other fats.
- They are one of main cause of Type-2 Diabetes and linked to insulin resistance.
- Note: WHO released progress report on Trans-Fat Elimination titled 'Countdown to 2023: Global Trans Fats Elimination 2020'.
- Steps taken by India against Trans Fats:
 - FSSAI capped amount of TFA in 'oils and fats' to 3% for 2021, 2% by 2022 from current limit of 5%.
 - Eat Right Movement: It is to cut down on salt, sugar, oil consumption by 30% in 3 years by educating customers.
 - Heart Attack Rewind: It is campaign about Health Hazards of consuming trans fats.
 - Trans Fat Free logo: Food establishments which use trans-fat free fats and do not have industrial trans-fat more than 0.2g/100g of food, can display it.

State Food Safety Index

- It is released by FSSAI.
- It creates a sense of competition among states to improve food safety.
- It is divided into 3 categories.
 - Large states, Small states, UTs.
- Blissful Hygienic Offering to God (BHOG):
 - It encourages Places of Worship (POW) to adopt and maintain food safety and hygiene.

Food Adulteration

- It is an act of adding of poor quality, harmful, useless substances to food (added substances may be food or non-food item).
- Food items, medicines, vegetables, paste, creams, products etc. are adulterated.

COMMON FOOD ADULTERATION

Food Stuffs	Adulterants
Cereal	Soil, pieces of stone, infested cereal
Pulses	Khesari dal
Bengal gram Flour	Starch powder, maize flour
Ghee	Vegetable ghee, Animal fat, sweet potato
Milk	Water
Tea	Used tea leaves
Pepper	Papaya seeds
Clove	Clove after extraction
Dhaneya	Saw dust, horse dung
Red Chelli Powder	Saw dust, Powdered Red Brick
Honey	Sugar, Water
Turmeric	Yellow Soil

Nuclear Magnetic Resonance (NMR) Spectroscopy

- It is a technique used in quality control, research for determining content, purity of a sample, its molecular structure.

Draft Food Safety and Standards (Amendment) Bill, 2020

- It amends Food Safety and Standards Act, 2006.
- It gives more power to FSSAI's like: Enhancing penalties etc.

Key amendments

- Jurisdiction of FSSAI extended to include animal feed.
- So far, FSSAI had powers just on food industry.
- There will be a CEO at FSSAI as member secretary.

Poliomyelitis (Polio)

- It is a infectious viral disease that invades nervous system.
- There are 3 types of Wild Polio Virus: Type 1, Type 2, Type 3.
 - Only Type 1 wild poliovirus remains in circulation.
- There is no cure for polio, it can only be prevented through immunization.

There are 2 types of vaccinations against this:

- Inactivated polio vaccine: It is made up of inactivated (killed) polio virus and provides immunity from all strains of polio.
- Oral Polio Vaccine: It contains a live, attenuated (weakened) vaccine-virus.
 - When a child is vaccinated, the weakened vaccine-virus replicates, triggering a protective immune response.
- However, in some cases, vaccine-virus is genetically altered during replication.
- This is called a vaccine derived poliovirus (VDPV).
 - VDPVs are extremely rare.
 - They are found in children with immune deficiency.
- Note: Diseases eradicated from India: Yaws, Polio, Guinea worm, smallpox, Maternal and neonatal Tetanus.
- News Context: WHO certified African region free of wild polio.

WHO Emergency Use Listing (EUL)

- WHO adds Novel Oral Polio vaccine type 2 (nOPV2), useful in treatment of Vaccine derived polio virus (VDPV) strain to its EUL.
- EUL is a risk-based procedure to assess and list unlicensed vaccines during public health emergencies, such as polio and COVID.
- It makes vaccines available faster.

Yellow Fever

- It is an acute viral haemorrhagic disease transmitted by mosquitoes (Aedes and Haemagogus species).
- 'Yellow' in name refers to jaundice that affects some patients.
- Symptoms:** Fever, Headache, Jaundice, Muscle pain, Vomiting, Fatigue.
- It is endemic in tropical areas of Africa, Central and South America.
- Note:** Vaccine is available for this disease.
 - WHO launched Eliminate Yellow Fever Epidemics strategy in 2017.
- News Context:** Geography of yellow fever to shift to Central and East Africa from West Africa by 2050.
 - Climate change-related factors, temperature, rainfall, leads to this.

Malaria

- It is caused by parasites that are transmitted to people through infected female Anopheles mosquitoes.
- Out of 5 malaria causing parasite species, Plasmodium falciparum and Plasmodium vivax pose greatest threat.
- News Context:** World Malaria Report is released by WHO.
 - India is only high endemic country which reported a decline of 17.6% in 2019 as compared to 2018.

Steps to eradicate Malaria:

- High Burden to High Impact (HBHI) initiative:** WHO initiated it in 11 high malaria burden countries, including India.
- Global technical strategy for malaria 2016-2030:**
 - It is to reduce malaria cases, mortality rate of at least: 40% by 2020, 75% by 2025, 90% by 2030.

Glucose-6- Phosphate Dehydrogenase (G6PD) Deficiency

- It is a genetic abnormality (more prevalent in males).
- It results in an inadequate amount of G6PD in blood.
- CGPD is an important enzyme (Protein) to regulate various biochemical reactions in body.
 - It is responsible for keeping red blood cells healthy.

Kala-azar or Visceral Leishmaniasis (VL)

- It is a tropical disease characterised by irregular fever, weight loss, anaemia, swelling of spleen and liver.
 - It is caused by a protozoan Leishmania parasite.
- It is transmitted to humans by bite of infected female sandflies.
- India accounts for about 2/3rd of total global cases.
 - It is endemic to: Bihar, Jharkhand, UP, West Bengal.

Antimicrobial Resistance (AMR)

- It happens when microorganisms (Bacteria, Fungi, Viruses, Parasites) change.
 - When they are exposed to antimicrobial drugs (Antibiotics, Antifungals, Antivirals).
- Microorganisms that develop AMR are sometimes referred to as superbugs.
 - As a result, medicines become ineffective.
- AMR occurs naturally over time, usually through genetic changes.
 - However, misuse and overuse of antimicrobials is accelerating this process.

Initiatives by WHO to address AMR:

- Global Antimicrobial Resistance Surveillance System (GLASS):**
 - It supports standardized approach to collect, analyse, sharing of data related to antimicrobial resistance at a global level.
- AWaRE Tool:** It aims at guiding policymakers and health workers to use antibiotics safely and more effectively.
- It classifies antibiotics into 3 groups:**
 - Access:** Antibiotics used to treat most common and serious infections.
 - Watch:** Antibiotics available always in healthcare system.
 - Reserve:** Antibiotics to be used sparingly or preserved and used only as a last resort.
- Global Antibiotic Research and Development Partnership (GARDP):** It encourages R&D through public-private partnerships.
- Interagency Coordination Group on Antimicrobial Resistance (IACG):** It is established by UN Secretary-General.
 - It is to improve coordination between international organizations and to ensure effective global action.

AMR Situation in India

- AMR bacteria and their genes have been reported from different water sources.
- Major sources are pharmaceutical waste waters and hospital effluents that are released into nearby water bodies without adequate treatment.

Plasma Bank

- It will be set up at Institute of Liver and Biliary Sciences (ILBS).
 - It will be made available to Government and Private Hospitals.
- It functions like a blood bank.
- It is created for those who are suffering from COVID-19 and have been advised for plasma therapy by doctors.
- Idea is to extract and store plasma from people who have recovered from COVID-19 and give it to someone suffering from the disease.

Convalescent Plasma Therapy

- It uses antibodies developed in recovered patient against coronavirus.
 - Plasma from such people is taken.
- It is then injected in critically ill patients so that antibodies are transferred and boost their fight against virus.
- Either blood fractionation process is used to separate plasma from donated blood.
 - Or a special machine called aphaeresis machine is used for it.

Plasma

- It transports nutrient, Hormones, Proteins.
- It is yellow liquid which makes about 55% of body's blood volume.

Red Blood Cells

- It carries fresh O₂ through blood and removes CO₂.
- It makes up 40-45% of blood.

White Blood Cells

- It is part of body's immune system.
- It detects, fights virus and bacteria.
- There are 5 major types of WBCs and makes upto 1% of blood.

Platelets

- It forms clots to stop bleeding.
- It makes up less than 1% of blood.

Antimicrobial Chemical Triclosan

- Triclosan can cause neurotoxic effects and damage neurons.
- It is used as antimicrobial chemicals to increase shelf life of consumer products.
- It is added to personal care products, as: Hand Soaps, Cosmetics, Athletic Clothing, Food Packaging.

Alternative Medicines (Traditional, Complementary, Integrated, Integrative Medicine)

- News Context: Parliament passed 3 Bills related to it.
 - National Commission for Indian System of Medicine (NCISM) Act, 2020.
 - National Commission for Homoeopathy (NCH) Act, 2020
 - Institute of Teaching and Research in Ayurveda (ITRA) Act, 2020.

Alternative Medicine System in India

- It is any practice, to achieve healing effects of medicine.
 - But which lacks biological plausibility and is untested, untestable, or proven ineffective.
- In India, it is known as **Indian System of Medicine (ISM)**.
- ISM comprises AYUSH streams (Ayurveda, Unani, Yoga, Naturopathy, Siddha, Homeopathy).

National Commission for Indian System of Medicine Act (NCISM), 2020

- It repeals Indian Medicine Central Council Act, 1970.
- It will provide a medical education system which ensures:
 - Availability of high-quality medical professionals of Indian System of Medicine.

Synopsis IAS

207, Apsara Arcade, Karolbagh delhi-5

- Adoption of latest medical research by medical professionals.
- Periodic assessment of medical institutions.
- **Advisory Council for Indian System of Medicine:**
 - It will be primary platform through which states and UTs can put forth their views and concerns before NCISM.
 - Council will advise NCISM to maintain minimum standards of medical education.
- **Entrance Examinations:** For under-graduates to get admission.
- **Common Final year National Exit Test:** To obtain license for practice.
- There will also be **Uniform Post-Graduate National Entrance Test.**

National Commission for Homoeopathy (NCH) Act, 2020

- It repeals Homoeopathy Central Council Act, 1973.
- It provides medical education system which ensures availability of adequate and high quality homoeopathic medical professionals, etc.
- **Functions:** Same as of NCISM but with regards to Homeopathy.
- **Autonomous Boards:** Act sets up certain autonomous boards under supervision of NCH. These are:
 - Advisory Council for Homoeopathy
 - Entrance examinations for UG, PG and license for practice.
 - National Teachers' Eligibility Test
- **Appeal on matters related to professional and ethical misconduct:**
 - State Medical Councils and Board of Ethics and Medical Registration for Homoeopathy have power to take disciplinary action against medical practitioner.

Institute of Teaching and Research in Ayurveda (ITRA) Act, 2020

- It merges 3 Ayurveda institutes into 1 institution by name of **ITRA**:
 - Institute of Post Graduate Teaching and Research in Ayurveda, Jamnagar,
 - Shree Gulabkunverba Ayurveda Mahavidyalaya, Jamnagar, and,
 - Indian Institute of Ayurvedic Pharmaceutical Sciences, Jamnagar.
- It will be situated at **Gujarat Ayurveda University, Jamnagar**.
- **Members: 15.**
 - AYUSH Minister, Director-General, Central Council for Research in Ayurveda.
 - 3 experts in Ayurveda with expertise in education, Industry and Research.
 - 3 Members of Parliament.
- **Note:** It will be declared as **Institute of National importance**.

Institute of National Importance (INI)

- **As per Education Ministry:**
 - It is a status of premier public higher education institution in India.

- Which serves as a **pivotal player in developing highly skilled personnel within specified region** of country or state.
- This status is **granted by an act of Parliament**.
- **Note:** at present, there are 159 INI institutes.
- ITRA will be 1st institution with INI status in AYUSH Sector.

Assisted Reproductive Technology (ART)

- It includes **medical procedures used primarily to address infertility**.
- It involves **procedures such as:**
 - In Vitro Fertilization (IVF), Intracytoplasmic Sperm Injection (ICSI).
 - **Cryopreservation of gametes or embryos, use of fertility medication.**
- When used to address infertility, ART may also be referred to as **fertility treatment**.
- ART belongs to field of reproductive endocrinology and infertility.
- Some forms of ART may be used **about fertile couples for genetic purpose**.
- News Context: ART (Regulation) Bill, 2020, was introduced in Lok Sabha.
- Objective: To standardise protocols of growing fertility industry and to regulate ART services.
- It is 3rd proposed legislation to protect reproductive rights of women after:
 - Surrogacy Regulation Bill 2019.
 - Medical Termination of Pregnancy Amendment Bill, 2020.

Provisions of Bill:

- It will include all techniques that:
- Obtains a **pregnancy by handling sperm or oocyte** (immature egg cell) outside human body and transfer **gamete or embryo** into reproductive system of a woman.
- Eg of ART services include:
 - Gamete (sperm or oocyte) Donation.
 - In-vitro-fertilisation (fertilising an egg in the lab).
 - Gestational surrogacy (Child is not biologically related to surrogate mother).
- ART services will be provided through:
 - ART clinics: Which offer ART related treatments and procedures.
 - ART Banks: Which store and supply gametes.
- Regulation of ART clinics and banks: Every ART clinic and bank must be registered under **National Registry of Banks and Clinics of India**.
- Conditions for gamete donation and supply, offering ART services have also been prescribed.
- Rights of a child born through ART:
 - A child born through ART will be deemed to be a **biological child of commissioning couple**.
 - It will be entitled to rights and privileges available to a natural child of commissioning couple.
 - A donor will not have any parental rights over the child.

- National and State Boards: It will regulate ART services.
 - State Boards will coordinate enforcement of policies and guidelines for ART as per recommendations, policies, and regulations of the National Board.
- Offences and penalties for:
 - Abandoning, or exploiting children born through ART.
 - Selling, purchasing, trading, or importing human embryos or gametes.
 - Using intermediates to obtain donors.
 - Exploiting commissioning couple, woman, or gamete donor in any form.
 - Transferring human embryo into a male or an Animal.

Monoclonal Antibodies (mAbs)

- They are **man-made proteins that act like human antibodies in immune system**.
- **Antibodies are proteins that are released naturally by body's immune system** to fight pathogens.
- They are called **mAbs when produced by identical immune cells**.
 - That are all **clones of a unique parent cell**.
- Unlike a vaccine, that protects a person from future infection.
- Antibodies help in treating infected patients by providing **passive immunization**.
- There are **4 different ways to make Mabs and named based on what they are made of:**
 - **Murine:** Made from mouse proteins and names of treatments end in -omab.
 - **Chimeric:** A combination of part mouse and part human protein and names of treatments end in - ximab.
 - **Humanized:** Made from small parts of mouse proteins attached to human proteins and names of treatments end in -zumab
 - **Human:** Fully human proteins and names of treatments end in -umab.
- mABs have more potential, as they are derived from a single recovered cell and have a targeted response.
- They can either be used alone or in combination with other therapies to neutralize virus in body.
- In case of covid-19, mABs target specific spike proteins on virus surface, which facilitates entry into host cells.
- Apart from therapeutics, mABs could also be useful for antigen-detection tests and serological assays targeting.
- It is a natural extension of convalescent plasma therapy (CPT) and in future can replace CPT.
- News Context: New Millennium Indian Technology Leadership Initiative (NMITLI) program is approved as **multi-institutional project**.
 - It is to develop hmAbs that can neutralize SARS-CoV-2 in patients.

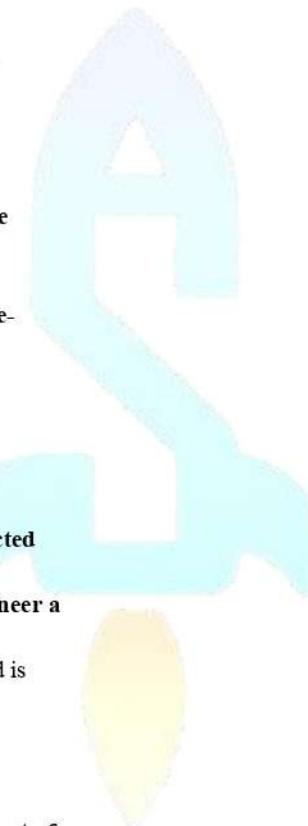
Human Growth Hormone (hGH)

- News Context: Pardeep Singh (2018 Commonwealth Games silver medallist), is suspended provisionally after his blood sample tested positive for hGH.

- It is produced in body and secreted by pituitary gland near base of brain.
- It helps in bone, organ, cartilage growth, helps in repairing damaged muscles.
- It is banned both in and out-of-competition by World Anti Doping Agency.

Rheumatoid Arthritis

- It is an autoimmune disorder that affects joints in feet and hands.
 - Zinc levels are reported to get reduced in such patients.
- Scientists have formulated nanoparticles with chitosan.
 - These are loaded with zinc gluconate for reducing severity of rheumatoid arthritis.
- Chitosan is a natural polysaccharide obtained from exoskeleton of Crustaceans.
- It is biodegradable, Biocompatible, Non-toxic, Mucoadhesive in nature.



Pneumosil

- It is India's 1st pneumococcal conjugate vaccine (PCV).
- Pneumosil targets pneumococcal bacterium.
- Which causes pneumonia and other serious life-threatening diseases such as:
 - Meningitis and Sepsis.

Plant Based Vaccine (PBV)

- It is an affordable and efficient alternative for vaccination.
- PBV are a kind of recombinant vaccines that introduce antigens against pathogens into selected plant.
- Rather than replicating a virus, it aims to engineer a virus-like protein (VLP) in living plants.
- When administered, a VLP mimics a virus and is recognised by immune system, thus eliciting a protective response.

New Organ in Throat

- It is a set of salivary glands set deep in upper part of throat.
- It is about 1.5 inches (3.9 cm) in length on average and are located over a piece of cartilage called Torus Tubarius.
- This discovery may be important for cancer treatment.

Antisera

- They are blood sera that contain antibodies against a specific viral toxin or antigen.
- This therapy works like plasma therapy.
 - But here plasma is obtained from horses that have recovered from viral infection.

Sero-Survey

- It involves testing of blood serum of a group of individuals.
- It helps in monitoring Covid-19 trends and to check for community transmission.
- It was conducted by ICMR and National Centre for Disease Control.

- Some other tests for testing COVID-19:

- Rapid Antigen Test (RAT), TrueNAT.
- CB-NAAT or Cartridge Based Nucleic Acid Amplification Test (Genexpert Test).