IAS PARLIAMENT

TARGET 2024

SCIENCE & TECHNOLOGY

MAY 2023 TO DECEMBER 2023

iasparliament.com
shankariasacademy.com

Total number of questions directly reflected from IAS Parliament (including Target 2023 series)	22
Number of questions directly reflected from the Target Series 2023	15
Total number of questions partially reflected from IAS Parliament	20

INDEX

TARGET 2024

SCIENCE & TECHNOLOGY

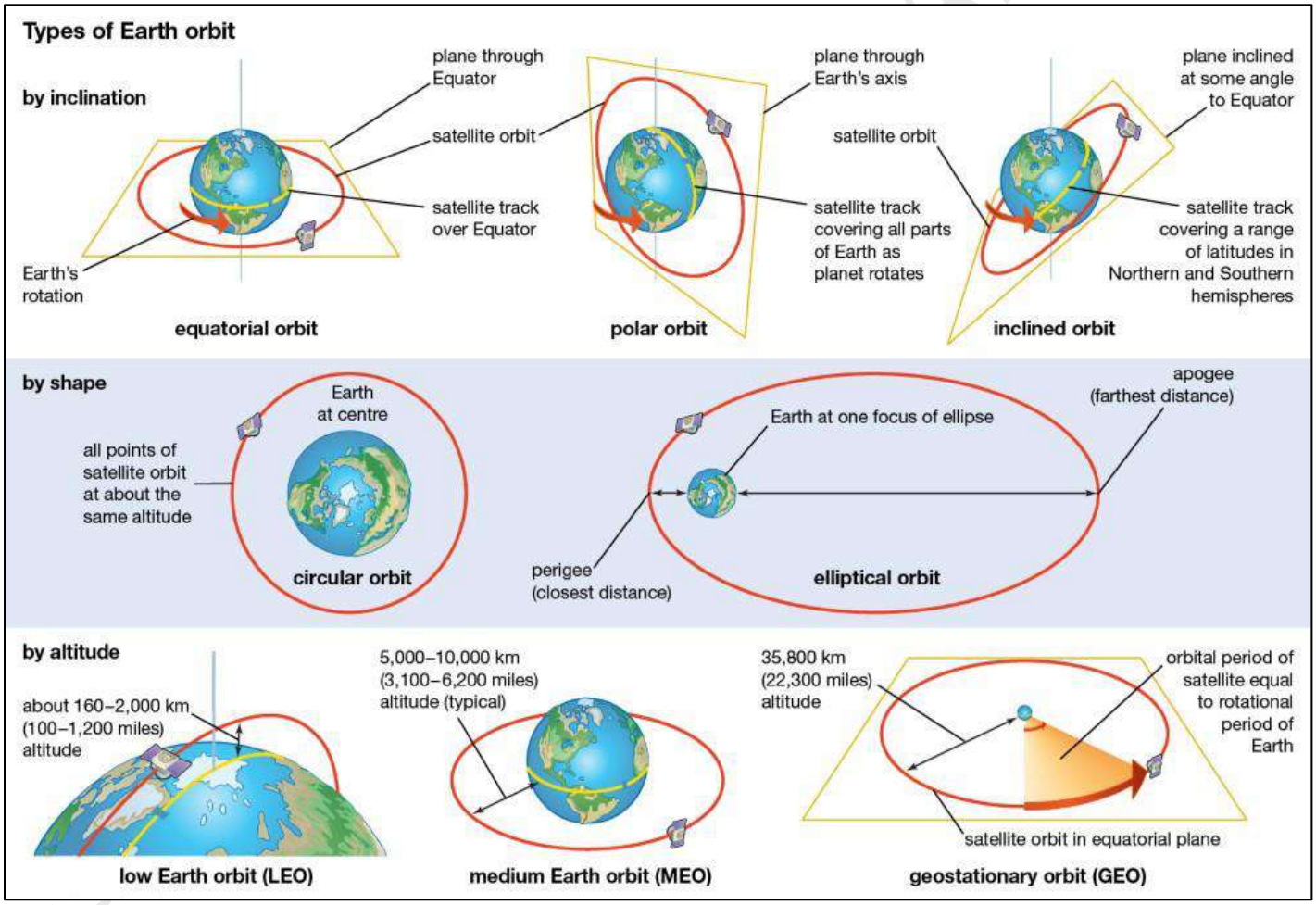
May 2023 to December 2023

1. SPACE TECHNOLOGY

INTRODUCTION

1.1 Types of Orbits

- There are different satellite orbits that can be used depending upon satellite's functions and area it is to serve.
- Most satellites, International Space Station, Space Shuttle, and Hubble Space Telescope are in Low Earth Orbit.



Orbit	About	Observation	Application
Polar Orbit	Satellites placed in polar orbits have an inclination of about 90 degrees to the equator and travels north-south over the poles at lower altitudes.	Satellites in polar orbit approx. takes 90 minutes for a full rotation. As a result, a satellite can observe the entire surface in 24 hours.	Monitoring crops, forests and even global security

Sun Synchronous Orbit	Special case of Polar Orbit moving from pole to pole allowing satellite to pass over any given point of the planet's surface at roughly the same local time each day	Since there are 365 days in a year and 360 degrees in a circle, the satellite has to shift its orbit by 1 degree per day.	Used for satellites that need a constant amount of sunlight and are useful for imaging, spy, and weather satellites.
Geosynchronous orbit	It is located at 35,790 km and has the same orbital period as the sidereal rotation period of the Earth (can have any inclination).	Allows satellites to synchronize with the rotation of Earth (only in time and not in direction).	Telecommunications and other remote sensing applications.
Geostationary orbit	Type of Geosynchronous orbit but satellite rotates in the same direction as the rotation of the Earth and has an approximate 24-hour period (lie on the same plane as the equator).	The satellite placed in geostationary orbit remains in the same position relative to the Earth.	Direct broadcast as well as communications or relay systems.

1.2 Launch Vehicles

- Launch Vehicles are used to transport and put satellites or spacecrafts into space.
- In India, the launch vehicles development programme began in the early 1970s.

Historic Launchers

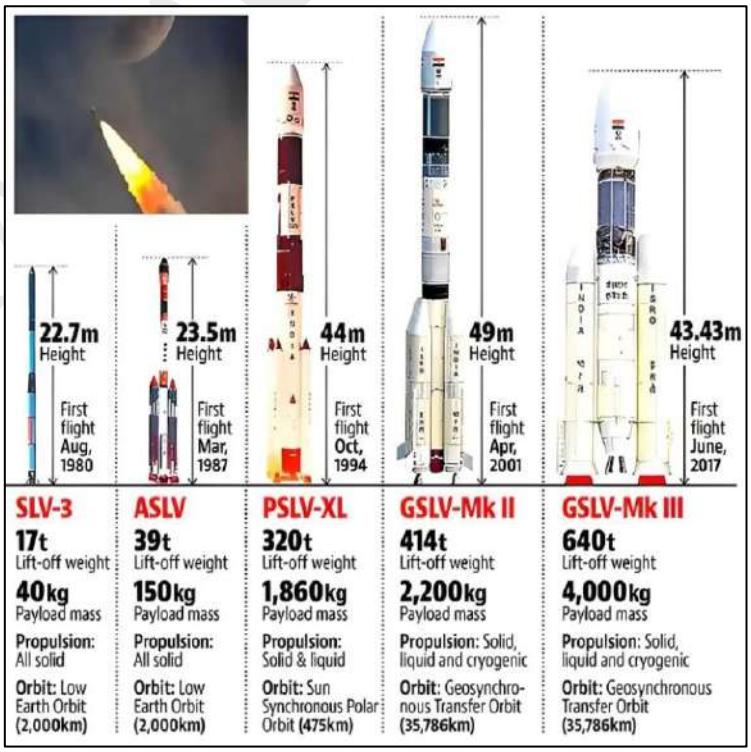
- Satellite Launch Vehicle (SLV – 3)
- Augmented Satellite Launch Vehicle (ASLV)

Operational Launchers

- Polar Satellite Launch Vehicle (PSLV)
- Geosynchronous Satellite Launch Vehicle (GSLV)
- Sounding Rockets
- Small Satellite Launch Vehicle

Future Launchers

- Reusable Launch Vehicle – Technology Demonstrator (RLV-TD)



Satellite Launch Vehicle (SLV – 3)

- India's first experimental satellite launch vehicle was successfully launched in 1980 from SHAR Centre Sriharikota, when Rohini satellite, RS-1, was placed in orbit.

Augmented Satellite Launch Vehicle (ASLV)

- Developed in ***1992*** to act as a low-cost intermediate vehicle to demonstrate & validate critical technologies.
- Under the ASLV programme, 4 developmental flights were conducted.

Polar Satellite Launch Vehicle (PSLV)

- ***3rd generation*** launch vehicle and first Indian launch vehicle to be equipped with *liquid stages.*
- PSLV emerged as the ***reliable and versatile workhorse launch vehicle of India***.
- It successfully launched two spacecraft such as *Chandrayaan-1 in 2008 and Mars Orbiter Spacecraft in 2013.*
- 3 variations in PSLV - ***PSLV-G (General), PSLV-XL variants and PSLV-CA (Core Alone).***
- It has 4 stages in its operation to provide thrust in launching spacecraft to different orbits.
- **Stage I**: It uses **solid** rocket motor that is augmented by 6 solid strap-on boosters. Strap on boosters is used only in G and XL variation.
- **Stage II**: It uses an Earth storable **liquid** rocket engine, known as the ***Vikas engine.***
- **Stage III**: It uses **solid** rocket motor that provides high thrust after the atmospheric phase of the launch.
- **Stage IV**: It comprises two Earth storable **liquid** engines.
- **Capacity** - 1,750 kg of payload to Sun-Synchronous Polar Orbits of 600 km altitude.
- 1,425 kg of payload to Geosynchronous and Geostationary orbits, like satellites from the IRNSS constellation.
- **PSLV launches–** EOS 06, EOS 04, Amazonia-1, RISAT-2BR1, CARTOSAT-3, Chandrayaan-1, MOM, IRNSS.

Geosynchronous Satellite Launch Vehicle (GSLV)

- ***4th generation*** launch vehicle, a 3-stage vehicle with 4 liquid strap-on boosters.
  1. **Stage I**: It uses ***solid rocket*** motor with 4 liquid strap-ons.
  2. **Stage II**: It uses ***liquid rocket*** engine (similar to vikas engine of PSLV stage II).
  3. **Stage III**: It uses India's ***first cryogenic engine*** (CE-7.5) in the upper stage. It enabled the launching of 2000 kg of communication satellites.
- **Capacity -** 5000 kg of pay load to Low Earth Orbits (LEO)
- 2500 kg of payload to Geosynchronous Transfer Orbit (GTO), primarily INSAT class communication satellites.
- **GSLV Launches -** EOS 03, GSAT-7A, GSAT-6A, INSAT-3DR

Sounding Rockets

- Sounding rockets are ***one or two stage solid propellant rockets*** used for probing the upper atmospheric regions and for space research.
- They serve as platforms to test or prove prototypes of new components or subsystems intended for use in launch vehicles and satellites.
- It is possible to conduct coordinated campaigns by simultaneously launching sounding rockets from different locations in a single day.
- ISRO started launching indigenously made sounding rockets from 1965.

Operational sounding Rockets

Currently, three versions are offered as operational sounding rockets , which cover a payload range of 8-100 Kg and an apogee range of 80-475 km.

Vehicle	RH-200	RH-300-Mk-II	RH-560-MK-II
Payload (in kg)	10	60	100
Altitude (in km)	80	160	470
Purpose	Meterology	Aeronomy	Aeronomy
Launch Pad	Thumba Balasore	SDSC-SHAR	SDSC-SHAR

- In 1975, ISRO consolidated all its sounding rocket activities under ***the Rohini Sounding Rocket (RSR) Programme.***
- ***RH-75*** was the first truly Indian sounding rocket from the Thumba Equatorial Rocket Launching Station (TERLS) [Numbers in the name indicates the diameter of the rocket in mm].

Reusable Launch Vehicle – Technology Demonstrator (RLV-TD)

- RLV-TD is a fully reusable launch vehicle to enable low-cost access to space.
- Its configuration is similar to that of an aircraft and combines the complexity of both launch vehicle and aircraft.

Small Satellite Launch Vehicle

- It is a 3-stage launch vehicle configured with ***three Solid Propulsion Stages*** and *liquid propulsion-based Velocity Trimming Module (VTM)* as a terminal stage.
- **Payload capability** - 500 kg to 500 km planar orbit or 300 kg to Sun Synchronous Polar Orbit.
- Unlike the PSLV and GSLV, the SSLV can be ***assembled both vertically and horizontally.***
- **Key features**
  - Low cost with low turn-around time
  - Flexibility in accommodating multiple satellites
  - Launch on demand feasibility
  - Minimal launch infrastructure requirements

1.3 Types of Satellites

Satellite Type	Applications	Examples
Communication Satellites	Telecommunication, television broadcasting, satellite newsgathering, weather forecasting, disaster warning and Search and Rescue operations.	The Indian National Satellite (INSAT) series (INSAT-3A, 3C, 4A, 4B, 4CR), GSAT series
Earth Observation Satellites	Agriculture, water resources, urban planning, rural development, mineral prospecting, environment, forestry, ocean resources and disaster management.	Indian Remote Sensing (IRS) series, RESOURCESAT-1, 2, 2A, CARTOSAT-1, 2, 2A, 2B, RISAT-1 and 2, OCEANSAT-2, INSAT -3DR
Navigation Satellites	Used to meet the emerging demand of positioning, navigation and timing and also civil aviation requirements.	GAGAN and IRNSS (NAVIC)
Space Science and Exploration Satellites	Encompasses research in areas like astronomy, astrophysics, planetary and earth sciences, atmospheric sciences and theoretical physics.	Mars Orbiter Mission, AstroSat, Chandrayaan -1,2

- **GPS Aided GEO Augmented Navigation (GAGAN),** is implemented jointly by ISRO and Airport Authority of India (AAI).
- The main objectives of GAGAN are to provide Satellite-based Navigation services with accuracy and integrity required for civil aviation applications and to provide better Air Traffic Management over Indian Airspace.

1.4 Propellants

- Propellant is the chemical mixture burned to produce thrust in rockets and consists of a ***fuel and an oxidizer***.

Propellant	Description
Solid Propellant	They consist of a casing filled with a mixture of solid compounds (fuel and oxidizer) which burn at a rapid rate, expelling hot gases from a nozzle to produce thrust.
Liquid Propellant	The fuel and oxidizer are stored in separate tanks (liquid form), and are fed to a combustion chamber where they are combined and burned to produce thrust.
Cryogenic Propellants	Cryogenic propellants are liquefied gases stored at very low temperatures Example- ***Liquid hydrogen (LH2)*** as fuel and ***liquid oxygen (LO2 or LOX)*** as oxidizer.
Hybrid Propellants	One of the substances is solid, usually the fuel, while the other, usually the oxidizer, is liquid.

Hypergolic Propellants	Hypergolic propellants are fuels and oxidizers that ignite spontaneously on contact with each other and require *no ignition source*.
Green Propellants	The propellants are based on ***Glycidyl Azide Polymer (GAP)*** as fuel and ***Ammonium Di-Nitramide (ADN)*** as oxidizer. Green propellant combinations - *Hydrogen Peroxide (H2O2), Kerosene, Liquid Oxygen (LOX), Liquid Methane* ISRO has successfully developed ***ISROSENE***, a rocket grade version of kerosene as an alternative to conventional hydrazine rocket fuel.

1.5 Engine

Vikas Engine

- The Vikas is a ***liquid fueled rocket*** engine built by ISRO.
- The engine uses up about 40 metric tons of ***Unsymmetrical dimethylhydrazine (UDMH)*** as fuel and ***Nitrogen tetroxide (N_2O_4)*** as oxidizer with a maximum thrust of 725 kN.
- It was developed by Nambi Narayanan and his team during the 1970s. It is similar to *Viking rocket engines*.
- The Vikas Engine is the workhorse liquid rocket engine powering
    - The second stage of India's Polar Satellite Launch Vehicle (PSLV),
    - The second stage and the four strap on stages of Geosynchronous Launch Vehicle (GSLV) and
    - The twin engine core liquid stage (L110) of GSLV Mk-III.

Cryogenic Engine

- Cryogenic engine makes use of ***Liquid Oxygen (LOX)*** and ***Liquid Hydrogen (LH2)*** as propellants which liquefy at ***-183 deg C and -253 deg C*** respectively.
- The ISRO has successfully conducted the hot test of CE20 cryogenic engine, which has been indigenously developed for LVM3.

Scramjet Engine

- Nearly, 70% of the propellant by weight consists of oxidiser. Therefore, air-breathing propulsion system which can utilise the atmospheric oxygen during their flight is being developed by various space agencies.
- Ramjet, Scramjet and Dual Mode Ramjet (DMRJ) are the three concepts of air-breathing engines.
- *India is the 4th country* (after USA, Russia and Europe) to demonstrate flight testing of Scramjet Engine.

Engine Type	Description
Ramjet engine	Uses the vehicle's forward motion to compress incoming air for combustion without a rotating compressor It works most efficiently at *supersonic speeds* around **Mach 3** (3 times the speed of sound) and can operate up to speeds of **Mach 6.** However, the ramjet efficiency starts to drop when the vehicle reaches hypersonic speeds.
Scramjet (Supersonic Combustion Ramjet) engine	It efficiently operates at *hypersonic speeds* and allows supersonic combustion. ISRO's ***Advanced Technology Vehicle (ATV),*** an advanced sounding rocket, was the solid rocket booster used for test of Scramjet engines at supersonic conditions.
Dual mode ramjet (DMRJ)	A type of jet engine where a ramjet ***transforms into scramjet over Mach 4-8 range***, it can efficiently operate both in subsonic and supersonic combustor modes.

1.6 Brief History of ISRO

- Indian Space Research Organisation (ISRO) is the space agency of India.
- **Role-** Involved in science and engineering to harvest the benefits of outer space for India and the mankind.
- **Formation** - On August 15, 1969 and superseded *Indian National Committee for Space Research (INCOSPAR),* set up in 1962 by Dr. Vikram Sarabhai with an expanded role to harness space technology.
- Department of Space (DoS) was set up and ISRO was brought ***under DoS*** in 1972.
- **Objective-** Development and application of space technology for various national needs.
- **Space system**- ISRO has established major space systems for
  - Communication, television broadcasting & meteorological services
  - Resources monitoring and management;
  - Space-based navigation services.

Dr.Vikram Sarabhai is known as father of Indian Space Programme.

Specifications	Locations
Headquarters of ISRO	Bengaluru, Karnataka
Launch Vehicles	Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram
Satellites	U R Rao Satellite Centre (URSC), Bengaluru
Integration and launching of satellites and launch vehicles	Satish Dhawan Space Centre (SDSC), Sriharikota
Development of liquid stages including cryogenic stage	Liquid Propulsion Systems Centre at Thiruvananthapuram and Bengaluru
Sensors for Communication and Remote Sensing satellites	Space Applications Centre (SAC), Ahmedabad
Remote Sensing satellite data reception processing and dissemination	National Remote Sensing Centre (NRSC), Hyderabad

Planetary explorations of ISRO

- **Mangalyaan-** It is the *maiden interplanetary mission of the ISRO* to explore and observe Mars surface features, morphology, mineralogy and the Martian atmosphere.
- Launched in *2013*, the probe was successfully inserted into Martian orbit in 2014 in its first attempt.
- ISRO was the 4th agency to reach the Mars orbit after Russia's Roscosmos, NASA, and ESA.
- **Moon exploration**-
  - **Chandrayaan-1** - Chandrayaan-1's orbiter detected the evidence of water on the Moon. It was launched on 2008.
  - **Chandrayaan-2-** It is India's first lander mission; it was launched in 2019.
  - **Chandrayaan-3-** With this, India becomes 1st country to land on Moon's South Pole and 4th country (after Russia, the U.S. and China) to land on the Moon.

Aryabhata, *launched in 1975, marked India's entry into the space era and became the forerunner of our space programme.*

1.7 Indian Space Policy 2023

The Indian Space Research Organisation (ISRO), released the Indian Space Policy 2023.

- The 'Vision' is to enable, encourage and develop a flourishing commercial presence in space economy.
- It defines the role of ISRO in socio-economic development, protection of environment, pursuing peaceful exploration of outer space, stimulation of public awareness and scientific quest.

- The policy creates 4 distinct entities that will facilitate greater private sector participation in activities that have usually been the traditional domain of the ISRO.
- **Indian National Space Promotion and Authorisation Centre (InSPACe)** – It will be a single window clearance and authorisation agency.
- It will provide clearance for space launches, establishing launch pads, buying and selling satellites, and disseminating high-resolution data among other things.
- It will also share technologies, products, processes and best practices with non-government entities (NGEs) and this will include private companies and government companies.
- **New Space India Limited (NSIL) –** It will be responsible for commercialising space technologies and platforms created through public expenditure.
- It is also responsible for manufacturing, leasing, or procuring space components, technologies, platforms and other assets from the private or public sector.
- **Department of Space –** It will provide overall policy guidelines and be the nodal department for implementing space technologies.
- It will also co-ordinate international cooperation and coordination in the area of global space governance and programmes in consultation with the Ministry of External Affairs.
- It will also create an appropriate mechanism to resolve disputes arising out of space activity.

INDIAN MISSIONS

1.8 Chandrayaan-3

The Indian Space Research Organization (ISRO) has launched the Chandrayaan-3.

- Chandrayaan-3 is India's 3rd lunar mission and a follow-on to the unsuccessful Chandrayaan-2.
- It will demonstrate India's end-to-end capability in safe landing and roving on the lunar surface.
- **Objective**
  1. To demonstrate safe and soft landing on the lunar surface
  2. To demonstrate rover roving on the moon
  3. To conduct in-situ (on-site) scientific experiments.
- It also aims to develop and demonstrate new technologies required for interplanetary missions.

> ***Chandrayaan-3*** *is the world's 1st mission to soft-land near the lunar South Pole and India 4th country to soft-land on the moon*

- Chandrayaan-3 was launched by **LVM3** from Satish Dhawan Space Centre, Sriharikota.
- **Modules** - Chandrayaan-3 spacecraft is a composite of three modules.
  1. A Propulsion module (PM): Life - 3-6 months
  2. An indigenous Lander module (LM) - ***Vikram***
  3. A Rover - ***Pragyan***
- **Slingshot Manoeuvre** - The Chandrayaan-3, like Chandrayaan-2, will circle the Earth 5-6 times, then sling off to the Moon.
- This manoeuvre uses Earth's gravity to impart velocity to the spacecraft thereby reducing the fuel used.

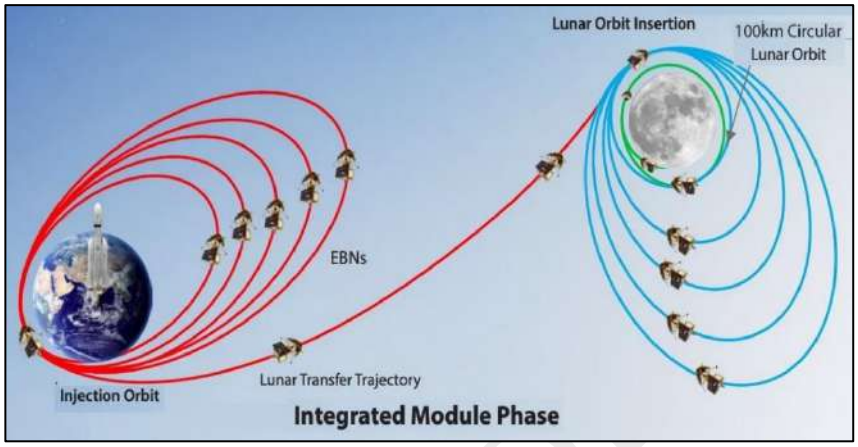
Launch Vehicle Mark-III (LVM3)

- It is a *three-stage* medium-lift launch vehicle developed by ISRO.
- Earlier known as '***GSLV Mk-III'***, it is the most powerful rocket in the ISRO's stable.
- It includes 2 solid boosters, the core liquid fuel-based stage, and the cryogenic upper stage which uses cryogenic engine (CE20).
- It can carry a payload of up to 8,000 kgs to a low-Earth orbit (LEO) and about 4,000 kgs to geostationary transfer orbit (GTO).
- LVM-3 was used also in launching Chandrayaan-2.

- **Lunar Orbit -** The module enters lunar orbit and the reverse will happen.
- Loop-by-loop the spacecraft will get closer to the moon until it reaches a circular path 100 km above the moon's surface before the lander separates.

- **On the Moon -** The lander will soft land at a specified lunar site (lunar South Pole) and deploy the rover.
- The rover will explore the lunar terrain for *14 Earth days* (1 lunar day) and will carry out in-situ chemical analysis of the lunar surface.

Payloads carried by Chandrayaaan-3



- **Propulsion Module payload**: It has one scientific payload - Spectro-polarimetry of Habitable Planet Earth (*SHAPE*) to study the spectral and Polari metric measurements of Earth from the lunar orbit.
- **Lander Module payloads:**
  1. ***ChaSTE*** (Chandra's Surface Thermophysical Experiment) - To measure the thermal conductivity and temperature;
  2. ***ILSA*** (Instrument for Lunar Seismic Activity) - For measuring the seismicity around the landing site;
  3. **LP (*Langmuir Probe*)** - To estimate the plasma density and its variations.
- **Rover payloads:** Has 2 payloads for deriving the elemental composition in the vicinity of landing site.
  1. Alpha Particle X-ray Spectrometer (APXS)
  2. Laser Induced Breakdown Spectroscope (LIBS)

Chandrayaan 4 is a lunar sample-return mission planned by ISRO and is expected to launch in 4 years.

Chandrayaan-3 vs Chandrayaan-2

- ISRO has designed Chandrayaan-3 with a ***failure-based approach***. , Chandrayaan-3 was upgraded with
  1. The lander incorporates enhanced features to ensure a successful landing by overcoming obstacles.
  2. The rover is equipped with *hazard detection and avoidance systems*, ensuring a safe traversal of the moon's surface.
- **Orbiter -** Chandrayaan-3 will not carry an orbiter but it will use data from the Chandrayaan-2 orbiter.
- **Landing site -** The site is at around 70 degree S near the Southern pole of the moon.
- It has been fed with high resolution pictures captured by the Chandrayaan-2 orbiter and does not depend only on pictures clicked during descent to determine landing.
- The landing area has also been expanded from a patch of 500mx500m to a broad 4kmx2.4km area.
- **Weight -** Due to the modifications made for a safe landing, the weight of the payload is slightly more than the previous mission.
- **More fuel -** Travel longer distances to the landing site or an alternate landing site, if needed.

Significance of Chandrayaan-3 mission

- It represents ISRO's commitment to expanding our understanding of the moon and beyond.
- ISRO aims to mitigate risks and ensure a successful mission, by taking a failure-based approach in its design.
- The mission's success will solidify India's position as a prominent player in the realm of space exploration.
- It has enormous promise for the future of space travel and interplanetary missions.
- The data from this is likely to benefit NASA's Artemis program, as India has signed NASA's Artemis Accord.

1.9 Aditya L1 Mission

Why in news?

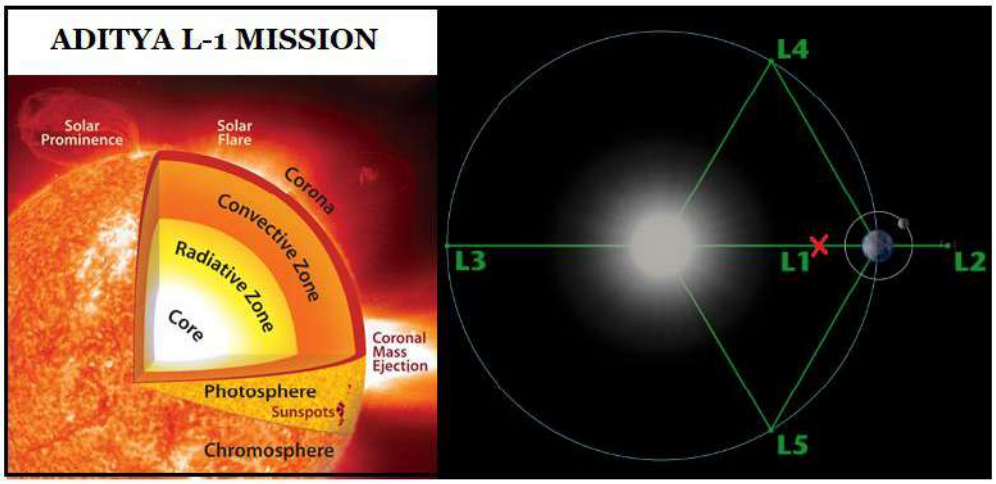
The Indian Space Research Organisation (ISRO) has placed the Aditya-L1 spacecraft in a halo orbit around the Lagrangian point (L1).

What is Aditya L1 Mission?

- **Aim-** To observe the Sun from a close distance, and try to obtain information about its atmosphere and magnetic field.
- **Payloads-** It is equipped with 7 payloads on board to study the
  - Photosphere, Chromosphere
  - Sun's corona, solar emissions, solar winds and flares
  - Coronal Mass Ejections (CMEs)

Aditya L1 shall be the first space based Indian mission to study the Sun.

- **Detectors-** It will carry out round-the-clock imaging of the Sun using electromagnetic and particle and magnetic field detectors.
- **Halo orbit-** The spacecraft shall be placed in a halo orbit around the ***Lagrange point 1 (L1)*** of the Sun-Earth system, which is about 1.5 million km from the Earth.



- Aditya L1 will perform continuous observations looking directly at the Sun.

What are the objectives of the mission?

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

What is the importance of placing the satellite in L1?

- **Lagrange points** - Lagrange points are positions in space where objects sent there tend to stay put.
- At Lagrange points, the ***gravitational pull of two large masses precisely equals the centripetal force required for a small object*** to move with them.
- These points in space can be used by spacecraft to reduce fuel consumption needed to remain in position.
- Of the five Lagrange points, three are unstable *(L1, L2 and L3)* and two are stable *(L4 and L5)*.
- **Importance of L1 -** The L1 point is about 1.5 million km from Earth, or about 1/100th of the way to the Sun

Lagrange point	Home to
L1	Solar and Heliospheric Observatory Satellite SOHO
L2	WMAP spacecraft; Current home of Planck; Future home of the James Webb Space Telescope

- A satellite placed in the halo orbit around L1 of the Sun-Earth system has the major advantage of ***continuously viewing the Sun without any occultation/eclipses.***

Why is studying the sun important?

- **Source for survival**- The ultimate source of energy for the Earth is nothing else but the sun.
- Without the sun life on Earth would not exist. It would be so cold that no living thing would be able to survive and our planet would be completely frozen.
- **Parent star-** The evolution of every planet, including Earth and the exoplanets beyond the Solar System is governed by its parent star.
- **Solar weather -** The solar weather and environment affect the weather of the entire system.
- **Solar storms-** Continuous solar observation is needed as it is important to learn about and track Earth-directed storms.

Heliophysics - *The science of studying the Sun and its influence throughout the solar system*

- Every storm that emerges from the Sun and heads towards Earth passes through L1.
- **To study universe**- The sun is a normal star that is much closer to us than any other star, and by studying the sun, we can learn more about other stars.
- The better we understand other stars, the more we know about the Milky Way. From there we know more about other galaxies and in the end, we learn more about the universe.
- **Gravity**- Sun creates gravity that keeps our planet and the other planets of the solar system in a small space, without this our planet would simply fly.

INTERNATIONAL MISSIONS TO SUN			
Mission	**Aim**	**Country**	**Year**
Helios 1 and 2	To study the solar wind from an orbit carrying the spacecraft inside Mercury's orbit.	US & Germany	1970
Pioneer 9	To measure solar wind and solar magnetic field)	U.S.A	1983
SOHO	Investigation of Sun's core, corona, and solar wind; comet discoveries	Europe & U.S.	1995
Yohkoh	To observe the solar flares at X-ray wavelengths	Japan	1991
Hinode	Exploring the Sun's magnetic field and outer atmosphere	Japan	2006
Solar Terrestrial Relations Observatory (STEREO) mission	To capture unseen images of Sun	U.S.A	2006
Interface Region Imaging Spectrograph (IRIS)	To study the solar atmosphere.	U.S.A	2013
Parker solar probe	To unlock the mysteries of the Sun's corona and solar wind.	U.S.A	2018
Aditya L1	Solar corona observation	India	2023

1.10 Visible Line Emission Coronagraph (VELC)

Aditya-L1 has been successfully launched from the Satish Dhawan Space Research Centre in Sriharikota recently carried the VELC payload.

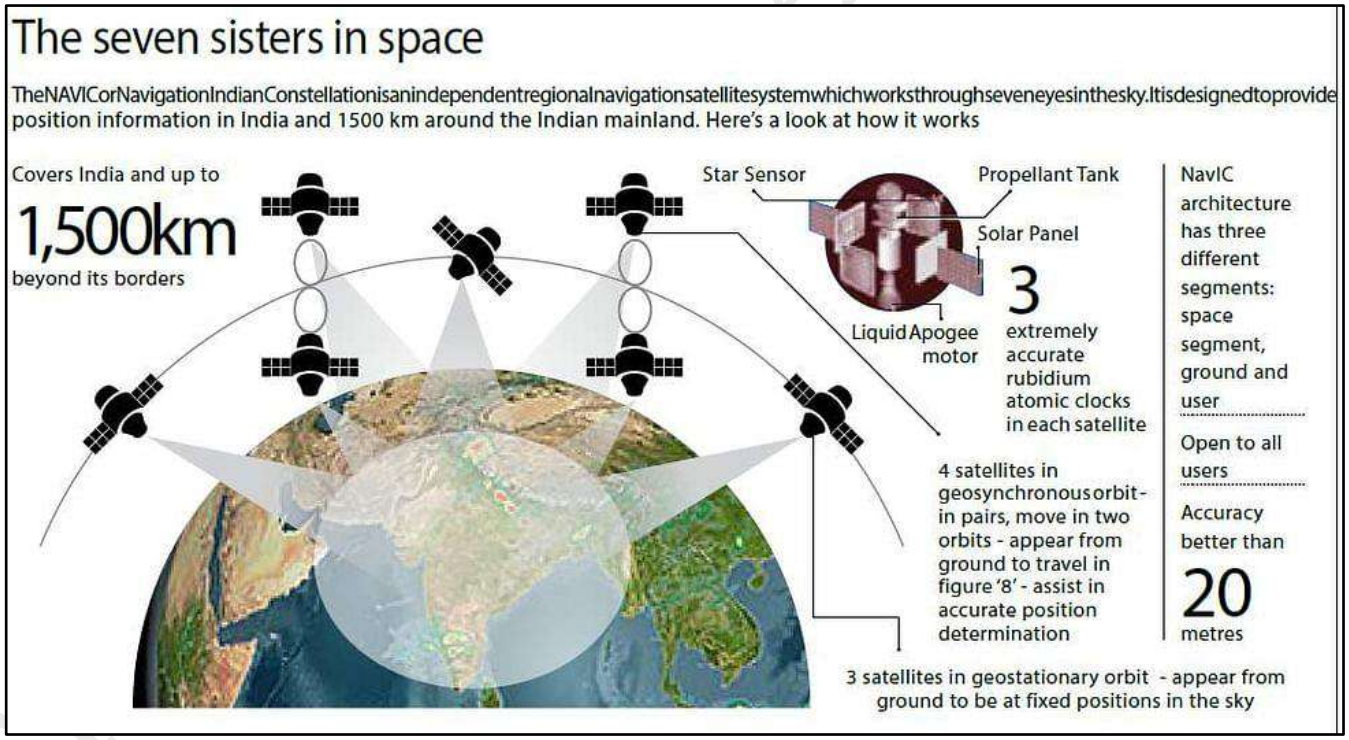
- The Aditya-L1 mission (first Sun mission from India) carried by the Polar Satellite Launch Vehicle (PSLV)-C57 rocket is equipped with seven payloads.
- Among these, the Visible Line Emission Coronagraph (VELC) is the primary payload that Aditya-L1 will use to focus on the Sun's Corona.

- **Landing Point -** Aditya-L1 will be placed in a halo orbit around Lagrangian Point 1 (L1), which is 1.5 million kilometers from Earth in the direction of the Sun.
- **Aim –** It will create a total solar eclipse continuously since it will be positioned at L1, providing an unobstructed view of the Sun.
- **Built by –** Indian Institute of Astrophysics (IIA).
- VELC has the capability to capture images of the solar corona closer to the Sun's disc than any other solar space observatory.
- This allows it to observe the Sun as if it were a solar eclipse, enabling the study of the corona and its characteristics, including its origin and the source of coronal mass ejections.

1.11 ISRO's NavIC satellite

The ISR) launched the first of the 2nd generation satellites for its navigation constellation successfully.

- NavIC (Navigation with Indian Constellation) is a *regional navigation satellite* system of India.
- It is erstwhile known as the ***Indian Regional Navigation Satellite System (IRNSS).***
- NavIC is designed with a constellation of ***7 satellites***, all launched by PSLV rockets - 3 satellites of the constellation are placed in *geostationary orbit* and the other 4 are placed in inclined *geosynchronous orbit.*
- Services offered: ***Standard Position Service (SPS)*** for civilian users and ***Restricted Service (RS)*** for strategic users.
- NavIC satellites will broadcast SPS signals in L1, L5 and S bands after the addition of NVS-01.
- RS signals will be broadcasted in L5 and S bands.



- **Second generation satellites** - They are *replacement satellite for the Indian Regional Navigation Satellite System.*
- The second-generation satellites will replace satellites located at a ***geosynchronous orbit*** with additional features.
- **NVS-01** - It is the first of the second-generation satellites envisaged for NavIC services.
- NVS-01 was launched by a Geosynchronous Satellite Launch Vehicle (GSLV) rocket.

New features in second generation satellites

- **Mission Life -** The second-generation satellites will also have a longer mission life of more than 12 years.

- **New band (L1) -** The NVS series incorporates L1 band signals additionally to increases the interoperability with other satellite-based global navigation systems widen the services.
- It will increase the use of NavIC in wearable devices and personal trackers that use low-power, single-frequency chips.
- **Atomic clock -** For the first time, an indigenous atomic clock will be flown in NVS-01.
- The satellite will have a Rubidium atomic clock onboard, indigenously developed by Space Application Centre-Ahmedabad.

Applications of NavIC constellation for users

- NavIC is in use for projects like public vehicle safety, power grid synchronisation, real-time train information systems, and fishermen's safety.
- Initiatives such as common alert protocol-based emergency warning and unmanned aerial vehicles are in the process of adopting NavIC system.
- The Ministry of Electronics and IT urging smartphone companies to make their handsets NavIC compatible.

Global Satellite-Based Navigation Systems

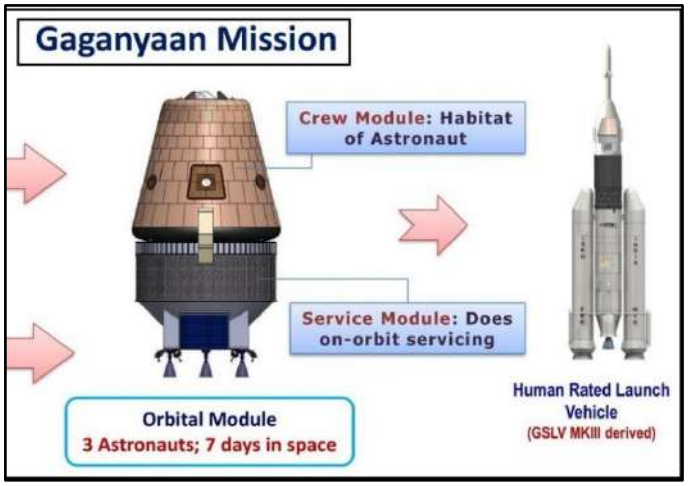
- The American GPS
- The Russian GLONASS
- The European Galileo
- The Chinese Beidou

Advantage of having a regional navigation system

- Japan has a 4-satellite system that can augment GPS signals over the country, similar to India's GAGAN.
- India is the only country that has a regional satellite-based navigation system.
- **Accuracy -** GPS signals are accurate up to around 20 metres whereas NavIC open signals will be accurate up to 5 metres and restricted signals will be even more accurate when fully operational.
- **Coverage -** NavIC provides coverage over the Indian landmass and up to a radius of 1,500 km around it.
- **Consistency -** NavIC uses satellites in high geo-stationery orbit which enables the satellite to look over the same region on Earth always.
- **Penetration -** NavIC signals come to India at a 90-degree angle, making it easier for them to reach devices located even in congested areas, dense forests, or mountains.

1.12 Gaganyaan Mission

ISRO successfully demonstrated the TV D1 mission, the first uncrewed developmental flight of 'Gaganyaan' human spaceflight mission.



- India's first human space mission.
- **Mission of -** Indian Space Research Organisation (ISRO)
- **Objective-** To send humans into space on a *Low Earth Orbit of 400 km for 3 days* and bring them safely back to the Earth
- **Timeline -** By 2025
- **Components** - Crew module (CM) and the service module (SM), which together will form the orbital module.
    - **Crew Module**- It is the habitable space with Earth like environment in space for the crew and is designed for re-entry to ensure safety of the crew during descent till touchdown.
    - **Service Module**- It is an unpressurized structure that will be used for providing necessary support to CM while in orbit.
- **Launch Vehicle** - *Launch Vehicle Mark III (LVM3)*
- **Other features** - For Gaganyaan, ISRO signed an agreement with Russia's Glavkosmos to select and train Indian astronauts.

If it succeeds, India will become only the 4th country to send a human into space after the Soviet Union, the US, and China.

- The US has also offered to provide advanced training to the astronauts selected for the Gaganyaan.
- The second phase of this mission will involve the launch of ***Vyommitra***, a female spacefaring half humanoid robot that will function as a prototype for the Gaganyaan missions.
- Astronaut training facility is established in *Bengaluru.*

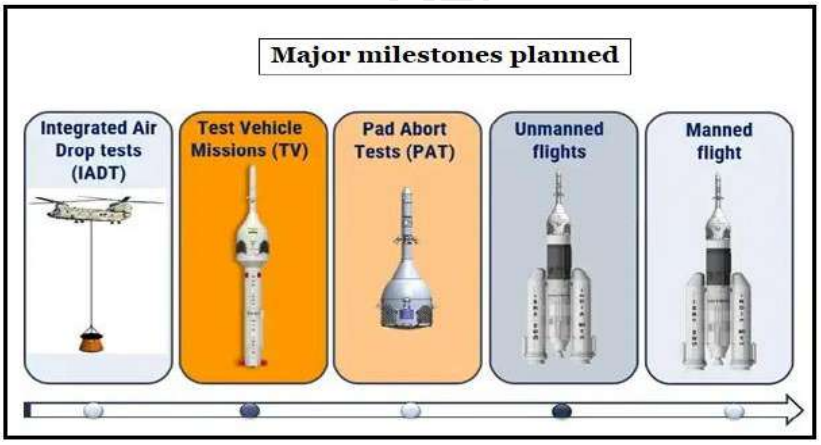
Tests planned as a part of the mission

- **Integrated Air Drop Tests-** It involve dropping a simulated crew module from an aircraft and deploying parachutes to slow down its descent and land safely in the sea.
- The tests also verify the performance of the flotation system.

LVM3 & HLVM3

- LVM3 - It is the heaviest rocket of ISRO.
- It was earlier called Geosynchronous Launch Vehicle Mark III (GSLV Mk III).
- Consists of 3 stages - solid, liquid & cryogenic stage.
- **HLVM3**- All systems in LVM3 launch vehicle are re-configured to meet human rating requirements and christened Human Rated LVM3.
- Consists of Crew escape system which ensures that Crew Module along with crew is taken to a safe distance in case of any emergency.

- **Test Vehicle Missions-** It involve launching a single-stage liquid propulsion rocket, equipped with a crew module and a crew escape system.
    - Test Vehicle Abort Mission-1 (TV-D1) was successfully demonstrated by the ISRO recently.
- **Pad Abort Tests (PAT)-** It is a test of a launch escape system, which is designed to quickly get the crew and spacecraft away from the rocket in case of an emergency on the launch pad.
- **Uncrewed mission-** Its purpose is technology demonstration, safety and reliability verification and studying the performance of systems before crewed flight.
- **Manned flight mission-** It carries human crew members who operates its control and performs various tasks.



Test Vehicle Abort Mission-1 (TV-D1)

- It is an in-flight *abort demonstration of Crew Escape System (CES)* at Mach number 1.2 followed by Crew Module separation and safe recovery.
- TV- D1 features a *single-stage rocket* powered by liquid propellants for this mission.

1.13 India's First Satellite Network Portal Site

OneWeb is to set up India's first 'satellite network portal site' through a MoU signed with Gujarat government in Gujarat.

- **OneWeb -** OneWeb is a Low Earth Orbit (LEO) satellite company aiming to establish a global communication network.
- It offers broadband Internet access with lower latency of less than 100 ms, by utilizing LEO satellites.
- The GEO-based networks by traditional geostationary satellites provide efficient network services with latencies of 500-700 ms.
- The technology is currently working in Europe and Canada.

India's 1st round-the-clock solar-powered village Modhera is also located in Mehsana district.

Key features of the project

- **Location -** The satellite network portal is to be set up in *Katosan and Tejpura, Mehsana district of Gujarat.*
- Gujarat was chosen as the site for its combination of geographical and business interests.

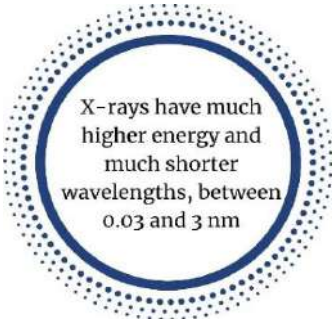
- Long coastline - Caters maritime interests
- Business - Policy and incentives available in Gujarat met with OneWeb's needs

- **Cost -** It is scheduled to launch in 2023 with an estimated cost of over Rs. 100 crores for its Phase-1.
- **Regulatory Approvals -** Setting up an SNP like this will require regulatory approvals from Indian National Space Promotion and Authorisation Centre *(IN-SPACe), Ahmedabad* and spectrum allocation from the *Telecom Regulatory Authority of India (TRAI) and DoT (Department of Telecom).*
- **Role of DST -** DST Gujarat handles telecommunications and the Gujarat Electronics Policy (2022-2028).
- So, DST-Gujarat will facilitate fiscal, non-fiscal incentives and assistance with regulatory and statutory approvals, such as change of land use, building permits, and fibre connectivity.

Satellite broadband technology
• Also known as satellite telephony, it is a satellite communication technology using satellite constellations in the Low Earth Orbit (LEO). • StarLink, Kuiper and OneWeb are some of the forerunners in this technology. • LEO satellites operate at an altitude of 500 to 1,200 km. • The lesser distance offers high-speed and low latency.

1.14 XPoSat

The XPoSat was launched by the Indian Space Research Organisation (ISRO).



- The X-Ray Polarimeter Satellite (XPoSat) is being built in collaboration with the ***Raman Research Institute (RRI), Bengaluru***
- ***India's first, and only the world's second*** polarimetry mission.
- It is meant to study various dynamics of bright astronomical X-ray sources in extreme conditions.
- **IXPE -** The first polarimetry mission is NASA's Imaging X-ray Polarimetry Explorer (IXPE) that was launched in 2021.
- **Payloads -** The spacecraft will carry two scientific payloads in a low earth orbit – ***POLIX & XSPECT***

POLIX (Polarimeter Instrument in X-rays)	• Developed by RRI in collaboration with ISRO's U.R.Rao Satellite Centre (URSC) in Bengaluru. • Will measure the polarimetry parameters (degree and angle of polarisation).
XSPECT (X-ray Spectroscopy and Timing)	• Will give spectroscopic information. • Would observe several types of sources, such as X-ray pulsars, blackhole binaries, low-magnetic field neutron star, etc.

1.15 PSLV C-56

The Indian Space Research Organization (ISRO) successfully launched the PSLV-C56 carrying Singapore's DS-SAR satellite and six other satellites including nano satellites.

- PSLV-C56 is configured in its core-alone mode similar to that of C55.
- Core alone mode is one of the variants of PSLV.
- ***Core-alone mode*** does not utilize solid rocket strap-on motors in its first stage.
- PSLV-C56 / DS-SAR, is the Dedicated Commercial Mission of NewSpace India Limited (NSIL) for ST Engineering, Singapore.

Nano Satellite
• Any satellite weighing less than 10 kilograms. • Developed under CubeSat standards. • **Standard CubeSat unit -** 10x10x10 centimetres with a mass of somewhere between 1 and 1.33 kg. This unit is known as **1U**.

- This is the 58th flight of PSLV and 17th flight of PSLV in Core Alone configuration.
- After injecting all the 6 satellites, the upper stage of the rocket would be placed in lower orbit to ensure its reduced orbital life.

1.16 PSLV-XL variant

Aditya-L1 will be launched with the PSLV-XL Variant (PSLV-C57) Launch Vehicle.

Polar Satellite Launch Vehicle (PSLV)

Aditya-L1 aims to study Sun's Corona, Chromosphere, and Photosphere and marks 25th flight of PSLV-XL.

- **About -** PSLV is the 3rd generation launch vehicle of India and the *1st Indian launch vehicle* to be equipped with liquid stages.
- PSLV earned its title *'the workhorse of ISRO'*.
- **Features -** PSLV is a ***4-stage/engine*** expendable rocket powered by solid and liquid fuels alternately, with 6 booster motors strapped onto the first stage to provide higher thrust during the initial flight moments.
- **Types -** ISRO has 5 types of PSLV rockets – Standard, Core Alone (no strap-on motors used), XL, DL, and QL.
- The major difference between them lies in the use of strap-on boosters, which in turn largely depends on the weight of the satellites to be orbited.
- The strap-ons are powered by the solid rocket propellant Hydroxyl-terminated polybutadiene (HTPB).
- **PSLV-XL -** The PSLV-XL is the 'full configuration' PSLV, fitted with 6 strap-on motors, the maximum for this expendable launch vehicle.

Mission	Launch Vehicle (XL)	Location	Year
Chandrayaan–1	PSLV C-11	First mission to moon	2008
Mangalyaan	PSLV- C25	First mission to Mars	2013
AstroSat	PSLV-C30	India's first dedicated Space Astronomy Observatory	2015
EOS-06 satellite, 8 nano-satellites	PSLV-C54	To orbit around the earth.	2022
TeLEOS-2	PSLV-C55	To observe Earth	2023
DS-SAR	PSLV-C56	To observe Earth	2023
Aditya L1 mission	PSLV-C57	First mission to Sun	2023

1.17 Naming of space objects

The point where the Chandrayaan-3 lander touched down on the lunar surface will be named Shiv Shakti.

The Moon does not come under the jurisdiction of any one country.

- **Moon's ownership -** In 1966, the United Nations Office for Outer Space Affairs came out with the Outer Space Treaty.
- Article II of this treaty said that the countries had to cooperate in their Space exploration activities and could not stake a claim to the Moon.
- However, the Treaty does not talk about naming sites on the Moon.

Naming the landing sites on the Moon

- ***The International Astronomical Union (IAU)*** determines some other rules for Space activities.
- The IAU has been the arbiter of planetary and satellite nomenclature since its inception in 1919 and ***India is among its 92 members.***

Elements on the moon

- Analyses have unveiled the presence of Aluminum (Al), Sulphur (S), Calcium (Ca), Iron (Fe), Chromium (Cr), Titanium (Ti), manganese (Mn), silicon (Si), and oxygen (O) on the lunar surface.
- **Sulphur –** Evidence of the presence of Sulphur can reveal insights on the formation and evolution of the Moon.

1.18 LUPEX Mission

With Chandrayaan-3 successfully landing on the Moon's South Pole, ISRO is planning for its next lunar mission LUPEX.

- **LUPEX** - *Lunar Polar Exploration* will be accomplished in partnership with Japan's space agency, ***Japan Aerospace Exploration Agency (JAXA).***
- The mission is slated to be launched in *2025.*
- The launch vehicle and rover for this programme are supposed to be contributed by the Japanese agency, while the lander will be contributed by ISRO.
- **Mission Objectives**
  - To explore lunar polar region's suitability for establishing a base on the Moon for sustainable activities.
  - To obtain knowledge regarding the availability of lunar water-ice resources.
  - To demonstrate lunar and planetary surface exploration technologies such as vehicular transport and overnight survival.

	Upcoming Missions of ISRO
ISRO - NASA Joint human spaceflight mission	• A joint mission to send humans to International Space Station (ISS). • Through this mission, the first Indian astronaut will go in to space after 40 years.
NISAR Satellite	• A collaboration between NASA & ISRO. • It will map the entire globe in 12 days and provide spatially and temporally consistent data for understanding changes in Earth's ecosystems, ice mass, sea level rise, and natural hazards.
Spadex Mission	• A short form of space docking experiment. • The Spadex project of ISRO is a twin spacecraft mission to mature technologies related to orbital rendezvous, docking, formation flying, with scope of applications in human spaceflight, in-space satellite servicing and other proximity operations.
Gaganyaan	• Gaganyaan project envisages demonstration of human spaceflight capability by launching crew of 3 members to an orbit of 400 km for a 3 days mission and bring them back safely to earth, by landing in Indian sea waters.
Shukrayaan	• An Orbiter to Venus to study the surface and atmosphere of Venus.

1.19 Ejecta Halo

According to ISRO, the Chandrayaan-3 Lander Module (Vikram lander) generated 'ejecta halo' of lunar material as it descended towards the Moon's South Pole in 2023.

- **Regolith** – A blanket of unconsolidated, loose, heterogeneous superficial deposits covering the solid rock which is present in Earth, the Moon, Mars, some asteroids, and other terrestrial planets and moons.
- **Epiregolith** - Lunar rocks and soil, or regolith, or Moon dust.
- **Ejecta Halo** – It is a halo (a bright circle of light around something) of epiregolith which appeared as an *irregular bright patch surrounding the lander*.

1.20 Spacecraft Passivation

Recently Part of Chandrayaan-3 launch vehicle made uncontrolled re-entry into Earth's atmosphere and underwent Passivation to minimise the risks of accidental explosions.

- Spacecraft Passivation is the ***elimination of all stored energy on a spacecraft*** or orbital stages to reduce the chance of accidental explosions.

- Passivation and post-mission disposal of the rocket body is in adherence to the internationally accepted guidelines prescribed by the United Nations and IADC.
- **Inter-Agency Space Debris Coordination Committee (IADC)** – Is an international forum of governmental bodies for the coordination of activities related to the man-made and natural debris in space.
- The primary purpose of the IADC includes:
    - Exchange information on space debris research activities between member space agencies,
    - Facilitate opportunities for co-operation in space debris research and
    - Review the progress of ongoing co-operative activities and to identify debris mitigation options.
- ***ISRO is a member*** to the forum.

1.21 Lunar Sample Return Mission (LSRM)

Lunar Sample Return Mission (LSRM) is the proposed mission by ISRO to collect soil or rock samples from the Moon and bring them to Earth.

- LSRM aims to bring back rock or soil samples from the ***Shiv Shakti point*** where Vikram had landed.
- The proposed mission will have 2 separate launch vehicles.
- The mission involves 4 modules - Transfer module, Lander module, Ascender module, Re-entry module
- **The Geosynchronous Satellite Launch Vehicle (GSLV) Mark-II** will be used for the injection of the transfer and the re-entry modules whereas **Launch Vehicle Mark-III** will be used for the direct injection of the Ascender and the Lander module.

1.22 Bharatiya Antariksh Station

- Bharatiya Antariksh Station, 1st module of India's planned space station will be launched by 2028.
- It will be operated by Indian Space Research Organisation (ISRO).

GLOBAL MISSIONS

NASA

1.23 TROPICS Mission

NASA launches 'TROPICS' mission to improve understanding about hurricanes, cyclones.

- TROPICS is a constellation of ***4 Cubesats in three low earth orbital planes*** that will measure temperature, humidity and precipitation with spatial resolution on hourly basis.
- It will provide microwave measurements over the tropics to observe the thermodynamics of the troposphere.
- The objective of the mission is to focus on terrestrial disasters, tropical cyclone analysis, and cyclone modelling and data assimilation and understand tropical cyclones and tropical dynamics.
- **Tropospheric Emissions: Monitoring of Pollution (TEMPO) Satellite -** It is a spectrometer that provides hourly updates on atmospheric pollutants over North America.

1.24 Artemis Accord

India became the 27th signatory to the American-led Artemis Accords.

- The ***US*** established the Artemis Accords together with 7 other members in 2020 to return humans to the moon by 2025.
- The Artemis Accords reinforce and implement key obligations in the ***1967 Outer Space Treaty.***
- These Accords are a ***non-binding*** set of principles designed to guide civil space exploration cooperation among nations participating in the agency's 21st century lunar exploration plans.

- It currently has ***27 signatories including India.***
- Artemis mirrors a Chinese-Russian plan for an '***International Lunar Research Station' (ILRS).***
- The Artemis plan includes
    - a base on the lunar surface
    - multiple spacecraft to ferry humans and cargo
    - a small orbiting space station called the 'Lunar Gateway'
    - a constellation of satellites to help with navigation and communication
- The Artemis Accords was created by the U.S to act as a soft-law alternative to the Moon Agreement, which limits resource extraction in celestial bodies.
- A key provision in the Artemis Accords allows for actors to extract and utilise space resources.

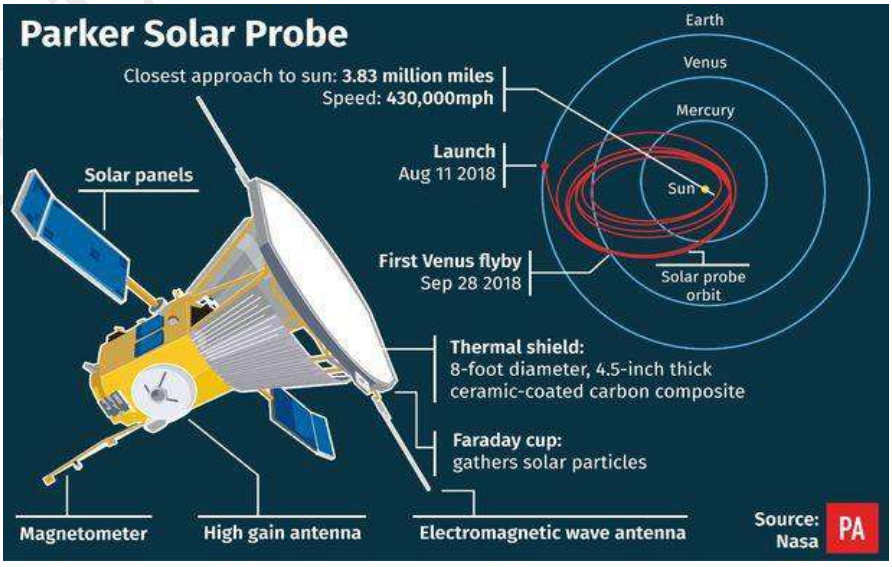
Moon Agreement of 1979

- The Moon Agreement of 1979 is directed towards the use of the Moon and other celestial bodies.
- It limits the scope of exploitation of resources from these celestial bodies and establishes that the moon and other celestial bodies are 'the province of all mankind'.
- It declares that these regions of space must only be for peaceful purposes, with no state allowed to establish military bases or place weapons on celestial bodies.
- Despite being instrumental in the drafting of the Moon Agreement, the ***United States did not ratify it.***
- ***India is a signatory*** *to the Moon Agreement, but is* ***yet to ratify*** *it.*

1.25 Parker Solar Probe

Recently the NASA's Parker Solar Probe just completed its 16th close approach to the Sun.

- **Aim -** To unlock the mysteries of the Sun's corona and solar wind.
- It is a part of ***Living with a star*** programme of ***NASA.***
- It carries 4 instrument suites that are designed to study magnetic fields, plasma and energetic particles and image the solar wind.
- The spacecraft travels directly through the Sun's atmosphere ultimately to a distance of about 4 million miles from the surface.
- NASA's Parker Solar Probe is the first-ever mission to "touch" the Sun.
- Launched using Delta IV-Heavy with Upper Stage in 2018.



- The spacecraft and its instruments are protected from the heat of the Sun by a 4.5-inch-thick carbon composite shield that can withstand temperatures of around 1,777 degrees Celsius.

1.26 NASA's DIMPLE Instrument

NASA selects Artemis instrument – DIMPLE to study Irregular Mare Patch on the Moon.

- **DIMPLE** – Refers to "*Dating an Irregular Mare Patch with a Lunar Explorer*" scientific payload.
- **Aim** - To establish the age and composition of hilly terrain created by volcanic activity on the near side of the Moon.

- **Program -** It travels to the Moon as a part of Artemis program.
- DIMPLE is accepted through NASA's Payloads and Research Investigations on the Surface of the Moon (PRISM) program via the Commercial Lunar Payload Services (CLPS) initiative.
- It will investigate the **Irregular Mare Patch**, (smooth, rounded, slightly mounded areas on the Moon) discovered in 1971 by Apollo 15 orbital images.
- The mission will use a rover, a collection instrument and a spectrometer that can determine the composition of lunar material.

1.27 Phosphorus on Enceladus

High concentrations of phosphorus have been detected by NASA's Cassini spacecraft in ice crystals spewed from the interior ocean of Saturn's moon Enceladus.

- Enceladus is a small ***moon of Saturn*** with an ocean of liquid water beneath its icy crust.
- It's the first time phosphorous has been discovered in an ocean beyond Earth.
- The interior ocean of Enceladus is about 1/7th the size of Earth's moon and the 6th largest among Saturn's 146 known natural satellites.
- ***Titan*** is the largest moon in Saturn and 2nd largest moon in our solar system.

DID YOU KNOW?
According to NASA, Jupiter has 95 Moons and Saturn has 146 moons, as on May 23, 2023

Cassini Spacecraft

- It is a joint *NASA-European space agency* mission.
- Cassini-Huygens is an *unmanned spacecraft* sent to the planet Saturn in 2004.
- It is the *4th space probe* to visit Saturn (Pioneer 11, Voyager1, Voyager 2) and the *first to enter orbit*.
- Its design includes a Saturn Orbiter and a Lander called "Huygens" for the moon Titan.
- This was the first landing ever accomplished in the outer solar system.

1.28 Curiosity Rover

NASA's Curiosity rover sends a beautiful postcard image from Mars.

- **Launch Year** – 2012.
- It is a part of *Mars Science Laboratory (MSL) mission* of ***NASA***.
- It is the largest and most capable rover ever sent to ***Mars.***
- **Aim** - To climb onto the layered deposit in the center of the Gale Crater to assess its possible origins.
- ***Gale crater***, located just south of the Martian equator was formed by the impact of a large meteorite sometime between 3.5 and 3.8 billion years ago.
- **Findings -** Curiosity's scientific tools found chemical and mineral evidence of past habitable environments on Mars.
- It continues to explore the rock record from a time when Mars could have been home to microbial life.

Mars Missions	Countries
Mangalyaan	India
Perseverance	U.S.
Hope	UAE
Tianwen-1	China
Mars 2 and Mars 3	Russia
Insights	U.S.

1.29 Voyager Mission

More than a week after the NASA lost communication with Earth's longest-running space probe, Voyager 2, the space agency detected a heartbeat signal from the spacecraft.

- The twin spacecraft Voyager I and Voyager II were launched by ***NASA*** in separate months in 1977.
- **Instruments** - Television cameras, infrared and ultraviolet sensors, magnetometers, plasma detectors, and cosmic-ray and charged-particle sensors.

- Each Voyager spacecraft is adorned with a golden phonograph record, a 12-inch disc, intended to be a sort of time capsule from Earth to any extraterrestrial life that might intercept the probes.

Voyager – 1	Voyager 2
• Launched in 1977, sent to space about two weeks after Voyager 2. • Voyager 1 was set on a path to reach Jupiter and Saturn, ahead of Voyager 2. • Voyager 1 reached its first target planet, Jupiter, on 1979. • Voyager 1 found that Io, one of Jupiter's moons, was geologically active • It will take 300 years to reach the Oort cloud, the most distant region of our solar system.	• Launched in 1977, sent to space two weeks before Voyager 1. • The spacecraft arrived at Uranus in 1986, becoming the first human-made object to fly past the aquamarine planet. • **Great Dark Spot** – The spacecraft observed the Great Dark Spot, a huge spinning storm in the southern atmosphere of Neptune about the size of the entire Earth. • Voyager 2 is about *19.9 billion kilometres* away from Earth, is still operating.

Interstellar is the region that lies outside the impact of our Sun's constant flow of material and magnetic field and begins just over 18 billion kilometres from the sun.

1.30 OSIRIS-Rex mission

NASA's Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer (OSIRIS-Rex) mission is set to drop a capsule containing samples from the asteroid Bennu to Earth.

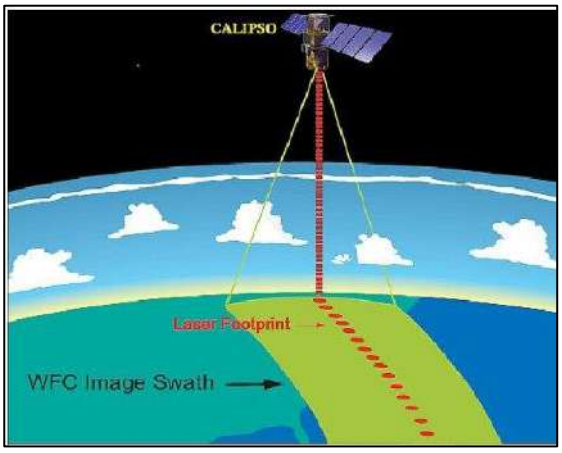
- It is a spacecraft that traveled to an ***asteroid named Bennu*** and collected a sample of rocks and dust from the surface.
- This mission will help to investigate how planets formed and how life began, as well as improve the understanding of asteroids that could impact Earth.
- **Asteroid Bennu** - Named after an Egyptian deity, Bennu is located about 200 million miles away from the Earth.
- It is a B-type asteroid, implying that it contains significant amounts of carbon and various other minerals.
- There is a slight chance that Bennu, a Near Earth Object (NEO), might strike the Earth in the next century, between 2175 and 2199.

NEOs are comets and asteroids nudged by the gravitational attraction of nearby planets into orbits, which allow them to enter the Earth's neighborhood.

1.31 CALIPSO Science Mission

CALIPSO satellite which monitors climate, weather and air quality using LIDAR has ended its science mission after 17 years.

- **CALIPSO** - Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) Misison
- **Launched in** - 2006 by the NASA and France's CNES (Centre National d'Etudes Spatiales).
- **Orbit** - Sun Synchronous Orbit
- **Objective** - It is a cloud and aerosol observation satellite.
- **Mission Type** - Earth Observation.
- **Significance** - Its observations are used to determine the role of clouds and aerosols in regulating the Earth's climate.
- **Instruments** - CALIPSO carries 3 instruments
  - Cloud-Aerosol Lidar with Orthogonal Polarisation (CALIOP)
  - Imaging Infrared Radiometer (IIR)
  - Wide Field Camera (WFC)



1.32 APEP Mission

NASA's APEP Mission will send 3 rockets flying into the shadow of the upcoming rare "annular" solar eclipse.

- **APEP** - Atmospheric Perturbations around the Eclipse Path Misison.
- **Background** - Annular Solar Eclipse is expected to occur on October 14, 2023 in the western hemisphere.
- An annular solar eclipse occurs when the apparent size of the Moon is slightly less than that of the Sun, which leaves the outer rim of the latter uncovered, giving the appearance of a "***ring of fire***".
- Due to this, the brightness of the Sun will be diminished to 10% its normal brightness.
- **Aim of APEP** - To study how the sudden drop in sunlight affects our upper atmosphere.
- **Scientific measurements** – Each rocket holds 4 instruments to measure parameters like ionosphere density, temperature, and changes in electric and magnetic fields.

1.33 NASA-ISRO Synthetic Aperture Radar (NISAR) mission

- It is a joint Low Earth Orbit observatory mission between ***NASA and ISRO*** scheduled to take place in the early 2024.
- **Aim** - To survey all of Earth's land and ice-covered surfaces every 12 days.
- NISAR carries L and S dual-band Synthetic Aperture Radar (SAR), which operates with the Sweep SAR technique to achieve large swaths with high-resolution data.

1.34 Psyche Mission

Psyche mission fires lasers at Earth from 16 million kilometres away, successfully demonstrating the future of communication in space.

- **Launched by - NASA** in 2023, to study the ***metallic asteroid called '16 Psyche'***, located in the main asteroid belt between Mars and Jupiter.
- **Type**- Orbiter
- **Mission** – *By 2029,* the spacecraft will begin exploring the asteroid and will spend about *2 years* orbiting the asteroid.
- It will *take pictures, map the surface, and collect data* to determine Psyche's composition.
- Psyche was discovered in 1852 by Italian astronomer Annibale de Gasparis and is referred to as 16 Psyche.
- **Scientific instruments** – Multispectral Imager, Gamma-Ray and Neutron Spectrometer, Magnetometer, Deep Space Optical Communications (DSOC).
- It uses solar electric propulsion and communicates with Earth through NASA's *Deep Space Network (DSN)*.
- **Significance** – It will help to unlock the secrets of planets formation and evolution.

Deep Space Optical Communications (DSOC) – Psyche Mission

- It is a new laser communication technology that encodes data in photons at ***near-infrared wavelengths*** (rather than radio waves) to communicate between a probe in deep space and Earth.
- Using light instead of radio allows the spacecraft to communicate more data in a given amount of time.
- It is planned for the 1st 2 years of the spacecraft's cruise and so it does *not relay Psyche mission data* to earth.
- Optical communications have been demonstrated previously in Low-Earth Orbit and even to the Moon but DSOC of Psyche mission is NASA's 1st test between Earth and distances far exceeding the Moon (deep space).

1.35 Atmospheric Waves Experiment (AWE)

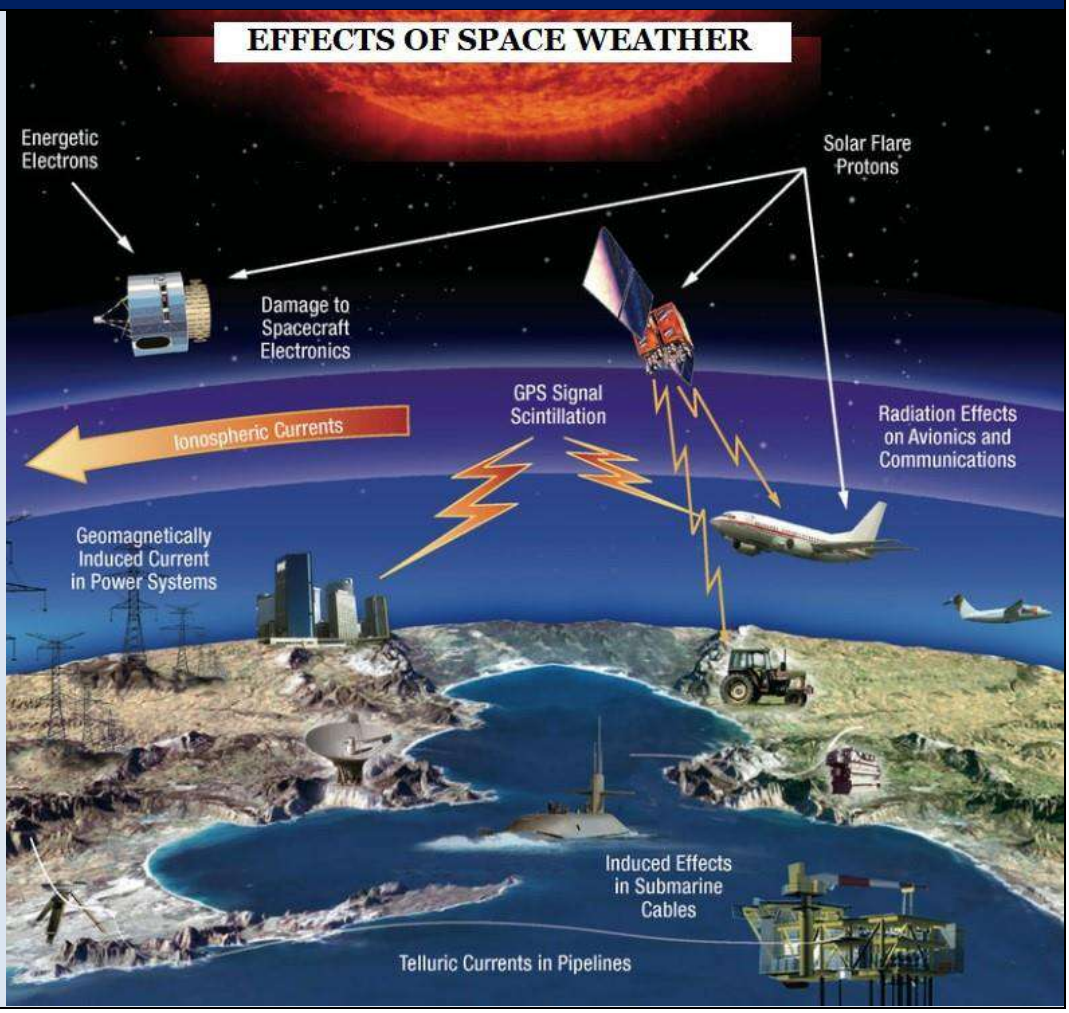
Atmospheric Waves Experiment will determine the combination of forces that drive space weather in the upper atmosphere.

- AWE is a Mission of Opportunity under ***NASA's Heliophysics Explorers Program*** that studies the Sun and its interactions with the Earth and the solar system, including space weather.
- **Objectives -** To study the interactions between terrestrial and Space weather

- To study colourful bands of light in Earth's atmosphere, called ***airglow***
- **Features -** ***Advanced Mesospheric Temperature Mapper (ATMT)*** will be mounted on the exterior of the Earth-orbiting International Space Station (ISS) to record the airglow at mesopause in the infrared bandwidth.
- **Mesopause** is a region between the mesosphere and thermosphere at about 85 to 87 km above the Earth's surface where the atmospheric temperature dips to -100° C.
- **Functions -**Continuously image airglow in Earth's atmosphere
- Study *atmospheric gravity waves (AGW)* which are *vertical wave of displaced stable air* produced during thunderstorms, hurricanes, tornadoes, regional orography, etc. in the lower atmosphere and continue all the way to Space contributing to the Space weather.

Space weather

- It is the *environment around the earth and other planets*.
- They remains constantly under the influence Sun-bound emissions along with other matters surrounding the space.
- **Earth's influence** – When the weather over Earth turns rough or extreme, space weather too can suffer extreme events.
- **Importance** – They have a direct impact on vital installations on Earth, like satellite-based communication, radio communication, and Space-based aircraft orbits or stations.



1.36 Deep Space Network (DSN)

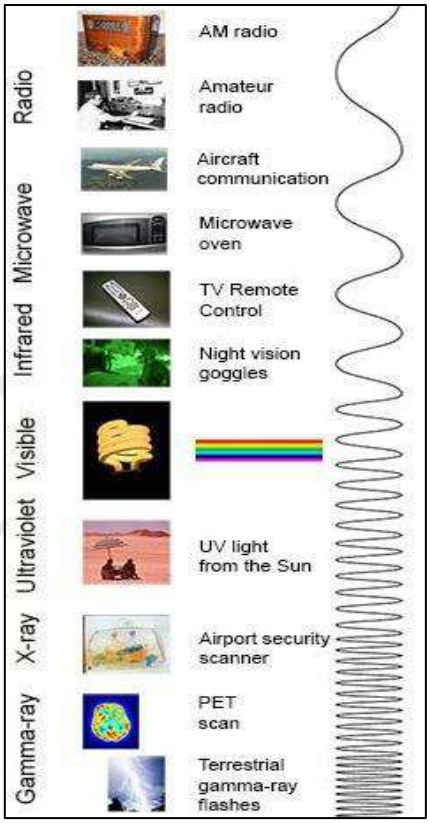
NASA's telecommunications network and navigation system, Deep Space Network, celebrated its 60th anniversary on December 24.

- **Initiative by -** Deep Space Network (DSN) is an initiative of NASA started in the year 1963.
- **Operated by -** NASA's Jet Propulsion Laboratory (JPL),
- **Applications -** DSN is an array of giant radio antennas that supports interplanetary spacecraft missions, plus a few that orbit Earth.
- The DSN also provides radar and radio astronomy observations that improve our understanding of the solar system and the larger universe.

- DSN is what makes it possible for NASA to communicate with spacecrafts further away from the moon.
- The DSN also supported ISRO during India's Chandrayaan-3 mission.
- **Sites -** The DSN consists of three facilities spaced equidistant from each other, approximately 120 degrees apart in longitude, around the world - Goldstone, California; near Madrid, Spain; and near Canberra, Australia.

1.37 Electromagnetic Spectrum

Recently NASA spacecraft, Psyche successfully fired a laser signal at Earth as part of a mission to test high-bandwidth optical communications to Earth.



- The electromagnetic spectrum is a range of wavelengths of electromagnetic radiation.
- Energy is propagated through space in the form of electromagnetic (EM) waves, which are composed of oscillating electric and magnetic fields.
- EM waves ***do not require a substance*** (like air or water) to travel through and can travel through empty space.
- In a vacuum, all EM waves travel at the ***same speed which is at the speed of light*** (which is itself an EM wave).
- Like all waves, an EM wave is characterised by its wavelength, and the range of wavelengths we observe, from very long to very short, is what is referred as the EM spectrum.
- From long to short wavelength, the EM spectrum includes radio waves, microwaves, infrared, visible light, ultraviolet, x-rays and gamma rays.
- Radio waves are more widely used for communication than other electromagnetic waves primarily because of their desirable propagation properties, stemming from their large wavelength.
- Shorter wavelengths tend to scatter when in contact with any interference.

Other Space Agencies

1.38 Global Space Missions: 2023 & 2024

Mission	Significant global spaceflights in 2023
OSIRIS-REx (NASA)	• Studied the asteroid Bennu and returned a sample from Bennu
Psyche (NASA)	• Aims to explore the origin of planetary cores, Psyche is believed to have a high metal content.
Shenzhou 16 (China)	• Sent 3 humans to Tiangong space station and created a world record with 17 humans in orbit, 6 aboard Tiangong and 11 on the ISS.
Chandrayaan-3 (ISRO)	• With a soft landing on the Moon, India became the 4th country in the world to soft-land a spacecraft on the Moon and 1st spacecraft to land near the South Pole of the Moon.
Aditya L1 (ISRO)	• It is India's 1st mission to study the Sun and space weather and will travel around 1.5 million km away from the planet to the 1st Lagrange point, or L1, between the Sun and the Earth.
Global space missions in 2024	
NASA	

Europa Clipper	To explore Europa, Jupiter's moon.	It will study the icy shell, its surface's geology and its subsurface ocean and will also look for active geysers.
Artemis II	To send 4 humans to the Moon for 10 days.	It includes **the 1st woman and the 1st person of colour** to the moon.
VIPER	To survey water at the south pole of the Moon.	Volatiles Investigating Polar Exploration Rover, a robot the size of a golf cart to search for volatiles.
Lunar Trailblazer and PRIME-1	To look for water on the Moon with PRIME-1 to drill into the Moon.	It will orbit the Moon, measuring the temperature of the surface and mapping out the locations of water molecules across the globe.
JAXA (Japan Space Agency)		
MMX	To study the Mars moon – **Phobos, Deimos.**	MMX stands for Martian Moon eXploration.
ESA (European Space Agency)		
Hera	To study the **Didymos-Dimorphos** asteroid system.	It will study physical properties of the asteroids.

Quick Facts

- **DART mission -** NASA's mission to the ***Didymos-Dimorphos*** asteroid system in 2022, collided with Dimorphos with such force that it actually changed its orbit to test a planetary defense technique called kinetic impact.
- **SIMPLEx -** It is NASA's small, low-cost planetary missions which stands for Small, Innovative Missions for PLanetary Exploration.
- **Luna-25 -** Russia's 1st independent lunar mission crashed onto the lunar surface as it attempted to become the 1st mission to land near the moon's South Pole.
- **The Hakuto mission -** The 1st privately-led lunar mission (Tokyo based), that crashed onto the moon after spending nearly 5 months in space.

1.39 Space Industry Debris Mitigation Recommendations

The World Economic Forum (WEF) and the European Space Agency (ESA) jointly released the Space Industry Debris Mitigation Recommendations to mitigate the space debris problem.

- Space Debris is any piece of machinery or debris left by humans in space.
- It can be dead satellites, bits of debris or paint flecks that have fallen off a rocket.
- ***Russia*** has the most space debris with over 7000 rocket bodies floating in space.

*The **Kessler syndrome** is a scenario in which the density of objects in LEO is high enough that collisions between objects could cause a cascade that increases the likelihood of further collisions*

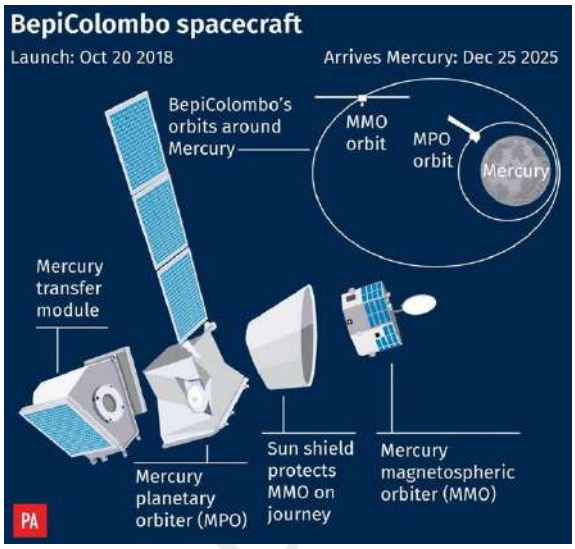
Countries	Space Debris Mission
Europe	ClearSpace-1
India	NETRA Project
Japan	Elsa-D
EU	RemoveDebris
USA	NASA Orbital Debris Program

1.40 Juice Mission, dearMoon Project

- **dearMoon Project –** A lunar tourism mission by Japanese billionaire Yusaku Maezawa.
- **Juice mission** – It will make detailed observations of the giant gas planet, ***Jupiter*** and its 3 large ocean-bearing moons that include Ganymede, Callisto and Europa.
- It is an initiative of the ***European Space Agency (ESA).***

1.41 BepiColombo Spacecraft

Recently, BepiColombo spacecraft flew close to Mercury to take pictures of the planet.



- **Launched on –** 2018; **Launch Vehicle** - Ariane 5.
- **Aim** – It will study and understand the composition, geophysics, atmosphere, magnetosphere and history of ***Mercury,*** the least explored planet in the inner Solar System.
- **Agency** –European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA).
- The BepiColombo mission is based on two scientific spacecraft and one transfer module:
    - Mercury Planetary Orbiter (MPO)
    - Mercury Magnetospheric Orbiter (MMO)
    - Mercury Transfer Module (MTM)
- It will chart the planet's mineralogy and elemental composition, determine whether the interior of the planet is molten or not, and investigate the extent and origin of Mercury's magnetic field.
- It made its first flyby of Mercury on 2021 and sent back several images.
- This is the first Mercury missions for the *ESA and Japan.*

Other Mercury Missions	Countries	Launch
Mariner 10	NASA	1973
MESSENGER	NASA	2004

1.42 Smart Lander for Investigating Moon (SLIM)

Japan's space Agency JAXA has recently launched the SLIM moon lander.

- **SLIM** – A small-scale exploration lander designed for pinpoint landings on the Moon's surface and investigate into the Moon's origins.
- The mission was dubbed as the ***Moon Sniper***.
- It will also test technology fundamental to exploration in low-gravity environments, an important requirement for future scientific investigation of the solar system.
- **Agency -** Japan Aerospace Exploration Agency (JAXA).
- **Launch vehicle -** H-IIA rocket.
- This is the ***first Moon-landing attempt*** being made by Japan Aerospace Exploration Agency (JAXA).
- If successful,
    - Japan would be the 5th country to successfully soft land on the moon.
    - SLIM would be the smallest and lightest spacecraft to land on the Moon.
- The chosen landing site for SLIM is near a small crater named ***Shioli*** in the equatorial region of the Moon.
- SLIM is set to touch down on the near side of the moon close to ***Mare Nectaris***, a lunar sea that, viewed from Earth, appears as a dark spot.
- **Rover -** No lunar rover is loaded on SLIM.

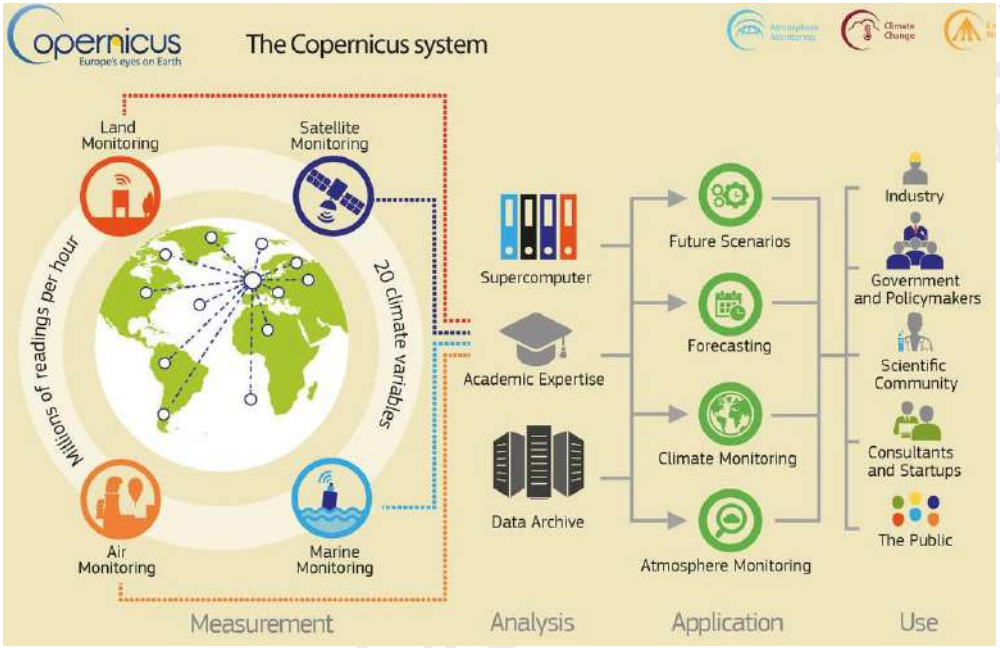
1.43 The Copernicus System

2023 marks the 25th anniversary of Copernicus, the earth observation component of the EU's space programme.

- **Launch year**- 1998
- **Previous name** - Global Monitoring for Environment and Security Programme (GMES)

- **Aim** - To provide information on the earth's environment to aid sectors like agriculture, climate change, disaster management, urban planning, and more.
- **Working** - Copernicus integrates satellite and non-space data, including ground-based, airborne, and seaborne measurement systems, to offer data related to earth observation.
- The mission relies on a group of satellites, called ***Sentinel satellites***, for gathering data.
- **Implementing agency** - Copernicus was implemented by member states in association with
    1. The European Space Agency (ESA),
    2. The European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT),
    3. The European Centre for Medium-Range Weather Forecasts (ECMWF),
    4. EU Agencies and Mercator Ocean.
- It is managed by the European Commission.
- **Access** - Its data is freely available for anyone to access.

DID YOU KNOW?
The programme is named after Nicolaus Copernicus, the 15th-century Polish scientist who first proposed a heliocentric universe model



Sentinel Satellites

The European Space Agency (ESA) is developing a new family of missions called Sentinels specifically for the operational needs of the Copernicus programme.

These missions carry a range of technologies, such as radar and multi-spectral imaging instruments for land, ocean and atmospheric monitoring.

1.44 XRISM (X-Ray Imaging and Spectroscopy Mission)

A powerful X-ray observatory is launched along with Japan's SLIM mission.

***Hitomi** was a high-energy astrophysics space observatory, developed by JAXA.*

- **Aim -** To investigate celestial X-ray objects in the Universe with high-throughput imaging and high-resolution spectroscopy.
- These observations will enable in determining the flows of mass and energy, revealing the composition and evolution of celestial objects.
- This mission acts as a semi-replacement for the Hitomi (Astro-H) X-ray observatory, launched in 2016.
- **Launch Vehicle -** H-IIA rocket; **Agency -** NASA and JAXA.

1.45 Shenzhou-16

China launches Shenzhou-16 mission to Chinese space station.

- The spacecraft, Shenzhou-16, or Divine Vessel, and its three passengers lifted off atop a Long March-2F rocket from the Jiuquan Satellite Launch Centre in the Gobi Desert in northwest China.
- **Xuntian –** By the end of 2023, China is due to a launch space telescope the size of a large bus.

- Known as Xuntian, or Surveying the Heavens in Chinese, the orbital telescope will boast a field of view 350 times wider than that of the Hubble Space Telescope, which was launched 33 years ago.
- **Tiangong –** Tiangong is China's permanent space station that will operate in low-Earth orbit at an altitude from 340 km to 450 km.
- It has a designed lifespan of at least 10 years.

1.46 Luna 25 Mission

Russia's first moon mission in decades fails as Luna-25 crashes into lunar surface.

- The mission was launched from the Vosthochny cosmodrome in the Russian Far East on August 11, 2023.
- It was the Russia's first mission to the lunar surface in 47 years.
- The mission was scheduled to land on the Moon on August 23, the same day as Chandrayaan-3's planned landing.
- The mission aimed at a prized destination that may hold significant quantities of ice that could be used to extract oxygen and fuel in the future.
- **Soft Landing –** Luna-25 practiced soft-landing, analyse soil samples and conduct long-term scientific research on the Moon's surface.

The Russian mission was expected take a lot less time to reach the Moon than Chandrayaan-3 because the latter is taking a longer route that takes advantage of the gravities of the Earth and the Moon & uses less fuel.

1.47 MBR Explorer

United Arab Emirates is heading for the asteroid belt.

- The spacecraft, named MBR Explorer after Sheikh Mohammed bin Rashid al-Maktoum, the ruler of Dubai and prime minister of the UAE, is scheduled to launch in 2028.
- Building off the success of its Hope spacecraft, which is still circling and studying Mars, the United Arab Emirates announced plans for an ambitious follow-up mission.
- In February 2030, the spacecraft will arrive at ***Wester Wald,*** a 1.4-mile-wide asteroid, in the asteroid belt between Mars and Jupiter.
- **Justitia –** The seventh asteroid, Justitia, is the most intriguing.
- About 30 miles wide, Justitia is very reddish, an unusual colour for an asteroid.

4.1 Malligyong-1 satellite

- ***North Korea's 1st military spy satellite*** that was launched on a new carrier rocket, "Chollima-1".
- North Korea has also developed a class of experimental satellites called the Kwangmyongsong program

PRIVATE SECTOR IN SPACE

1.48 Steps taken by India to support private sector in space

IIT-Madras based space tech startup, Agnikul Cosmos, will soon launch its small satellite rocket, Agnibaan SOrTeD (SubOrbital Technological Demonstrator).

- **NSIL-** New Space India Limited launched in **2019** as a wholly owned Government of India Undertaking under the administrative control of Department of Space (DOS).
- It will help in transferring technologies developed by ISRO to industries for commercialisation
- **IN-SPACe-** Indian National Space Promotion and Authorisation Centre is an autonomous body established in 2020 under the Department of Space.

Agnibaan

- It is a ***2-stage launch vehicle*** capable of taking payloads of up to ***100kgs*** to a low-earth orbit around (700 kms).
- **Engine -** 3D-printed ***Agnilet engines***.
- **Propellant -** Liquid kerosene and super cold liquid oxygen

- It aims to create an eco-system of industry, academia and start-ups and to attract major share in the global space economy.
- **Indian Space Association-** It was launched in 2021, to help private players carry out independent space activities, facilitate services and technology developed by ISRO to be utilised in the private sector.
- **Revised FDI guidelines-** This would open up huge investment opportunities for the foreign companies.
- FDI in space sector is allowed ***up to 100%*** in the area of Satellites- Establishment and Operations through Government route.
- **Atal Tinkering Labs-** To boost participation of young people and students in the Indian space sector.
- It is an initiative of NITI Aayog, in collaboration with ISRO and the Central Board of Secondary Education (CBSE) as part of the Atal Innovation Mission.

Indian space contribution 2% of global market share	
% of global market share	
US	40%
UK	7%
India	2%
Global space economy (in 2021)	USD 386B
India (in 2021)	USD 7.6B

- **Indian Space Policy 2023** - The policy laid down the regulations of privatizing space missions in India, and also denoted clear guidelines of operations for NSIL, ISRO's commercial arm ANTRIX and IN-SPACe.

1.49 Vikram 1 Rocket

Hyderabad-based space startup Skyroot Aerospace has recently unveiled 'Vikram-1' with an expected space launch in early 2024.

- **Fuel -** Mixture of solid fuel at the lower stage and a mixture of liquid fuel in the upper stages
- It has a Raman-II engine in the 4th stage.
- The Raman-II engine is regeneratively cooled and uses Mono Methyl Hydrazine and Nitrogen Tetroxide as propellants.
- It also features ***3D-printed liquid engines***.

Vikram-1
• **Stages -** Multi-stage launch vehicle • **Payload -** 300 kg payloads • **Orbit -** Low Earth Orbit

- The Vikram-1 is the second rocket from the company after ***'Vikram-S,'*** the country's first privately-built rocket.
- The 'Vikram' in the launch vehicles' name is a tribute to ***Vikram Sarabhai***, the father of India's space programme.

1.50 Legal Framework for Space Missions

In the wake of the unprecedented space race, there comes a need to look at the international laws and domestic regulations that govern ventures into space.

International laws that govern space ventures

- **Treaties** - 5 United Nations treaties are generally thought to form the bedrock of international space law.
- **Declarations** - There are 5 declarations pertaining to space activities.

*Of the 5 UN Treaties on Space Venture, **India has ratified 1st four** and signed Moon Agreement without ratifying it.*

UN Treaties governing international space law	Declarations pertaining to space activities
1. The Outer Space Treaty	1. Declaration of Legal Principles Governing the Activities of States in the Exploration and Uses of Outer Space - 1963
2. The Rescue Agreement	2. Declaration governing the use of satellites for television broadcasting
3. The Liability Convention	3. Declaration regarding remote sensing from outer space
4. The Registration Convention	4. Declaration regarding the use of nuclear power sources in outer space
5. The Moon Agreement	5. Declaration on international cooperation in space exploration for the benefit of all states, particularly developing countries

- **UNGA resolutions** - There are UN General Assembly resolutions, which, though ***non-binding,*** help guide international action on the issue and may shape consensus in the space community.
- ***Res communis***— It is the concept of ***ownership in common*** by mankind of certain natural resources.
    - Example - The resources of the high seas (governed by the United Nations Convention on the Law of the Sea), or airspace above the Arctic.

UNCLOS *(United Nations Conventions on the Law of the Sea), 1982 lays down rules governing all uses of the world's oceans and their resources.*

Salvage Convention of 1989, *incorporated the "'no cure, no pay" principle under which a salvor is only rewarded for services if the operation is successful.*

- **The UN policy brief** – It recently recommended the development of a new treaty to ensure peace, security, and the prevention of an arms race in outer space.
- **A UN Summit of the Future** – It is scheduled for 2024 in New York, with advancement of the peaceful and sustainable use of outer space a potential area of work.

UN Treaties on Space Ventures

The Outer Space Treaty –1967

- It is often called the *magna carta of space law.*
- Governs the exploration and use of Outer Space only for peaceful purpose.
- Prohibits the weaponisation of space
- No claim of sovereignty over any bodies in space
- Liability on countries for damage caused by any objects launched into space from their territory
- Countries must help astronauts who are in distress
- Space installations and vehicles of one nation are to be open to other nations on a reciprocal basis
- ***Binding*** on its signatories

The Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (ARRA) –1968

- Obligation of nations towards astronauts in distress and emergency situations, return of space objects and astronauts. It includes cost of rescue and operations covered in ***UNCLOS & Salvage Convention.***

The Convention on International Liability for Damage Caused by Space Objects –1972

- Liable to compensate for any damages incurred on the earth's surface or to aircraft or in outer space.
- ***No provision*** for damage caused by a rocket crashing back down to earth

The Convention on Registration of Objects Launched into Outer Space – 1976

Register & maintain records about every object launched into space and furnish those information to the U.N.

The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies – 1984

- Using space only for peaceful purposes.
- Non-disruption of space environments.
- Countries should also inform UN of the location and aim of any station established on such a body.
- Moon and its natural resources *as Common heritage of mankind.*

- **Section 10(2)** - Extraction of space resources does not inherently constitute national appropriation
- **Section 11** - Signatories will support the development of 'safety zones' to ensure that states do not come into conflict with one another.

Domestic space law of India

- ISRO released the ***Indian Space Policy 2023*** to develop a flourishing commercial presence in space.
- India also has *Satellite Communications Policy, 2000* and the revised *Remote Sensing Data Policy, 2011.*

1.51 AX-2 Mission

A SpaceX capsule delivered the crew members of Axiom Mission 2 (AX-2) which includes first Saudi Arabian female astronaut at the ISS.

- AX-2 is the ***2nd all private mission to the International Space Station*** (ISS) after AX-1.
- Ax-2 carried 4 astronauts Peggy Whitson, John Shoffner, Ali Alqarni and Rayyanah Barnawi.

Rayyanah Barnawi
• Barnawi is ***Saudi Arabia's first female astronaut***, heading to the ISS to advance breast cancer research. • Sultan al-Neyadi and Rayyanah Barnawi are the first Saudi Arabia's Astronauts. • **Other Saudis in Space -** A prince of Saudi is the only Saudi flown to space before in 1985.

1.52 Hughes JUPITER 3 Mission

SpaceX successfully launched the Hughes' Jupiter 3, which could be the largest private communications satellite ever.

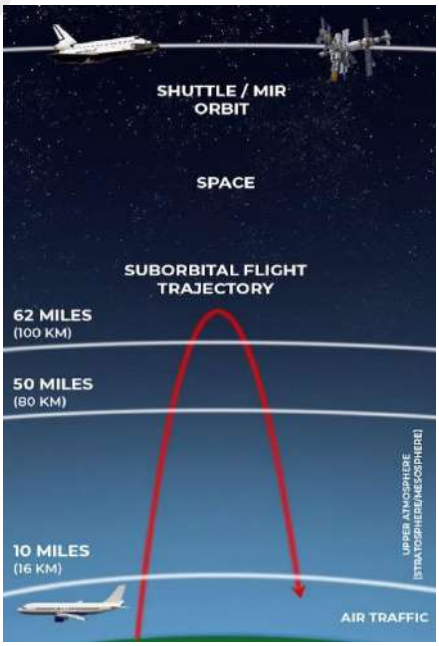
- Jupiter 3 (EchoStar XXIV) is the highly anticipated, next generation Ultra High Density Satellite (UHDS).
- **Agency –** SpaceX: **Launch vehicle** - Falcon Heavy
- JUPITER 3 will travel into a *geosynchronous orbit* above the Earth to its destination at the 95 degrees west orbital slot.
- **Application** – Will support in-flight Wi-Fi, maritime connections, enterprise networks, backhaul for Mobile Network Operators, and Community Wi-Fi solutions, satellite internet connectivity.

JUPITER 3
• Coverage - North & South America • Speed - Up to 100 Mbps • Capacity - More than 500 Gbps

1.53 VSS Unity

Recently a 6-person crew on Virgin Galactic's VSS unity spaceship took a suborbital flight and reached the edge of space.

- Virgin Galactic is a British-American space tourism company, operating in the United States.
- It is launching space tourists and researchers onto suborbital trajectories.
- **VSS unity** - A rocket-powered plane that took its first commercial space flight in the '**Galactic 01**' mission.



The Edge of Space

- **Karman line -** The Karman line is the boundary between the Earth's atmosphere and outer space at ***an altitude of 100km (62 miles)*** above sea level.
- It is an internationally recognised boundary of space.
- The Karman line is near the transition between the *upper mesosphere and lower thermosphere.*
- NASA and the US Air Force, considers ***50 miles*** as the border of space.

3.1 BlueWalker 3

Observations of the BlueWalker 3 prototype satellite show it is one of the brightest objects in the night sky, outshining all but the brightest stars.

- It is a *prototype satellite* of a satellite constellation belonging to *AST SpaceMobile.*
- Its antenna array is 64 square meters, the ***largest commercial antenna system*** deployed in low Earth orbit.
- **Launch** – 2022
- **Objective** – To deliver mobile or broadband services anywhere in the world.

Project	Owner
BlueBird satellites	AST SpaceMobile.
Starlink network	SpaceX
Project Kuiper	Amazon
OneWeb	ISRO & Uk's OneWeb Group

- It successfully relayed its first 5G connection to a smartphone in a cellular coverage gap on Earth.

Issues with the Brightness of BlueWalker 3

- The streaks of satellites could mask objects in the vicinity of Earth.
- The light interferes with astronomical observations thus hampering the progress in understanding the cosmos.
- This happens as it uses *wavelengths close to those of radio telescopes*.
- Light pollution also affects people's circadian rhythms and migratory patterns for other animals.

1.54 Zhuque-2 carrier rocket

A private Chinese company launched first methane-liquid oxygen rocket into orbit named Zhuque-2 recently, beating U.S. rivals.

- **Launched by –** LandSpace, a Chinese private company.
- **Fuel** - A methane-powered rocket, also known as Methalox, uses methane as the fuel and liquid oxygen (LOX) as the oxidizer.
- **Mission** - In this mission 2 planned rockets will carry the spacecraft; one will land on the moon's surface and the other will transport the astronauts.
- **Advantages -** Less polluting, Safer, Cheaper, and are suitable propellant for a reusable rocket.
- **Landspace** - It became the 2nd private Chinese company to ever launch a liquid-propellent rocket.

To know about reusable rockets - Next-Gen Launch Vehicle, RLV-TD

Methane-based rockets in development stage		
Rockets	**Agencies**	**Country**
Starship	SpaceX	U.S.A
New Glenn	Blue Origin	U.S.A
Vulcan Centaur	United Launch Alliance	U.S.A
Neutron	Rocket Lab	U.S.A
Terran R	Relativity Space	U.S.A

1.55 Space Launch System (SLS) & Starship

NASA and Elon Musk's SpaceX suffered setbacks in SLS (Unaffordable) and Starship (Explosive) programs recently.

- The SLS rocket and Starship play crucial role in NASA's Artemis program to put humanity back on the Moon.

Space Launch System (SLS)	Starship
• **Agency –** NASA, U.S. • It is a super heavy-lift rocket that provides the foundation for human exploration beyond Earth orbit. • **Stages –** Core stage, boosters with 4 RS-25 engines. • **Fuel -** Liquid Hydrogen (LH2) & Liquid Oxygen (LO2). • SLS will be the only rocket with the capability to carry Orion and astronauts, as well as large cargo to the moon during a single mission. • It is the most powerful rocket NASA has ever launched. • SLS was successfully launched as part of the Artemis I Mission in 2022.	• **Agency –** SpaceX, U.S. • Starship spacecraft and Super Heavy rocket is collectively referred to as Starship. • It represent a fully reusable transportation system designed to carry both crew and cargo to Earth orbit, the Moon, Mars and beyond. • Starship will be the world's most powerful launch vehicle ever developed, capable of carrying up to 150 metric tonnes fully reusable and 250 metric tonnes expendable. • **Payload capacity -** 100 – 150 tonnes (fully reusable). • **Starship -** Starship is the ***fully reusable spacecraft*** and 2nd stage of the Starship system. • **Super Heavy** – It is the first stage, or booster, of the Starship launch system and is fully reusable and will re-enter Earth's atmosphere. • **Raptor engine** – It is a reusable methane-oxygen staged-combustion engine that powers the Starship system.

2. PLANETARY SYSTEMS

2.1 Different Kinds of Moon Missions

ISRO has launched Chandrayaan-3, India's 3rd lunar mission and 2nd attempt to make a soft landing on the surface of the moon.

- **Flybys** - Flybys are the missions in which the spacecraft passed near the Moon but did not get into an orbit around it.
- These were either designed to study the Moon from a distance or were on their way to some other planetary body or deep space exploration and happened to pass by the celestial body.
    - Example - **Pioneer 3 and 4 (U.S.A), Luna 3 (USSR)**

Only 4 countries have achieved the soft-landing on the moon's surface - US, Russia, China & India

- **Orbiters** - Orbiters were spacecraft that were designed to get into a lunar orbit and carry out prolonged studies of the Moon's surface and atmosphere.
    - Example - **Chandrayaan 1 & 2 – India, Lunar Orbiter program – U.S.A**
- **Impact missions -** Impact missions are an extension of Orbiter missions.
- While the main spacecraft keeps going around the Moon, one or more instruments on board make an uncontrolled landing on the lunar surface.
- They get destroyed after the impact, but still send some useful information about the Moon while on their way.
    - Example - **Chandrayaan-1's Moon Impact Probe**.
- **Landers** - Lander missions involve the soft landing of the spacecraft on the Moon.
    - Example - The 1st landing on the moon in 1966, by the **Luna 9** spacecraft of the then USSR.
- **Rovers -** Rovers are an extension of the lander missions and special wheeled payloads on the lander that can detach themselves from the spacecraft and move around on the moon's surface to collect data.
    - Example – **Pragyaan** rover in Chandrayaan-2 (India).
- **Human missions** - These involve landing of astronauts on the moon's surface.
    - So far, only NASA of the United States (**Apollo mission)** has been able to land human beings on the moon. **NASA's Artemis III**, currently planned for 2025, is set to place human in the lunar surface.

2.2 Lunar Missions

- **International Lunar Research Station (ILRS)** - ILRS is a set of research facilities to be constructed with the possible involvement of international partners on the surface and/or in the orbit of the Moon.
- It is a joint venture between ***China and Russia.***

Mission	Country	Objective	Status
Chang'e 5	China 	Soft-landed on the south pole of the moon and collected samples	Launched on November 2020
Danuri mission	South Korea 	Orbiter will study moon from January 2023 after entering lunar orbit	Launched on Aug,2022
Artemis - I	USA 	First uncrewed integrated flight mission to moon	Launched on November 2022

ispace's Hakuto-R Mission	Japan 	UAE rover and Japanese payload on a lander; crash-landed	Launched on Dec,2022
Chandraayan-3	India 	Lunar exploration with a landing module and rover	Launch on 14th July 2023
Luna 25	Russia 	Sample gathering from southern pole	Launch on August 2023
Artemis II	U.S.A 	Crewed mission to the moon	Yet to launch on 2024
Unnamed Mission	China 	Crewed mission to the moon	Yet to launch on 2030

2.3 Role of Moon in the Development of Life on Earth

Moon, the only natural satellite of Earth played vital role in the geology of Earth and evolution of life.

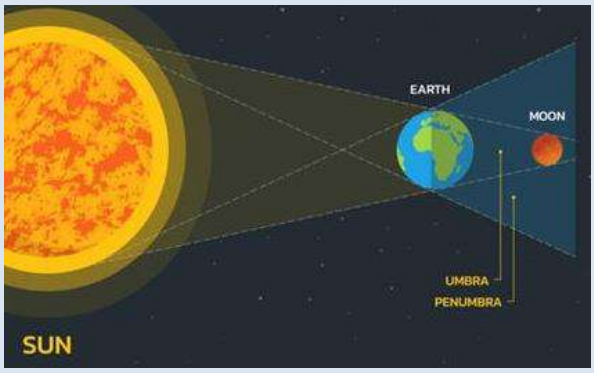
- **Moon -** It is the Earth's most constant companion, which orbits at a mean distance of about 384,400 km.
- The Earth and Moon are ***tidally locked***. Their rotations are so in sync we only see one side of the Moon.
- Humans didn't see the lunar far side until a Soviet spacecraft flew past in 1959.
- The Moon has a solid, rocky surface cratered and pitted from impacts by asteroids, meteorites and comets.
- It is approximately ***1/4th the size*** of Earth in terms of diameter.
- In surface area, the Moon covers about *1/16th of Earth's total surface area* & roughly has *1.2% of Earth's mass.*
- The moon's gravitational force is only about ***16.6 % of Earth's gravity*** which means a person would weigh 6 times less on the moon than they do on Earth.
- Moon takes 27 days to revolve around Earth, its lunar cycle (from one new moon to other new moon) is 29.5 days.
- **Formation -** Moon was formed when a Mars-sized object ***(Theia)*** smashed into the Earth about *4.5 billion years ago.* This enormous collision spun out a *cloud of debris* that evolved into the moon.
- As per research, Theia came from outer solar system that collided with the Earth.

Lunar Eclipse

The lunar eclipse of the Moon is caused by Earth which completely blocks the direct Sun rays which reach the Moon, with the only light reflected from the lunar surface being refracted by Earth's atmosphere.

Types

- **Total lunar eclipse-** It occurs when the Moon and Sun are on opposite sides of Earth.
- **Partial lunar eclipse-** It happens when only part of Earth's shadow covers the Moon.



Role of Moon in the development of life on Earth

- **Effect of tides on evolution -** Tides resulting from the gravitational force of the moon affect *animal life in the intertidal zone* (where the ocean meets the land between high and low tides).
- Big tidal ranges have been responsible for forcing bony fish into shallow pools on land, prompting the evolution of weight-bearing limbs and air-breathing organs.
- The tides eroded the coastal areas, *adding minerals to the oceans* an essential element for life to evolve quickly.
- **Effect of lunar cycle on reproduction-** The reproductive cycles of many marine creatures are *closely synchronised* with lunar phases.
    - **Example -** The mass spawning of corals on the Great Barrier Reef is triggered by the Moon.
- Nocturnal animals behave differently depending on where the moon is in the sky during lunar phase.
- There is also a link of *lunar rhythms with human behaviour*, activity and even fertility.
- Some scholars arguing that human reproductive behaviour was originally synchronous with the moon, but got modified recently by modern lifestyles.
- **Impact on climate change**- Moon's gravitational pull helps *transport heat away from equator* to the poles, shaping earth's climate.
- The absence of moon would lead to extreme climate change as there would be huge differences between temperatures and daylight throughout the year.

Recent Lunar Missions

- Moon also *stabilises the Earth's rotation on its axis* by slowing Earth's rotation on its axis.
- **Impact of Moon's light-** The ability to see and to be seen enhances in the moonlight.
- Studies have documented changes in the *success rates of predators and foraging patterns of prey animals* due to this added night time illumination.
    - Studies have shown that lions are less likely to hunt during the full moon and lion attacks on humans happen 10 days after the full moon.
- **Water distribution-** It is with the formation of the Moon, water came to Earth for the first time in 4.4 billion years ago.
- *Theia's collision with Earth* led to the formation of moon provided sufficient *carbonaceous material* to account for the entire amount of water on Earth.
- **Tectonic plates**- The *moon's pull of gravity* might have set the Earth's tectonic plates. It raises the level of the world's oceans towards the equator.

2.4 Granite under moon's surface

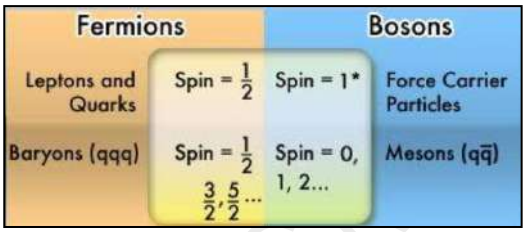
NASA scientists discover huge granite 'mass' buried on Moon based on the data gathered by the Chinese Chang'E-1 and Chang'E-2 lunar orbiters and NASA's Lunar Prospector and Lunar Reconnaissance Orbiters.

- Scientists have discovered a mass of granite 50km in diameter below the thorium-rich feature and an extinct volcanic caldera between the craters Compton and Belkovich on the Moon's far side.
- Granite is known to have higher concentrations of ***radioactive uranium and thorium*** than in other rocks in the lunar surface.
- Granites are ***igneous rocks*** that form remnants of the underground plumbing systems of extinct volcanoes.

2.5 Fermi Energy and Fermi Level

More research in quantum physics in recent times have shown that the fermi energy are significant and produce high energy.

- **Fermi energy** - The highest occupied energy level of a material at *absolute zero temperature (-273° C or 0K).*
- In other words, all electrons in a body occupy energy states at or below that body's Fermi energy at 0K.
- It is an energy difference of the kinetic energy of a system containing fermions and Fermi energy is *constant* for each solid.
- **Fermion** - Any member of a group of subatomic particles having odd *half-integral angular momentum* (spin 1/2, 3/2).
- Fermions mainly include *quarks and leptons* along with electrons, protons, and neutrons.



- Fermions obey
  - **Fermi-Dirac statistics** - when one swaps two fermions, the wave function of the system changes sign.
  - **Pauli Exclusion Principle** - no two fermions can exist in the same quantum state at the same time.
- **Fermi level** - It is the surface of that sea at absolute zero where no electrons will have enough energy to rise above the surface.
- The fermi energy levels enable us to
  1. Calculate the density of electrons and number of holes in the material
  2. Relative proportion of holes and density with respect to temperature
  3. Applied to Determine the electrical and thermal characteristics of solids
  4. Important in nuclear physics to understand the stability of white dwarfs
  5. Used in semiconductors and insulators and used to describe insulators, metals, and semiconductors

2.6 Scary Barbie

Scientists discovered a supermassive black hole and have named it 'Scary Barbie,' after a beloved children's character.

- Scary Barbie is a **supermassive black hole** that is devouring a star with a thousand times the brightness of a supernova.
- It is one of the most luminous, energetic, long-lasting transient objects in the sky.
- The researchers discovered it using an AI engine called ***REFITT*** (Recommender Engine For Intelligent Transient Tracking).

DID YOU KNOW?

Spaghettification is a process in which the forces around a black hole, called tidal disruption, pull other objects apart

2.7 Polar Cyclone on Uranus

NASA's Jet Propulsion Laboratory (JPL) announced that for the first time, scientists have strong evidence of a polar cyclone on Uranus.

- Uranus is the 7th planet from the Sun and it takes about 84 years to complete a full revolution.
- The evidence of a Polar Cyclone on Uranus shows the dynamic nature of the planet.
- ***Apart from Mercury***, every planet in the solar system have been identified with cyclones at the pole now. Mercury does not have a substantial atmosphere to have cyclones.
- **Uranus cyclone -** Unlike Earth, cyclones on Uranus are not formed over water as they don't have water.

2.8 Da Vinci glow

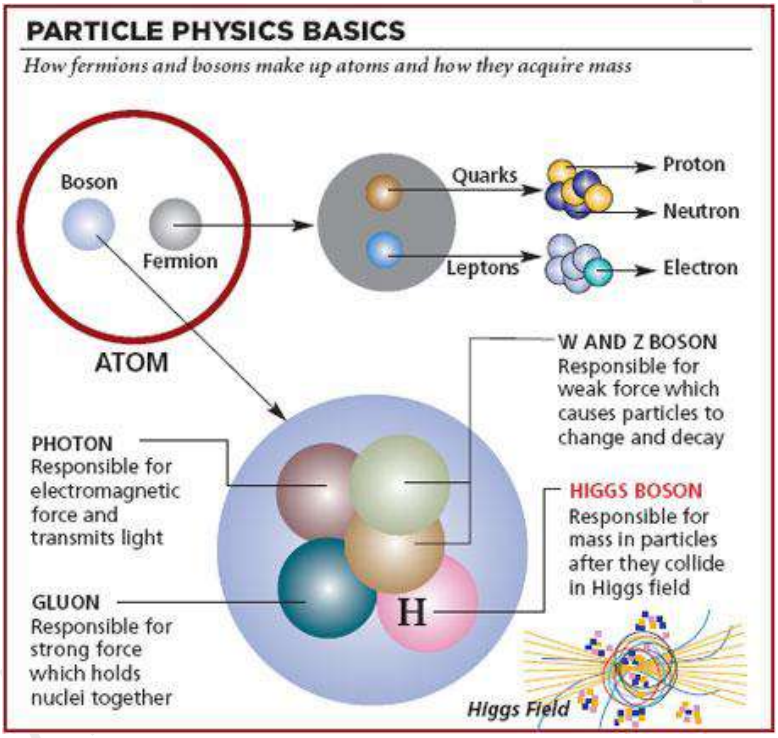
The experts predicted that a 'da Vinci glow' would be visible around the new moon on May 19, 2023.

- The da Vinci glow is a phenomenon in which the ***crescent moon is on the horizon, but the outline of a full moon is visible.***

- This glow is also called ***earthshine***, since it occurs due to light reflected from the earth and not the sun.
- The phenomenon usually happens close to sunset. Since Leonardo da Vinci was the 1st person to describe the phenomenon in the 16th century, it was named after him.

2.9 Higgs-Boson Decay

Physicists detected a Higgs boson decaying into a Z boson particle and a photon in the Large Hadron Collider (LHC) at CERN.



- The Higgs boson is the fundamental force-carrying particle of the Higgs field, which is responsible for granting other particles their mass.
- Known as ***'God's Particle'***, it was first discovered by the ATLAS and CMS detectors in 2012.
- **Properties -** The Higgs boson ***has mass but is chargeless.***
- It has ***zero spin,*** making it the only elementary particle with no spin.
- The mass of the subatomic particle depends on the particle's interaction with the Higgs boson.
- The stronger the interaction the more the mass it has.
    - Photons (particles of light) have no mass because they don't interact with Higgs bosons.
- The Higgs boson has a mass of 125 billion electron volts which is 130 times more massive than a proton.

Large Hadron Collider

- The Large Hadron Collider (LHC) is the world's largest and most powerful particle accelerator.
- Started in 2008, it is located in the ***CERN's accelerator complex.***
- It consists of a 27-kilometre ring in which two high-energy particle beams travelling in opposite directions are made to collide.
- It has 4 particle detectors - ***ATLAS, CMS, ALICE and LHCb*** at 4 colliding locations.

2.10 PRL Advanced Radial-velocity Abu-sky Search spectrograph (PARAS)

Indian scientists discover new exoplanet with mass 13 times that of Jupiter.

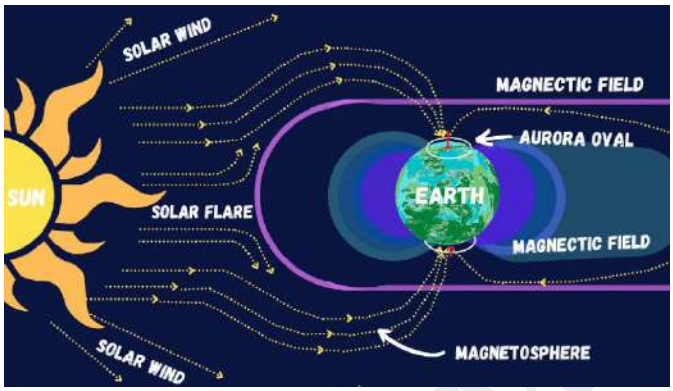
- **Exoplanet –** An exoplanet is any planet beyond the solar system.
- Massive giant exoplanets are those having mass greater than ***four times that of Jupiter.***
- **PARAS –** A ground-based device designed for the purpose of detecting extrasolar planets.
- Located at the ***Mt. Abu observatory*** in India, it operates on a 1.2m telescope.

2.11 Carbon-dioxide Auroras

NASA's satellite spots infrared carbon dioxide aurora from outer space

- **Aurora -** When ***solar storm interacts with the magnetic field lines*** at the north and south poles into Earth's atmosphere, it results in beautiful displays of light called auroras.

- Auroras are ***only visible at night***, and usually only appear in ***lower polar regions***.
- ***Oxygen*** gives off green and red light and ***Nitrogen*** glows blue and purple.
- Auroras are visible near the Arctic and Antarctic Circles, which are about 66.5 degrees north and south of the Equator.
- In the north, the display is called ***aurora borealis***, or northern lights.
- In the south, it is called ***aurora australis***, or southern lights.
- Other planets (Jupiter, Saturn, Uranus, Neptune) in our solar system have auroras.



- **Carbon-dioxide Auroras** - While carbon dioxide is known for its effects on the troposphere as a greenhouse gas, it also exists in trace amounts in Earth's atmosphere at the edge of space.
- High above Earth, near 90 km, CO_2 becomes vibrationally excited during an aurora, emitting more infrared radiation than typically observed in the atmosphere.

X-ray Auroras in Mercury

- High energy electrons from the solar wind rain down on Mercury's surface and, because they are *not restricted by a thick atmosphere,* they hit the surface. This process emits an auroral glow in the form of X-rays.
- **MESSENGER Mission**- Aurorae at Mercury had previously been observed by the MESSENGER mission, but the exact processes that cause the x-ray aurora had not been well understood.
- Mercury's magnetosphere is much smaller than Earth's and has a different structure and dynamics, that is evident that generates aurorae is the same throughout the Solar System.

Auroras in Earth	Auroras in Mercury
Auroras on Earth are triggered when a stream of charged particles emitted by the Sun interact with the ionosphere, the electrically charged upper layer of the planet's atmosphere.	Mercury has thin/no atmosphere and auroras on the planet are created when solar wind interacts directly with the planet's surface.

2.12 Dark stars

Recently, Webb telescope captures tantalizing evidence for three mysterious 'dark stars'.

- Immense, ultrabright hypothetical objects that are ***powered by dark matter*** rather than nuclear fusion.
- Dark matter is an ***invisible material*** whose presence is known mainly based on its gravitational effects at a galactic scale. It does not produce or directly interact with light.
- As per the findings of Webb telescope, Dark stars are described as made almost entirely of ***hydrogen and helium*** with 0.1% of their mass in the form of dark matter.
- **Mass** - Dark stars would be able to achieve a mass at least a million times greater than the sun and a luminosity at least a billion times greater. Dark stars are so massive that they end their lives as a black hole.
- **Diameter** - Roughly 10 times the distance between Earth and the sun.
- Dark stars are ***cooler than ordinary stars*** and unlike ordinary stars, they would be able to gain mass by accumulating gas falling into them in space.

2.13 Markarian 421

NASA's IXPE Mission unveils twisted mysteries of the Supermassive Black Hole Markarian 421.

- It is a ***supermassive black hole*** that is firing high energy particles directly towards Earth.
- It is located in the constellation ***Ursa Major*** and is a strong source of gamma rays.
- ***Blazar*** is the name given to black hole systems that have jets pointed at Earth and blazars can outshine all the stars in the galaxy that they inhabit. They are exceptionally bright since particles approach the speed of light.

Stellar Black holes	Supermassive Black holes
• Stellar-mass black holes are formed from the gravitational ***collapse of a single star or from the merger of two neutron stars.*** • Therefore, stellar-mass black holes have ***masses similar to the masses of stars.*** • They have masses ranging from about 3 times the mass of our sun to about 50 times the mass of our sun.	• Supermassive black holes have a ***mass greater*** *than about 50,000 times the mass of our sun.* • Supermassive black holes are far too large to have formed from the gravitational collapse of a single star. • Scientists do not currently know how supermassive black holes form.

- Supermassive black holes are always found at the center of a galaxy and almost all galaxies have a supermassive black hole at its center, which suggest that each supermassive black hole is formed as part of the formation of its galaxy.
- **Imaging X-ray Polarimetry Explorer (IXPE) Mission** - IXPE is NASA's first mission to study the polarization of X-rays from many different types of celestial objects.

2.14 Einstein Cross

Astronomers have discovered a stunning, rare example of an Einstein cross splitting and magnifying light from the far depths of the universe.

- ***Einstein's theory of general relativity*** describes the way massive objects warp the fabric of the universe, called space-time.
- Einstein discovered that gravity is not produced by an unseen force; rather, it is simply our experience of space-time curving and distorting in the presence of matter and energy.
- This curved space, in turn, sets the rules for how energy and matter move.
- Even though light travels in a straight line, light moving through a highly curved region of space-time, like the space around enormous galaxies, also travels in a curve.
- This bends around the galaxy and splaying out into a halo.
- What this halo looks like depends on the strength of the galaxy's gravity and the perspective of the observer.
- **Einstein ring –** In this case, Earth, the lensing galaxy and the quasar have aligned to perfectly duplicate the quasar's light, arranging them along a so-called Einstein ring.
- The general effect is known as *gravitational lensing, and this specific case is known as the Einstein Cross*.

2.15 Blue Supermoon

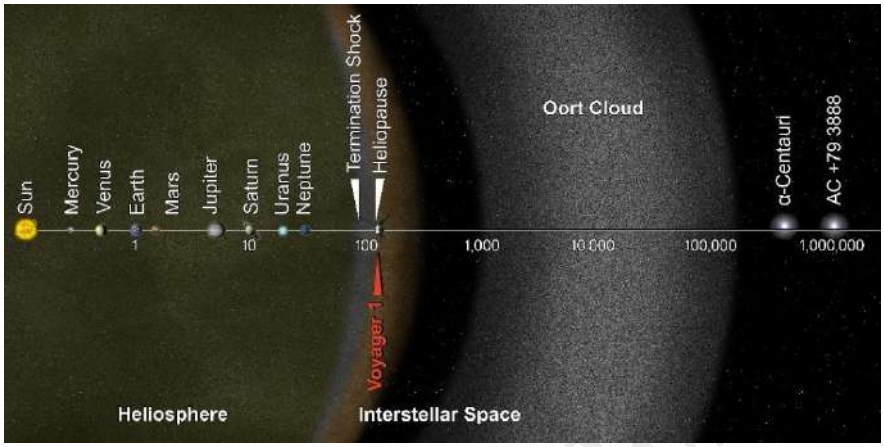
There will be two supermoons in August and one of them will be only happen again nine years later.

- Supermoon refers to when the *Moon's orbit is* ***closest to the Earth*** *at the same time the* ***Moon is full.***

Sturgeon Supermoon	Blue Supermoon
• **Farmer's Almanac –** The full moon on August 1 will be a sturgeon supermoon, according to Farmer's Almanac. • **Origin –** It gets its name from the Native American tribes who found that the giant sturgeons from the Great Lakes were most easily caught during this time of the summer. • **Other names –** The sturgeon moon is also referred to as a green corn moon, grain moon, flying-up moon, harvest moon, ricing moon, black cherries moon, and mountain shadow moon.	• There are 2 kinds of blue moons; one definition is for when a full moon appears for the second time in a single month. • A blue moon is not rare. • Full moons are separated by 29 days and since most months are 30 or 31 days long, it is quite possible for two full moons to fit within a month. • In fact, it happens every two and a half years on average, however, a Supermoon coinciding with a blue moon is a much rarer occurrence. • The next time such an occurrence will take place only in 2032.

2.16 Oort Cloud

- The Oort Cloud is the ***most distant region of our solar system.***
- Because the orbits of long-period comets are extremely long, scientists suspect that the Oort Cloud is the source of most of the comets.
- ***Kuiper Belt*** is the collection of millions of icy objects, collectively referred to as Kuiper Belt objects (KBOs) or trans-Neptunian objects (TNOs), in this distant region of our solar system.



2.17 Demon Particles

Scientists recently claimed to have found a "demon particle" while plunging into the depths of atoms.

- Electrons have ***both mass and charge.***
- In 1956, physicist David Pines predicted that the combinations of electrons in a solid could form a composite particle that is ***massless, has no charge and does not interact with light*****.** This is called as a demon particle.
- This particle demonstrates its capabilities regardless of temperature, in contrast to standard superconductors, which need very low temperatures to function.
- This could pave the way for *room-temperature superconductors*.
- The newly discovered demon particle exhibits *Plasmon-like behavior* and presents particular experimental difficulties because it is electrically neutral.

Plasmons are collective oscillations of the electrons which are present at the bulk and surface of conducting materials and in the neighborhood of conducting particles.

2.18 Magnetars

A Star, HD 45166, that could become the strongest magnet in the universe has been discovered by astronomers.

- Magnetars are ***neutron stars.***
- They are the most magnetic objects in the universe. The magnetic field in a magnetar is 1000 times stronger than in the neutron star.
- They are very rare - only 31 magnetars have been confirmed so far.

2.19 Ghost particles

*China is building the World's largest neutrino detector called "**Trident**" in the Western Pacific Ocean.*

- ***Neutrino***s, also known as the Ghost Particles, are a type of electron but they *do not have any charge*.
- Neutrinos belong to the family of particles known as ***leptons***. There are 3 main leptons- electrons, muons and tau particles.
- **Symbol -** Neutrinos are denoted by the Greek symbol **ν**, or **nu**.
- **Mass -** They are among the most abundant and tiniest particles in the universe and ***have very small mass***.
- **Source -** Neutrinos come from all kinds of different sources and are often the product of heavy particles turning into lighter ones, a process called ***decay***.
- **Interactions -** Neutrino's weak charge and almost non-existent mass have made it difficult to observe.

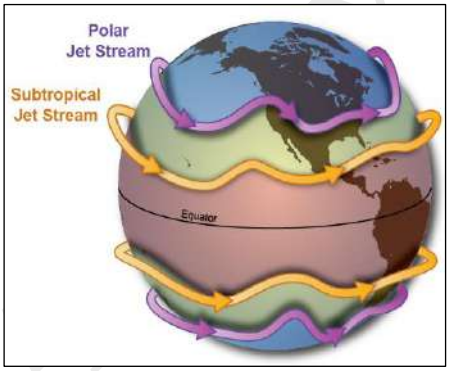
*Currently, the largest neutrino-detecting telescope is the University of Madison-Wisconson's "**IceCube**" telescope situated in the Antarctic.*

2.20 Jet Stream in Jupiter

Researchers using James Webb Space Telescope's NIRCam (Near-Infrared Camera) have discovered a high-speed jet stream sitting over Jupiter's equator, above the main cloud decks

James Webb Space Telescope is infrared telescope, an international partnership between NASA, European Space Agency (ESA) and Canadian Space Agency (CSA).

- **Jet stream in Jupiter** – It is located *about 40 kilometres above* the clouds in Jupiter's lower stratosphere.
- It is more than 3,000 miles (4,800 kilometers) wide and about *515 kilometers per hour* (kmph)
- Significance – To understand planet's turbulent atmosphere
- To understand how different layers of the planet's atmosphere interact with each other
- **Jet Streams in Earth** - They are relatively narrow bands of strong wind in the ***upper levels of the atmosphere*** and typically occurs around 30,000 feet in elevation that blows ***from west to east.***
- It keeps *moving from north to south* and then north again.
- **Jupiter** is the largest planet in the solar system and the gas giant's atmosphere is one of the most turbulent regions in our planet's vicinity.



2.21 Lucy spacecraft

The National Aeronautics and Space Administration's (NASA) Lucy spacecraft is on an epic 6-billion-kilometre-long journey to study the Jupiter Trojan asteroids.

- Lucy mission was launched in 2021. **Agency –** NASA, U.S.
- **Aim -** To observe the ***Jupiter Trojan asteroids***, huge group of small bodies that orbit the Sun in two swarms.
- Lucy will first fly by ***Dinkinesh asteroid*** in the main belt called Donaldjohnson in 2025.
- Dinkinesh orbits the Sun in the main belt of asteroids between the orbits of Mars and Jupiter.
- NASA's *Wide-field Infrared Survey Explorer (WISE)* is supporting the flyby.

2.22 Gravitational Constant (G)

The strength of the gravitational force depends on the gravitational constant.

- Any mass warps the fabric of space-time around itself and more the mass, the more the warping.
- **Gravity** – The force that an object feels when travelling along the warped path which tends to move the object towards the mass.
- **Gravitational constant** – It is denoted by a 'G', a fundamental physical constant.
- **Newton's theory** – The gravitational force between two objects is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

Gravitation constant was 1st accurately determined by Henry Cavendish in 1797 and it is an essential component of Isaac Newton's law of universal gravitation and Albert Einstein's theory of general relativity.

- *G is the proportionality constant* whose value is ***6.673 × 10−11 N m2 kg−2.***
- **Importance of G** – The precise value of G is crucial to understand celestial mechanics and *to determine the mass of celestial bodies*.

2.23 Disappearance of Saturn's Rings

Scientists revealed that in 2025, Saturn will align edge-on with Earth, rendering its splendid rings virtually invisible.

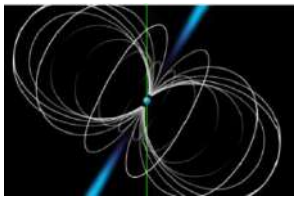
- **Saturn** is the 6th planet from the Sun, 2nd largest in the solar system after Jupiter and a gas giant composed primarily of hydrogen and helium.

- It has radius about 9 times that of Earth, has a low density and is only about 95 times more massive than Earth.
- **Saturn's Rings** – It is primarily ice particles with a smaller fraction of rocky debris and dust ranging from micrometres to meters in size that spreads out over 280,000km from the planet.
- ***7 distinct rings*** are named as A, B, C, D, E, F, and G rings with varying transparency and brightness.
- In 1610, Galileo Galilei, the pioneer of modern astronomy, 1st laid eyes upon the magnificent rings of Saturn.
- **Origin** – May be from remnants of comets, asteroids, and moons which were ripped apart by the planet's immense gravitational pull. It is younger than a tenth of Saturn's own age.
- **Rings orbit** – Directly above Saturn's equator and so they are tilted to the plane of Saturn's orbit.
- While Earth's equator is tilted by 23.5 degrees, ***Saturn's equator has a 26.7 degree*** **tilt** and so just like Earth, Saturn experiences seasons, but more than 29 times longer than ours.
- **Disappearance** – As Saturn tilts, its rings will *seem to vanish* due to the planet's tilt and Earth's perspective.

2.24 Pulsar Glitch

In 1969, scientists noticed an abrupt and brief increase in the rotation rate of a pulsar called as pulsar glitch.

- **Pulsars** – They are ***rotating neutron stars*** (super-dense object) whose ***rotation rate is slowed over time***.
- Pulsars have very ***strong magnetic fields*** which funnel jets of particles out along the two magnetic poles.
- These accelerated particles produce very powerful beams of light.



- Young pulsars create jets of matter and antimatter that move away from their poles, along with an intense wind, creating what is known as a ***pulsar wind nebula***.
- When heavy stars die, their cores implode and if they're heavy enough, they become black holes. Else, they collapse to form a ball of neutrons called as neutron stars.
- **Emission of radio signals** – The energy saved by reducing the rotation rate was used to accelerate *electric charges outside the star*, producing the radio signals that are emitted near the poles.
- It forms a cone that sweeps past the earth with every rotation.
- **Pulsar glitch** – An ***abrupt and brief increase in the rotation rate*** of the pulsar before relaxing to the original value slowly.
- ***The 1st pulsar*** *was discovered in 1967* and 1st pulsar glitch was observed in 1969. Till date, we have spotted more than 3,000 pulsars and around 700 pulsar glitches.

2.25 Amaterasu

Recently, astronomers have detected a rare and extremely high-energy particle falling to Earth.

Cosmic Rays

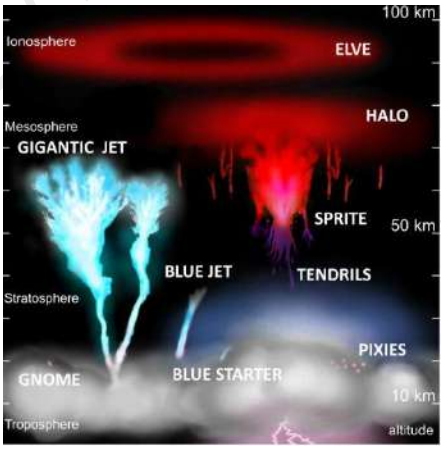
- A radiation that constantly rains down on Earth from space
- **Properties** – They are *electrically charged* and so *deflected by various magnetic fields* throughout the galaxy.
- **Detection** - The rays *don't point directly back to their sources*.
- **Composition** – They are *mainly protons (89%)* but also includes nuclei of helium (10%) and heavier nuclei (1%).
- **Impact** – When they crash into our atmosphere, they are broken up and fall to Earth in even smaller fragments.
- **Significance** – Helps in understanding the chemical evolution of the universe.

- It is one of the ***most powerful cosmic rays*** slamming into Earth and has been named "Amaterasu" after the *Japanese sun goddess.*
- These ultra-high energy particle passes atmosphere smoothly without any deflection by magnetic fields.

- **Spotted by** – ***Telescope Array observatory in Utah***, a collaboration of the United States, Japan, Korea, Russia, and Belgium to observe cosmic rays.
- **Energy** – It ***exceeds 240 exa-electron volts (EeV)***, millions of times more powerful than the particles produced by the *Large Hadron Collider*, which is the most powerful accelerator ever built.
- It is ***2nd only to the 'Oh-My-God' particle***, a high-energy cosmic ray at 320 EeV that was detected in 1991.
- **Source** – Only the most powerful cosmic events, on scales far exceeding the explosion of a star, are thought to be capable of producing such energetic particles.
- However, Amaterasu appears to have emerged from the ***Local Void***, an empty area of space bordering the Milky Way galaxy.
- **Reasons for non-detection**
    - It could be from a source that we have not yet identified.
    - It might have been magnetically deflected much higher than current models predict.
    - Scientists might need to rewrite their incomplete understanding of high-energy particle physics.

2.26 Red Sprite

The European Space Agency (ESA) astronaut captures images of red sprite from ISS Cupola observatory.



- It is dubbed as ***red lightening*** which lasts merely a millisecond.
- It is a part of ***transient luminous event (TLE),*** a rare electrical discharge that can appear over thunder clouds.
- Unlike typical lightning bolts that descend from the clouds to the ground, a sprite behaves inversely, ascending into the atmosphere, resembling a form of reverse lightning.
- **Location** – It forms ***between 40 and 80 kilometers above Earth***
- **Thor-Davis ISS experiment** – It aims to investigate upper atmospheric lightning and its implications on greenhouse gas levels, thereby influencing global warming.
- It will photograph storms from the vantage point of the International Space Station's (ISS) observatory.
- **Davis Camera** – It works like the retina in our eyes that is sensitive to changes in light, allowing it to take up to the equivalent of 100.000 pictures per second.

2.27 Cosmic Expansion

Euclid telescope observed that galaxies belonging to the Perseus Cluster and others move further away showing the expansion of universe.

- **Cosmic expansion** – The universe was born with the Big Bang as an unimaginably hot, dense point and at ***10-34 of a second of big bang***, it had an inredible burst of expansion known as ***inflation*** which expanded faster than the speed of light.
- **Expansion rate** – After inflation, it ***continued at a slower rate*** as the matter in the universe pulled on itself via gravity.

> ***Euclid telescope****, designed and built by European Space Agency (ESA) to explore dark matter and dark energy which are thought to make up 95% of the universe.*

- About 5 or 6 billion years after the Big Bang, ***dark energy began speeding up the expansion again*** that continues even today.

Measuring the rate of expansion

- It is calculated using 2 models such as Lambda-cold dark matter (ACDM) and Modified Newtonian Dynamics (MOND).
- **Lambda-cold dark matter (ACDM)** – It is based on observation of the light left over from the Big Bang called as cosmic microwave background (CMB).

- **Hubble's constant** – Predict how fast an astronomical object (star or galaxy) is moving away from us.
- **Hubble tension** – It refers to the discrepancies in the expansion rate when measured using nearby galaxies and supernovas (exploding stars).
- **Modified Newtonian Dynamics (MOND)** – It suggests that Newton's law of gravity breaks down when the gravitational pull is very weak and the structure (such as galaxy clusters) would grow faster.
- **Bulk flow** – It is the average velocity of matter in a given sphere, which varies with the radius of the sphere.

The universe's expansion makes galaxies move away from each other. The further away they are from us, the more quickly they move.

2.28 Apophis

NASA probe to observe Apophis, an asteroid as wide as Empire State Building near-Earth encounter.

- Asteroid 99942 Apophis is a ***near-Earth object (NEO)*** estimated to be about 1,100 feet (340 meters) across.
- Its next approach in 2029 will bring the asteroid within less than one-tenth the moon's distance to the earth.
- **OSIRIS-Rex** has been rebranded as ***OSIRIS-APEX*** to probe the Apophis by the NASA.
- The spacecraft is set to observe the asteroid's Earth flyby as it nears and ultimately catch up with Apophis.

2.29 Chicxulu impact

- It was a 100 million megaton blast that occurred 66 million years ago by an asteroid or comet that crashed into Earth off the coast of Mexico.
- The impact generated a core of superheated plasma that was over 10,000 degrees, wiped out 75% of all species on Earth, created a 2-year cloud of dust that caused an extreme and abrupt shift in climate.

2.30 Mouse embryos in Space

- ***Japanese scientists*** have said that mouse embryos were grown in International Space Station for 1st time.
- The embryos cultured under microgravity conditions developed normally into blastocysts, cells that develop into the foetus and placenta and demonstrates that gravity had no significant effect.

2.31 Pandora's cluster

- Recently, scientists used the James Webb Space Telescope to discover the 2nd and 4th most ***distant galaxies*** in a part of space known as Pandora's cluster.
- Pandora's Cluster is the nickname of Abell 2744, a giant galaxy cluster in the constellation Sculptor.
- It's about 4 million light-years across and has the mass of 4 trillion suns (Dark matter – 75%).
- The gas (around 20%) is so hot that it shines only in X-rays.

2.32 Mars solar conjunction

- It is a phenomenon that occurs when the ***Sun is between Earth and Mars***. This happens *once every 2 years.*
- During conjunction, Mars is located on the opposite side of the Sun from Earth

2.33 Devil Comet

Mount Everest-sized Devil comet hurtling in Earth's direction could explode today.

- Comet 13P/Pons-Brooks, also called the Devil Comet, is about the size of Mount Everest and it is hustling towards Earth.
- The comet is ***cryovolcanic,*** meaning that it has volcanoes that erupt material into the extremely cold environment of space.

2.34 Cosmic Distances

No human probe has travelled much beyond the Solar System, yet we are able to measure distances across billions of light-years.

- For cosmic distances other types of units such as astronomical units, light years and parsecs are used.
- All these methods are collectively known as the cosmic distance ladder.

Astronomical units (AU)	• They are a useful unit of measure within our solar system. • 1 AU is the distance from the Sun to Earth's orbit, which is about 93 million miles.
Light year	• A light year is the distance a photon of light travels in one year, which is about 6 trillion miles. • A light year is how far one can travel in a year if they could travel at the speed of light, which is ***186,000 miles per second.*** • The Sun is about 8 light minutes from Earth.
Parsecs	• This is the unit used when the number of light years between objects climbs into the high thousands or millions. • One parsec is 3.26 light years. • Astronomers talk about distances in terms of how much a galaxy's light has been shifted toward longer, redder wavelengths by the expansion of the universe, a measure known as **redshift.**

2.35 Kilonova Explosions

Kilonova explosions from neutron star collisions could explain how Earth got gold.

- When some type of massive stars die, the nuclear fusion process that fuels them stops. This forms an ultra-dense and neutron rich star.
- When such stars collide with each other, these free neutrons are released into space and taken up by atoms to form very heavy elements beyond the scope of the periodic table.
- The collision of these ultra-dense, dead stars causes ripples in the very fabric of space-time, called ***gravitational waves***.

A neutron star is the remnant of a collapsed supergiant star that was between 10 and 25 times the mass of our Sun.

- The collision also causes high-energy gamma-ray bursts and a flash of light (Kilonova) which can be detected across large distances in space.
- Gold and other metals heavier than iron are formed in space when two neutron stars collide.
- Among the natural elements, boron, cadmium, and gadolinium are the best absorbers of slow neutrons by the capture process.

Gold	Uranium
• Gold (Au), a dense lustrous yellow precious metal of Group 11 (Ib), Period 6, of the periodic table of the elements. • Gold has several qualities that have made it exceptionally valuable throughout history.	• Uranium (U), of the actinoid series of the periodic table, and is an important nuclear fuel. • Some important uranium minerals are pitchblende, uraninite, carnotite, autunite, and torbernite.

2.36 M-Star

- M star was detected recently using Hobby-Eberly Telescope, which is 100 times less luminous than sun.
- M Star is the ***smallest star in Earth's solar system.*** They are also known as ***red dwarfs.***
- M dwarfs are the most common stars in the galaxy, making up over 70% of all stars.

3. TELESCOPES & OBSERVATORIES

3.2 Hanle Dark Sky Reserve (HDSR)

In a 1st of its kind event, the Indian Institute of Astrophysics (IIA) hosted an official Star Party 2023 at the Hanle Dark Sky Reserve in eastern Ladakh.

- It was ***India's 1st dark sky*** organised by the IIA in collaboration with Department of Wildlife Protection, ***Ladakh*** to observe the optical phenomenon in the sky.
- **Objectives of HDSR**– It *preserves the dark skies* by reducing light pollution in the surrounding areas. It uses these dark skies to *promote astrotourism*.

Venus can be so bright in the night sky that its light can cast shadows on the ground, just as moonlight does.

- **Significance of Dark Sky** – To observe stars, star clusters, nebulae, and galaxies (such as Milky Way, Andromeda and Triangulum) with the naked eye.
- **Bortle Scale** - It *measure the night sky's brightness* at a given location.
- It scales ranges from Class 1 (darkest skies available over the earth) to Class 9 (pale, light-marred skies over the insides of cities). HDSR comes under Bortle Class 1 skies.

Optical phenomenon in the sky

- **Zodiacal light** – A *faint glow of diffuse sunlight* scattered by interplanetary dust in the Solar System.
- **Airglow** – An optical phenomenon caused by *faint emission of light* in the earth's atmosphere.
- **Gegenschein** – It is also known as counterglow, which is *a bright spot in the night sky* centred at the antisolar point, caused due to backscatter of sunlight by interplanetary dust.

3.3 25 years of the International Space Station (ISS)

International Space Station (ISS), a place of peaceful collaboration for science, has completed more than 140,000 Earth orbits in its journey of 25 years.

- ISS is a multi-nation construction project that is the *largest single structure humans ever put into space.*
- **Origin –** Mainly a creation of USA and later Russia was invited to participate.
- **Operated by** – 5 agencies
  - Canadian Space Agency (CSA)
  - The European Space Agency (ESA)
  - The Japan Aerospace Exploration Agency (JAXA)
  - The National Aeronautics and Space Administration (NASA)
  - The State Space Corporation "Roscosmos"

Among the 1st "live-in" astronauts were Bill Shepherd of NASA and Roscosmos cosmonauts Yuri Gidzenko and Sergei Krikalev

- **Size** – Measures 109 meters (357 feet) end-to-end at *Low Earth Orbit* (430 kilometers)
- **Components** – It consists of
  - **Zarya Control Module** – Russia based component that was launched in 1998 for supplying fuel storage, battery power, and serving as a docking zone for other vehicles
  - **Unity Node 1 module** – US based component
- It passes over our heads ***16 times every 24 hours*** (orbits Earth every 90 minutes at a speed of ***8 km/s***)
- **Achievements** - Its discoveries have benefitted drug development, new water purification systems, methods to mitigate muscle and bone atrophy and lead to innovations in food production.
- **Future of ISS** - NASA, CSA, and the ESA have committed to operate *till 2030*, while Russia has said that it will withdraw after 2024 to focus on building its own space station around 2028.
- NASA plans to spend up to $1 billion to build the **US Deorbit Vehicle (USDV) to deorbit ISS.**

3.4 Stratospheric Observatory for Infrared Astronomy (SOFIA)

- It's a Boeing 747SP aircraft modified to carry a 2.7-meter (106-inch) reflecting telescope and is the ***world's only airborne telescope.***
- It was designed for infrared astronomy observations in the ***stratosphere*** at altitudes of about 12 kilometers.

3.5 Euclid Space Telescope

- The Euclid space telescope that was launched in 2023 was developed by ***European Space Agency (ESA)*** and the Euclid Consortium (includes NASA) to study the composition and evolution of the ***dark universe.***

4. DEFENSE

4.2 Atmanirbhar Bharat in Defence Production

The US-India military deal is not enough to cut the partnership that India has with Russia.

Status of India's Defence Production

- **Arms import** - India is the ***world's biggest arms importer*** but the major weapons purchases include provisions for joint manufacture or technology transfer.
- Of India's total volume of procurement in 2016–20, ***84%*** was of foreign origin.

> *The US remained the top arms exporter during 2018-22.*

- As per Stockholm International Peace Research Institute (SIPRI), India bought weapons worth over $60 billion in the last 20 years, of which ***65% were from Russia***.
- **Military spending** - India is the ***third largest military spender*** after the United States and China.
- **Indigenisation** - According to SIPRI, *64% of capital outlays* in the military budget of 2021 were earmarked for acquisitions of *domestically produced arms.*

History of India-Russia defence relations

- USSR was *India's strategic partner* during the Cold War and also its primary military equipment supplier.
- Moscow loaned *the 1st nuclear submarine to India in 1988,* which was commissioned as ***INS Chakra.***
- **Joint exercises**- "***INDRA"*** is held between the three-Armed Forces. Indian contingent participated in International Army Games, Ex Vostok in Russia.
- **Agreement for 2021-2031**- To develop and strengthen the military and technical cooperation in research and development, production and after sales support of armament systems and various military equipment.

History of India-US defence relations

- *India-US 2+2 Ministerial dialogue* further enhanced the defence ties.
- **Bilateral Exercises**- Tiger Triumph, Vajra Prahar, Malabar exercises etc.,
- In 2016, *US recognised India as "Major Defence Partner"* which commits the U.S. to facilitate technology sharing with India.
- Both have signed 4 agreements that cover areas of military information, logistics exchange, compatibility, and security.

Agreement	About	Signed in
GSOMIA	General Security of Military Information Agreement	2002
LEMOA	Logistics Exchange Agreement	2016
COMCASA	Communications Security Agreement	2018
BECA	Basics Exchange Cooperation Agreement	2020

- **QUAD (Quadrilateral Security Dialogue) -** It is a strategic security dialogue between Australia, India, Japan and the United States.
- **Other agreements-** *'Security of Supply' (SoS) arrangement* and a *'Reciprocal Defence Procurement' (RDP) agreement* aims to promote long-term supply chain stability and enhance security and defense cooperation.
- India's first indigenous fighter jet ***LCA Tejas*** is powered by *GE's F404 engines* exported from US, talks to buy MQ-9 UAV (also known as Sea Guardian) is also under the table.

Measures announced by India to attain Atmanirbhar in defence sector

- ***Make-in India***
- **IDEX-Prime** - To encourage projects that may necessitate support beyond Rs. 1.5 crore and up to Rs. 10 crore, to help developing start-ups in the defence sector.
- An indigenisation portal called ***SRIJAN*** would be launched to support indigenisation by Indian entities, including MSMEs. Two *industrial defence corridors* would be launched in Uttar Pradesh and Tamil Nadu.

4.3 Defence Research and Development Organisation (DRDO)

It is necessary to focus the Defence Research and Development Organisation (DRDO) that performs research activity for the Armed Forces.

- **Ministry** - Department of Defence Research and Development, Ministry of Defence
- **Role**- Military's research and development
- **Headquarters-** New Delhi, India
- **1958-** It was formed by the merger of the
  - Technical Development Establishment
  - Directorate of Technical Development and Production of the Indian Ordnance Factories
  - Defence Science Organisation
- **1979-** Defence Research & Development Service (DRDS) was constituted in 1979.
- **Motto-** "*Balasya Mulam Vigyanam*" – "The source of strength is science"

4.4 Emerging Technologies in Defence

Emerging technologies like artificial intelligence, cyber technology, etc. are vital for Indian military and defence organisations.

- **Emerging technologies** - It refers to innovative advancements or developments that have the potential to significantly change the way we live and work.
- These technologies arise from cutting-edge research and offer new opportunities for industries, economies, and societies. Example, Artificial intelligence, 3D Printing, etc.

Steps taken to use emerging technologies in Indian defence sector

- **Chanakya Defence Dialogue**- It was held in 2023 which serves as a forum to *enhance national and regional security* by discussing contemporary issues, including the impact of emerging technologies.
- **Integrated Unmanned Roadmap**- It is a comprehensive plan for the development and deployment of unmanned systems in the *Indian Navy* that aims to achieve standardization, interoperability and jointness.
- **Project Swavlamban**- It is an initiative to promote Atmanirbhar (self-reliance) in the defence sector by encouraging indigenisation of defence equipment and technology.
- **AIDef**- Artificial Intelligence in Defence is a symposium held in 2022 that showcased cutting edge AI enabled solutions developed by industry, start-ups etc.,
- It includes Defence AI Council and Defence AI Project Agency that facilitates AI integration in defence.
- **Defence Cyber Agency**- Launched in 2018 to handle cyber security threats & develop cyber warfare doctrine.
- **Defence Space Agency**- It is responsible for operating space warfare and satellite intelligence assets of India.

4.5 AI in Defence Sector

Artificial Intelligence is shaping India's defence landscape providing a potential advantage in operations while also enhancing border security.

- Artificial intelligence (AI) is when computers and other machines mimic human cognition, and are capable of learning, thinking, and making decisions or taking actions.

Initiatives taken by Government to promote AI in defence sector

- **Roadmap -** NITI Aayog and the Ministry of Defence partnered to build a roadmap for integrating AI within the defence forces in 2018.
- **Defence Artificial Intelligence Council** - It is led by Ministry of Defence to provide overall guidance and support for projects involving cutting-edge technologies.
- **Defence AI Project Agency -** As per ***Chandrasekaran committee*** recommendation it was launched with an annual budget of 100 crores for AI programs to provide necessary guidance and structural support.
- **Defence India Startup Challenge** - It is under the Innovations for Defence Excellence (iDEX) programme which aims to fund startups that address AI, sophisticated imaging, sensor systems, big data analytics, autonomous unmanned systems, and secure communication systems, among other technologies for the defence forces.
- **WARDEC -** The Army Training Command has signed an MoU with Rashtriya Raksha University (RRU) to develop a Wargame Research and Development Centre (WARDEC) in New Delhi. It will be India's first simulation-based training centre.
- **India-US Defence Artificial Intelligence Dialogue**- During the recent 4th U.S.-India 2+2 Ministerial Dialogue between India and US Defence and External Affairs Minister, there was a call for increased collaboration.
- **AI in defence symposium**- Ministry of Defence launched 75 newly-developed AI technologies during the 1st "AI in Defense" symposium where products like robotics, and intelligence surveillance were on display.
- **Agni-D**- It is an AI-based surveillance software developed by the Indian military for border security and threat detection which was unveiled at Aero India, one of Asia's largest air shows, in 2023. It was deployed in eastern Ladakh sector, a region of strategic importance due to its closeness to China.
- **Research institutions**- DRDO has three dedicated laboratories for application oriented research in AI in different domains.
    - Centre for Artificial Intelligence and Robotics (CAIR), Bengaluru and
    - DRDO Young Scientist Laboratory (DYSL)-AI and
    - DRDO Young Scientist Laboratory (DYSL)-CT (Cognitive Technology)

4.6 Maternity leave for women in Armed Forces

Union Defence Minister has approved a proposal to grant maternity, child care and child adoption leave to women soldiers, sailors and air warriors on par with their officer counterparts.

- At present, the women officers get maternity leave of ***180 days with full pay*** for each child, subject to a ***maximum of 2 children.***
- Childcare leave of 360 days is granted in total service career (subject to the child being less than 18 years of age) to women officers.
- Child adoption leave of 180 days is granted after the date of valid adoption of a child below 1 year age.

4.7 Agniveervayu (Women)

- Agniveervayu (Women) is a group of female soldiers in the ***Indian Air Force (IAF).***
- They are appointed to the Army wings under the ***Agnipath scheme***, a short-term service youth recruitment.
- They are recruited for a period of ***4 years***, with the option to extend their service for an additional 4 years.
- After completing their service, *25% of them will be selected* to join the regular military as permanent soldiers.

4.8 Agni Missiles

Recently, training launch of Short-Range Ballistic Missile 'Agni-1' was carried out successfully from APJ Abdul Kalam Island in Odisha.

- It is a family of medium to long-range ***surface-to-air ballistic missile***.
- **Development** –DRDO under Integrated Guided Missile Program (IGMP)

Integrated Guided Missile Development Programme (IGMDP)	
• It is a Ministry of Defence programme to research and develop missiles. • The project was started in ***1982–1983*** under the leadership of ***Dr APJ Abdul Kalam.*** • It accomplished its design objectives by 2012. • The DRDO and erstwhile Ordnance Factories Board (OFB) managed the programme with other Indian government political organizations.	**Missiles developed under IGMDP** 1. PRITHVI 2. AGNI 3. TRISHUL 4. AKASH 5. NAG

- **Operated by** – ***Strategic Forces Command (SFC),*** a key tri-services formation that administers all the strategic assets and falls under the *Nuclear Command Authority of India.*
- **Purpose** - To act as deterrence & meet the country's security requirements.

Missile	Range (Km)	Features
Agni-I	Medium Range (700-1200)	Customized weapon load, Have high degree of precision
Agni-P	Medium Range (1000-2000)	2-stage canister missile, Launched from train or road, India's 1st Multiple Independently targetable Re-entry Vehicle missile
Agni-II	Medium Range (2000-2500)	Nuclear capable, Night operable
Agni-III	Intermediate Range (Up to 3500)	Can target Pakistan and China
Agni-IV	Intermediate (3500-4000)	Launch from road mobile launcher
Agni-V	Inter-Continental Ballistic Missile (>5500)	India's 1st ICBM, Night capable
Agni-VI	Inter-Continental Ballistic Missile (8000-10000)	Under development, Launched from land and submarine

4.9 Agni Prime or Agni - P

New Generation Ballistic Missile 'Agni Prime' was successfully flight-tested by Defence Research and Development Organisation (DRDO).

- It is a ***nuclear-capable*** new-gen advanced variant of the Agni class of missiles.
- **Aim** – To counter Pakistan's forces as its range is insufficient to reach all parts of mainland China.
- **Agency** – Developed by DRDO. It is lighter than all the earlier Agni series of missiles.
- **Programme -** It is developed under ***Integrated Guided Missile Development Program (IGMDP).***
- **Range** - It is a ***medium – range*** ballistic missile with a range of 1,000 to 2,000-km.
- It is a 2-stage canisterised missile that can be launched from rail or road, be stored for longer periods and can be transported as per operational requirements.
- ***Canisterisation*** of missiles reduces the time required to launch the missile while improving its storage and mobility.

4.10 ASTRA Missile

Light Combat Aircraft (LCA) Tejas successfully test fired the indigenously made ASTRA missile.

- **ASTRA** – It is a Beyond Visual Range (BVR) class of ***Air-to-Air Missile*** (AAM) system.
- It was designed and developed by the Defence Research and Development Laboratory (DRDL), Research Centre Imarat (RCI) and other laboratories of the ***DRDO***.
- **Targets** - It was designed to be mounted on fighter aircraft to destroy highly manoeuvring *supersonic aerial targets*.
- **Range - Astra -1** - Around 100 km, **Astra - 2** - Around 160 km
- **Capability** - The missile has all weather day and night capability.
- The ASTRA Mk-I Weapon System integrated with SU-30 Mk-I aircraft is being inducted into the Indian Air Force (IAF).

LCA Tejas

- LCA Tejas is a ***4.5 generation***, all weather and multi-role fighter aircraft with maximum speed of ***1.6 Mach***.
- It is an ***indigenously*** manufactured 4th generation multi-role fighter aircraft.
- ***LCA Mk1A*** is the most advanced version of LCA Tejas.

LCH Prachand

- It is a Light Combat Helicopter that was ***indigenously developed*** by Hindustan Aeronautics Ltd (HAL).
- The LCH is the only attack helicopter in the world that can land and take off at an ***altitude of 5,000 metres*** (16,400 ft), which makes it ideal to operate in the high altitude areas of the Siachen glacier.
- It is also capable of firing a range of air-to-ground and air-to-air missiles.

4.11 Medium Range Anti-Ship Missile (MRASHM)

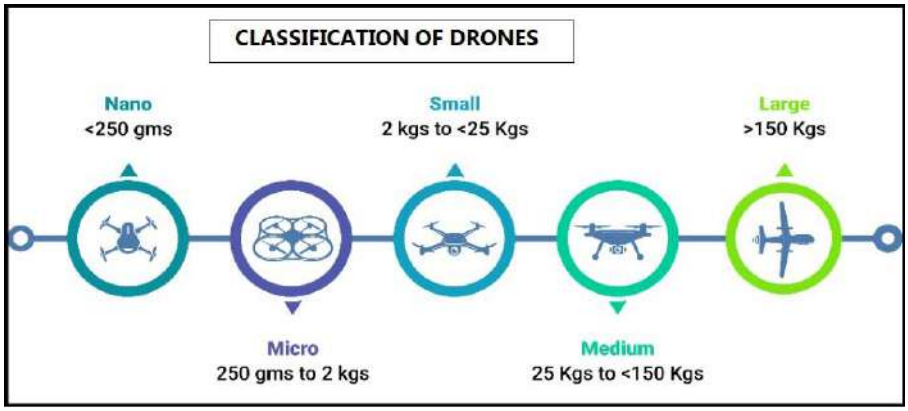
The Defence Acquisition Council (DAC) has recently decided to procure the Medium Range Anti-Ship Missile (MRASHM) to boost the offensive capabilities of the Indian Navy.

- MRASHM is an ***indigenously*** developed lightweight ***Surface-to- Surface Missile.***
- It was jointly developed by DRDO and Israeli Aerospace Industries (IAI).
- MRSAM can hit multiple targets at a range of 70 kilometres.

4.12 Nano Drones

The emergence of Nano and micro drones and compact unmanned aerial vehicles (UAVs) with advanced capabilities, introduce fresh security challenges.

- **Drone**- It means an aircraft that can *operate autonomously or remotely* without a pilot on board.
- India reported 79 cases of using drones for weapon delivery 2020, 109 in 2021 and 266 in 2022.



Provisions under Drone (Amendment) Rules 2022

- **Criteria**- To operate a drone legally, the criteria set by the Civil Aviation Ministry and the Directorate General of Civil Aviation must be adhered to.
- **Exception-** Nano/micro category drones for non-commercial use.
- All drone activities are permitted only after receiving prior approval for a flight or series of flights.
- **Licence**- The remote pilot certificate will not be required for flying small-to-medium size drones of *up to 2 kg* for non-commercial purposes.

Drone Policy of India

- **Drones Rules, 2021** - It provides the regulatory framework for commercial use of drones through certification, registration and operation of drones, airspace restrictions, research, development and testing of drones, training and licensing, etc.
- **Drone Airspace Map**- It has opened nearly 90% of Indian airspace as a green zone for drone flying up to 400 feet.
- **Production Linked Incentive (PLI) Scheme**- To promote the growth of drone manufacturing by private companies.
- **UAS Traffic Management (UTM) Policy Framework**- It is an approved public or private entity that would assist various stakeholders to meet the operational requirements for enabling safe and efficient use of airspace,
- **Drone Certification Scheme**- It was notified for making it easier to obtain type certificate by drone manufacturers.
- **Drone Import Policy**- It banned import of foreign drones and freeing up import of drone components.
- **Drone (Amendment) Rules, 2022**- It abolished the requirement of a drone pilot licence for drones of *up to 2 kg* for non-commercial purposes.

4.13 TAPAS

DRDO's TAPAS unmanned aerial vehicle crashes.

Tapas-BH is the answer to India's quest for ISTAR (Intelligence, Surveillance, Target Acquisition, Tracking, & Reconnaissance) requirements.

- TAPAS-BH is a Medium Altitude Long Endurance (MALE) UAV with an operating altitude of 30000 ft, and an endurance of 24 hours.
- TAPAS-BH also projects a range of 250 km which can carry a variety of payloads up to a maximum of 350 kg with a wing span of 20.6 meters.
- It is based on the ***Rustom-2 platform*** which has been originally conceptualized and designed to perform Intelligence, Surveillance, and Reconnaissance missions for the Indian armed forces.
- RUSTOM drones will use Indian GPS ***GAGAN (GPS Aided Geo Augmented Navigation)*** developed by ISRO.
- The Tapas embraces greater technological improvement and range because of SATCOM (Satellite Communication) against regular line-of-sight communication.
- It addresses the issues of automatic landing and take-off that were missing in the initial Rustom 2 prototype.

4.14 Predator Unmanned Aerial Vehicles (UAV)

Defence Acquisition Council (DAC) approved the procurement of armed Predator Unmanned Aerial Vehicles (UAV) from General Atomics Aeronautical Systems (GA-ASI), United States.

- **Unmanned Aerial Vehicle (UAV) -** It is an aircraft that carries no human pilot or passengers. UAVs are called as drones that can be fully or partially autonomous but are more often controlled remotely by a human pilot.
- **Predator Unmanned Aerial Vehicles -** The Predator drone or the ***MQ-9 Reaper*** is a long-endurance, medium-altitude, turboprop-powered, multi-mission, unmanned aircraft system (UAS).
- **Developed by** - General Atomics Aeronautical Systems, U.S.
- **Endurance** - >27 hours; **Height** - up to 50,000 feet.
- **Speed** - 240 KTAS (KTAS - True Airspeed of an Airplane charter measured in Knots).
- **Payload Capacity** - 1,746 kilograms.
- **Advantages** - Long-endurance, persistent surveillance/strike capability.

- It is equipped with a fault-tolerant flight control system and triple redundant avionics system architecture.

4.15 Unmanned Aerial Systems (Drone) Common Testing Centre

India's first Unmanned Aerial Systems Common Testing Centre to be established in Tamil Nadu.

- The UAS Common Testing Centre would be established at the SIPCOT Industrial Park, Vallam Vadagal near Sriperumbudur under ***Defence Testing Infrastructure Scheme (DTIS).***

Defence Testing Infrastructure Scheme (DTIS)

- **Aim -** To boost domestic defence & aerospace manufacturing.
- **Launch -** May 2020 by **Ministry of Defence (MoD).**
- **Duration -** 5 years.

An integrated facility for testing for UAS (Drone) is available only with DRDO at Chitradurga, Karnataka.

- It envisages setting up of 6-8 greenfield defence testing infrastructure facilities that are required for defence and aerospace related production.
- **Funding Pattern -** 75% Government funding in the form of 'Grant-in-Aid' + 25% to be borne by the Special Purpose Vehicle (SPV) constituents.

4.16 Bharat Drone Shakti 2023 & C-295 aircraft

First ever drone exhibition cum display 'Bharat Drone Shakti 2023', was inaugurated by Raksha Mantri at Hindan Air Force Station.

- **Bharat Drone Shakti 2023** – It hosted live aerial demonstrations of a variety of drone operations and applications by over 75 drone start-up companies from across the country.
- Organized by - Indian Air Force (IAF) and Drone Federation of India (DFI).
- The drones with the capability to carry 50kg-100 kg payload & *Kamikaze drone* also witnessed.
- **C-295 MW transport aircraft** - It is a robust, reliable and highly versatile tactical transport.

Kamikaze drones

- Also known as ***loitering munitions or suicide drones***.
- Unlike missiles, a kamikaze drone is capable of occupying an airspace known as loitering for a relatively long period before engaging a target.

- It has remarkable *short take-off & landing (STOL) performance* from unpaved, soft, and sandy/grass airstrips.
- Uses - Carrying troops and cargo, maritime patrol, airborne warning, surveillance, reconnaissance to signals intelligence, armed close air support, medical evacuation, VIP transport and airborne firefighting.

National Drone Policy

- With this policy flying drones or remotely-piloted aircraft have become legal in India.
- Ministry of Civil Aviation has kick-started the online registration of drones in line with this policy in India through its Digital Sky portal.
- **Categories -** The Directorate General of Civil Aviation (DGCA) has designed 5 different categories of drones as Nano, Micro, Small, Medium, and Large.
- Under the new policy, Nano drones which weigh less than 250 grams or equal does not need a registration or license.
- **Digital Sky portal -** It is an online platform as part of an enforcement system designated as No Permission No Takeoff (NPNT).

4.17 Fuel cell AIP Vs Stirling AIP

The German shipbuilders signed an agreement India's Mazagon Dock Limited (MDL) to cooperate in building 6 state-of-the-art submarines for the Indian Navy.

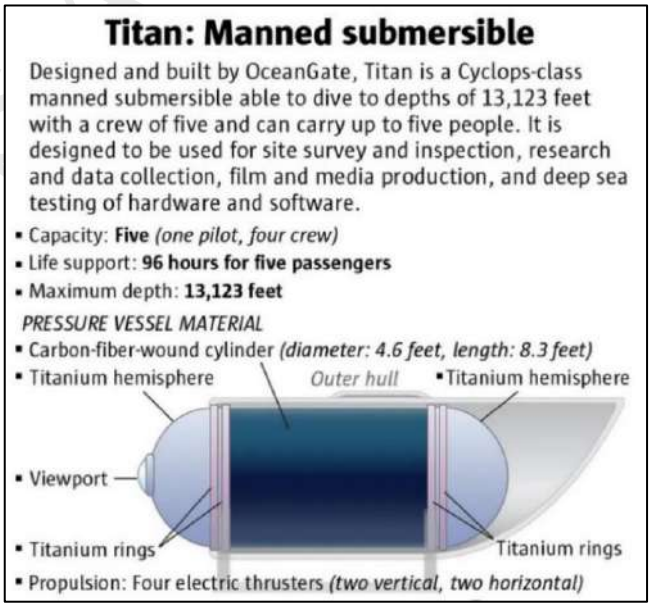
- The submarines, powered by air-independent propulsion (AIP), are planned to be built under Rs 45,000 crore programme called ***Project 75-I*** under the "strategic partner" (SP) acquisition category.
- **Conventional diesel-electric submarines** – It can operate underwater silently for up to 48 hours.
- **AIP-driven submarines** – Remain underwater for up to 2 weeks before they surfacing for battery charging.

Fuel cell AIP	Stirling AIP
• Fuel cell-based AIP generates power through the ***reverse electrolysis*** *of oxygen and hydrogen.* • This process does not need air, but requires storage of highly inflammable hydrogen on board. • Fuel cell AIP systems are associated with German submarines of Class 212A and Class 214, and will power the ***Project 75-I*** submarines too. • A key problem in fuel cell development was to master hydrogen storage.	• The 2nd type of AIP, based on the Stirling engine, is the first modern combat-ready system. • It is a simple system that uses ***diesel fuel*** *(typical for the submarine) and liquid oxygen,* discharging the plant overboard at small and medium depths. • Low-power Stirling engines are *much quieter* than main diesel generators of submarines. • Although this system ***lacks stealth***, it is good in small area, shallow depths, complex hydrology and heavy traffic.

4.18 Submersible vs Submarine

The Titan, one of the crewed submersibles operated by OceanGate, went missing in the area of the Titanic wreck in the North Atlantic.

- **Titan -** Titan is the only ***crewed submersible*** in the world that can take 5 people as deep as 4,000 meters enabling it to reach almost 50% of the world's oceans.
- It is made of carbon fiber and titanium.
- The submersible was part of an 8-day journey conducted by OceanGate Expeditions to reach the Titanic wreck site.
- The wreck site is about 900 miles off the coast of ***Cape Cod, Massachusetts.***
- Once submerged, the platform uses a ***patented motion-dampening flotation system*** to remain coupled to the surface that provide a stable underwater platform.
- At the conclusion of each dive, the entire system is brought to the surface in approximately 2 minutes by filling the ballast tanks with air.



Submersible	Submarines
• A submersible is a small boat or other craft, designed especially for research and exploration. • It does not function as an autonomous craft and ***needs a mother ship*** that can launch and recover it. • The submersibles have a top speed of 3 knots (5.5 kmph). • It can't stay underwater for as long compared to submarines. • Since there is no GPS underwater, the submersible is only ***guided by text messages*** from the surface ship. • The pilot steers the sub using a video game controller but if that fails, a hard-wired system can control the propellers.	• A submarine is a watercraft capable of ***independent operation underwater.*** • When submarine is to dive, water is filled in water tanks and it is made heavier. • Since the average density of submarine becomes greater than the density of sea water, it sinks. • To make the submarine rise to the surface of water, water tanks are emptied.

4.19 New Scorpene class submarines

The DAC has cleared proposals to buy 3 additional Scorpene submarines and 26 Rafale Marine fighter jets for the Navy.

- Indian Navy has 16 conventional submarines
    1. 7 of the Sindhughosh class (Russian Kilo class)
    2. 4 of the Shishumar class (modified German Type 209)
    3. 5 of the Kalvari class (French Scorpene class)
- It also has 2 nuclear submarines, INS Arihant and INS Arighat.
- **Project 75** – Signed in 2005 to construct 6 Scorpene class submarines over 30 years with technology transfer from France. So far, 5 submarines have been commissioned and the last one, INS Vagsheer is under trials.
- **Project 75I** – It is a follow-up to Project 75 and aims to procure diesel-electric attack submarines with fuel cells and Air-Independent Propulsion System (AIP) for the Indian Navy.

Scorpene Submarine

Length: Around 220 feet

Height: Approximately 40 feet

Top speeds:

Surfaced - 11 knots (20 km/h)

Submerged - 20 knots (37 km/h)

Endurance - Approx. 50 days

System - Diesel electric propulsion systems

Defence Acquisition Council is the apex decision-making body for the acquisition of military equipment for India's armed forces.

Projects-75	Meaning	Commissioned Year
INS Kalvari	Tiger Shark	2017
INS Khanderi	Island Fort built by Chhatrapati Shivaji	2019
INS Karanj	Island located South of Mumbai	2021
INS Vela		2021
INS Vagir	Sand Fish	2023
INS Vagsheer	Sand Fish	Launched in 2022 (under trail)

4.20 Project 17A

The 7th and last stealth frigate of Project 17A, Mahendragiri, was launched into water at Mazagon Dock Shipbuilders Limited (MDL) in Mumbai recently.

- Under Project 17A, a total of ***7 ships*** were constructed, 4 at Mazagon Dock Shipbuilders, Mumbai and 3 at Garden Reach Ship Builders Limited (GRSE), Kolkata.
- **Designed by** – Indian Navy's Warship Design Bureau
- The project is aligned with *'Aatma Nirbharata' or self-reliance campaign*, 75% of the orders for equipment and systems of Project 17A ships have been ordered from indigenous firms, including MSMEs.

7 Ships *- INS Nilgiri, INS Himgiri, INS Udaygiri, INS Dunagiri, INS Taragiri, INS Vindhyagiri and INS Mahendragiri. The ships are named after hill ranges in India.*

- **Vindhyagiri** – It is named after the *mountain range in Karnataka*, is the 6th ship of Project 17A
- It is a technologically advanced ***Frigate,*** and a tribute to the erstwhile INS Vindhyagiri, the Leander Class ASW Frigate.
- **Mahendragiri -** It is named after a mountain peak in Eastern Ghats located in the state of Odisha.
- Developed by - Mazagon Dock Shipbuilders, Mumbai.
- It is a technologically advanced warship and 7th ship of the Project 17A 'Shivalik Class' Frigates.

4.21 Project 15B & INS Imphal

INS Imphal, a Project 15B stealth guided missile destroyer, was commissioned into the Indian Navy

- INS Imphal (Pennant D68), the third of four warships of ***Project 15B*** that together form the ***Visakhapatnam class*** stealth-guided missile destroyers, is set to be commissioned into the Indian Navy.
- Imphal has the unique distinction of being the first warship to be named after a city in the Northeast.
- It is the first naval warship commissioned with accommodation for women officers and sailors.
- **Built by -** Mazagon Dock Shipbuilders Limited (MDSL).

Project 15

- **Project 15 -** These ships were a step ahead of their precursor *Delhi class of ships*.
- It includes INS Delhi, INS Mysore and INS Mumbai, and was commissioned between 1997 and 2001.

- **The Project 15A -** Launched in 1986, the Kolkata class of guided missile destroyers is a successor to Delhi class.
- The Kolkata class included INS Kolkata, INS Kochi and INS Chennai.

- **Project 15B -** The Visakhapatnam-class destroyers, also classified as the P-15 Bravo class, or simply P-15B, is a class of guided-missile destroyers currently built for the Indian Navy.
- These ships will be equipped to operate two multi-role helicopters.
- The overall indigenous content of the project is approx. 75%.

The 4 ships of Project 15B are christened after major cities from all 4 corners of the country -Visakhapatnam, Mormugao, Imphal & Surat.

4.22 Maritime Infrastructure Perspective Plan (MIPP)

*The Minister of State for Defence released the Maritime Infrastructure Perspective Plan (MIPP) **2023-37** at the 2nd edition of the biennial Naval Commanders Conference recently.*

- **Aim -** To synchronize and enmesh the infrastructure requirements of the Navy through a comprehensive perspective plan model for the ***next 15 years***.
- The Plan Document is aligned with the Government's vision on creation of sustainable infrastructure.

4.23 Sagar Maitri Mission

Recently, an oceanographic research vessel 'INS Sagardhwani' embarked on Sagar Maitri (SM) Mission-4.

- **Sagar Maitri** - A novel initiative of ***DRDO*** to support Safety and Growth for All in the Region (SAGAR) policy.
- **Objective** - To promote closer cooperation in socio-economic aspects and long-term *scientific partnerships & collaborations* with the 8 Indian Ocean Rim (IOR) countries.

8 IOR countries *- Oman, Maldives, Thailand, Malaysia, Singapore, Myanmar, Sri Lanka & Indonesia*

- **MAITRI** – Marine and Allied Interdisciplinary Training and Research Initiative is a scientific component initiated by DRDO under SAGAR Policy
- It establishes long-term collaboration with IOR countries in Ocean Research and Development.
- **INS Sagardhwani** - A marine acoustic research ship

4.24 Stitched Ship

The Ministry of Culture has joined hands with the Indian Navy and Goa-based Hodi Innovations to reconstruct an ancient stitched ship.

- They are ships that sailed the oceans on India's *ancient maritime trade routes* around 2,000 years ago.

- These ships are constructed by stitching wooden planks together rather than using nails.
- This offers flexibility and durability, making them less susceptible to damage from shoals and sandbars.

The Project

> ***Project Mausam*** *- To re-establish communication between countries of the Indian Ocean, to create an understanding of cultural values & concerns.*

- **Funded by –** 100% by the Ministry of Culture.
- The ***ministries of Shipping and External Affairs*** will be supporting the project in its execution stage.
- **Coordinating agency –** The National Implementation Committee
- **Significance -** Once the ship is ready, the voyage will be sent to Bali in Indonesia, in November 2025.
- This initiative is in synergy with the Ministry of Culture's ***Project Mausam.***

4.25 Information Fusion Centre for Indian Ocean Region (IFC-IOR)

Recently, IFC-IOR marked its 5th anniversary and it also played key role in the backend in tackling vessel hijacking episode near Gulf of Aden.

> *IFC-IOR is located within the premises of the Information Management and Analysis Centre (IMAC), the nodal agency for maritime data fusion.*

- **Established by** – The government of India at Gurugram ***in 2018*** and is ***hosted by the Indian Navy***.
- **Tagline** – Collaboration for Safety and Security.
- **Aims** – To strengthen ***maritime security in Indian Ocean Region (IOR) and beyond*** by acting as a maritime security information sharing hub for the region.
- **Mission** – To be a *nodal centre of excellence* for promoting maritime safety towards a peaceful, stable and prosperous IOR.

> *Major hotspots for piracy and armed robbery - South East Asia, Gulf of Guinea and Horn of Africa.*

- **Maritime domain** – Piracy & Armed Robbery, Contraband Smuggling, IUU Fishing, Irregular Human Migration and other maritime incidents.
- **Reports** - Weekly, Half-Yearly, Annual, Weather Forecast & others.
- **Collaboration** – 43 organisations, ***25 partner countries and 12 International Liaison Officers (ILO)***, now gearing up for expansion to eventually host 40 ILO.

4.26 Varunastra

Indigenously made Varunastra was successfully test-fired with a live warhead by the Indian Navy.

- Varunastra is a ship launched, heavy weight, electrically-propelled ***anti-submarine torpedo.***
- **Agencies** - It was designed and developed by Vizag-based Naval Science and Technological Laboratory (NSTL) under the ***Defence Research and Development Organisation (DRDO).***
- **Manufacturer** - Bharat Dynamics Ltd (BDL), Inducted by Indian Navy in 2016.
- It can be fired from all Anti-submarine warfare (ASW) ships capable of firing heavy weight torpedoes.
- **Warhead & Range** - It can carry a warhead weighing *250 kg* and has an operational range of *40 km*.
- ***India*** is in a group of 8 countries that have the capability to manufacture heavyweight torpedoes.
- **Torpedo** – It is cigar-shaped, self-propelled underwater missile, launched from a submarine, surface vessel, or airplane and designed for exploding upon contact with the bodies of surface vessels and submarines.

4.27 Maya OS

Indian Navy has decided to install Maya OS in their systems while the Army and the Air Force are evaluating it.

- The Microsoft Operating System (OS) in all computers connected to the Internet will be replaced with a new OS, Maya.

- Maya is based on ***open-source Ubuntu*** that is developed locally.
- Maya has the interface and all functionality like Windows and users will not feel much difference.
- Maya was developed by government development agencies and it would prevent malware and cyberattacks.

4.28 Kavro Doma 360

- It is the ***world's 1st rifle protection ballistic helmet***, indigenously developed by Kanpur-based MKU Limited.
- It offers uniform protection in all 5 zones of the head against threats like the AK-47 MSC, M80 NATO BALL, and M193 rifle bullets.
- ***'Back Face Signature'*** is a way to measure how much a protective helmet deforms or indents on the inside due to the impact of a high energy bullet.

4.29 Project Udbhav

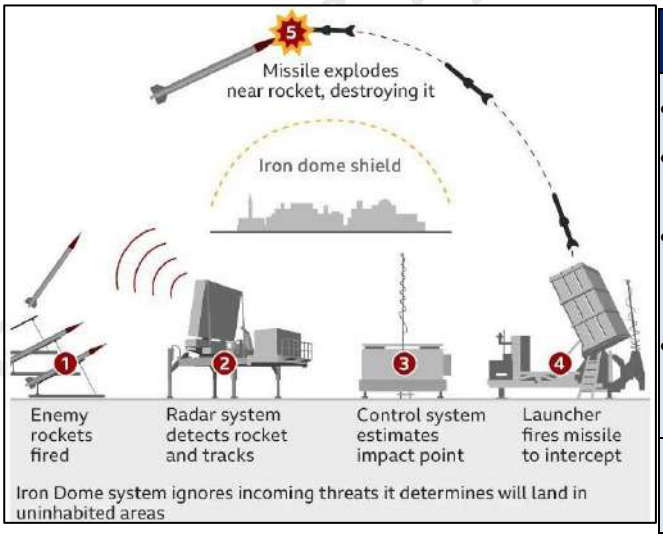
The Indian Army has started an initiative, named Project Udbhav in collaboration with the United Service Institution (USI) of India.

- **Aim -** To rediscover the Indic heritage of statecraft and strategic thoughts derived from ancient Indian texts of statecraft, warcraft, diplomacy and grand strategy.
- It focuses on ***indigenous military systems***, historical texts, regional texts and kingdoms, thematic studies, and intricate kautilya Studies from 4th century BCE to the 8th century CE.
- The first scholarly outcome of the initiative is the ***Paramparik Bhartiya Darshan Ranniti aur Netriyta ke Shashwat Niyam.***

4.30 Iron Dome

Hamas militant group of Palestine in their attack against Israel since 1948 were able to breach Israel's renowned Iron Dome defense system.

- **Developed by** - The state-owned Rafael Advanced Defence Systems with the backing of the United States during *2006 Israeli-Lebanon war.*
- On reaching within 10 metres of target, *laser-controlled fuse, activates and blasts* the missile with shrapnel.
- **Targets** - Rockets, artillery & mortars (C-RAM), Aircraft, helicopters and unmanned aerial vehicles.



Features	3 Main Systems
• Short range • Ground-to-air defence • Laser Controlled Fuse • Tamir interceptor missiles	• **Detection and tracking radar** - To spot any incoming threats • **Battle management and weapon control system (BMC)** - It basically coordinates between the radar and the interceptor missile. • **Missile Firing Unit** - Neutralise any rockets or missiles.
Iron dome is capable of being used in all weather conditions, including during the ***day and night***.	

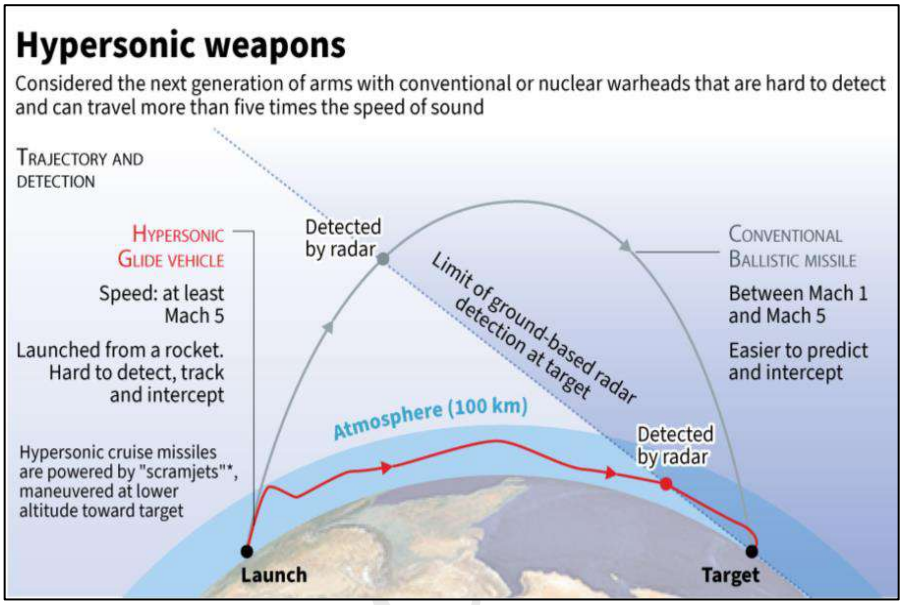
Other systems of Israel

- **David's Sling and Arrow** - To identify and eliminate medium-and long-range threats like drones and planes.
- **Arrow-3** - It was designed to intercept and counter ballistic missiles outside the atmosphere of the earth.

4.31 Fattah or Conqueror

Iran unveils a hypersonic missile, able to beat air defences amid tensions with U.S.

- It is the first-ever domestically-made hypersonic ballistic missile created by ***Islamic Revolutionary Guard Corps (IRGC), Iran.***
- **Islamic Revolutionary Guard Corps (IRGC)** - It is a multi-service (ground, naval, and air forces) primary branch of the Iranian Armed Forces.
- **Speed** – Mach 15
- **Range** – Upto 1400 kms
- It is named by the Iranian Supreme Leader Ayatollah Ali Khamenei 'Fattah' in Farsi, which means conqueror.
- It can bypass the most advanced anti-ballistic missile systems.



Hypersonic Missiles

- Hypersonic missiles are ***manoeuvrable***, unlike the ballistic missiles that follows a set course or a ballistic trajectory.
- It moves at 5 times the speed of sound or greater and are manoeuvrable, making them difficult for defence systems and radars to target.
- Like traditional ballistic missiles, they can ***deliver nuclear weapons.***

4.32 ASEAN Defence Ministers' Meeting Plus (ADMM-Plus)

Indonesia is hosting the 10th Association of South East Asian Nations (ASEAN) Defence Ministers' Meeting-Plus (ADMM-Plus) at Jakarta in 2023 as the chair of ADMM-Plus.

- **ADMM –** It is the highest defence consultative and cooperative mechanism in ASEAN.
- **ADMM-Plus** – It is a platform for the ASEAN member-states and its 8 dialogue partners collectively called as 'Plus Countries'.
- **Meeting** – 1st edition was held in Hanoi (Capital of Vietnam) in 2010 and it is held ***annually since 2017***.
- **Objectives** - To enhance regional peace and stability through cooperation in defence and security.

> ***Plus Countries*** *of ADMM-Plus were India, U.S., China, Russia, Japan, South Korea, Australia and New Zealand. India became the dialogue partner of the ASEAN in 1992.*

- To contribute to the realisation of Bali Concord II and Vientiane Action Programme.
- **Bali Concord II** embodies ASEAN's aspiration to achieve peace, and stability with one another and with the world at large.
- **Vientiane Action Programme** calls for ASEAN to build a secure and prosperous ASEAN and to adopt outward-looking external relation strategies with its friends and Dialogue Partners.
- **7 Focus areas –** maritime security (MS), counter-terrorism (CT), humanitarian assistance and disaster management (HADR), peacekeeping operations (PKO), military medicine (MM), humanitarian mine action (HMA) and cyber security (CS).
- **Experts Working Groups (EWGs) –** 1 EWG has been created for each of the 7 focus areas.
- Each EWGs is co-chaired by 1 ASEAN Member States and 1 Plus Country, operating in a ***3-year cycle***.
- In the present cycle ***from 2021-2024, India is co-chairing EWG*** on HADR along with Indonesia.

4.33 INDUS-X Initiative

Recently the 1st INDUS-X Investors Meet held was held at Delhi ahead of 2+2 Indo-US Ministerial Dialogue.

- INDUS-X stands for enhanced strategic and defence partnership between ***India and the US.***
- It is aimed at deepening the partnership between the US and Indian defence innovation sectors.
- INDUS-X Investors Meet was organised by the **Innovations for Defence Excellence (iDEX)** under the Department of Defence Production, Ministry of Defence and US Department of Defence.

4.34 India- Australia 2+2 Defence Dialogue

Recently, India and Australia held 2+2 Ministerial Dialogue to step up defence cooperation and deepen the strategic relationship in sectors such as critical minerals and trade and investment.

- ***2+2 Dialogue*** is a format of meeting of the *foreign and defence ministers* of India and its allies on strategic and security issues.
- **India-Australia 2+2 Defence Dialogue** – 1st session held in 2021 and 2nd dialogue held in 2023 at New Delhi, India.
- **Areas of cooperation** - Defence and security, trade & investment, critical minerals, energy, climate change, S&T, space, education and people to people linkages along with regional and global issues.

At present, India has 2+2 dialogue with UK (2023), Australia (2021), Russia (2021), Japan (2019) & USA (2018).

4.35 Indian Ocean Naval Symposium (Ions) – 2023

The 8th edition of Indian Ocean Naval Symposium (IONS) Conclave of Chiefs (CoC) was conducted by Royal Thai Navy at Bangkok, Thailand.

- The inaugural edition of IONS was held in 2008 at New Delhi, with ***Indian Navy as the Chair for 2 years.***
- IONS is a ***voluntary initiative*** that seeks to increase maritime co-operation among navies of the littoral states (states with coast) of the Indian Ocean Region.
- IONS provides an open and inclusive forum for discussion of regionally relevant maritime issues.
    - As a first, Flag designed by India was selected as the IONS Flag.
- The members have been geographically grouped into the following 4 sub-regions:
    - **South Asian Littorals -** Bangladesh, India, Maldives, Pakistan, Seychelles, Sri Lanka and United Kingdom (British Indian Ocean Territory).
    - **South East Asian and Australian Littorals -** Australia, Indonesia, Malaysia, Myanmar, Singapore, Thailand and Timor-Leste.
    - **East African Littorals -** France (Reunion), Kenya, Mauritius, Mozambique, South Africa, and Tanzania.
    - **West Asian Littorals -** Iran, Oman, Saudi Arabia and United Arab Emirates.
- India also took over as the co-Chair of IONS Working Groups on Maritime Security.
- ***Republic of Korea*** Navy was welcomed by the Conclave as the ***latest 'Observer',*** raising the collective strength of IONS to 34 (25 Members & 09 Observers).

India is scheduled to take over as the Chair of IONS (2025-27) during 9th CoC planned to be conducted in India in end 2025.

4.36 Igla-S anti- aircraft missiles

Russia has recently signed a contract to supply Igla-S hand-held anti-aircraft missiles to India and allow production of the Igla under licence in India.

- The Igla-S is a ***man-portable air defence system (MANPADS***) that can be fired by an individual or crew to bring down an enemy aircraft with a range of upto 6km.
- It is also known as the Igla-Super and SA-24 Grinch

4.37 Nuclear Gravity Bombs

The United States' plans to build new nuclear gravity bomb will be designated as B61-13.

- Gravity bombs work by being pulled to the ground by the force of gravity instead of flying to the target on a powered missile.
- In this case, a bomber or an aircraft flies over the target and drops the bomb.
- These bombs do not consist of a guidance system and, hence, follow a ***ballistic trajectory.***
- **B61 – 13 -** According to reports, the new bomb is estimated to be 360 kilotons, which is roughly 24 times powerful than the blast that destroyed Hiroshima.

The 2 bombs that the US dropped on Japan's Hiroshima was about 15 kilotons of TNT equivalent and Nagasaki was of 25 kilotons.

4.38 National Cadet Corps (NCC)

NCC celebrated its 75th Anniversary on November 26, 2023.

- It was established in 1948 as a largest uniformed youth organization of ***Indian Armed Forces*** with its headquarters in New Delhi.
- It aims at developing character, comradeship, discipline, secular outlook, the spirit of adventure and ideals of selfless service amongst young citizens.
- It is open to school and college students on ***voluntary basis*** as a Tri-Services Organization, comprising the Army, the Navy and the Air Force.

4.39 INS Mahe, INS Malvan and INS Mangrol

- 3 ***anti-submarine warfare ships*** for Indian Navy launched at Cochin shipyard recently.
- The ships are part of the ASW Shallow Water Craft (CSL) project. The Mahe Class of ships will replace the in-service Abhay class ASW.

4.40 Astrashakti 2023

India demonstrated the firepower of the indigenous Akash missile system during the recent exercise 'Astrashakti 2023'.

- **Astrashakti** - It is an ***air force exercise*** that held at Suryalanka Air Force Station in Andhra Pradesh.
- **SAMAR (Surface to Air Missile for Assured Retaliation)** - It is an air defence system developed by a unit under IAF's Maintenance Command.
  - It can engage aerial threats with missiles operating at a speed range of 2 to 2.5 Mach.
  - **Akash weapon** - Designed and developed by DRDO
  - **Deployed by** – Indian Air Force and the Indian Army

According Stockholm International Peace Research Institute (SIPRI), India has been the world's largest arms importer since 1993.

4.41 Bharat NCX 2023

Recently, 2nd edition of the National Cyber Security Exercise 'Bharat NCX 2023' was organised.

- Organised by National Security Council Secretariat in partnership with Rashtriya Raksha University (RRU), Defence Ministry.
- Aims to strengthen India's Cyber posture of India's Critical Sector.
- **National Security Council Secretariat** - It is a *permanent body* under the National Security Council (NSA).
- It provides technical support to the 'Council Proper' of NSA.
- It is headed by the Director General / ***National Security Adviser.***

4.42 Major Defence Exercises

Defence Exercises	
Malabar Exercise	A multilateral naval exercise among ***United States, Japan, Australia and India***
NATPOLREX-IX	National Level Pollution Response Exercise conducted by the ***Indian Coast Guard*** off Vadinar, Gujarat.
AUSTRAHIND	Joint Military Exercise between ***Australia and India.***
VAJRA PRAHAR	Joint military special force exercise between ***India and U.S.A***
Sea Gaurdian-3	Bilateral naval exercise between ***China and Pakistan*** in the Northern Arabian Sea.
SURYA KIRAN	Joint Military Exercise between ***India and Nepal***
MILAN	biennial naval exercise hosted by the ***Indian Navy***
BONGOSAGAR	Bilateral Naval Exercise between ***India and Bangladesh***
VINBAX	Joint Military Exercise between ***India and Vietnam.***
HARIMAU SHAKTI	Joint bilateral training exercise between ***Indian and Malaysian Army.***
Mitra Shakti	joint military exercise between ***India and Sri Lanka***
Bright Star	Multinational tri-services joint military exercise that led by ***US Centcom and Egyptian Army.***

4.43 Important Operations

Operation All Clear	Military operation conducted by Royal Bhutan Army forces against Assam separatist insurgent groups in the southern regions of Bhutan.
Operation Cactus	Military operation led by the Indian Armed Forces in the Maldives in 1988 to thwart a coup attempt against the Maldivian Government headed by President Abdul Gayoom
Operation 1027	A joint military operation by Ta'ang National Liberation Army, (TNLA) the Myanmar National Democratic Alliance Army (MNDAA), and Arakan Army to combat the Myanmar Junta's armed forces and allied militias in northern Shan State, close to the Myanmar-China border.
Operation Nanhe Faristey	A Railway Protection Force (RPF) initiative to reconnect children who have been lost or separated from their families.
Railway Protection Force (RPF)'s Operations	
Operation Jeevan Raksha	To protect the lives of passengers, who had accidently fallen while deboarding/boarding.
Operation Yatri Suraksha	To improve the security of passengers traveling by Indian Railways.
Operation NARCOS	It is pan-India drive against smuggling of Narcotics through Rail.
Operation Uplabdh	To curb the illegal sale of railway tickets.

Operation Sanraksha	To enhance the safety of passengers.
Operation Seva	To assist those who (elderly citizens, women, physically disabled and sick/injured persons) in need in their travel.
Operation Satark	To stop the transportation of illegal items through railway networks.
Operation AAHT	To curb Anti-Human Trafficking Efforts.

5. HEALTH

COVID-19

5.1 Covid Strains & Variants

EG.5.1 variant, a new Covid Strain, code-named Eris, is in circulation and has been behind almost 15% cases in the UK, may not be a concern in India.

- **Eris or EG.5.1** - A *new strain of the novel coronavirus* (COVID-19) was identified in the United Kingdom.
- The World Health Organisation has classified the EG.5 strain as a ***variant of interest (VOI).*** It has been designated as a variant under monitoring (VUM).
- **Pirola or BA2.86** - One of the lineages of highly-mutated Omicron variant of Covid-19 virus.
- It is currently in the WHO list of ***'variants under monitoring'***.
- **JN.1** - It is a *descendant of the Pirola variant (BA.2.86)*, which itself stems from the Omicron sub-variant.

> ***INSACOG*** *- Indian SARS-CoV-2 Genomics Consortium, a network of genomic laboratories.*

Classification of variants

- **Variant -** When usual virus change and become significantly different to a previously detected virus form, this new virus types is known as variant.

- **Variants Under Monitoring (VUM) -** Used to signal public health authorities that a SARS-CoV-2 variant may require prioritized attention and monitoring

- **Variant of Interest (VOI)** - It is used to describe a SARS-CoV-2 variant with changes that are known to affect how the virus behaves.
- WHO is required to review global epidemiology, monitor and track global spread, facilitate the sharing of virus isolates via WHO Bio-hub.
- It indicates that the country has to keep a close eye on three things:
  1. Genomic surveillance
  2. How a VOI spreads
  3. Variant's clinical behaviour

- **Variant of Concern (VOC)** - The VOC associates it with more severe disease or increased transmissibility.
- The variant has to have at least one of the following characteristics to be classified as a VOC:
  1. Detrimental change in clinical disease severity.
  2. Change in COVID-19 epidemiology causing a substantial impact on the ability of health systems.
  3. Significant decrease in the effectiveness of available vaccines in protecting against severe disease.
- WHO has identified four variants of concern namely ***Alpha, Beta, Gamma and Delta.***

- **Variant of High Consequences (VOHCs)** - If the variant has clear evidence that prevention, measures or medical countermeasures (MCMs) have significantly reduced effectivene ss relative to previously circulating variant.

No SARS-CoV-2 variants have been classified as VOHCs.

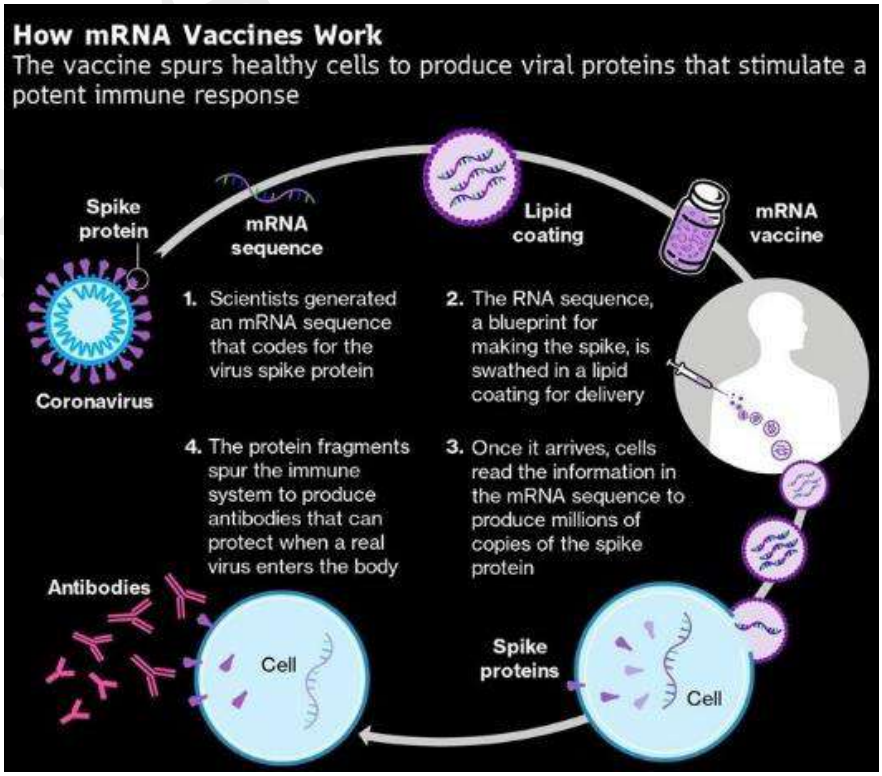
5.2 GEMCOVAC-OM

India's first indigenous mRNA vaccine (GEMCOVAC-OM) for the Omicron variant, was approved under emergency use guidelines by the Drug Controller General of India.

- **Developed by** - Pune-based Gennova Biopharmaceuticals Ltd.
- **Features** – It is ***India's first mRNA vaccine*** developed to address the problems in the earlier approved mRNA vaccines.
- This mRNA-based vaccine uses spike protein of the omicron variant (BA.1) of the SARS- CoV-2 as an antigen.
- It was stable in a 2-8 °C range and could therefore be stored in ordinary refrigerators.
- The vaccines could be administered as an ***intradermal (ID) injection*** only (into the skin) via a "***needle-free****" PharmaJet system.*
- It is indicated as a ***single booster dose*** in individuals aged more than 18 years administered at least 4 months after completion of primary vaccination with either Covishied or Covaxin.

5.3 mRNA Vaccines

Recently, 2023 Prize in Physiology or Medicine was awarded to Katalin Karikó and Drew Weissman for their discoveries concerning nucleoside base modifications that enabled the development of effective mRNA vaccines against COVID-19.



- **Messenger RNA (mRNA)** – It is a type of vaccine that uses a copy of mRNA to produce an immune response. mRNA is a molecule that encodes a sequence that can be made into a protein.
- mRNA vaccine attempts to activate the immune system to produce antibodies that help counter an infection from a live virus.
- **Spike protein**- mRNA vaccines *only introduce a piece of the genetic material* that corresponds to a viral protein. This is usually a protein found on the membrane of the virus called *spike protein.*
- Therefore, the mRNA vaccine *does not expose individuals to the virus itself.*
- **Foreign protein**- The vaccine delivers molecules of antigen-encoding mRNA into immune cells, which use the designed mRNA as a blueprint to build foreign protein that would normally be produced by a pathogen or by a cancer cell.
- The vaccines inject cells with instructions to generate a protein that is normally found on the surface of SARS-CoV-2, the virus that causes COVID-19.
- **Immune response**- The protein molecules stimulate an adaptive immune response that teaches the body to identify and destroy the corresponding pathogen or cancer cells.

Nobel Prize in Medicine 2023
• In human cells, genetic information encoded in DNA is transferred to messenger RNA (mRNA), which is used as a template for protein production. • In 1980s, researchers were able to produce mRNA "in vitro", which was highly unstable and triggered the immune system, leading to inflammatory responses in the body. • Kariko and Weissman found out that *mRNA with chemically modified bases did not lead to inflammatory reactions*, and it significantly increased protein production. • Their work helped in understanding how mRNA interacts with our immune system thereby contributing to the unprecedented rate of vaccine development during the pandemic.

mRNA based vaccines	Developed by	Doses	Storage
GEMCOVAC-19	India	Booster	2-8 °C
Pfizer-BioNTech	USA-Germany	2	-80 to -60°C (6 months) & 2 to 8°C (up to 5 days)
Moderna COVID-19	USA	2	-25 to -15°C (6 months) and 2 to 8°C (up to 30 days)

mRNA vaccine vs traditional vaccines

- **Working-** Traditional vaccines work by giving a person either viral proteins or an inactivated or weakened version of a virus that triggers an immune response.
- Viral vector vaccines like Covishield, carry DNA wrapped in another virus, but mRNA are only a sheet of instructions to make spike proteins wrapped in a lipid (or a fat molecule) to keep it stable.
- **Impact on DNA-** There is no risk of an mRNA vaccine changing DNA because mRNA does not have the ability to alter DNA.
- **Pace of development-** While traditional vaccines can take years, creating an mRNA-based vaccine that targets a newly discovered virus can be accomplished in a short period of time (days to weeks).

Advantages	Disadvantages
They are easy to design, speed and lower cost of production. They only need the genetic code and is possible to update vaccines to emerging variants and use them for a variety of diseases.	They may require ultra-cold storage before distribution. They need to be frozen from -90 degree Celsius to -50 degree Celsius.
They induce both cellular and humoral immunity.	They may cause adverse reactions in people susceptible to an autoimmune response.
They do not interact with the genomic DNA.	They may have unknown long term effects.

Diseases in News

VIRAL DISEASES

5.4 Mpox

WHO declares end to viral disease 'mpox' public health emergency.

- Mpox is a rare disease caused by infection with the ***mpox virus.***
- Mpox virus is part of the same family of viruses as variola virus, the virus that causes smallpox.
- **Symptoms –** Mpox symptoms are similar to smallpox symptoms, but milder, and mpox is rarely fatal. Mpox is ***not related to chickenpox.***
- **Source –** Despite being named monkeypox, the source of the disease remains unknown. However, African rodents and non-human primates (like monkeys) might harbor the virus and infect people.
- The first human case of mpox was recorded in 1970.
- **Types –** There are two types of mpox virus: Clade I and Clade II.

5.5 Dengue

Developing a viable universal vaccine for dengue has remained a challenge.

- Dengue is largely accepted as an annual epidemic in several countries and it is the world's fastest-growing ***vector borne viral disease***.
- **Spread -** It is more common in tropical and subtropical climates.
- **Transmission -** By the ***Aedes mosquito*** species, which also spreads ***Chikungunya and Zika virus.***
- **Types -** There are four serotypes of the dengue virus - DEN-1, DEN-2, DEN-3 and DEN-4.
- Each virus interacts differently with antibodies in the human body and is capable of manifesting into dengue fever, dengue hemorrhagic fever and dengue shock syndrome.
- **Symptoms -** mostly asymptomatic, but the most common symptoms are high fever, headache, body aches, nausea and rash.
- **Treatment -** No specific treatment. Generally treated with pain medicine.
- **Vaccine - *Dengvaxia*** is a live attenuated vaccine for children aged 9 to 16 years. But Dengvaxia's efficacy is limited to those with confirmed previous infections. Dengvaxia is not licensed in India.

Vaccine Type	Description	Example
Live Attenuated Vaccine	Uses the weakened or "attenuated" form of the virus	Measles or chickenpox vaccine
Inactivated vaccine	Uses the dead virus	Hepatitis A and rabies
Recombinant subunit vaccine	Non-structural proteins of the dengue virus are used, aiding a balanced immune response	COVISHIELD
Viral vectored vaccine	A modified, weakened version of a different virus	Ebola vaccine
DNA vaccine	Use engineered DNA to induce an immunologic response	HIV, malaria, TB

5.6 Chikungunya

Recently, the world's 1st vaccine for chikungunya was approved by the Food and Drug Administration (FDA),U.S.A.

- It is a ***ribonucleic acid (RNA) virus*** that belongs to the alphavirus genus of the family Togaviridae.
- Chikungunya outbreak was 1st recognized in 1952 in southern Tanzania.
- **Transmission**– By the bites of infected female '***Aedes aegypti and Aedes albopictus mosquitoes***'.
- CHIKV has been described as '***an emerging global health threat'***.
- **Symptoms** – Primarily ***severe joint pain, impaired mobility*** with fever and also includes muscle pain, nausea, and rash. Deaths from chikungunya are rare.
- **Treatment** - As of now, there is no cure, only symptomatic relief, with *analgesics to help with the pain*, *antipyretics for the fever*, rest, and adequate fluids.
- **Prevention** - Mosquito control activities like preventing mosquito's breeding and mosquito bites.
- **Vaccine** - It has been developed by *European vaccine manufacturer* and to be branded as ***Ixchiq*** and has been approved for administration in people who are 18 years or older.

5.7 Polio

- *Poliomyelitis* (commonly called polio) is a highly infectious ***viral disease*** that can leave patients disabled, and in some cases, even prove fatal.
- The virus enters the nervous system and can cause total paralysis in just a few hours.

- **Types of Polio virus -** Wild poliovirus (WPV) has three known strains – types 1, 2, and 3 – each with a slight difference in structure.
- Immunity to one type does not guarantee immunity to others.
    - **Type 1 WPV** - remains in circulation and endemic to Pakistan and Afghanistan.
    - **Type 2 WPV** - declared eradicated in September 2015.
    - **Type 3 WPV** - declared eradicated in October 2019.

India was declared polio free in 2014 by WHO

- **Spread -** The polio virus is most commonly spread through the *faecal-oral route* and through *contaminated water or food.* The virus multiplies in the host's intestine.
- **Treatment -** There is *no known cure* for polio. It can only be prevented by way of vaccination.
- **Vaccine -** Oral poliovirus vaccine (OPV) and inactivated poliovirus vaccine (IPV).

Oral Polio Vaccine	Inactivated Polio Vaccine
• OPV is a live attenuated vaccine for Polio. • It contains weakened polioviruses (all three types – 1, 2, and 3) to induce an immune response in a human body without causing disease.	• IPVcontains inactivated polioviruses (all three types). • IPV is administered by injection. • It induces a strong systemic immune response, thus protecting against paralytic poliomyelitis, without any risk of causing VAPP or VDPV.

Alternatives in development

- **Novel OPV (nOPV)** –It is manufactured using attenuated polioviruses in which certain mutations have been introduced using genetic engineering.
- nOPV makes it 5 times harder for the virus to regain its neurovirulence.
- All clinical trials shows that novel OPV is safer and effective than monovalent oral polio vaccine type 2 (mOPV2).
- **Sabin IPV -** Researchers are trying to use attenuated viruses instead of wild viruses to make the IPV-manufacturing safer.
- Sabin IPV is currently undergoing clinical trials in Japan and China.
- **Adjuvant -** Experts are also testing specific adjuvants (substances that enhances the body's immune response to an antigen) to be added to the IPV to induce a mucosal immune response.

Global Polio Eradication Initiative (GPEI)

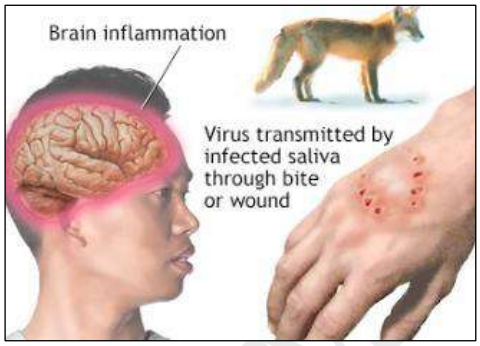
- GPEI was launched in 1988 after the World Health Assembly passed a resolution to eradicate polio.
- It is a public-private partnership led by national governments with 6 core partners -
    1. World Health Organization (WHO),
    2. Rotary International,
    3. US Centers for Disease Control and Prevention (CDC),
    4. United Nations Children's Fund (UNICEF),
    5. Bill & Melinda Gates Foundation and
    6. GAVI, the Vaccine Alliance.
- In 2020, the GPEI launched a revision of the strategy for polio eradication called 'Polio Eradication Strategy 2022-2026: Delivering on a Promise'
- **Polio Endemic countries - *Afghanistan and Pakistan*** are the only countries where indigenous wild poliovirus subtype-1 transmission continues uninterrupted.
- **Polio Status -** When the World Health Assembly established GPEI, wild poliovirus subtype-2 and subtype-3 have been successfully eradicated.

5.8 Rabies

Recently Bhutan becomes first country to sterilise all stray dogs after 14-year-long project.

- Rabies is a ***vaccine-preventable, zoonotic, viral disease*** affecting the central nervous system.
- It can affect ***both domestic and wild animals***.
- **Symptoms** - fever, pain and unusual tingling, pricking, or burning sensations at the wound site.

- **Transmission** - Deep bite or scratch from an animal with rabies, which is, in 99% of the cases, a dog.
- Transmission can also occur if saliva of infected animals comes into direct contact with mucosa (e.g. eyes or mouth) or fresh skin wounds.
- **Prevention** - Vaccinating dogs, including puppies.
- There are 2 forms of rabies that includes:
    1. **Furious rabies** results in hyperactivity, excitable behaviour, hallucinations, lack of coordination, hydrophobia (fear of water) and aerophobia (fear of drafts or of fresh air). Death occurs after a few days due to cardio-respiratory arrest.
    2. **Paralytic rabies** accounts for about 20% of the total number of human cases and runs a usually longer course.



- Rabies is included in ***WHO's 2021–2030 Roadmap for the global control of neglected tropical diseases***.

5.9 Nipah Virus

A recent outbreak of cases of Nipah infection have been found in Kerala again, after two people were confirmed to have died of the viral disease in Kozhikode district.

- **About -** It is a ***zoonotic disease*** that spreads primarily between animals and humans.
- **Transmission -** Can be transmitted to humans from animals (such as bats or pigs), or contaminated foods and can also be transmitted directly from human-to-human.
- **Host-** Fruit bats of the Pteropodidae family and Pteropous genus, widely found in South and South East Asia.
- **Symptoms -** Fever, headache, cough, sore throat, difficulty in breathing, and vomiting.

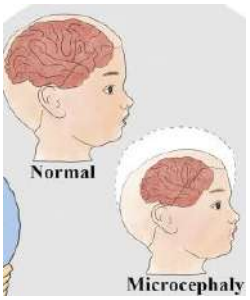
The WHO says the infection has been found to be fatal in 40% to 75% of the infected patients.

- Patients either show no symptoms of the infection (asymptomatic infections). Otherwise, patients develop acute respiratory problems, or encephalitis that often becomes fatal.
- **Treatment -** There is currently no specific treatment available for the Nipah virus.
- **Countries -** Common in Asia, primarily Bangladesh and India.

5.10 Zika Virus

Karnataka has stepped up surveillance after a mosquito pool in Chickballapur was found to be positive for Zika virus.

- Zika virus is a mosquito-borne virus 1st identified in Uganda in 1947 in a Rhesus macaque monkey followed by infection in humans in other African countries.
- It is a ***vector-borne*** *flavivirus*.
- **Transmission** – Bite of Aedes mosquitoes, mainly *Aedes aegypti & Aedes Albopictus*.
- It is also transmitted ***from mother to foetus*** during pregnancy, as well as through sexual contact, blood transfusion and possibly through organ transplantation.
- **Symptoms** – *Most people do not develop* symptoms and who develops may have rash, fever, conjunctivitis, muscle & joint pain, headache that last for 2–7 days.



- It is associated with ***Guillain-Barré syndrome,*** neuropathy and myelitis in adults and children.
- Infected pregnant mothers can *cause* ***microcephaly in infants***.
- **Treatment** – There is no specific treatment available but symptoms can be treated with antipyretics or analgesics.
- **Prevention** – *Vector control* by using larvicides and protection against mosquito bite.

In 2016, WHO declared Zika-related microcephaly a Public Health Emergency of International Concern (PHEIC) and later declared the end of the PHEIC.

5.11 H9N2

- ***H9N2*** is a subtype of the ***influenza-A virus*****,** which causes human influenza as well as bird flu.
- H9N2 viruses are found worldwide in wild birds and are ***endemic in poultry*** in many areas.
- The first case globally was reported from Hong Kong in 1998. The first case for humans in India was observed in February 2019 in villages of Korku tribes in **Maharashtra**.
- **Symptoms** – Flu-like symptoms or eye inflammation to severe, acute respiratory disease.
- **Prevention** – Minimise contact with animals in areas known to be affected by animal influenza viruses.

5.12 Cucumber Mosaic Virus (CMV) & Tomato Mosaic Virus (ToMV)

The current sharp increase in the price of tomato is due to lower production of the vegetable because of CMV and ToMV viruses in Maharashtra and Karnataka.

Virus	Cucumber mosaic virus (CMV)	Tomato Mosaic Virus (ToMV)
Origin	It was first found on cucumber and other cucurbits.	It was first found in tomatoes in Europe.
Distribution	It is distributed worldwide, primarily in temperate to tropical climate zones.	It is distributed worldwide, primarily in temperate to tropical climate zones.
Family	*Bromoviridae*	*Virgaviridae*
Hosts	Cucumber, melon, eggplant, tomato, carrot, lettuce, celery, cucurbits squash, pumpkin, zucchini, some gourds, and some ornamentals.	Tomato, tobacco, peppers, and certain ornamental plants.
Spread	Spread by aphids, which are sap-sucking insects. CMV can spread through human touch, but the chances of that are extremely low.	Spread by infected seeds, saplings, agricultural tools. It can spread through the unsanitised hands of nursery workers.
Favorable conditions to spread	Conditions of high temperature followed by intermittent rain, which allow aphids to multiply.	It can transmitted plant-to-plant by many species of aphids. It would require only a few infected saplings for the virus to take over an entire field in a matter of days.
Damage	It can cause almost 100% crop loss unless properly treated on time.	It can cause almost 100% crop loss unless properly treated on time.
Symptoms	CMV causes distortion of leaves. **In *cucumber*** - the virus causes a mosaic-like pattern of alternating yellow and green spots. **In tomato** - fruit formation is affected, and in some cases the fruit is distorted and small.	The foliage of plants shows alternating yellowish and dark green areas, which often appear as blisters on the leaves. Distortion of leaves and twisting of younger leaves. The fruit develops necrotic spots, which leads to overripening.

5.13 Crimean- Congo Haemorrhagic Fever

In India, one person recently succumbed to CCHF recently in Gujarat, the state that reports the majority of the country's cases of this disease.

- It is a ***viral haemorrhagic fever*** usually transmitted by ***Ixodid (hard) ticks.***
- It can also be contracted through contact with ***viraemic animal tissues*** (animal tissue where the virus has entered the bloodstream) during and immediately post-slaughter of animals.
- CCHF can be transmitted from one infected human to another by contact with infectious blood or body fluids.
- The CCHF is endemic to Africa, the Balkan countries, Middle East, and parts of Asia.

- **Diagnosis** - Enzyme-linked immunosorbent assay (ELISA), real time polymerase chain reaction (RT-PCR), virus isolation attempts, and detection of antibody by ELISA (IgG and IgM).
- **Treatment** - The virus is sensitive in vitro to the antiviral drug ***ribavirin*.**
- **Prevention** - Insect repellants containing *DEET (N, N-diethyl-m-toluamide)* are the most effective in warding off ticks.

5.14 Elephant Endotheliotropic Herpes Virus (EEHV)

- EEHV is a double-stranded DNA herpesvirus that can cause a fatal haemorrhage in young Asian elephants.
- The disease has a mortality rate of up to 85%.

BACTERIAL DISEASES

5.15 Tuberculosis

Johnson & Johnson's patent on bedaquiline expired recently which will allow generic manufacturers to supply this crucial drug for Tuberculosis.

- Tuberculosis (TB) is an infectious ***bacterial disease*** that most often affects the lungs.
- **Cause** - *Mycobacterium tuberculosis.*
- **Transmission -** Through air from one person to another
- **Treatment -** Preventable and curable.
- Globally, DR-TB is a major contributor to antimicrobial resistance.

Symptom

- **Bedaquiline -** Bedaquiline is a crucial drug in the treatment of multi-drug resistant TB (MDR-TB) patients for whom the first-line drug treatment has stopped working.
- It is also an oral medicine with minimal side-effects as compared to other such medicines like Kanamycin
- **3HP -** A short-course ***Tuberculosis Preventive Treatment (TPT)*** regimen which is endorsed by the WHO.
- It combines high dose ***Isoniazid (H)*** and high dose ***rifapentine (P)*** once weekly for 3 months.
- While 3HP is expensive in the short-term, the shorter duration of treatment and higher rates of treatment completion make it more cost-effective in the long-term.
- Children of age 2 and above can take 3HP.

5.16 Scrub Typhus and Leptospirosis

Odisha is reeling from two major disease outbreak, Scrub Typhus and Leptospirosis which have killed six people in the state so far.

Scrub Typhus	Leptospirosis
• Also known as Bush Typhus. • **Cause** - Bacteria: Orientia tsutsugamushi. • **Transmission** - Spread through bites of infected chiggers (larval mites). • **Symptoms** - Fever, headache, body aches, and sometimes rash. • **Vaccine** - Currently there is no vaccine available.	• **Cause** – Bacteris (Leptospira interrogans) • **Transmission** - Humans can become infected through contact with urine (or other body fluids, except saliva) from infected animals either directly or indirectly through contaminated water, soil or food. • Person to person transmission is rare. • **Symptoms** - High fever, headache, chills, vomiting, red eyes, abdominal pain, rashes, and diarrhoea. • Some infected persons may have no symptoms at all.

• **Treatment** - Treated through antibiotic doxycycline which can be used in persons of any age. • **Distribution** - Most cases of scrub typhus occur in rural areas of Southeast Asia, Indonesia, China, Japan, India, and northern Australia.	• The illness lasts from a few days to 3 weeks or longer. • **Effects** - kidney damage, meningitis, liver failure, respiratory distress, and even death if not treated early. • **Treatment** - It is treated with *antibiotics, such as doxycycline or penicillin*.

5.17 Anti-Microbial Resistance (AMR)

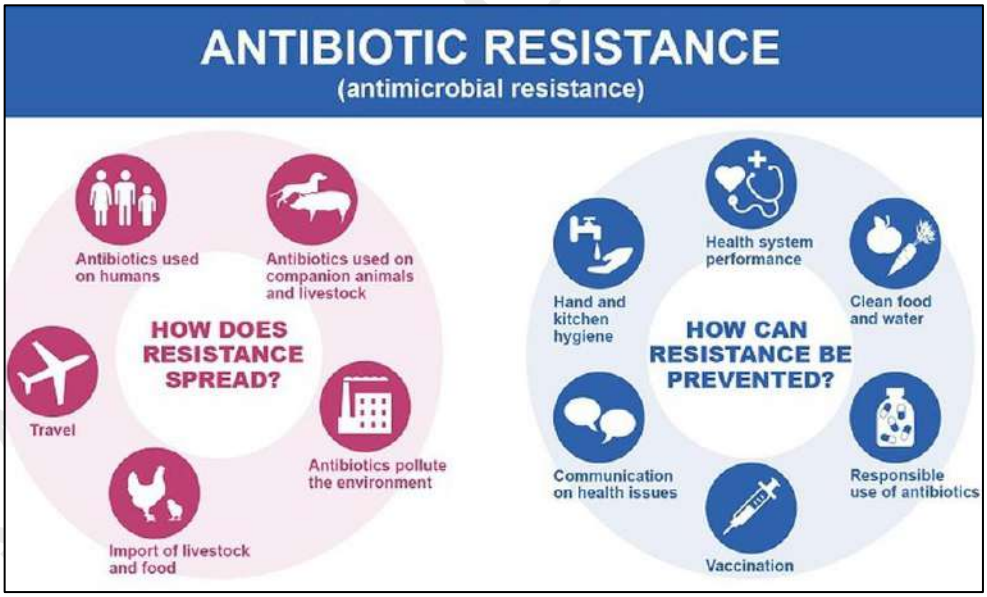
Anti-Microbial Resistance (AMR) is one of the biggest challenges which threatens the global public health.

- **Antimicrobials**- It includes antibiotics, antivirals, antifungals and antiparasitics that are medicines used to prevent and treat infections in humans, animals and plants.
- Anti-Microbial resistance occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines making infections harder to treat.
- It also increases the risk of disease, leads to severe illness and death.

WHO has declared that AMR is one of the top 10 global public health threats facing humanity.

Causes of AMR

- **Unregulated access to antibiotics-** Use of antibiotics in animal husbandry, dairying, and poultry sectors enters the food chain of other organisms and human beings naturally become victims to it.
- **Usage of antibiotics-** Irrational and improper use of drugs leads to under-use and over use of antibiotics.
- **Lack of hygiene-** Effluents and waste from pharmaceutical industry, healthcare facilities and animal husbandry leads to the spread of microbes.
- **Lack of awareness-** It leads to misuse of antibiotics resulting in a major public health threat.



- **Containment of COVID-** The entire focus of health sector is shifted to the management and containment of COVID, this had impact on public health programs.

Steps taken to contain AMR

International efforts

- **Global-One Health Approach:** A Quadripartite initiative of UNEP, WHO, FAO and World Organisation for Animal Health that promotes best practices to reduce the level of AMR.
- **AMR Multi stakeholder Partnership Platform-** An inclusive international & multi stakeholder approach.
- **Global Action Plan on AMR-** It is comitted to the development and implementation of multisectoral national action plans which was launched by World Health Assembly in 2015.
- **World Antibiotic Awareness Week-** A global campaign that aims to raise awareness of AMR worldwide.
- **Global Anti-Microbial Resistance and Use Surveillance (GLASS) –** Launched by WHO in 2015 to strengthen AMR surveillance.

- **Muscat Ministerial Manifesto**- It has 3 goals - to protect the efficacy of antimicrobials and curb the development of AMR worldwide, reduce environmental pollution and lower the spread of AMR.**Access, Watch and Reserve (AWaRe)** – An initiative of WHO that takes into account the impact of different antibiotics.

National efforts

*India has been referred to as **AMR capital of the world**. It is also the world's largest consumer of antibiotics in terms of total volume.*

- **National Action Plan on AMR (NAP-AMR) for 2017-2021** addresses 6 critical issues.
- The country is in the process of updating its NAP-AMR for the period 2022-2026 through an extensive consultative process.
- The Indian Council of Medical Research-National Institute for Cholera and Enteric Diseases, with support from UNEP, has collated scientific studies on the environmental aspects of AMR to support the process.
- **One health consortium**- Country's first one health consortium that enhance medical surveillance.
- **Delhi Declaration on AMR-** A multi-sectoral initiative to recognize the emergence and spread of AMR and to adopt a collaborative approach for preventing AMR.
- **Indian priority pathogen list-** Implemented to guide, research, discovery and development of new antibiotics.
    - **Types of priority**- Critical, High, Medium. (Example of critical priority- Colistin-R.)
- **Red Line Campaign**- Aimed at discouraging unnecessary prescription and over the counter sale of antibiotics.
- **Chennai Declaration**- To formulate recommendations to tackle AMR.

5.18 Anthrax

- It is a serious infectious disease caused by gram-positive, rod-shaped bacteria - ***Bacillus anthracis.***
- It occurs naturally in soil and commonly affects domestic and wild animals around the world.
- It is a ***zoonotic disease*** resulting in severe lung problems, difficulty breathing, and shock in humans.

5.19 Chlamydia

Australian scientists have begun vaccinating wild koalas against chlamydia in an ambitious field trial in New South Wales.

- Chlamydia is a common ***sexually transmitted disease (STD)*** caused by bacteria called ***Chlamydia trachomatis.***
- A pregnant person can also pass chlamydia to the baby during childbirth.

DISEASES CAUSED BY PARASITES, PROTOZOANS

5.20 Lymphatic Filariasis

Lao PDR becomes 2nd country in 2023 after Bangladesh to eliminate lymphatic filariasis.

- Lymphatic filariasis, commonly known as *elephantiasis*, is a *neglected tropical disease (NTD).*
- **Caused by** – Parasites classified as nematodes (roundworms) of the family Filariodidea.
    - *Wuchereria bancrofti* (90% of the cases)
    - *Brugia malayi*
    - *Brugia timori*

***Sarva Dawa Sevan or Mass Drug Administration (MDA)** campaign -Door-to-door to administration of anti-filaria medicine in 10 filaria affected States.*

- **Transmission** - Through the bite of infected ***Culex, Anopheles and Aedes*** mosquitoes
- **Symptoms** – Lymphoedema (swelling in arms or legs due to lymph fluid), Hydrocele (swelling in scrotum), Temporary or permanent disability

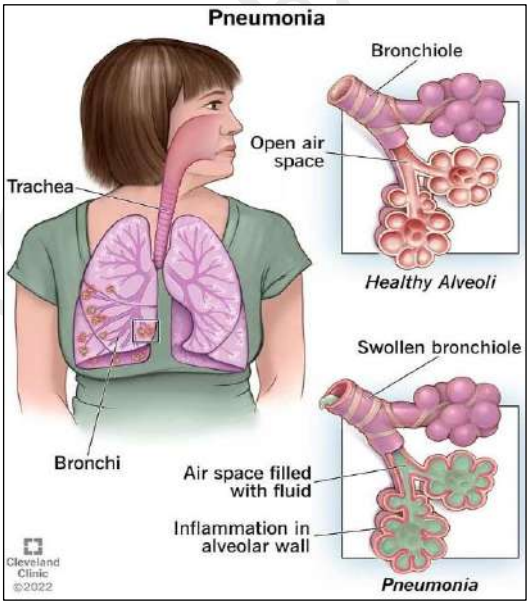
- **Elimination** – The WHO recommended *preventive chemotherapy strategy* for lymphatic filariasis elimination is *mass drug administration (MDA).*
- The elimination of NTDs including filariasis ***by 2030*** comes under "Health for All" (SDG 3).
- India gears up to eliminate filariasis ***by 2027***, 3 years ahead of the global target.

5.21 Pneumonia

Recently, World Health Organization (WHO) has requested China for a detailed report of a widespread outbreak of an undiagnosed pneumonia like respiratory illness affecting children.

Pneumonia is the single largest infectious cause of death in children worldwide.

- Pneumonia is an ***acute respiratory infection*** that affects the lungs.
- **Causes** – Infectious agents like *viruses, bacteria and fungi*
  - **Bacteria** – *Streptococcus pneumonia*, *Mycoplasma pneumoniae* and Haemophilus influenzae type b (Hib)
  - **Virus** – Respiratory syncytial virus
- **Transmission** - By ***direct contact*** with infected people via air-borne droplets (cough or sneeze) and through blood, especially during and shortly after birth.
- **Pathology** – ***Alveoli (air sacs) are filled with pus and fluid***, making breathing painful and limits oxygen intake.
- **Symptoms** – ***Wheezing*** is more common in viral infections.
- Severely ill may be unable to feed or drink and may experience unconsciousness, hypothermia and convulsions.
- **Risk factors** – Pre-existing illness like HIV, children and old age people who are above 65 years of age.
- **Treatment** - Pneumonia caused by bacteria are treated with antibiotics, amoxicillin tablets is used as 1st line of treatment.
- **Prevention** – By immunization (vaccines), adequate nutrition, and by addressing environmental factors.



5.22 Artemisinin-based combination therapy (ACT)

- ACT has been a highly effective treatment for non-severe cases of ***malaria*** since the early 2000s.
- ***Plasmodium falciparum*** is the parasite responsible for malaria's most dangerous form, is transmitted to humans via ***female Anopheles mosquitoes***.
- ACT reduces the number of parasites during the first three days of treatment, while the role of the partner drug is to eliminate the remaining parasites and cure the infection.
- P. falciparum parasite gene ***Pfkelch13*** is the reason behind the growing drug resistance.

NON-COMMUNICABLE DISEASE

5.23 Anaemia

The 6th round National Family Health Survey (NFHS), is scheduled to begin on July 1.

- Anaemia is linked to insufficient *healthy red cells* (haemoglobin) that carry oxygen in the body.
- **Reasons -** Iron deficiency, deficiencies in folate, Vitamin B12, Vitamin A, chronic conditions such as diabetes or inherited genetic disorders.

WHO standard on Haemoglobin diagnostic cut-off for
- *Men - 14 gm/deciliter,*
- *Women 12 gm/decilitre*
- *Boys & girls - 11-12 gm/deciliter.*

- There are 5 documented types of anaemia:
  - Aplastic anaemia,
  - Iron deficiency anaemia,
  - Sickle cell anaemia,
  - Thalassemia,
  - Vitamin deficiency anaemia.

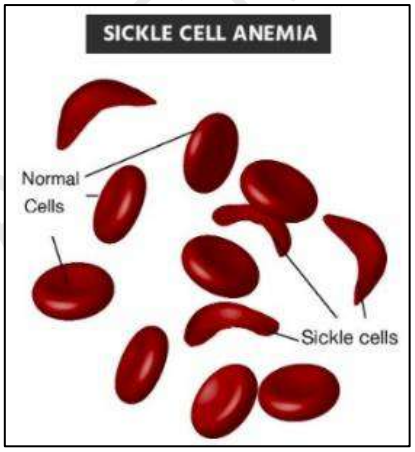
Schemes related to Anaemia

- Anaemia Mukt Bharat (AMB) strategy,
- Integrated Child Development Services (ICDS),
- National Nutritional Anaemia Prophylaxis Programme (NNAPP) & Pradhan Mantri Surakshit Matritva Abhiyan

5.24 National Sickle Cell Anaemia Elimination Mission

Recently, Prime Minister launches the National Sickle Cell Anaemia Elimination Mission.

- Sickle Cell Anaemia (SCA) is a collection of ***inherited red blood cell conditions*** that have an impact on *haemoglobin*, which transports oxygen throughout the body.
- Caused by a mutation in the haemoglobin-β gene found on Chromosome 11 affecting only the beta chain
- Mutation in haemoglobin chains makes them into a crescent shape under low oxygen level



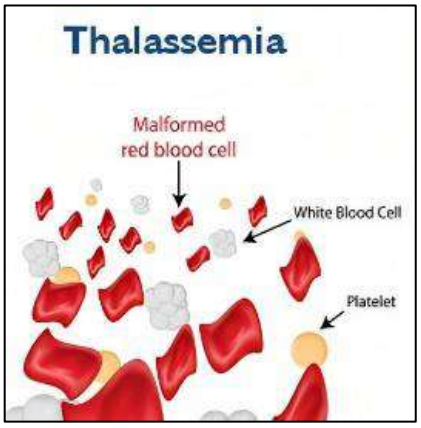
National Sickle Cell Anaemia Elimination Mission

- **Aim** - To eliminate Sickle Cell Anaemia by 2047
- **Ministry** - Ministry of Health and Family Welfare, and the Ministry of Tribal Affairs and state governments.
- It is now implemented in *17 high-focus states* across the country.
- The program is executed as part of the *National Health Mission (NHM)* through the platform of *Rashtriya Bal Swasthya Karyakram* (RBSK) and *Pradhan Mantri Surakshit Matritva Abhiyan (PMSMA).*
- **Beneficiaries** - Mission mode to cover 0 to 18 years of age and shall incrementally include the entire population up to 40 years as a part of National Health Mission.
- The program envisages *Sickle Cell Genetic Status Cards* to beneficiaries.

5.25 Thalassemia

On 8th May 1994, Thalassemia International Federation (TIF) observed World Thalassemia Day in memory of George Englezos.

- Thalassemia is an ***inherited blood disorder*** caused when the body doesn't make enough of a protein called ***haemoglobin***, an important part of red blood cells.
- When there isn't enough haemoglobin, the body's red blood cells don't function properly and they last shorter periods of time, so there are fewer healthy red blood cells traveling in the bloodstream.
- There is also not enough oxygen delivered to all the other cells of the body, which may cause a person to feel tired, weak or short of breath.
- People with thalassemia may have mild or severe anaemia.
- In India, thalassemia, along with two other blood disorders, was recognised as a ***benchmark disability*** in the ***Rights of Persons with Disabilities Act, of 2016.***



Quick Facts

- Thalassemia is part of a group of disorders called hemoglobinopathies.
- Thalassemia, Haemophilia and Sickle Cell Disorder all come under the umbrella of hemoglobinopathies.

5.26 Diabetes in India

Scientific evidence shows that diets heavy with ultra-processed food and beverages or high in sugar, fat, and salt are risky and can lead to diabetes.

- Diabetes mellitus is a chronic metabolic disorder which is the most common pancreatic endocrine disorder (Non-Communicable Disease).

Factors	Type-1 (Insulin dependent diabetes)	Type-2 (Non-insulin dependent diabetes)
Prevalence	10-20%	80-90%
Age of onset	Juvenile onset (Less than 20 years)	Maturity onset (Greater than 30 years)
Body weight	Normal or underweight	Obese
Defect	Insulin deficiency due to destruction of β-cells	Target cells do respond to insulin
Treatment	Insulin administration is necessary	Can be controlled by diet, exercise and medicine.

- **Characteristics-** It is caused due to insufficient, deficient or failure of *insulin secretion*.
  - **Hyperglycaemia**- Increase in blood sugar level
  - **Glycosuria**- Excretion of excess glucose in the urine
  - **Polyuria**- Frequent urination
  - **Polydipsia**- Increased thirst
  - **Polyphagia-** Increase in appetite

India is the infamous diabetes capital of the world accounting for one sixth of the world's population with considerable occurrence at younger age (45-64 years).

- **Types of Diabetes -** There are 3 main types of diabetes.
  - **Type 1 diabetes** is thought to be caused by an autoimmune reaction that stops your body from making insulin.
  - **Type 2 diabetes is** caused when your body does not use insulin well and can't keep blood sugar at normal levels.
  - **Gestational diabetes** is caused by the insulin-blocking hormones that are produced during pregnancy.

5.27 Hypertension

Recently, World Health Organisation (WHO) released its first-ever report on global impact of hypertension.

- Hypertension (high blood pressure) is when the pressure in your blood vessels is too high ***(140/90 mmHg or higher).***
  - **Systolic pressure** – The first number represents the pressure in blood vessels when the heart contracts or beats.
  - **Diastolic pressure** – The second number represents the pressure in the vessels when the heart rests between beats.
- **Modifiable risk factors** – It includes unhealthy diets, physical inactivity and being overweight or obese.
- **Non-modifiable risk factors** – It includes a family history of hypertension, age over 65 years and co-existing diseases such as diabetes or kidney disease.
- **Symptoms** - Hypertension is often noted as *'silent killer'* as it does not show any symptoms.
- **Complications** – Cardiovascular diseases, kidney damage, Preeclampsia and many other health problems.

Rule of Half

- Only 50% the people with hypertension get diagnosed in any population.
- Only 50% end up in treatment among the diagnosed people.
- Only 50% manage to control their blood pressure among people getting treatment.
- In India, the outcome is worse than the rule of half.

- **Treatment –** Lifestyle changes such as eating a healthier diet, quitting tobacco and increasing physical activity.
- Once diagnosed, regular intake of medicines can control it effectively and prevent related complications.

Steps taken to manage hypertension

- **India Hypertension Control Initiative programme (ICHI) -** It is a 5-year initiative that was launched in 2017 under the National Health Mission.
- It is a collaborative initiative of Ministry of Health and Family Welfare, Indian Council of Medical Research (ICMR), state governments and WHO Country Office for India.
- **25 by 25 goal** - The Government of India has adopted the "25 by 25" goal, which aims to reduce premature mortality due to non-communicable diseases (NCDs) *by 25% by 2025.*
- Under this initiative, India has committed to reduce salt intake by 30% in the mean population by 2025. (WHO's Target)
- **75/25 initiative** - It is an initiative in which 75 million people with hypertension and diabetes is put on standard care by 2025 through primary health care centres.
- **Food related measures** - The Food Safety and Standards Authority of India (FSSAI) has implemented the *'Eat Right India'* movement, which strives to transform the nation's food system to ensure secure, healthy, and sustainable nutrition for all citizens.
- In line with this goal, the FSSAI launched a social media campaign called *'Aaj Se Thoda Kam.'*

Average daily sodium intake of Indians is approximately 11 grams.

5.28 Noma

Recently, the World Health Organization (WHO) has added the health challenge noma to its official list of neglected tropical diseases (NTD).

- It is a severe ***gangrenous disease of the mouth and face***.
- It is also known as cancrum oris or gangrenous stomatitis.
- **Susceptible** – *Children aged 2-6 years old*.
- **Spread** – In developing countries, especially in sub-Saharan Africa.
- **Risk factors** - Poor oral hygiene, malnutrition, weakened immune systems, infections, and extreme poverty.
- While it is not contagious, it prefers to attack when the body's defences are weak.
- **Symptoms** – It begins with *gum inflammation* and leads to *facial disfigurement*, spasm of the jaw muscles, oral incontinence and *speech problems*.
- **Oral contamination by** – Bacteroidaceae and a consortium of other microorganisms
- **Higher mortality rate** – Approximately 90% as many children are not given care or brought for care in time.
- **Prevention and treatment** – Its spread can be slowed with basic hygiene, measles vaccination, antibiotics, rehydration, correction of electrolytic imbalances and nutritional rehabilitation.
- **Significance of NTD status** – It will amplify global awareness, catalyse research, stimulate funding, and boost efforts to control the disease through multisectoral and multi-pronged approaches.

*Noma is called as **'Face of poverty'** as effective drugs like sulfonamides and penicillin and adequate surgical treatment remain inaccessible for many*

5.29 Osteoporosis

According to a new study, India has 6 crore osteoporosis patients, of which 80% are women.

- It is a ***progressive disease that weakens bones***, increasing the risk of fractures.
- **Causes** – Hormonal changes at ***menopause where oestrogen levels decline*** initiating bone loss as higher oestrogen protects bone strength in adulthood.
- **Risk factors** – ***Gender***, advancing age after menopause, low body mass index (BMI), family history, poor diet, sedentary lifestyle, smoking and alcohol consumption.
- **Symptoms** – Usually, ***no symptoms in the early stages*** but once the bones weakens back pain, loss of height over time, a stooped posture, ***fracture and chronic pain*** develops.

- **Diagnosis** - People above 65 years and those people prone to fractures
- **Prevention** – Proper nutritional foods, a healthy lifestyle including exercises and avoiding smoking and alcohol.
- **Treatment** – There is ***no cure*** but proper treatment can help strengthen the bones like Bisphosphonates , Calcitonin (hormone of thyroid gland), Selective oestrogen receptor modulator (SERM), Tissue-selective oestrogen complex (TSEC) and Parathyroid hormone (PTH)

> ***Dual-energy x-ray absorptiometry (DXA)*** - *Test using low levels of X-rays to measure the bone mineral density of the skeleton*

5.30 Huntington's disease

- It is a ***rare, inherited disease*** that causes the progressive breakdown of nerve cells in the brain.
- It's also known as Huntington's chorea. HD attacks areas of the brain that help to control voluntary movement, as well as other areas.
- Symptoms usually start between the ages of 30 and 50. No cure exists, but drugs, physiotherapy and speech therapy can help manage some symptoms.

5.31 Pompe Disease

- Also known as ***Glycogen Storage Disease Type II***, it is a rare ***genetic disorder*** caused by a deficiency of the enzyme acid alpha-glucosidase (GAA) (crucial for breaking down glycogen into glucose within the lysosomes of cells).
- Currently, there is no cure for Pompe disease and to improve quality of life Enzyme Replacement Therapy (ERT) is a standard treatment.

OTHERS

5.32 Palliative Care

The Government's revised non-communicable diseases guidelines were criticised for the lack of focus on palliative care.

- Palliative care is the branch of medicine focusing on ***improving the quality of life*** and preventing suffering among those with ***life-limiting illnesses.***
- It aims to identify patients at risk of over-medicalisation at the expense of quality of life and financial burden on the family.
- It is an approach to care that addresses the person as a whole, not just their disease
- Palliative care is available at any time, regardless of the stage of the illness or life expectancy whereas *Hospice care* is available only at the end of life.

Steps taken to promote Palliative care

- **Policy** - Only three states have implemented the palliative care policy - Kerala, Karnataka, and Maharashtra.
- Among them, *Kerala is the only state with a policy which integrates palliative care with the public health system* and it is decentralized down to the primary health care.
- **National Program for Palliative Care**- It was launched in 2012 in line with 2014 World Health Assembly Resolution for achieving universal access to palliative care as part of Universal Health Coverage (UHC).
- **NP-NCD & NCD Guidelines**- In 2023, the revised operational guidelines of National Programme for Prevention of Non-Communicable Diseases for 2023 to 2030 was released.
- **75/25 initiative-** It is an initiative in which *75 million people* with hypertension and diabetes is put on Standard Care *by 2025,* through the primary health care centres.
- **Shashakt Portal-** It was launched for *training of 40,000 primary health care medical officers* on standard treatment workflow.

5.33 Indian Drug Makers

Recently, Gambia declared that from July 1, 2023, it is running strict quality control checks on all pharma products imported from India due to contaminated drugs.

Position of India in pharma Industry

- India is known as the ***"pharmacy of the world"*** due to the low cost and high quality of its medicines.
- The Pharmaceutical industry in India is the ***third largest*** in the world in *terms of volume* and ***14th largest*** *in terms of value*.
- The Pharma sector currently contributes to around ***1.72% of the country's GDP.***
- India is the ***world's largest provider of generic medicines*** by volume, with a 20% share of total global pharmaceutical exports.
- It is also ***largest vaccine supplier*** in the world by volume, accounting for more than 50% of all vaccines manufactured in the world.
- India is the ***12th largest exporter of medical goods*** in the world.

Regulatory process in pharma industry

- **Central Drug Standard Control Organization (CDSCO) -** It is the apex drug regulatory framework. It
  - Ensures safety, efficacy and quality of the medical product manufactured, imported and distributed in the country.
  - Regulates the market authorization of new drugs and clinical trials standards.
  - Supervises drug imports and approves licenses to manufacture the products.
- **Drugs and Cosmetics Act, 1945 -** CDSCO is responsible for approval of New Drugs, Conduct of Clinical Trials. It
  - Lays down the standards for Drugs, control over the quality of imported Drugs in the country.
  - Coordinates the activities of State Drug Control Organizations by providing expert advice.
- **Indian Council of Medical Research (ICMR) -** Formulates, coordinates, and promotes biomedical research and Ethical principles.
- **Power of the Central Government-** It is responsible for imports and approving new drugs based on safety and efficacy data.
- **Power of the State Government-** Deals with Licensing and prosecutions of pharma companies.
- **Legislation-** Under Drugs and Cosmetics Act 1945, manufacturers not adhering to good manufacturing practices can be subjected to a maximum punishment of imprisonment for life death.

5.34 Dual Disinfection-Solidification System

National Institute for Interdisciplinary Science and Technology (NIIST) has recently developed a technology that will safely and sustainably manage pathogenic biomedical waste.

- **About** - Dual disinfection-solidification system is a fully-automated machine
- **Aim** – It instantly disinfect *both liquid and solid biomedical waste*, including urine, saliva and blood, bacterial broths, cotton, tissues, swabs, needles, and syringes.
- It converts the *degradable wastes into soil additives* and lab disposables are prepared for direct recycling.

National Institute for Interdisciplinary Science and Technology (NIIST)

- NIIST, Thiruvananthapuram, is a constituent Laboratory of the Council of Scientific and Industrial Research(CSIR).
- Initially established in 1975 as a CSIR Complex, it was named as the Regional Research Laboratory in 1978 and later renamed as NIIST in 2007.

- This waste can include urine, saliva and blood, bacterial broths, cotton, tissues, and swabs.

5.35 Biosimilar Guideline (2016)

Health activists and patient groups seek revision of existing Biosimilar Guideline for increased access to critical drugs.

- **Biologics –** Biologics are medicinal products which are mainly composed of living tissues or cells.
- It mainly include vaccines, blood and blood components, gene therapy, tissues and recombinant therapeutic proteins.
- **Biosimilar** – A biologic which is found similar to another biologic is called a biosimilar (similar biologic).
- It is a medicine that is very close in structure and function to a biologic medicine and is safe and effective treatment options for many illnesses including arthritis, kidney conditions, and cancer.
- They increase access to lifesaving medications at potentially lower costs.

Biosimilar Guideline (2016)

- **Prepared by**- Central Drugs Standard Control Organization (CDSCO), Ministry of Health & Family Welfare.
- **Aim** – To address the regulatory pathway regarding manufacturing process and safety, efficacy and quality aspects for similar biologics.
- **Features** - A 'similar biologic' can only be developed against an authorized reference biological that has been approved using a complete data package in India.
- If the reference biological is not authorized in India, it should have been approved/licensed and marketed in an ICH (International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use) country.
- The Draft Guidelines document the eligibility criteria for conducting clinical trials on biosimilars.
- Phase III trials on biosimilars should include minimum 100 patients for evaluation, whereas Phase IV trials need at least 200 evaluable patients.
- As other drugs and formulations, the biosimilars are allowed to be manufactured and marketed after the patent of the original drug or product expires.

5.36 Controlled Human Infection Studies (CHIS)

Recently, Indian Council of Medical Research (ICMR) released a policy statement for the ethical conduct of Controlled Human Infection Studies (CHIS).

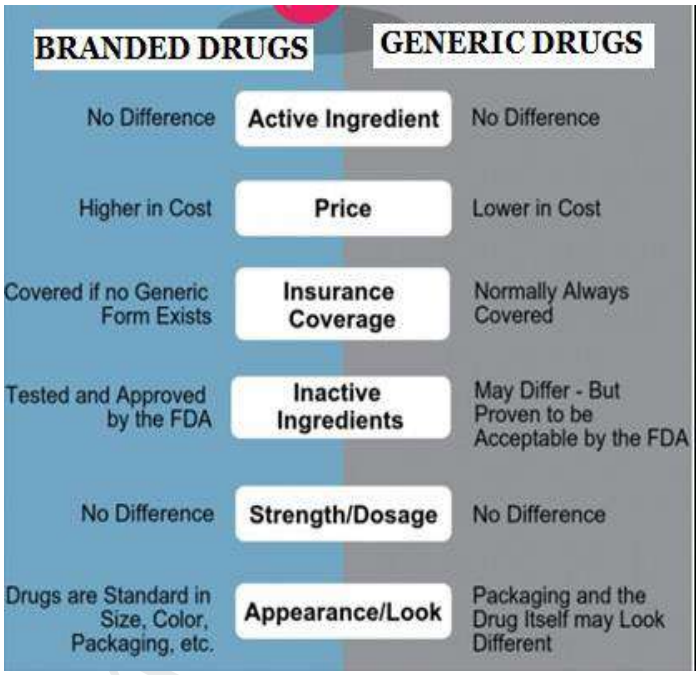
- CHIS refers to the research methodology that involves ***intentionally exposing healthy human volunteers to a specific pathogen or infectious agent*** under controlled conditions.
- It is also called as ***human challenge studies*** in India which is different from human clinical trials.
- **Aim**- To understand disease pathophysiology & immune responses, develop vaccines, test treatment modalities and evaluate the safety and efficiency of potential new chemical entities.
- **Types** - Vaccine development trails, Treatment studies, Challenge studies

About	Human clinical trials	Human challenge studies
Nature of exposure	They are strongly advised to adopt and adhere to safety measures to avoid getting infected.	Volunteers in a human challenge study are deliberately exposed to disease-causing pathogen
Aim	To study the safety and efficacy of drugs and vaccines	To understand the various facets of infection and disease pathogenesis besides selecting the best candidate drug or vaccine
Adverse effects	Safety is evaluated for the first time in humans during the phase-1 stage of a traditional trial	They face an additional risk when deliberately exposed to the pathogen.
Implementation	They are undertaken in four phases generally to test the efficacy.	They are undertaken to study less deadly diseases such as influenza, typhoid, cholera and malaria

5.37 Rules to Prescribe Generic Drugs

Doctors have been protesting on new guidelines for professional conduct to use generic names of medicines on the prescription instead of a particular brand name.

- A generic drug is a medication that has exactly the ***same active ingredient as the brand name drug*** and yields the same therapeutic effect.
- They do not involve repetition of extensive clinical trials over the years, unlike brands that undergo extensive R&D procedure.
- ***Indian Medical Council (Professional Conduct, Etiquette and Ethics) Regulations*** prescribes that every registered medical practitioner should prescribe drugs using generic names written legibly.
- **Exemption-**
    - **Narrow therapeutic index medicines** -Drugs where a small difference in dosage may lead to adverse outcomes
    - **Biosimilar** -A different version of biologic products that are manufactured in living systems



Steps taken to promote generic drugs

- **Pradhan Mantri Bhartiya Janaushadhi Pariyojana (PMBJP)-** It is implemented by Ministry of Chemicals and Fertilizers to provide quality generic medicines at affordable prices.
- Pharmaceuticals and Medical Devices Bureau of India procures medicines *only from World Health Organization – Good Manufacturing Practices (WHO-GMP)* certified suppliers.
- Each batch of drug is tested at laboratories accredited by *National Accreditation Board for Testing and Calibration Laboratories (NABL).*
- Only after passing the quality tests, the medicines are dispatched to PMBJP Kendras.
- **Janaushadhi Sugam-** It is a mobile application that provides information to public about location of kendras.
- It helps them search Janaushadhi medicines and compare the maximum retail price of generic vs. branded medicines.
- **Free drug initiative**- It is implemented under *National Health Mission (NHM).*
- It aims to provide essential generic drugs free of cost in public health facilities.
- **New guidelines**- *Indian Medical Council (Professional Conduct, Etiquette and Ethics) Regulations, 2002* prescribes that every physician should prescribe drugs with generic names legibly and preferably in capital letters.

5.38 Scheme for promotion of Research and Innovation in Pharma MedTech Sector (PRIP)

Union Minister of Health & Family Welfare launched Scheme for promotion of PRIP.

- **Aim -** To promote industry-academia linkage for R&D in priority areas and to inculcate the culture of quality research and nurture our pool of scientists.
- **Component A -** Strengthening the research infrastructure by establishment of seven Centre of Excellences at National Institute of Pharmaceutical Education and Research (NIPER).
- **Component B** - Promoting research in Pharma's 6 priority areas wherein financial assistance will be provided for both in- house and academic research.

5.39 Kidney Transplants in India

The Indian government has ordered a probe into an allegation that poor Myanmarese villagers were being lured into giving their kidneys to rich patients.

- **Regulated by**– Transplantation of Human Organs and Tissues Act, 1994.
- It allows living donations, in most cases, from close relatives such as parents, siblings, children, spouse, grandparents and grandchildren.
- A transplant can be either
  - From organs of *deceased persons* donated by their relatives
  - From a *living person* the recipient knows

> ***National Organ and Tissue Transplant Organization (NOTTO)*** *under the Ministry of Health and Family Welfare, is the apex centre for coordination of the registry, donation and transplantation of organs and tissues in India.*

Types of donations	
Donations from close relatives	**Donations from unrelated persons*(Altruistic donations)***
• The 1994 Act allows living donations, in most cases, from close relatives (parents, siblings, children, spouse, grandparents, grandchildren). • For donations involving either Indians or foreigners, documents establishing their identities, family tree, proving the donor-recipient relationship and financial standing of the donor have to be submitted.	• It involves donations from distant relatives, in-laws, or long-time friends are allowed after additional scrutiny. • For donations from unrelated persons, documents and photographic evidence showing their long-term association have to be submitted which is then *examined by an external committee*.

- Organ donations and transplants in ***exchange for money are forbidden*** in India.
- **Punishment** - Offering to pay for organs or document forgery is punishable by jail *up to 10 years and a fine of up to Rs 1 crore*.
- **Reasons for higher kidney transplantation scam**
  - Least risk to the donor
  - Cheaper than other transplantations
  - Higher survival time of kidneys
  - Higher demand for kidney due to increase in kidney failures

> *Kidney can survive up to 24-36 hours outside the body, the largest among other organs while the lungs remain viable only for 4-6 hours, and the liver for 8-12 hours.*

5.40 Transplant Games

- For the 1st time, ***Kerala*** is organizing Transplant Games, a competitive sporting event for organ transplant recipients and donors.
- The ***World Transplant Games Federation (WTGF)*** is a non-profit organization based in the United Kingdom with representation from more than 70 countries.
- The WTGF organizes the World Transplant Games (WTG), which are international multi-sport events that take place every two years.

5.41 Ayushman Arogya Mandir

- The Union Government has decided to rename the existing *Ayushman Bharat Health and Wellness Centres (AB-HWCs)* as 'Ayushman Arogya Mandir'
- The new tag line will be Arogyam Parmam Dhanam.
- ***National Health Policy, 2017*** envisioned the Health and Wellness Centres.

5.42 DISHA

- Diagnostic Services in Healthcare - Availability and Geo-mapping of Laboratory services in India (DISHA) is a portal that *helps the public access nearby diagnostic healthcare facilities.*
- It was launched by Indian Council of Medical Research (ICMR) - ***National Institute of Pathology (NIP).***

5.43 Global Initiative on Digital Health (GIDH)

India and the WHO launched the Global Initiative on Digital Health

- It is a WHO managed network of stakeholders organized to facilitate the implementation of the Global Strategy on Digital Health.
- It will serve as a platform to enable a wide global ecosystem to work collectively to promote country capacity and strengthen international cooperation in digital health.

*India's national platform, **e-Sanjeevani**, facilitated 140 million telehealth consultations to date.*

- **Aim** - To converge global efforts for digital health and scale up digital solutions with the use of cutting-edge technologies.
- In partnership with the WHO, the Global Initiative on Digital Health has been established, fostering collaboration among nations and organizations to realize this transformative vision.
- It will support the WHO global strategy on digital health and amplify other initiatives including the WHO global digital health certification network.

5.44 World Health Organization (WHO)

On global world health day, April 6, 2023 the WHO has completed 75 years, despite some great successes, the WHO has received its fair share of criticism.

- The World Health Organization (WHO) came into effect on April 7, 1948.
- It is a ***specialized agency of the United Nations (UN)*** that is responsible for international public health.
- The WHO's mission is to achieve health for all people.
- The WHO's headquarters is based in ***Geneva, Switzerland.***
- **Smallpox** is the only human disease to be eradicated by WHO.
- **Malaria** - WHO launched the Global Malaria Eradication Programme (GMEP) in 1955.

5.45 International Pathogen Surveillance Network (IPSN)

The IPSN was launched on the side-lines of the World Health Assembly in Geneva by WHO.

- IPSN is a global network to help ***protect people from infectious disease threats*** through the power of pathogen genomics.
- **Aim** - To help ensure infectious disease threats are swiftly identified and tracked and the information shared and acted on to prevent catastrophes like the COVID pandemic.
- **Function** - IPSN will provide a platform for connecting countries and improves systems for collecting and analysing samples.
- The data gathered will feed into a broader disease surveillance system used to identify and track diseases.
- **Organisational Structure** - The IPSN consists of 3 main operational bodies that bring together different sets of stakeholders and supported by a Secretariat.

The WHO Hub for Pandemic and Epidemic Intelligence

- The WHO Pandemic Hub forms part of the WHO Health Emergencies Programme.
- It was established in in Berlin, in response to the COVID-19 pandemic.
- It facilitates a global collaboration of partners from multiple sectors to address future pandemic and epidemic risks.

1. Communities of Practice (COPs) - To collaborate partners and increase harmonization and innovation in pathogen genomics.
2. Country Scale-Up Accelerator (CSUA) - To scale-up country capacity building through stakeholders working together.
3. Funders Forum - To coordinate philanthropic, multi-lateral and governmental donors and financing efficiency of pathogen genomic surveillance.

- **Secretariat -** The IPSN Secretariat will be hosted by the WHO Hub for Pandemic and Epidemic Intelligence.

5.46 Preterm Births

WHO has released the "Born Too Soon: Decade of Action on Preterm Birth" report.

- **Preterm babies** - Babies born alive ***before 37 weeks of pregnancy*** are completed.
- It is the *single largest killer of children* under five years of age.
- **Subcategories of preterm births**
  1. Extremely preterm - less than 28 weeks
  2. Very preterm - 28 to less than 32 weeks
  3. Moderate to late preterm - 32 to 37 weeks
- **Reasons for preterm births**
  1. Spontaneously
  2. Medical reasons – Infection, chronic conditions such as diabetes and high blood pressure, pregnancy complications that require early induction of labour or caesarean birth
  3. Other reasons - Multiple pregnancies, genetic influence

> ***SDG Target 3.2*** *aims to end preventable deaths of new-borns and children under 5 years of age by 2030*

5.47 The Next Pandemic

The WHO Director-general at the 76th world health assembly has cautioned against the threat of emerging pathogens.

A pandemic is a disease outbreak that spreads across countries or continents.

- COVID-19 is one such pandemic in recent years, which led to waves of infections and deaths in all countries.
- The World Health Organisation (WHO) declared that COVID-19 was no longer a Public Health Emergency of International Concern.

WHO Blueprint priority disease	Fatality rate	Recent outbreaks
CCHF	10%–40%[38]	Pakistan, 2010.[39]
Filoviruses (Ebola and Marburg)	24%–90%	West Africa, 2013–2016 and DRC 2017 and 2018 (Ebola). Uganda and Kenya, 2017 (Marburg).
Lassa fever	1–15%[43]	Annual recurring outbreaks in West Africa.[44]
MERS-CoV	~35%	Saudi Arabia, 2013–2018. South Korea, 2015.
SARS	~10%[47]	Global, 2003.[47]
Nipah and henipaviral diseases	~30%	Bangladesh, 2004. India, 2018.[50]
Rift Valley fever	<1%[51]	Republic of Niger, 2016.[51]
Zika virus disease	Not fatal	South and North America, 2015–2016.
Disease X		

5.48 Skin bank

North India's first skin bank opens in Safdarjung Hospital, Delhi.

- **Skin Bank** – It is a valuable resource in providing ***cadaveric allograft skin*** (human cadaver skin donated for medical use) as a cover for partial-thickness and full-thickness burn injuries.
- The skin from a donor is generally harvested ***within 6 – 8 hours*** of death.

- Only 1/***8th thickness part of the skin*** is taken and stored in glycerol, and then taken to a skin bank.
- **Donated skin** – It includes the skin obtained from
  - Any unburned spot of the same patient – **Autograft**
  - Cadaveric Skin – **Allograft**
  - Animals – **Xenograft**
- A person can donate their organs only in the case of *brain death*, but they *can* donate their eyes and skin even when they suffer a cardiac death.

DID YOU KNOW?

The first skin bank was established in the USA around 1950.
India has 16 skin banks across the country.

- **Preservation Methods -** *Cryopreservation* is the preferred method for long term storage of viable skin grafts.Donor skin can be frozen and stored for 4-8 degree Celsius up to 5 years.
- **Criteria for donating Skin**
  - A skin donor should be 18 years or above.
  - Only those suffering from HIV & Hepatitis B & Hepatitis C, generalized infection & Septicemia (Pneumonia, T.B, etc.), any kind of skin infection, malignancy and having evidence of skin cancer, *cannot* donate.

5.49 VISION 2020: The Right to Sight

- It is a global program that aims to ***eliminate avoidable blindness by 2020.***
- ***The World Health Organization (WHO)*** and the ***International Agency for the Prevention of Blindness (IAPB)*** established the program in 1999.
- **Support** – It is supported worldwide by Governments and health ministries, Non-governmental organizations (NGOs) and Eye care professionals, program managers and industry.
- **Causes of vision impairment and blindness** - Refractive errors, Cataract, Diabetic retinopathy, Glaucoma (a group of eye diseases that can damage the optic nerve, which connects the eye to the brain) Age-related macular degeneration.

5.50 Artificial Sweeteners

The WHO has recommended against using artificial sweeteners to achieve weight loss and prevent lifestyle diseases.

- **Artificial sweeteners** –They are sugar substitutes that are used to sweeten foods and beverages with *very little to no calories.*
- They are also called as *non-nutritive sweeteners (NNS), non-sugar sweeteners (NSS),* low calorie sweeteners and intense sweeteners.
- **Common NSS** - Acesulfame K (Ace-K), aspartame, advantame, cyclamates, neotame, saccharin, sucralose, stevia, and stevia derivatives

In India, FSSAI prescribes the maximum limit of artificial sweetener.

Food Safety and Standards Authority of India (FSSAI)

- **Establishment** - It is a statutory body established under the *Food Safety and Standards Act, 2006.*
- **Ministry** - *Ministry of Health & Family Welfare;* **Headquarters -** *Delhi*
- **Function** - To regulate and monitor, manufacture, processing, distribution, sale and import of food while ensuring safe and wholesome food to the consumers.
- To protect and promote public health through the regulation and supervision of food safety.

5.51 Methanol poisoning

Recently around 20 people died after consuming spurious liquor in Villupuram and Chengalpattu districts of Tamil Nadu.

- **Liquor** – It is an *alcoholic beverage made by distillation* rather than by fermentation.

- The alcohol content varies from the *5% or so (beer) to 12% or so (wine) to 40% or so (distilled spirits)* by volume.
- The alcohol used is almost always ***ethanol (C_2H_5OH),*** a psychoactive drug that, in low doses, reduces the level of neurotransmission in the body, leading to intoxicating effects.
- **Spurious alcohol** – It is an illicit liquor made up by *improper distillation.*
- It is a liquid mixture containing ***methanol (CH_3OH) as well ethanol***.
- **Methanol** – It is a colorless, fairly volatile, flammable liquid with a faintly sweet pungent odor like that of ethyl alcohol.

Beverage	Alcohol content
Beer	5% or so
Wine	12% or so
Distilled spirits	40% or so

- It is primarily used as an industrial solvent and as antifreeze.
- Methanol is also used as an alternative motor fuel and as an ingredient in paint and varnish removers.
- **Regulations** - The *Food Safety and Standards (Alcoholic Beverages) Regulations 2018* stipulate the maximum permissible quantity of methanol in different liquors.
- *Schedule I of the Manufacture, Storage and Import of Hazardous Chemical Rules 1989* includes methanol.

Liquor	Maximum permissible quantity of methanol
Coconut fenny	Absent
Country liquor	50 gm per 100 litre
Pot-distilled spirits	300 gm per 100 litre

- *The Indian Standard IS 517* applies to how the quality of methanol is to be ascertained.
- Ministry of Chemicals and Fertilizers has notified *Quality Control Order* for the ***mandatory certification*** for methanol that shall come into force on the 3rd August, 2023.

- **Methanol poisoning** - The deadliness of spurious liquor arises from methanol due to its conversion into ***formic acid.***
- The accumulation of formic acid over time leads to a baneful condition called *metabolic acidosis.*
- **Treatment** - There are 2 immediate ways to treat methanol poisoning.
- To administer *ethanol of a pharmaceutical grade* by healthcare workers & to administer an antidote called *fomepizole* (that is present in WHO's list of essential medicines)

WHO's Lists of Essential Medicines

- Essential medicines, as defined by the WHO, are the medicines that satisfy the priority health care needs of the population.
- These are the medications to which people should have access at all times in sufficient amounts and the prices should be at generally affordable levels.
- The lists are updated **every 2 years** by the ***Expert Committee*** on Selection and Use of Essential Medicines.
- The current versions, updated in 2021, are the 22nd Essential Medicines List (EML) and the 8th Essential Medicines List for Children (EMLc).

5.52 Animal health emergency in Brazil

Brazil has declared 180-day animal health emergency for the first time amid avian flu cases in wild birds.

- Avian influenza (AI) is a highly contagious viral disease that affects both domestic and wild birds.
- It is a ***viral disease*** and the viruses are divided into multiple subtypes (i.e. H5N1, H5N3, H5N8 etc.)

World Organisation for Animal Health (WOAH)

- WOAH is an intergovernmental organisation working across borders to improve the health of animals.
- Headquartered in Paris, it has 182 Members including India.
- They coordinate the global response to animal health emergencies, the prevention of zoonotic diseases and better access to animal health care.

5.53 Drug Reaction with Eosinophilia and Systemic Symptoms (DRESS) Syndrome

Recently the government issued an advisory about the side effects of Meftal, a commonly consumed painkiller as it could lead to Drug Reaction with Eosinophilia and Systemic Symptoms (DRESS) syndrome.

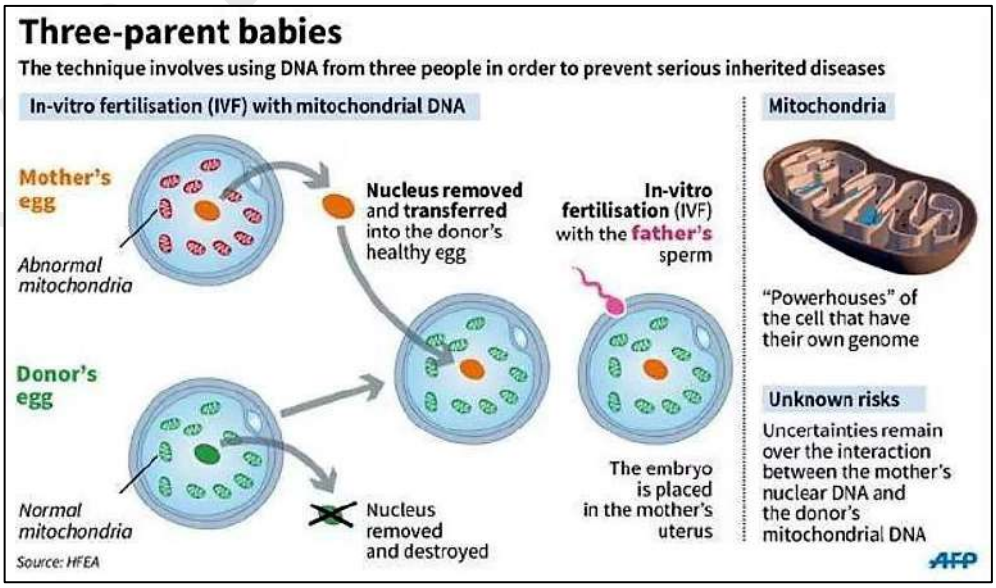
- It is a type of ***drug allergy*** that can occur as a hypersensitivity reaction to a large variety of medications.
- **Symptoms** – It includes skin rash, fever, lymphadenopathy, haematological abnormalities and internal organ involvement, which shows between 2 and 6 or 8 weeks after taking the drug.
- **Treatment** – The most important step to treat DRESS Syndrome is to stop the medication involved in the reaction, and sometimes, no further treatment is needed.
- ***Meftal-Spas*** is a commonly prescribed drug for a variety of conditions such as rheumatoid arthritis, osteoarthritis, dysmenorrhoea, mild to moderate pain, inflammation, fever, and dental pain.

6. BIO-TECHNOLOGY

6.1 Mitochondrial Donation Treatment

An announcement was made recently that a baby was born using three persons' DNA in the UK.

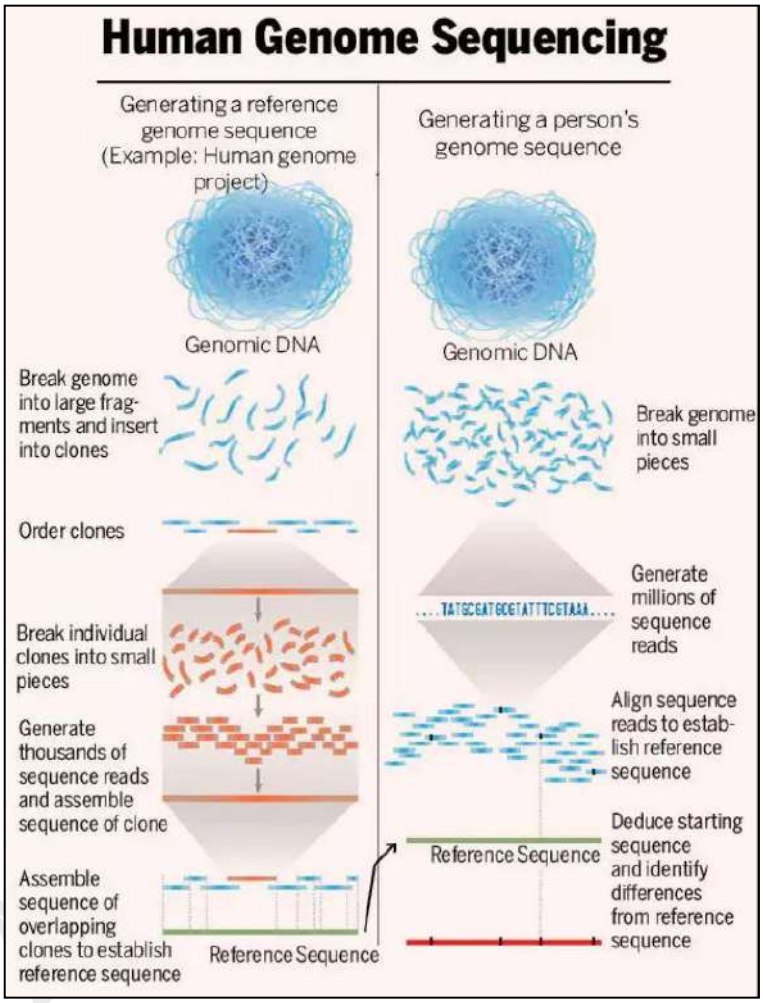
- **Mitochondria** - They are membrane-bound cell organelles that are the powerhouses of the cells as they generate the energy needed to power the cell's biochemical reactions.
- Chemical energy produced by the mitochondria is stored in a small molecule called *adenosine triphosphate (ATP).*
- Mitochondria contain their own *small chromosomes.* Generally, mitochondria, and mitochondrial DNA, are inherited ***only*** *from the mother.*
- **Mitochondrial diseases** - When the mitochondria are impaired and do not produce sufficient energy, it affects the functioning of organs and are called as mitochondrial diseases.
- Mitochondrial diseases are ***only*** *passed on by the mother.*
- In order to prevent the child from inheriting the mother's mitochondrial disease, the three parent technology was used.
- **Mitochondrial Donation Treatment** – It is also known as *mitochondrial replacement therapy (MRT).*
- ***Advanced in-vitro fertilization technique*** is used for mitochondrial donation treatment.
- The baby's biological father's sperm was used to fertilise the eggs from the biological mother, who has a mitochondrial disease, and a third, female donor with clear mitochondria, separately.



- Then, the nuclear genetic material from the donor's egg is removed and replaced with the genetic material from the biological parents'.
- The final product (the egg) which has the genetic material from the parents, and the mitochondria from the female donor, is implanted in the uterus.
- This baby (three-parent baby) will be ***free from the mother's mitochondrial disease.***

6.2 Pangenome Reference Map

A pangenome reference map has been built using genomes from 47 anonymous individuals (does not include Indians).



- **Genome** - It is the *entire set of DNA instructions* found in a cell. It contains all the information needed for an individual to develop and function.
- In humans, the genome consists of *23 pairs of chromosomes* located in the cell's nucleus, as well as in the mitochondria.
- Each chromosome is a contiguous stretch of DNA string which in turn is composed of millions of individual building blocks called ***nucleotides or bases***.
- The four bases include *adenine, thymine, guanine and cytosine (A, T, G and C).*
- The genome is an identity card like Aadhaar as each our genome is unique.
- To date, humans are the *only life form* that has successfully sequenced its own genome, yet there are many life forms that have substantially larger genomes.
- ***Genome sequencing*** – It is the method used to determine the precise order of the four bases (A, T, G and C) and how they are arranged in chromosomes.
- It helps us understand human diversity at the genetic level.

Feature	Reference Genome	Pangenome Map
Definition	A complete sequence of DNA for a particular species that acts as a reference map for newly sequenced genomes.	A collection of genomic sequences found in the entire species rather than a single individual.
Purpose	Used as a standard for comparing other genomes.	Used to study genetic diversity and identify genes associated with diseases.
Accuracy	Typically, more accurate than pangenome maps.	More comprehensive than reference genomes.
Diversity	Typically based on the genomes of a small number of individuals.	Typically based on the genomes of a large number of individuals.
Applications	Gene mapping, genome sequencing, and drug discovery.	Disease research, personalized medicine, and evolutionary biology.

Methods deployed for Genome sequencing

- **Clone-by-Clone method-** It is a traditional method that requires high density genome map and works well for larger genomes like eukaryotic genomes.
- **Whole genome shotgun sequencing-** It is the improved version of Clone-by-Clone method that doesn't require a genome map,
- It is the faster method of sequencing but not suitable for larger genomes as they have a number of repetitive DNA sequences.

- **Next-Generation Sequencing-** It is the most advanced, robust, accurate, faster, cheaper and high throughput genome sequencing technique.
- It relies on the chemistry of bridge amplification and can sequence more than 5 separate human genomes simultaneously. It is the most trusted Genome Sequencing method so far.

Quick facts

- **Human Genome Project**- The HGP was the international, collaborative research program for complete mapping and understanding of all the genes of human beings.
- **Genome India Project** – It was initiated and funded by the Department of Biotechnology (DBT) in 2020 for 3 years.
- It aims to build a grid of the Indian "reference genome", to understand fully the type and nature of diseases and traits that comprise the diverse Indian population.
- **The Human Pangenome Reference Consortium (HPRC)** – It is a project funded by the National Human Genome Research Institute, Maryland, United States.
- It aims to sequence and assemble genomes from individuals from diverse populations in order to better represent genomic landscape of diverse human populations.

6.3 Genetically Modified Insects

In April 2023, the Department of Biotechnology (DBT) issued the 'Guidelines for Genetically Engineered (GE) Insects'.

- A genetically modified insect is any insect whose genetic material has been altered using genetic engineering techniques. Such insects are also called Genetically Engineered insects (GE insects).
- These techniques help achieve the desired physiological traits or the production of desired biological products.
- **Control -** GE organisms or cells and hazardous microorganisms and products thereof are regulated as per ***'Rules 1989'*** under the *Environment (Protection) Act of 1986.*
- **Applications**
    - Vector management in human and livestock health;
    - Management of major crop insect pests;
    - Maintenance and improvement of human health and the environment through a reduction in the use of chemicals;
    - Production of proteins for healthcare purposes;
    - Genetic improvement of beneficial insects like predators, parasitoids, pollinators (e.g. honey bee) or productive insects (e.g. silkworm, lac insect).

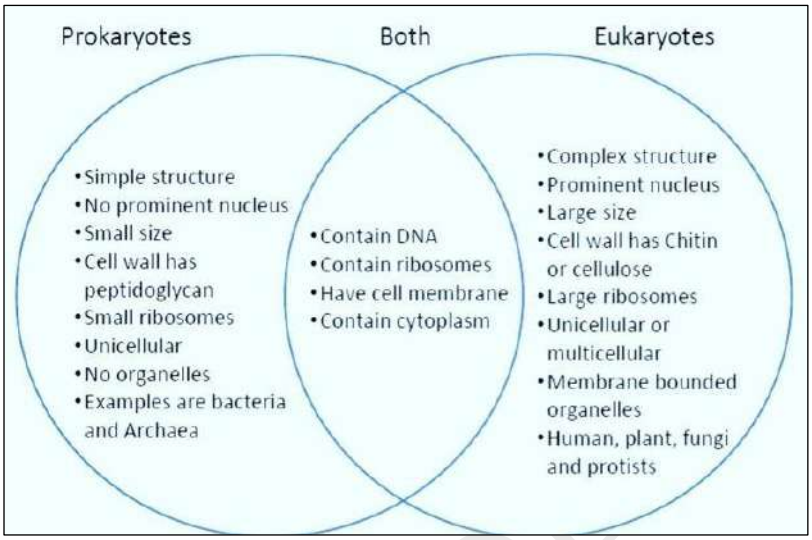
The Department of Biotechnology (DBT) functions under Ministry of Science and Technology (MoST) is the nodal agency and promoter of biotechnology in India.

6.4 Evolution of Eukaryotes

Mitochondria in eukaryotic cells and chloroplasts in plant cells have evolved from free-living bacteria.

- Present-day cells evolved from a common prokaryotic ancestor along 3 lines of descent, giving rise to ***archaebacteria*, *eubacteria*, and *eukaryotes*.**
- The first eukaryotic cells evolved about *2 billion years* ago, this is explained by the ***endosymbiotic theory.***
- ***Endosymbiosis*** came about when large cells engulfed small cells where the small cells were not digested by the large cells instead, they lived within the large cells and evolved into organelles.
- From independent cell to organelle the large and small cells formed a symbiotic relationship in which both cells benefited.
- **Mitochondria** - Some of the small cells were able to break down the large cell's wastes for energy.
- They supplied energy not only to themselves but also to the large cell.
- They became the mitochondria of eukaryotic cells.

- **Chloroplasts** - Other small cells were able to use sunlight to make food.
- They shared the food with the large cell.
- They became the chloroplasts of eukaryotic cells.
- The ancestor of mitochondria was a *proteobacterium* that was engulfed by an asgard archaean organism.
- Descendants of this endosymbiotic union gave rise to animals, fungi and plants.
- In plants, the asgard-mitochondrial union was followed by the intake of a photosynthesizing cyanobacterium, which became the chloroplasts.



6.5 Cholederm

Indian Drugs Controller approves first indigenously developed animal-derived tissue, named cholederm

- Cholederm is a ***wound healing material*** derived from the extracellular matrix of de-cellularised ***gall bladder of pig.***
- It is a Class D Biomedical Device material.
- **Indigenous one** - It is the first indigenously developed product to all statutory requirements of the Central Drugs Standard Control Organisation.
- **Developer** - Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), an autonomous institution of the Department of Science and Technology (DST).

Central Drugs Standard Control Organisation (CDSCO)

- The CDSCO is the national regulatory body for pharmaceuticals and medical devices in India.
- **Regulatory authority -** Ministry of Health & Family Welfare
- **Headquarters** - New Delhi
- Under the *Drugs and Cosmetics Act*, CDSCO is responsible for approval of drugs, conduct of clinical trials, laying down the standards for drugs, control over the quality of imported drugs in the country.
- CDSCO along with state regulators, is jointly responsible for grant of licenses of certain specialized categories of critical drugs such as blood and blood products, I. V. fluids, vaccine and sera.
- The ***Drug Controller General of India (DCGI),*** which is an organ of the CDSCO, is responsible for approving and licensing of drugs and medical devices.

6.6 Sequencing the Y Chromosome

Scientists have fully sequenced the Y chromosome for the first time, uncovering information that could have implications for the study of male infertility and other health problems.

- In the nucleus of a human cell, each DNA molecule is packaged into a long thread like structure called chromosome.
- Most human cells contain 23 pairs of chromosomes. One half of each pair of chromosomes from one parent, while other half comes from other parent.
- The 23rd pair are X and Y chromosomes, often called as ***sex chromosomes.*** The other 22 pairs called as ***autosomes***.
- Females have a pair of X chromosomes, whereas males have X and Y chromosome.

The Y is the last human chromosome to have been sequenced end-to-end, or telomere to telomere (T2T)

- The Y chromosome is male-determining because it bears a gene called ***SRY,*** which directs the development of a ridge of cells into a testis in the embryo.
- The embryonic testes make male hormones, and these hormones direct the development of male features in a baby boy.

6.7 Gene-edited Mustard

Recently, Indian scientists have developed the first ever low-pungent mustard that is pest and disease-resistant.

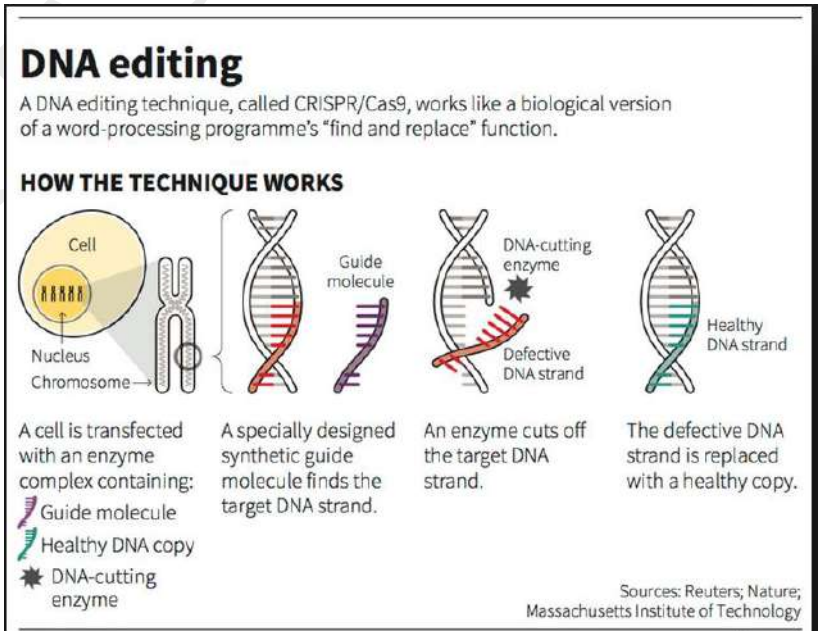
- Mustard is a self-pollinating oilseed crop; **Family** - Brassicaceae
- **Types**
  - White/Yellow mustard (*Sinapis alba*) - Mediterranean origin
  - Brown/Indian mustard (*Brassica juncea*) - Himalayan origin

India is the 4th largest oilseeds producer in the world.

- The seeds contain about 30-40% vegetable oil, a slightly smaller proportion of protein, and a strong enzyme called ***myrosin.***
- **Production - *Rajasthan*** is the largest producing state in the country.
- **Issues**- Mustard seeds have high levels of glucosinolates, a group of sulphur and nitrogen-containing compounds that contribute to the ***characteristic pungency*** of their oil and meal.
- Rapeseed meal is ***unpalatable to poultry and pigs*** thus reducing their feed intake.

*Nobel Prize in Chemistry was awarded to **Emmanuelle Charpentier and Jennifer Doudna** in 2020 for their work in CRISPR/CAS9.*

- High glucosinolates are also known to cause goiter (swelling of neck) and internal organ abnormalities in livestock.
- The ***canola quality*** seeds have low glucosinolates (30ppm). However, lowering of glucosinolate levels in seed weakens its defence.
  - **Genome editing** – It involves the use of technologies that *allow genetic material to be added, removed, or altered at particular locations* in the genome.
  - It is a group of technologies that enables change in the DNA/RNA of an organism.
  - It could introduce specific foreign DNA/RNA that is not available in the natural gene pool of the host plant species thereby introducing novel traits.
  - **Objectives**
    - Crop improvement
    - Nutrition enhancement
    - Crop protection from drought, pests and insects



- Glucosinolates are synthesised in the leaves and pod walls of mustard plants.
- Their translocation and accumulation in the seeds happens through the action of ***glucosinolate transporter or GTR genes.***
- ***CRISPR/Cas9,*** a gene-editing tool deploying an enzyme, acts as a "molecular scissors" to edit 10 out of the 12 GTR genes in 'Varuna', a high-yielding Indian mustard variety.
- The seeds of the resultant gene-edited Varuna variety had glucosinolate content below the 30 ppm canola-quality threshold.
- At the same time, the other plant parts had significantly higher glucosinolate accumulation.

CRISPR Cas-9
• It stands for Clustered Regularly Interspaced Short Palindromic Repeats. • It is the most prominent technology that enables to edit parts of the genome by removing, adding or altering sections of the DNA sequence. • The CRISPR-Cas9 system consists of two key molecules that introduce a change mutation into the DNA. • **Cas9-** An enzyme that acts as a pair of 'molecular scissors' that can cut the two strands of DNA at a specific location in the genome. • **Guide RNA (gRNA)-** The gRNA is designed to find and bind to a specific sequence in the DNA. • The Cas9 follows the guide RNA to the same location in the DNA sequence and makes a cut across both strands of the DNA. • At this stage, the cell recognises that the DNA is damaged and tries to repair it. • The DNA repair machinery is used to introduce changes to one or more genes in the genome of a cell of interest.

6.8 Global Vaccine Research Collaborative

India urges G-20 countries to join the proposed vaccine research collaborative on the sidelines of the 3rd meeting of the G-20 Health Working Group.

- **Aim** - It aims to leverage expertise and resources from various stakeholders to expedite vaccine development and mitigate the impact of future pandemics.
- The ***Department of Pharmaceuticals*** is working with a non-profit Program for Appropriate Technology in Health (PATH) and the Coalition for Epidemic Preparedness Innovations (CEPI) to build this collaborative.
- It will create a mechanism to improve coordination and foster an enabling environment for vaccine R&D.

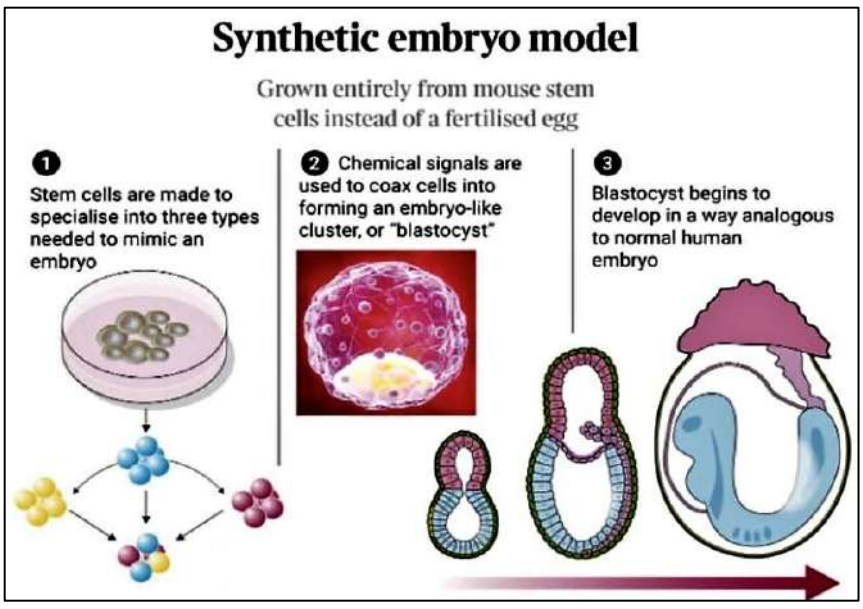
6.9 Synthetic Human Embryo

Recently, Israeli scientists have successfully grown a "human embryo" in the lab without using an egg or sperm.

- Embryo can be defined as an organism in the early stages of development. It undergoes multiple stages of development to develop into a new organism.
- Embryonic development is called ***embryogenesis*.**
- **Foetus**- It is the development of a single-cell (zygote) to a multicellular organism (foetus) characterised by the processes of cell division and cellular differentiation of the embryo that occurs during the early stages of development.

Synthetic embryo model created

- **Stem cell mix-** They used a mix of stem cells (early cells that have the ability to differentiate into other type of cells).
- **Foetus formation-** They used a mix of stem cells and chemicals, a small portion which was able to spontaneously assemble to form different types of cells that form the foetus.
    - Cells that provide nutrient to the foetus.
    - Cells that lay out the plan for development of the body, and



- Cells that create structures like placenta and umbilical cord to support the foetus.

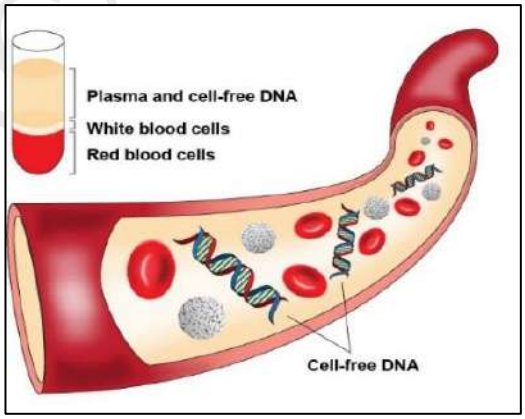
- The naive-state stem cells were programmed to become certain types of body tissue, including
  - **Epiblast cells** - It become the foetus
  - **Trophoblast cells**- It become the placenta
  - **Hypoblast cells-** It supports the yolk sac
  - **Extraembryonic mesoderm**- It contributes to the overall embryo development

These models are meant to study the early stages of development of a foetus. They cannot be used to get pregnant.

- **Early embryo**- This was able to spontaneously assemble into embryo like structure, mimicking molecular characteristics of an early embryo.
- **Complete model**- The scientists have called it one of the most complete models of a 14-day-old human embryo.
- None of them fully replicate the processes that happen during the early stages of embryo development, but all of them add to their understanding.
- **Issue faced**- Only 1% of this mixture actually assembled spontaneously, making the process not very efficient.

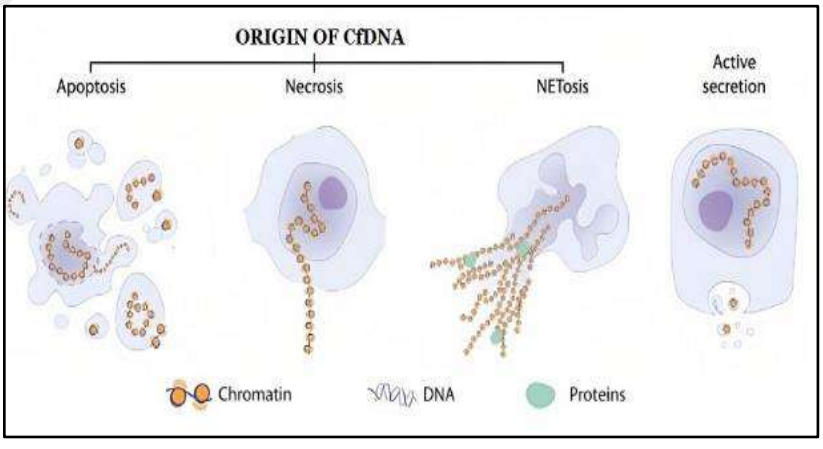
6.10 Cell Free DNA (cfDNA)

Cell free DNA is found to be promising in the field of disease discovery.



- DNA is a molecule that carries genetic information for the development and functioning of an organism.
- Cell-free DNA (cfDNA) refers to small DNA fragments found in the bloodstream and other bodily fluids, such as spinal fluid and urine.
- These fragments are derived from various sources, including the breakdown of cells, the release of DNA from damaged or dying cells, and the shedding of DNA by normal cells.
- The presence of cfDNA in bodily fluids is an indication of various processes that include physical injury, inflammation, and cancer.

Applications of cfDNA



- **Non-invasive prenatal test (NIPT) -** NIPT is a screening test that can be performed during pregnancy to assess the risk of chromosomal abnormalities in the fetus, such as
  - Down syndrome (trisomy 21)
  - Edwards syndrome (trisomy 18)
  - Patau syndrome (trisomy 13)
- **Cancer treatment-** The presence of cfDNA with specific genetic abnormalities can indicate the presence of cancer.
- The analysis of cfDNA can be used to diagnose cancer, monitor the treatment effectiveness, and detect recurrence after treatment.
  - **GEMINI-** Genome-wide Mutational Incidence for Non-Invasive detection of cancer adopts a whole-genome-sequencing approach to cfDNA extracted from patients.
- **Biomarker-** CfDNA finds its application in the neurological disorders like Alzheimer's disease, neuronal tumours, stroke, traumatic brain injury, and even metabolic disorders like type-2 diabetes and non-alcoholic fatty liver disease.

- **Heart attack**- The analysis of cfDNA has been studied as a potential tool for the diagnosis and prognosis of acute myocardial infarction (heart attack).
- **Stroke**- The presence of cfDNA in the blood is an indicator of brain injury in stroke patients, and the analysis of cfDNA has been studied as a potential tool for the diagnosis and prognosis of stroke.
- **Autoimmune diseases**- The analysis of cfDNA is a potential tool for diagnosing and monitoring autoimmune diseases, such as rheumatoid arthritis and systemic lupus erythematosus.
- **Pregnancy complications**- The analysis of cfDNA is a potential tool for diagnosing and monitoring complications during pregnancy, such as preterm labor and preeclampsia.
- **Organ transplantation-** It helps in understanding why a body is rejecting a transplanted organ.
- DNA obtained from the donor who is donating the organ – called donor-derived cfDNA, dd-cfDNA – could provide an early yet accurate estimate of how well the organ is being taken up.

Circulating tumor DNA (ctDNA)

- ctDNA refers to a small subset of the cfDNA and consists of small DNA fragments released into the bloodstream by cancer cells.
- ctDNA can be detected in the blood of individuals with cancer and can provide information about the characteristics of the cancer.
- **Size-** ctDNA fragments are typically smaller than normal DNA fragments due to the presence of breaks and mutations in the DNA.
- **Composition-** ctDNA comprises both normal DNA and DNA with mutations or abnormalities.
- **Stability-** ctDNA is relatively stable in the bloodstream and can be detected for an extended period after it is released from the cancer cells.
- **Concentration-** The concentration of ctDNA in the bloodstream can vary depending on the stage and size of the cancer.
- **Heterogeneity**- ctDNA can be highly heterogeneous, meaning it can contain various mutations and abnormalities making it challenging to detect and analyze accurately.

6.11 NexCAR19

Recently, India's homegrown CAR-T cell therapy, a form of immunotherapy got market authorisation.

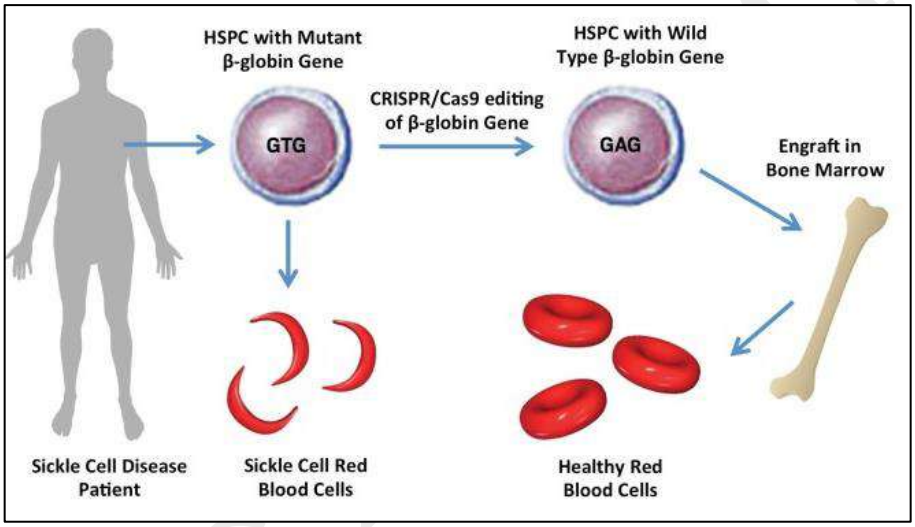
- It is an indigenously developed CD19-targeted CAR-T cell therapy.
- **Produced by** – Immunoadoptive Cell Therapy Private Limited (ImmunoACT) in Mumbai.
- **Treatment** – Relapsed refractory B-cell lymphoma and leukaemia.
- **Working Mechanism** – It works by redirecting a genetically altered patient's own immune cells (T-cells) in the laboratory, to directly identify and attack cancer cells.
- CAR T-cells have the *potential to act as 'living drugs'*, providing long-term protection against relapse.
- **Cytokine release syndrome (CRS)** – It is one among the side effects of CAR T-cell therapy.
- When CAR T-cells multiply, large amounts of cytokines is released into the blood, which ramp up the immune system.
- **Advantages**
    - NexCAR19 has relatively higher safety profile of CRS.
    - It has excellent balance of efficacy and low toxicity.
    - Phase I and II clinical trials data indicated a 70% overall response rate.
    - It can be accessible at 20 Indian government and private hospitals across major cities.
    - It will around Rs 30-35 lakh per patient which were previously around $400,000 or over Rs 3.3 crore.

***NexCAR19** is India's 1st CAR T-cell therapy to get approval from the CDSCO*

6.12 Casgevy & Lyfgenia

1st therapy based on Crispr-Cas9 for Sickle cell disease and Thalassaemia has been approved in UK.

- **Casgevy –** It is the 1st licensed therapy in the world based on the gene editing technology Crispr-Cas9.
- **Apheresis** - It is a *one-time treatment* for which the doctor has to first collect blood stem cells from the bone marrow using a process called ***apheresis*** (filtering out the blood for different components).
- The cells are then sent to the manufacturing site where it takes about 6 months for them to be edited and tested.
- **Gene editing** - The therapy uses the patient's own blood stem cells, which are precisely edited using ***Crispr-Cas9.***
    - So far, the only permanent treatment has been a bone marrow transplant, for which a closely matched donor is needed.
- A gene called ***BCL11A***, which is crucial for switching from foetal to adult haemoglobin, is targeted by the therapy.
    - Foetal haemoglobin (naturally present in everyone at birth), does not carry the same abnormalities as adult haemoglobin.

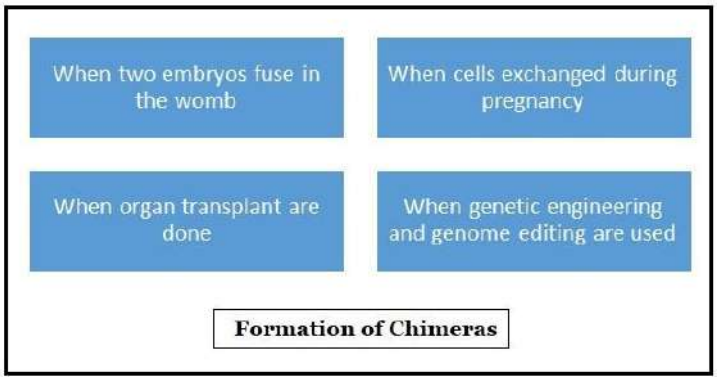


- The therapy uses the body's own mechanisms to start producing more of foetal haemoglobin, alleviating the symptoms of the two conditions.
- **Side effects**- They are similar to those associated with autologous stem cell transplants, including nausea, fatigue, fever and increased risk of infection.
- **Lyfgenia** – It is a cell-based gene therapy, uses a lentiviral vector (gene delivery vehicle) for genetic modification. It modifies a patient's blood stem cells to produce a modified version of the HBB gene.
- It is approved for the treatment of patients of 12 years of age and older with sickle cell disease and a history of vaso-occlusive events.

6.13 Chimeras of Nature

In a recent landmark study, scientists reported the successful generation of a live chimera in non-human primates.

- In Greek mythology, a chimera was a fearsome creature with the combined features of a lion, a goat, and a snake.
- **Chimerism-** It is defined as a phenomenon of occurrence of more than one type of different and distinguished genotype in an organism.
- **Chimera-** It is defined as an organism composed of cells with different genotypes altogether.
- **Formation of chimera**- They can arise in several ways
- **Natural chimeras**- It also occurs in natural ways. Example- Anglerfish, Sponges, Yellow Crazy Ants etc.,

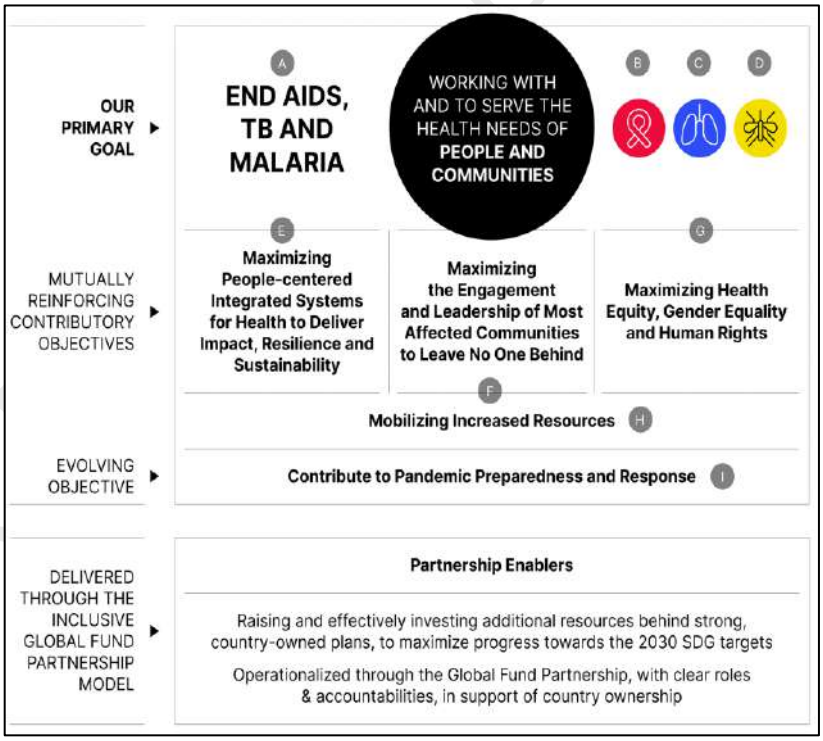


- **Genetic Chimeras-** It happens when an individual is derived from two or more zygotes.

Types	About
Animal chimeras	It results from the merger of two or more embryos. They may possess blood cells of different blood types and subtle variations in form.
Plant chimeras	It can have distinct types of tissue originating from the same zygote due to mutation during ordinary cell division.
Hybrid chimeras	An individual where each cell contains genetic material from two organisms of different breeds, varieties, species or genera.
Organ transplantation	The tissues from a different genome are introduced to an individual. Example- Bone marrow transplantation can determine the recipient's ensuing blood type.

6.14 Global Fund

The Global Fund recently announced a deal with generic pharmaceutical manufacturers to slash the price of a cutting-edge HIV drug.



- Global Fund is a worldwide movement to defeat ***HIV, TB and Malaria*** and ensure a healthier, safer, more equitable future for all.
- **Partners**- Governments, civil society, technical agencies, the private sector and people affected by the diseases.
- **Year** - It was set up in *2002*.
- **Funding** - The Fund pools the world's resources to invest strategically in programs to end AIDS, TB and malaria as public health threats.
- The financing is primarily from the *public sector, with 92%* of total funding coming from donor governments.
- **Strategy** – To accelerate impact towards the 2030 horizon as set out in Sustainable Development Goal 3.
- **Recent Initiative -** It envisages to provide the advanced pill known as TLD for under ***$45*** per person per year.
- **TLD -** The three-in-one pill bands together the drugs *Tenofovir disoproxil fumarate, Lamivudine and Dolutegravir.*
- It is recommended by the World Health Organization for first-line treatment of HIV.

6.15 Nasha Roko Committee

A vigilant wave is sweeping through villages in Punjab to tackle the decade-old drug problem.

- **About -** It is an informal committee to stop the use and sale of drugs.
- **Against -** It act against the drugs Chitta and the prescription-only pharma drug, pregabalin.
- **Campaign** - *'Nasha roko, rozgaar do'* (stop addiction, provide employment) campaign was started to end the drugs.

Only 250 gm or above of heroin is considered a commercial quantity under the Narcotic Drugs and Psychotropic Substances Act.

6.16 Monoclonal antibodies

India reached out to Australia to procure monoclonal antibody doses to combat the Nipah virus outbreak in Kerala.

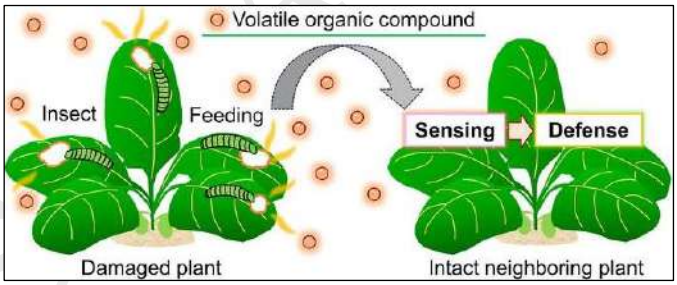
- These are laboratory-made proteins that mimic the behaviour of antibodies produced by the immune system to protect against diseases and foreign substances.
- An antibody attaches itself to an antigen, a foreign substance, usually a disease-causing molecule and helps the immune system to eliminate it from the body.
- Monoclonal antibodies are specifically designed to ***target certain antigens.***

Niels K. Jerne, Georges J.F. Köhler and César Milstein were awarded the medicine Nobel Prize in 1984 for their work on the the principle for production of monoclonal antibodies.

6.17 Green Leaf Volatiles (GLVs)

For the first time, scientists were able to visualise plants sensing compounds released by other plants in danger.

- **GLV** – A group of ***compounds that a plant releases into the air*** when it is injured which may be a *warning to other plants* that danger is near.
- They consist of ***six carbon (C6) compounds*** including alcohols, aldehydes and esters which are released from almost every plant.
- **2 major defence mechanisms -** When a plant is damaged, *GLVs* are released as by-products. Plants can *make themselves less palatable or even indigestible* to the insect attackers.
- When an insect takes a bite of a plant leaf, *calcium ions* flood the leaves in the cells.
- **Future prospects** – To fight agricultural pests *without using pesticides* and going organic.



- **Other internal defence responses of plants -** Jasmonic acid activates plants' defences and effectively repels insect pests.

7. NUCLEAR TECHNOLOGY

7.1 History of India's Nuclear Program

The nuclear 'chain reaction' and neighbourhood challenges led India to acquire nuclear weapons.

- **Dual intent strategy -** It was followed by then Prime Minister of India Jawaharlal Nehru.
- He made it clear in 1950 that while he was against the atom bomb, the call for a nuclear-free world must come from a position of strength, not weakness.
- **Nuclear program-** Homi Bhabha was tasked to develop the capability to use nuclear energy for peaceful purposes, but to retain the capacity to develop a weapon if the need arose.
- **Indo-China War 1962-** India's external environment became more challenging after the defeat to China in 1962.
- In 1960's almost all the permanent members in United Nations Security Council had tested nuclear weapons.

Homi Jehangir Bhabha was called as the father of India's nuclear program and he is the founder of Tata Institute of Fundamental Research.

Nuclear Command Authority		
Council	**Head**	**Function**
Political council	Prime Minister	Sole body which can authorize the use of nuclear weapons
Executive council	National Security Advisor	Provides inputs for decision making by the Nuclear Command Authority and executes the directives given to it by the Political Council

- **Smiling Buddha (Pokran 1)-** India's first nuclear test in 1974 where it demonstrated its capability to produce nuclear weapons.
- **Nuclear Suppliers Group-** It was founded in 1974 as response to India's nuclear test.
- It aims to control the export of materials, equipment and technology that can be used to manufacture nuclear weapons.
- **Operation Shakthi (Pokran 2)-** It is India's second nuclear test in 1998 which marked the beginning of the rise of a strong and self-confident India.

*A **Becquerel** (Bq) is a unit that measures the rate at which radioactive material emits radiation or how many atoms in the material decay in a given time.*

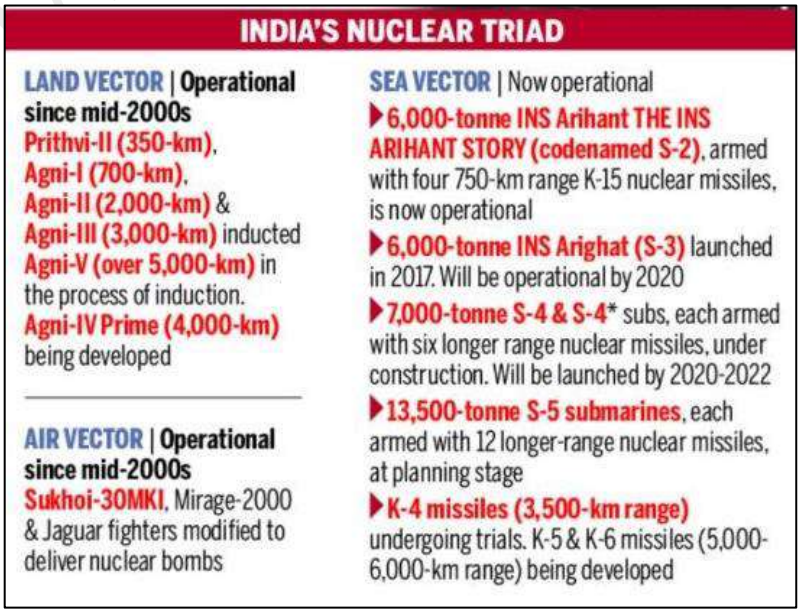
India's Nuclear Doctrine

- India's official nuclear doctrine is codified in a 2003 document, which takes cues from the 1999 draft doctrine.
- Since 2003, India's nuclear doctrine has had 3 primary components.
    - No First Use
    - Massive Retaliation
    - Credible Minimum Deterrence

- **No First Use -** India will only use nuclear weapons in response to a nuclear attack on Indian Territory or Indian forces. Non-use of nuclear weapons against non-nuclear weapon states.
- A warning is made about their possible use in response to a chemical or biological attack.
- **Massive Retaliation -** India's response to a first strike will be massive, to cause 'unacceptable damage'.
- While the doctrine does not explicitly espouse a counter-value strategy (civilian targets), the wording implies the same.
- **Credible Minimum Deterrence** - The number and capabilities of India's nuclear weapons and delivery systems should merely be sufficient to ensure intolerable retaliation.
- This should also keep in mind first-strike survival of its relatively meagre arsenal. India's strategic nuclear command was formally established in 2003.

India's nuclear triad

- It refers to the delivery of nuclear weapons via land, sea and air i.e.
    - Land-based intercontinental ballistic missiles (ICBMs),
    - Submarine-launched ballistic missiles (SLBMs), and
    - Strategic bombers.
- **Purpose -** To reduce the possibility that an enemy could destroy all of a nation's nuclear forces in a first-strike attack.
- It ensures a credible threat of a second strike, and thus increases a nation's nuclear deterrence.



Nuclear organisations

- **Comprehensive Test Ban Treaty (CTBT)** – It prohibits any nuclear weapon test explosion or any other nuclear explosion anywhere in the world.
- The treaty was opened for signature in 1996, and has been signed by 186 nations and ratified by 176.
- The treaty cannot formally enter into force until it is ratified by 44 specific nations, 8 of which have yet to do so:

*India is a member of the Multilateral Export Control Regime (All 3 groupings) **except the Nuclear Suppliers Group.***

China, ***India,*** Pakistan, North Korea, Israel, Iran, Egypt, and the United States.

- **International Atomic Energy Agency (IAEA)** – Also known as the world's *Atoms for Peace and Development* organization, it was established in 1957 as United Nation's autonomous organization.
- **Headquarters**- Vienna, Austria.
- **Role-** To promote the peaceful use of nuclear energy and to inhibit its use for any military purpose, including nuclear weapons.
- **Membership-** 177 member states. **India** is a member of this organization.
- **Nobel peace prize**- It was awarded in 2005 for their work for a safer and more peaceful world.

7.2 The Science behind Nuclear Bomb

Christopher Nolan's film "Oppenheimer" has ignited conversation around nuclear weapons.

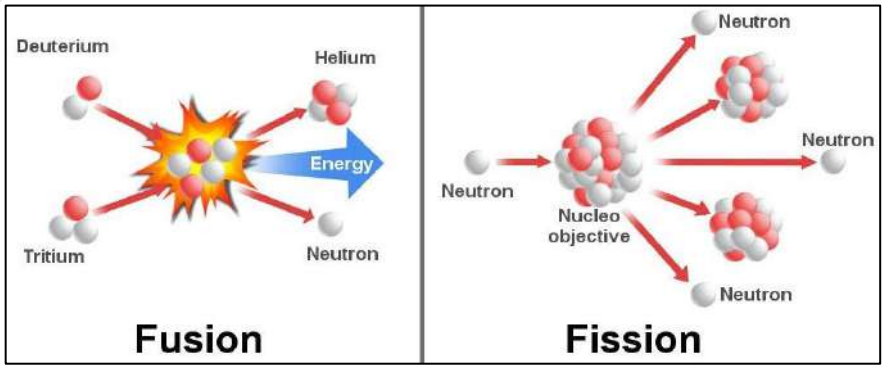
- Atoms are the *basic building blocks* of all matter, such that they cannot be "broken down" further by simple chemical processes.
- Atom comprises of ***3 sub-atomic particles*** **-** Positively charged proton, Negatively charged electron, Neutral neutron
- The protons and neutrons combine to form the atom's nucleus, around which circle a "***cloud" of electrons*****.**
- The number of protons in an atom determines the element, and the number of neutrons determines the isotope of that element.

The Manhattan Project *- R&D undertaking led by the United States with the support of the United Kingdom and Canada, during World War II to produce the 1st nuclear weapons.*

- The minimum mass of a fissile material necessary to sustain the chain reaction is called ***critical mass.***
- If the mass of the fissile material is less than the critical mass, it is termed as ***subcritical.***
- If the mass of the fissile material is more than the critical mass, it is termed as ***supercritical***

Nuclear fission

- In 1939, German Scientist *Otto Hahn and F.Strassman* discovered that when a uranium nucleus is bombarded with a neutron, it breaks up into 2 smaller nuclei of comparable mass along with the emission of a few neutrons and energy.



- This process of breaking up of a *heavier nucleus into 2 smaller nuclei* with the release of a large amount of energy and a few neutrons is called 'nuclear fission'.
  - **Example** - Nuclear fission of a uranium.

$$_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_{0}n^{1} + Q\ (\text{energy})$$

- **Atom bomb** - The atom bomb is based on the principle of ***uncontrolled chain reaction***, in which the number of neutrons and the number of fission reactions multiply in a geometrical progression.
- This releases a huge amount of energy in a very small time interval and leads to an explosion.
- An atom bomb consists of a piece of fissile material whose mass is *subcritical*.

J. Robert Oppenheimer is called as the father of atom bomb.

- Example- Hiroshima and Nagasaki atom bomb explosion in 1945.

- **Uranium enrichment** - Approximately *99.3%* of naturally occurring uranium is of the isotope *U-238, which is not fissionable*. Naturally occurring uranium, therefore, cannot be used in a weapon, or nuclear power plants.
- Uranium ore is enriched in order to increase the concentration of U-235.
- Most nuclear power plants require an ***enrichment of 3-4%*** U-235 to sustain a chain reaction.
- Fission bombs on the other hand need *closer to* ***90% enrichment***.

Nuclear fusion

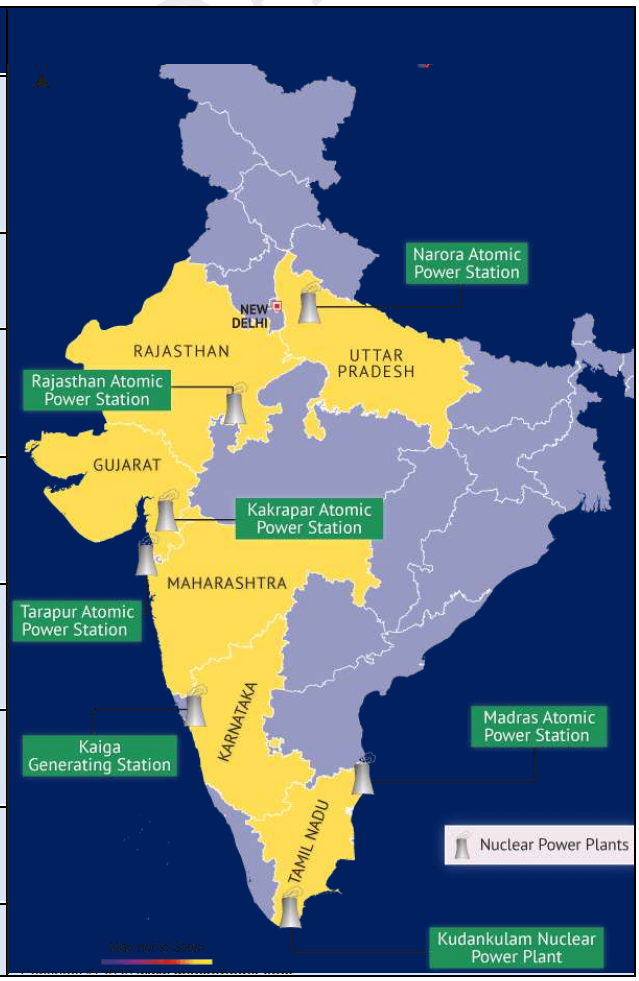
- The process in which *two lighter nuclei combine to form a heavier nucleus* is termed as 'nuclear fusion'.
- Nuclear fusion is also called as ***thermonuclear reaction*** which is possible only at an extremly high temperature and high pressure to push the hydrogen nuclei closer to fuse with each other.

$$^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n + energy$$

- **Hydrogen bomb** - It is based on the principle of *nuclear fusion.*
- A hydrogen bomb is always designed to have an *inbuilt atom bomb* which creates the high temperature and pressure required for fusion when it explodes.
- Then, fusion takes place in the hydrogen core and leads to the release of a very large amount of energy in an uncontrolled manner.

The energy released in a hydrogen bomb (or fusion bomb) is much higher than that released in an atom bomb

Features	Nuclear Fusion	Nuclear Fission
About	Lighter nuclei join together to produce heavy nucleus	Heavy nucleus is divided into two fragments along with few neutrons
Temperature	High temperature (107 kelvin)	Take place even at room temperature
Conditions required	High density and high temperature	Critical mass of the substances and high speed neutrons
Need of neutrons	No need of external neutrons	Atleast 1 thermal neutron is compulsory
Energy released per unit mass	Nearly 7 times more than fission	Energy released per unit mass is less
Reaction	No control on fusion reaction	Can be controlled
Emissions	Alpha rays, positrons, and neutrinos	Alpha, beta and gamma radiations
Example	Hydrogen bomb	Atomic bomb



7.3 Talabira power project

- The NLC Talabira Thermal Power Project is a 2,400 MW coal-based thermal power plant in ***Odisha.***
- The project is a Non-National Infrastructure Pipeline (NIP) Central PSU Electricity Generation project.
- It will be an ***ultra-super critical thermal plant.***

7.4 Cluster Bomb

United States has decided to send cluster munitions to Ukraine, as a part of a new military aid package to bolster Ukraine's war efforts against Russia.

- **Cluster bomb** - These are weapons that *release multiple explosive sub munitions*, also called *bomblets*, into the air.
- These sub munitions explode as soon as they hit the ground, killing and maiming people in the area.
- **Dud rate**- Many bomblets do not blow up instantly and remain *dormant for years* which is also known as the dud rate.
- These inactive bomblets act as precarious landmines, posing a grave threat to the civilian population.
- According to Cluster Munition Monitor, anywhere between 56,000 to 86,000 people have died in cluster munition-affected countries, since 1960s.

Convention on Cluster Munition (CCM)

- It was enacted in 2008 as a major step to eradicate cluster bombs.
- **Membership-** About 112 countries including many North Atlantic Treaty Organization (NATO) members such as Canada, Germany, France, and the United Kingdom.
- **Non-signatory countries-** Countries such as U.S., Russia, Ukraine, China, Israel, and India have not signed the CCM.
- **Feature-** It bans the use, production, stockpiling, and transfer of cluster bombs.
- The convention further obligates countries to destroy existing stockpile of cluster munitions in their possession.
- The countries are legally bound to provide support and rehabilitation to the cluster bomb victims in their jurisdiction.

Both Russia and Ukraine are not members to the CCM, but use of cluster bombs is the violation of International law.

7.5 Types of nuclear reactors

The rapid economic growth of India and the status of the primary energy consumption stands which stands at 3rd highest globally triggers the demand for energy.

About	Pressurized Heavy Water Reactor (PHWR)	Light Water Reactor (LWR)	Protype Fast Breeder Reactor
Type	Thermal Neutron Reactors	Thermal Neutron Reactors	Fast Neutron Reactors
Fuel	Natural Uranium	Low Enriched Uranium	Use uranium-238 to breed plutonium in a sodium-cooled fast reactor design.
Coolant	Heavy Water (deuterium oxide D2O)	Normal water	Liquid sodium is used in the Kalpakkam nuclear reactor.
Moderator	Neutron	Neutron	No moderator is used.

India	IPHWR 700 is designed by Nuclear Power Corporation of India Limited (NPCIL)	900 MWe LWR design is prepared by Department of Atomic Energy	It is designed by Indira Gandhi Centre for Atomic Research

- **European Pressurized Water Reactor**- It is a 3rd generation PWR, much safer than their predecessors.
- EPRs are more powerful, with 14% higher power output capacity.

8. INNOVATIONS

8.1 Neuralink Chip

Elon Musk's company Neuralink gets the U.S. Food and Drug Administration's (FDA) approval for study of brain implants in humans.

- Neuralink is brain-implant Company, co-founded by Elon Musk.
- Neuralink is making a ***Class III medical device*** known as a ***brain-computer interface (BCI).***
- The device connects the brain to an external computer via a Bluetooth signal, enabling continuous communication back and forth.
- The device itself is a coin-sized unit called a Link which is implanted within a small disk-shaped cut-out in the skull using a precision surgical robot.
- The robot splices a thousand tiny threads from the Link to certain neurons in the brain.

The Food and Drug Administration (FDA) has established classifications for different generic types of devices. Class III includes those with the greatest risk like pacemakers and breast implants.

- **Benefits**
  - If the Neuralink successfully works in humans, it would have wide range of benefits.
  - The device could enable precise control of prosthetic limbs, giving amputees natural motor skills.
  - It could revolutionise treatment for conditions such as Parkinson's disease, epilepsy, and spinal cord injuries.
  - It can also be used in the treatment of obesity, autism, depression, schizophrenia and tinnitus.

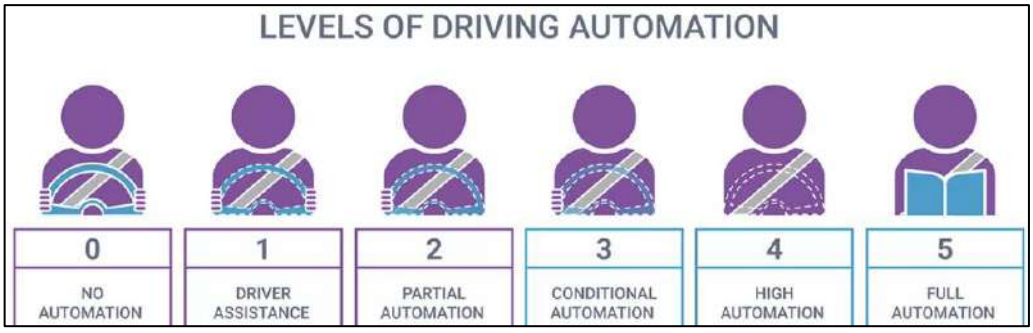
8.2 Advanced Driver Assistance Systems (ADAS)

Car manufactures have started providing ADAS which could create a safe traffic environment resulting in reduced accidental death.

- **Electronic system** - Advanced Driver Assistance Systems (ADAS) is an electronic system of automated vehicle safety features.
- The System uses innovative sensor technology to provide information, warnings, and assistance to the driver while they are driving.

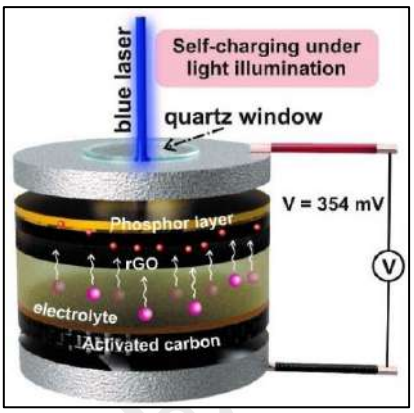
Applications of ADAS	
• Adaptive Cruise Control	• Autonomous Valet Parking
• Glare-Free High Beam Light	• Navigation System
• Adaptive Light Control	• Night Vision
• Automatic Parking	• Unseen Area Monitoring

- **Autonomous driving** - Autonomous driving is the ability of a vehicle to drive itself.
- There are different levels of autonomous driving.



8.3 Light-powered Supercapacitors

A group of researchers from India and South Korea have developed a portable supercapacitor that can be charged using light.



- Supercapacitors are a type of an ***electrochemical energy storage systems*** which have great power density and specific capacitance.
- Supercapacitor differ from ultracapacitor as they are built from different materials and structured in different ways to store different amounts of energy.
- A supercapacitor device consists of an electrode, electrolyte and a current collector.
- A capacitor stores energy by means of a static charge as opposed to an electrochemical reaction.
- Applying a voltage differential on the positive and negative plates charges the capacitor. They present ***lower energy densities*** (they store less energy per unit mass) than batteries.
- **Applications** - Portable and wearable devices such as smartphones, tablets, laptops and smartwatches.
- **Advantages of Supercapacitors**
    - Quick charging and discharging
    - Exhibit long life since they are not subject to chemical degradation as in conventional batteries
    - Greater power density (can release energy more quickly)
    - Smaller in size
    - Provides back-up power during power outages in space applications
    - Have little or no internal resistance (they store and release energy without using much energy)
    - Work at very close to 100% efficiency (97–98% is typical)

Light-powered Supercapacitors

- Researchers developed a design involving a stainless-steel electrode with a quartz transparent window in order to harvest visible light.
- A specially prepared 'down-conversion' phosphor is introduced before the quartz window to facilitate light-induced charging.
- Devices that are powered by such supercapacitors can be charged by simply keeping them under light.

8.4 Lithium Titanate Battery

Lithium titanate battery technology a boon to the energy storage market overcoming the limitations of Li-ion batteries.

- A lithium-titanate or lithium titanate oxide (LTO) battery is an improved version of Lithium ion batteries (LiB).
- **Comparison -** Lithium titanate battery ***utilises lithium-titanate nanocrystals instead of carbon*** on the surface of the anode.
- Lithium-titanate nanocrystals allow the anode to gain more surface area than carbon which permits the electrons to enter and exit the anode quickly.
- The ability to donate or accept electrons in the electrolytic solutions of lithium ions with titanium oxides is more likely than the same reaction with graphite.
- This allows for fast charging capacity in the case of lithium titanate than in the case of carbon.
- Unlike conventional LiB, it has lower inherent charge.

Advantages of LTO over Li battery	Disadvantages
• It offers fast charging. It has long battery life. • It has low-temperature resistance. It is fire-resistant. • Suitable for solar batteries, dedicated line buses, terminal trailers and other transportation systems.	• It will induce low specific energy of about 30–110 watt-hours per kilogram. • High cost of production.

8.5 Room Temperature Superconductivity

Recently, two South Korean researchers claimed that a lead-based compound (LK-99) had shown superconducting properties at room temperature under normal pressure conditions.

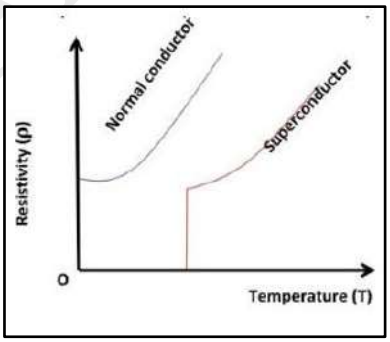
- **Superconductor** - A material that can conduct electricity or transport electrons from one atom to another with no resistance.
- Superconductivity refers to a state in which a material offers zero, or near-zero, resistance to electric current.

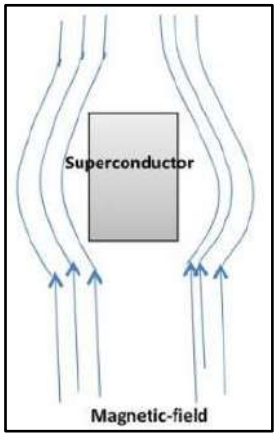
The phenomenon of superconductivity was first discovered in 1911 by Heike Kamerlingh Onnes, which earned him the 1913 Nobel Prize in physics.

- **Superconductive**- No heat, sound or any other form of energy would be released from the material when it has reached critical temperature (Tc), or the temperature at which the material becomes superconductive.
- **Critical temperature**- It is the temperature at which the electrical resistivity of metal drops to zero in superconductor.
- Example- Aluminium, niobium, magnesium diboride, etc.,

Properties of superconductors

- **Meissner Effect (Expulsion of Magnetic Field)** - A Superconductor, when it is cooled below the critical temperature Tc), expel the magnetic field and doesn't allow the magnetic field to penetrate inside it. This phenomenon in superconductors is called Meissner effect.
- In a solid material, this is called ***diamagnetism***, and a perfect conductor would be a perfect diamagnet.
- **Infinite Conductivity/ Zero Electric Resistance-** In the superconducting condition, the superconducting material illustrates the zero electric resistance.
- When the material is cooled under its transition temperature, then its resistance will be reduced to zero suddenly.
- **Critical Temperature/Transition Temperature** - Critical temperature of a superconducting material is the temperature at which the materials changes from normal conducting state to superconducting state.





- This transition from normal conducting state (phase) to superconducting state (phase) is sudden / sharp and complete.
- **Josephson Current-** If the two superconductors are divided with the help of thin-film in insulating material, then it forms a junction of low resistance to found the electrons with copper pair.
- It can tunnel from one surface of the junction to the other surface. The current, due to flow of such cooper pairs, is called Josephson Current.
- **Critical Current**- When a current is passed through a conductor under superconducting state, a magnetic field is developed.
- If the current increase beyond certain value the magnetic field increased up to critical value at which conductor returns to its normal state. This value of current is called critical current.

When a material becomes a superconductor, the superconducting state will induce four changes in the material.

- **Electronic effect –** The material will transport an electric current with zero resistance.
- **Magnetic effect –** A type I superconductor will expel a magnetic field from its body as long as the field strength is below a critical value.
- **Thermodynamic effect –** The electronic specific heat changes drastically at the superconducting transition temperature.
- The specific heat is the heat required to increase the temperature of the electrons in the material by 1 degree Celsius.
- **Spectroscopic effect –** The electrons in the material are forbidden from attaining certain energy levels, even if they could when the material was not a superconductor.

8.6 India-made MRI scanner

First India-made Magnetic Resonance Imaging (MRI) scanner to be launched for clinical work in October.

- The indigenously developed machine is characterized by several innovations, including avoiding reliance on scarcely available liquid helium, bottom-up software design, and customized hardware.
- This MRI scanner is designed in a way to ***avoid reliance on liquid helium***.
- Developed by - Bangalore-based Voxel grids Innovations Private Limited.
- MRI, the definitive tool to provide three-dimensional images of tissues, and the best bet for warning of *nascent Tumours*, continues to be inaccessible to several Indians who require it.

Helium

- Helium, despite being the ***2nd most abundant element*** in the universe, is a rare commodity on earth.
- The only way to source helium is to extract it from *natural gas reserves*.

9. IT & COMPUTER

9.1 Open Network for Digital Commerce (ONDC)

After the revolution of Unified Payments Interface (UPI), the Open Network for Digital Commerce (ONDC) is set to break new ground in India's digital commerce ecosystem.

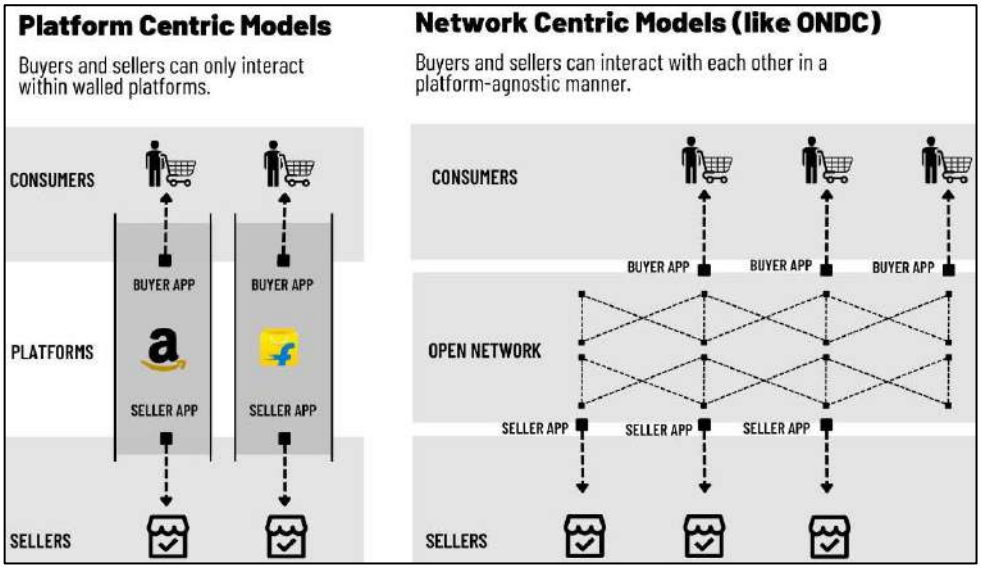
- **ONDC** – It is a *network based on open protocol* and will enable local commerce across segments (mobility, grocery, food order, hotel booking, etc.) to be engaged by any network-enabled application.
- **Aim** - To dramatically increase e-commerce penetration in the country by enabling inclusion of all types and sizes of sellers.
- ONDC goes beyond the current platform-centric digital commerce model where the buyer and seller have to use the same platform or application to be digitally visible and do a business transaction.

The government has set up a 9-member advisory council, including Nandan Nilekani and R S Sharma, to design and accelerate the adoption of ONDC.

- **Initiative of** - It is an initiative of ***Department for Promotion of Industry and Internal Trade (DPIIT)*** under the Ministry of Commerce and Industry.
- **ONDC entity** – It is a not-for-profit company incorporated under *Section 8 of the Companies Act 2013* that manages and operates the ONDC Network.
- **Founding members** - *Quality Council of India* and *Protean eGov Technologies Limited*.
- **Funding** - Multiple investors includes private and public sector banks, depositories, development banks, and other financial institutions.

Key features of ONDC

- **Backed by government** - It is backed by government to create a more open and inclusive digital commerce ecosystem in India.
- **Data storage** - Through ONDC, merchants will be able to save their data to build credit history and reach consumers.
- **Compliance** - The platform will be compliant with the Information Technology Act, 2000 and the emerging Personal Data Protection Bill.



- **Independency** - It aims at promoting open networks developed on open-sourced methodology, using open specifications and open network protocols independent of any specific platform.
- **Privacy** - ONDC shall take all measures to ensure confidentiality and privacy of data in the network.
- **Confidentiality** - It shall not mandate sharing of any transaction-level data by participants with ONDC.
- **User Council** - A User Council will be established, comprising representatives from Network Participants and civil society.
- It will provide regular guidance on various aspects of the network's functioning and governance, serving as a link between Network Participants, Consumers, and the network.

9.2 Digital Public Infrastructure

Recently held G20 meet adopted New Delhi Declaration, which recognised safe and trusted deployment of Digital Public Infrastructure (DPI) for enabling service delivery and innovation.

- Digital Public Infrastructure (DPI) is a set of technology building blocks that drive innovation, inclusion, and competition at scale, operating under open, transparent and participatory governance.
    - Examples – Internet, powered by common protocols like HTTP, HTML, and SMTP.
    - Telecom, with standards like GSM, SMS, CDMA, and IEEE 802.11.
- Digital system can be developed *either as **all government or all private***.
- Interoperability, security, maintaining registries and continuous updates are its vital aspects.
- A strong DPI has 3 foundational systems—*identity, payments, and data exchange.*
- **Significance of DPI**
    - Higher growth potential & Digital storage and verification
    - Digital & Financial Inclusion
    - Interoperable electronic payment system & Integration of global payments systems
    - Direct Benefit Transfer (DBT) & Eliminates black markets

Initiatives taken by India in digital sphere

- **Aadhaar** – Launched in 2009, Aadhaar is a 12 digit unique-identity number issued to all Indian residents based on the biometric and demographic data, and acts as a proof of residence.
- **Digital India initiative** – In 2015, the 'Digital India' initiative was launched to improve online infrastructure and increase internet accessibility among citizens.
- **PM-WANI** – It was launched in 2020 to provide ubiquitous and affordable internet connectivity.
- **Unified Payments Interface** – UPI is a system that powers multiple bank accounts into a single mobile application, merging several banking features, seamless fund routing & merchant payments into one hood.
- **CoWin** – CoWIN is a cloud-based IT solution for planning, implementation, monitoring, and evaluation of Covid-19 vaccination in India.
- **Network to villages** – The government has set a target to provide *4G network to all uncovered villages by 2024*.
- **Bhashini** – The government is building Bhashini, an AI powered language translation platform which will support digital inclusion in India's diverse languages.
- **India Stacks** – It is an online global public digital goods depository to ensure no one is left behind.
- **Sanchar Saathi portal** - It is an initiative of Department of Telecommunications to empower mobile subscribers and increase awareness about citizen centric Government initiatives.
- **Future prospects** – Sector specific DPIs such as account aggregators, Open Network for Digital Commerce, Ayushman Bharat Digital Mission and Agristack.

***Global Digital Public Infrastructure Repository (GDPIR)**, a virtual repository of DPI for use by other G20 members and beyond.*

***One Future Alliance (OFA)**, a voluntary initiative aimed to build capacity, and provide technical assistance and funding support for implementing DPI in low and middle income countries.*

9.3 NPCI's New Payment Products

The NPCI has recently launched a slew of new payment options on popular payments platform UPI.

Products	Specifications
Hello! UPI	• It is a feature for conversational payments on UPI. • It will help users make voice-enabled UPI payments via apps, telecom calls, and IoT devices in Hindi and English. • It will soon be available in several other regional languages also.
BillPay Connect	• Through a nationalized number for bill payment across India it enables users to fetch and pay their bills by sending a 'Hi' on the messaging app across the country. • It has been introduced by the NPCI's subsidiary Bharat BillPay. • Customers without smartphones or immediate mobile data access will be able to pay bills by giving a missed call as well. • It also connect offers Voice Assisted Bill Payments facility
Credit Line on UPI	• To increase access to credit, and promote financial inclusion and innovation through pre-sanctioned credit lines from banks via UPI.
UPI LITE X	• It was launched for offline payments • It was build based on the UPI Lite feature, which was launched in 2022. • UPI LITE X will be accessible to anyone with a compatible device that supports Near Field Communication (NFC), offering payments faster than other payment methods.
UPI Tap & Pay	• To enhance adoption of QR code and NFC technology, NPCI introduced 'UPI Tap & Pay'. • It will allow customers to tap NFC-enabled QR codes to make payments at merchant locations.

9.4 Bharat 6G Alliance (B6GA)

Department of Telecommunications Launches Bharat 6G Alliance aimed at launching the next-generation technology in India.

- It is a collaborative platform consisting of public and private companies, academia, research institutions, and Standards development organizations.
- **Objective** - To deploy 6G technologies to act as a powerful force multiplier for India by 2030.
- **Ministry** - Ministry of Communications.
- It accelerates an active contribution to international standardization organizations such as *3rd Generation Partnership Project (3GPP)* and *International Telecommunication Union (ITU).*
- It seeks to position India at the forefront of 6G innovation and atleast 10% of the intellectual property rights (IPR) related to 6G technology originate from India.

Technology Development Fund (TTDF)

- **Launch** - By Department of Telecommunications /Universal Service Obligation (USO) in 2022.
- **Aim** - To bridge the digital divide by developing and manufacturing state-of-the-art technologies to build and develop the telecom ecosystem.
- 5% of annual collections from USOF will be available for TTDF Scheme.
- ***Universal Service Obligation Fund (USOF)*** aims to provide for quality and affordable mobile and digital services across the rural and remote areas of the country.

9.5 5G Radio Access Network (RAN) Technology

The 5G RAN technology developed by two IITs and the R&D arm of MeiTY was recently handed over to an Indian tech company for advancement and commercial applications.

- 5G RAN is the latest architecture in ***wireless communication*** and uses 5G radio frequencies to provide wireless connectivity to devices.
- A radio access network (RAN) is a major component of a wireless telecommunications system that connects individual devices to other parts of a network through a radio link.
- RAN links user equipment, such as a cell phone, computer or any remotely controlled machine, over a fibre or wireless backhaul connection.
- A RAN is made up of 3 essential components that includes:
    1. **Antennas** – To convert electrical signals into radio waves.
    2. **Radios** – To transform digital information into signals that can be sent wirelessly and ensure that transmissions are in the correct frequency bands with the right power levels.
    3. **Baseband units (BBUs)** – To provide a set of signal processing functions that make wireless communication possible.

9.6 Akira

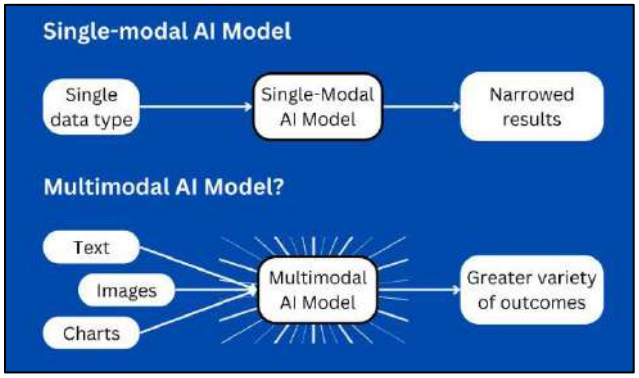
Recently the central government's Computer Emergency Response Team (CERT-In) issued an advisory flagging the emergence of a new ransomware called Akira.

- **About** - It is a kind of ***malware,*** a software used to gain unauthorised access to systems to steal data.
- **Operating system** - Akira targets computer systems that run on ***Windows and Linux*** operating systems and is known to spread laterally across networks.
- Akira steals personal data, encrypts it, and later extorts money from the victims.
- **Technique** - It uses a ***double-extortion technique*** to exfiltrate and encrypt data to increase the chances of extracting money from its victims.
- In case a user refuses to pay, the ransomware actors threaten to release their data on the dark web.

9.7 Multimodal Artificial Intelligence

Recently Microsoft-backed OpenAI made ChatGPT multimodal giving the bot the ability to analyse images and speak to users via its mobile app.

- **Multimodal AI** - It is artificial intelligence that combines *multiple types or modes of data* to create more accurate determinations, draw insightful conclusions or make more precise predictions about real-world problems.
- Multiple modalities include video, audio, speech, images, text and a range of traditional numerical data sets.
    - Example - OpenAI's text-to-image model, ***DALL.E***, upon which ChatGPT's vision capabilities are based, is a multimodal AI model that was released in 2021.



- **Coventional AI** - Most AI systems today are *unimodal* that are designed and built to work with one type of data exclusively.
    - Example- ***ChatGPT*** uses *natural language processing* ***(NLP)*** algorithms to extract meaning from text content, and the only type of output the chatbot can produce is text.

Advantages of multimodal AI over the current AI

- **Versatility-** It can handle multiple types of data, making it more adaptable to different situations and use cases.
- **Natural interaction-** By integrating multiple modalities, multimodal AI can interact with users in a more natural and intuitive way, similar to how humans communicate.
- **Improved accuracy**- Multimodal AI can also improve the accuracy of its predictions and classifications.
- **Enhanced user experience-** It can enhance the user experience by providing multiple ways for users to interact with the system.

- **Robustness against noise-** Multimodal AI can be more robust against noise and variability in the input data.
    - For example, in a speech recognition system, the system can continue to recognize speech even if the audio signal is degraded or the speaker's mouth is partially obscured.
- **Efficient usage of resources**- It can help to make more efficient use of computational and data resources by enabling the system to focus on the most relevant information from each modality.
- **Better interpretability-** It can help to improve interpretability by providing multiple sources of information that can be used to explain the system's output.

9.8 Global Partnership on AI Summit (GPAI)

The 2023 summit of the Global Partnership on Artificial Intelligence (GPAI) held on 12–14 December 2023, in New Delhi, India.

> ***Frontier AI*** *- Highly capable foundation generative AI model that could possess dangerous capabilities which pose severe risks to public safety.*

- **Launched in** – 2020
- **GPAI Secretariat** – OECD.
- The 1st 3 GPAI summits were held in Montreal, Paris and Tokyo, respectively.
- **Aim** – To bridge the gap between theory and practice on AI by supporting cutting-edge research and applied activities on AI-related priorities.
- **Mission** – To share multidisciplinary research and identifying key issues among AI practitioners and **to understand AI impacts**.
- **4 working groups** – Responsible AI, data governance, the future of work, and innovation and commercialization.
- **Values** – Based on **OECD Recommendation on Artificial Intelligence** grounded in the principles of human rights, inclusion, diversity, innovation and economic growth.
- **Membership** – 29 members. It is open to countries, including emerging and developing countries.

Major outcomes of GPAI summit 2023

- **Adopted GPAI New Delhi Declaration** on advancing safe, secure, and trustworthy AI and commitment to supporting the sustainability of GPAI projects.
- A call to prepare a global framework for the ethical use of AI.
- India brought together all major initiatives for AI – UN Advisory Group on AI, UK AI Safety Summit.
- AI Research Analytics and Knowledge Dissemination Platform (**AIRAWAT**) and **National Program on Artificial Intelligence** and its role in shaping AI ecosystem in India was prominently emphasized.
- Startup community and research community showcased their AI products and services in the expo.
- **AI Pitch fest** provided an opportunity to upcoming startups to pitch for their innovation and value-added products and services.
- Taking AI among the masses especially among youths and students.
- **Contrasts Bletchley declaration** – Unlike *UK AI Safety Summit* which mainly focused only on security and safety risks related to AI, this finds a balance between innovation and the risks associated with AI systems.

9.9 WTO Information Technology (IT) Agreement

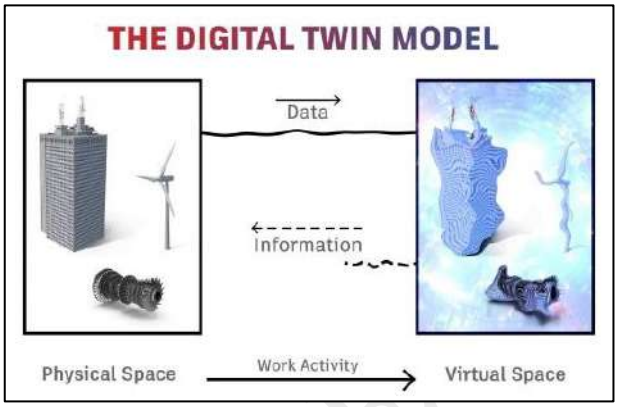
The WTO's IT Agreement has done little for India's IT services and India's hardware sector was hit instead of benefitting from the pact.

- The ITA was concluded by 29 participants at the Singapore Ministerial Conference in December 1996. It entered into force on 1st July 1997.
- It seeks to accelerate and deepen the reduction of trade barriers for the critically important ICT industry.
- ***India is a signatory*** to the agreement.
- The participants are committed to completely eliminating tariffs on IT products covered by the Agreement.

9.10 Digital Twins

A recent data shows that Digital twins will reshape business and society by 2035.

- **Digital twin -** It is a digital representation of a physical object, process, service or environment that behaves and looks like its counterpart in the real-world.
- It spans the object's lifecycle and uses real-time data sent from sensors on the object to simulate the behavior and monitor operations.
- Digital twins can replicate many real-world items, from single pieces of equipment in a factory to full installations, such as wind turbines and even entire cities.
- **Types** - Component twins/Parts twins, Asset twins, System or Unit twins, Process twins.

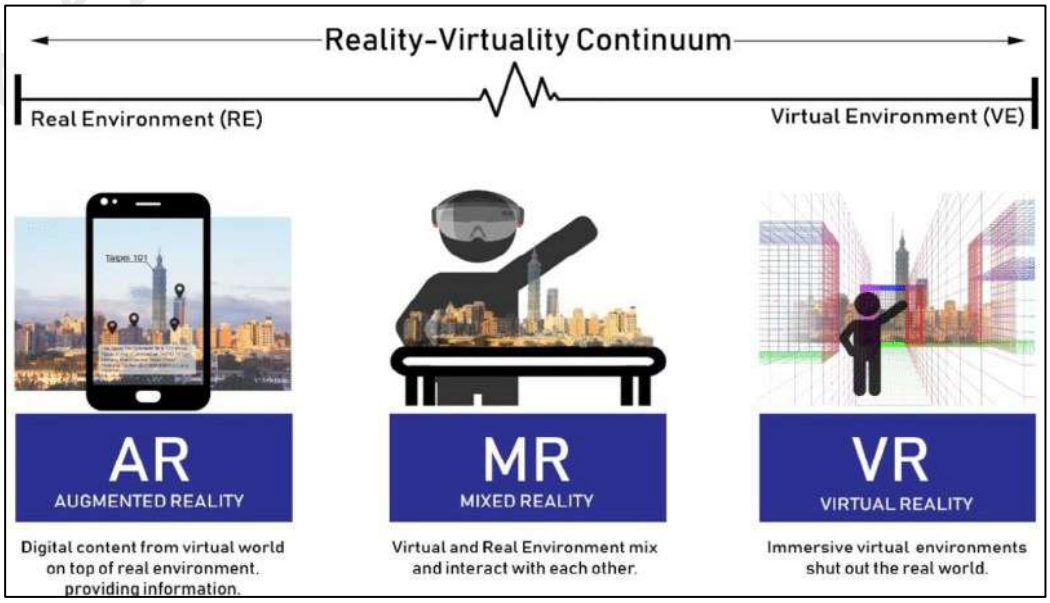


Digital Twin	Simulation
• Utilize digital models to replicate a system's processes • Studies multiple processes • Digital twins are designed around a 2-way flow of information. • A digital twin is built out of input from IoT sensors on real equipment, which means it replicates a real-world system and changes with that system over time. • A digital twin provides all parts of the business insight into how some product or system they're already using is working now.	• Utilize digital models to replicate a system's processes • Studies one particular process • Simulations usually don't benefit from having real-time data • A simulation is designed with a CAD system or similar platform, and can be put through its simulated paces, but may not have a one-to-one analog with a real physical object. • Simulations tend to be used during the design phase of a product's lifecycle, trying to forecast how a future product will work.

9.11 Immersive Reality

A French crime series shows the police using immersive technology to recreate the 3D image of a crime scene.

- Immersive reality creates a new virtual reality by using 360-degree space.
- It immerses the user in a new reality using special and sensing technologies, augmented reality and spatial computing.
- **Applications**
  - Virtual fitting rooms
  - Immersive learning experience.
  - Virtual layouts for construction of houses and residential locality.
  - Advertisement and marketing providing interactive ads and better recall value.



Underlying Technologies

- **Extended Reality (XR) -** It is an umbrella term encapsulating Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR), and everything in between.
- **Augmented Reality (AR) -** It is the overlay of digital content on the real-world environment.
- It uses different tools to make the real and existing environment better and provides an improved version of reality. Examples - Snapchat filters, Pokémon Go
- **Virtual Reality (VR) -** It is a simulated 3D environment that enables users to explore and interact only with the virtual environment.
- The users need to wear devices such as headgears or goggles to interact with the environment.
- ***360 VR*** technology is an interactive and immersive VR that allows the user to be in the middle of a virtually created scene.
- **Mixed Reality (MR) -** It is a mix of virtual reality and augmented reality in which one can interact with the digital as well as the real world simultaneously.
- It integrates digital objects and real-world in such a way that it makes it look like the objects really belong there.
- **Spatial computing** - It allows to use computer graphics, images and other functions in the backdrop of a physical space instead of a computer screen.
- It enables computers to blend in with the physical world in a natural way.

9.12 Graphene

India needs to catch up in the area of graphene to be among the leaders in AI and a potential challenger in quantum computing.

- Graphene is an ***allotrope of carbon*** consisting of a single layer of atoms arranged in a hexagonal lattice nanostructure.
- Graphene was discovered in 2004 for which the scientists received the ***Nobel Prize in Physics in 2010.***
- It is the *world's thinnest, strongest, and most conductive material* of both electricity and heat.
- **Properties -** It is 200 times stronger than steel but 6 times lighter.
- It is almost perfectly transparent as it absorbs only 2% of light.
- It is impermeable to gases, even those as light as hydrogen and helium.
- It has the potential to absorb and dissipate electromagnetic waves.
- It is highly sensitive to environmental changes.

> ***China & Brazil*** *- Global leaders in the commercial production of graphene*

Applications of Graphene

- Has huge potential to revolutionise electricity, conductivity, energy generation, batteries, sensors and more.
- Graphene composites are used in aerospace, automotive, sports equipment and construction.
- It is used for high-performance batteries and super-capacitors, touchscreens, and conductive inks.
- Graphene-based sensors are used for environmental monitoring, healthcare and wearable devices.
- Graphene oxide membranes are used for water purification and desalination.

9.13 Google Gemini

Alphabet, Google's parent company came out with its most advanced AI model, called Gemini.

- It a new multimodal general and flexible ***AI model,*** which comes in three sizes.
- Multimodal means it can work, understand, and operate across text, code, audio, image, and video.
- Gemini can understand, explain and generate high-quality code in the world's most popular programming languages, like Python, Java, C++ and Go.

> - ***ChatGPT*** *cannot work on video at the moment, at least not natively.*
> - ***Krutrim*** *- India's own AI' model*

Gemini Ultra	• The largest and most capable model for highly complex tasks. • 1st model to outperform human experts on massive multitask language understanding (MMLU), which uses a combination of 57 subjects.
Gemini Pro	• Best at scaling across a wide range of tasks and is now available in Bard for regular users.
Gemini Nano	• Manage on-device tasks, and is already available on Pixel 8 Pro.

9.14 Claude 2

AI start-up Anthropic unveiling the latest iteration of its AI chatbot Claude- 2

Chatbots	Claude 2	Bard	ChatGPT
Creator	Anthropic	Google	OpenAI
Accessibility	It is free to use for anyone.	It is free to use for anyone.	It is free to use for anyone.
Comparison of documents	Users can find commonalities between the two documents.	Users can upload images along with prompts, thus making Bard multi-modal.	ChatGPT can compare two documents
Information cutoff date	Early 2023	Early 2023	2021
Token Limit	Up to 1,00,000 tokens	Up to *2,000*	Up to *8,912*.
Languages	-	40 languages	-
Privacy	It allows users to delete their conversations and reportedly supports VPN browsing.	It comes with an option to auto-delete interactions in around 18 months. It does not allow users to retrieve past interactions.	ChatGPT allows users to delete their interactions and it does not support VPN access.
Others	Lacks internet access and is likely to offer incorrect information if prompted with requests for real-world data.	Supports VPN access making it available across the world, bypassing local restrictions. Bard's API access is limited and context handling capabilities are significantly lesser than Claude 2.	It has fewer context-handling abilities than Claude 2. It has been reported that while doing complex tasks, ChatGPT can throw up inappropriate results.

9.15 WorldCoin Project

WorldCoin project launched by OpenAI has claimed over 2 million sign-ups across the world.

- **Aim** - To provide a unique, verified identity for everyone.
- Worldcoin is an initiative to create a digital network in which everyone can claim some kind of stake, and join the digital economy.
- **Working** - Using a device called "Orb," Worldcoin volunteers known as 'Orb operators' scan a person's iris pattern to collect their biometric data and help them get a World ID through the World app.
- With the app, scanned participants can collect a cryptocurrency called Worldcoin [WLD] at regular intervals or make transactions with their World ID where possible.
- This process is called ***"proof of personhood"*** and makes sure that people do not sign themselves up multiple times in exchange for crypto.
- It is intended to be the world's largest identity and financial public network, open to everyone regardless of their ***country, background or economic status.***

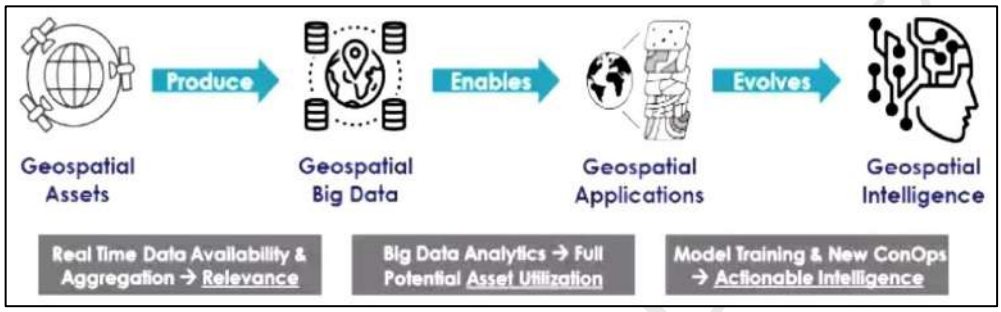
Ethereum has a native coin, Ether, which is the second-largest crypto by market capitalisation. However, anyone can create a token which runs on the Ethereum blockchain. WLD is one such cryptocurrency.

- **Uses** - Biometric data would help differentiate between humans and Artificial Intelligence systems and prevent duplication of IDs from the same person.
- It can be used as an ID in a variety of everyday applications such as a cryptocurrency wallet without revealing the user's identity.

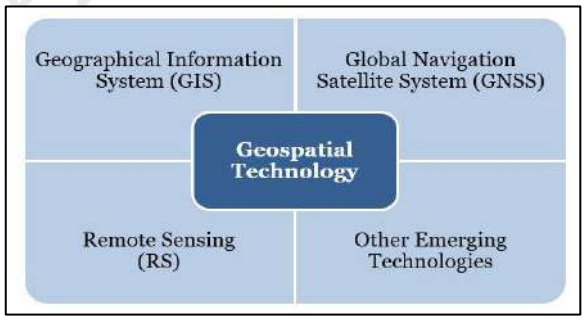
9.16 Geospatial Intelligence (GEOINT)

In recent times, geospatial intelligence has shown enormous potential from disaster management and environmental monitoring to military applications.

- **Geospatial intelligence** –It is the *collection and integration of data* from a network of technologies, including satellites, mobile sensors, ground-control stations and aerial images.



- The data is used to *produce real-time maps and simulations* to help identify when, where and to what extent a threat is likely to emerge.
- **Geospatial technology –** It is a term used to describe the range of modern tools contributing to the geographic mapping and analysis of the Earth and human societies.
- It can be used to create intelligent maps and models which help to collect geographically referenced data.
- **Applications of Geospatial Intelligence**
  - Military applications
  - Disaster Management
  - Environmental Monitoring
  - Logistics and global supply chains
  - Digital twins
  - Health Sector



9.17 SIM Card

SIM cards are the ID cards of the cellular world, and they have evolved in step with cellular networks.

- **SIM** – It stands for '*subscriber identification module'.*
- It is an integrated circuit (IC), or a microchip, that identifies the subscriber on a given network.
- **Design** – Accordance with ISO/IEC 7816 international standard
- **Sizes** – They are available in *standard, micro and nano sizes*.
- **Types**
  - **GSM SIM** (Global System for Mobiles) – It can be removed and inserted in any mobile cell phone.
  - **CDMA SIM** (Code Division Multiple Access) – It cannot be removed from the original Phone.
  - **eSIM Card** (Embedded SIM) – It is a small chip pre-assembled inside the phone that enables easier swap of network operator as the information on eSIM is re-writable.

German engineer Helmut Gröttrup 1st had the idea to stick an IC in a plastic panel in the late 1960s which was basis of origin of the SIM card.

Until 2G networks, SIM card comprised both the hardware and the corresponding software. With the advent of 3G networks, it became only software while hardware was called the Universal Integrated Circuit Card (UICC)

Functions of SIM card

- SIM card has a *unique authentication key* which when unlocked, allows access to the network.

- Any signals sent by the phone into the network are 'signed' by the key.
- **Connects mobiles to cellular network** – When a subscriber dials a recipient's number, the *phone sends data via the network signed by the key on the SIM card* to a telephone exchange.
- **Storage function of SIM Card**
    - Own ID number (the integrated circuit card identifier)
    - The International Mobile Subscriber Identity (IMSI)
    - The subscriber's location area identity
    - A list of preferred networks
    - The subscriber's contacts and SMS messages.
- **Challenges** – It is possible to duplicate a SIM card by accessing its key and storing it in multiple cards.

9.18 AI Safety Summit 2023

Recently, the World's 1st Artificial Intelligence (AI) Summit was held at Bletchley Park, a historic site in UK where the Enigma code was cracked during World War II.

Bletchley Park- The Birthplace of Artificial Intelligence (AI)

- It is a historic site in England that was the headquarters of the *Government Code and Cypher School* during World War II. It is considered the birthplace of modern computing and artificial intelligence.
- **Enigma code** - Bletchley Park is most known for cracking the Enigma code, the *complex cipher system* used by the Nazis during World War II to encrypt their radio messages
- It was cracked by ***Alan Turing*** who was often considered as the *father of modern computer science*.
- **Colossus**- A machine called Colossus was built at Bletchley Park to break the *Lorenz cipher*, used by the German High Command. It was the world's 1st programmable, electronic, digital computer, but it was destroyed and kept secret after the War.
- Bletchley Park houses the world's largest collection of working historic computers at the *National Museum of Computing*.

- **Key takeaways of the Summit**
    - ***Bletchley Declaration*** was signed at the summit, pledging to work together to understand and manage the potential catastrophic effects of AI, especially the cutting-edge frontier AI that could threaten humanity's existence.
    - The summit discussed the establishment of an *international register of frontier AI models* that will allow governments to assess the risks involved.
    - The ***world's first AI Safety Institute*** has been launched in the ***UK,*** tasked with testing the safety of emerging types of AI.

9.19 Copyright Infringement

The Delhi High Court has issued summons to an Instagram account called People of India (POI), in a copyright infringement suit filed by the storytelling platform Humans of Bombay (HOB).

- **Copyright -** It refers to the *right given by the law to creators* of literary, dramatic, musical, and artistic works and producers of cinematograph films and sound recordings.
- It is a bundle of rights that includes *rights of reproduction, communication* to the public, adaptation, and translation of a work related to
    - Literary works such as novels, poems, plays, reference works, newspaper articles
    - Computer programs, databases
    - Films, musical compositions, and choreography
    - Artistic works such as paintings, drawings, photographs, and sculpture

- Architecture
- Advertisements, maps, and technical drawings.

- **Copyright Infringement** – Copyright is considered infringed only if a substantial part is made use of *without authorisation.*
- In cases of infringement, the copyright owner can take legal action against any person who infringes on or violates their copyright.
- Copyright owner is entitled to remedies such as injunctions, damages, and accounts.
- **Injunction** – It is an *official order given by a law court*, usually to stop someone from doing something.
- It only acts as a deterrent and does not mean that all alleged instances of misuse will be corrected immediately.
- **Substantial Imitation** – The concept of 'substantial' varies from case to case. Often, it is a *matter of quality rather than quantity.*
  - For example, lyricist copying words from another song.
- **Passing Off** – If the infringed content is *identical or substantially similar* to the original content.
- It is a species of unfair trade competition or of actionable unfair trading by which one person, through deception, attempts to obtain an economic benefit of the reputation of other.
  - Suppose a brand logo is misspelt in a way that's not easy for the consumer to distinguish.

Intellectual Property Rights

- Refers to creations of mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commerce.
- 5 common types
  - Copyrights
  - Moral rights
  - Trademarks
  - Patents
  - Trade secrets
- Usually gives the creator an exclusive right over the use of their creation for a certain period of time.

Legal provisions in India

- Copyright Act, 1957
- Copyright Rules 2021
- Information Technology Act, 2000
- Indian Performing Right Society Limited (IPRS)
- Intellectual Property Appellate Board (IPAB)
- Scheme for Facilitating Start-Ups Intellectual Property Protection (SIPP)

Copyright Act of 1957

- It was *first passed in 1958* and the most recent amendment was in 2012.
- It is a legal right that protects original literary, dramatic, musical, artistic works and cinematograph films from unauthorized uses.
- **Rights under copyright**
  - **Economic rights** – Owner can derive financial reward.
  - **Moral rights** – To protect the non-economic interests.
- The owner has exclusive rights to adapt, reproduce, publish, translate, and communicate the work to the public.
- It safeguards expressions of ideas rather than the ideas themselves.
- **Term of copyright** – Allowed for the *life time of the author and 60 years beyond* i.e. 60 years after his death.
- In case of joint authorship, the term is to be construed as a reference to the author who dies at last.
- *25 years of broadcasting reproduction right* every broadcaster.
- Central Government to constitute *copyright board* for settlement of disputes, granting of licenses, etc.
- **Punishment** - Imprisonment for a term which may extend up to 3 years.

Copyright (Amendment) Rules 2021

- It aims to bring the copyrights in line with other relevant laws and ensures accountability and transparency in the collection and distribution of royalties.
- The Copyright Board has *been merged with the Appellate Board*.

- The applicant has the option to file the first 10 and last 10 pages of the source code, or the entire source code if it is less than 20 pages, with no blocked or redacted portions.
- The Central Government has *180 days to respond to an application* for registration as a copyright society.

9.20 Quantum Algorithms

Quantum computers can efficiently solve problems that are very difficult to solve with a classical computer.

- While hardware is available to build a quantum computer, exploiting its quantum features requires smart algorithms.
- **Algorithm** – It is a sequence of logically connected mathematical steps that solve a problem.
- **Shor's algorithm** – It is one of the earliest quantum algorithms which is the factorisation algorithm developed by Peter Shor.
- **Grover's and Deutsch-Jozsa algorithms** – It is the quantum search algorithm that looks for a numerical pattern in a large list of numbers.
- For every 100x increase in the list's size, Grover's algorithm will need only 10x more steps.

Classical Algorithm	Quantum Algorithm
Higher sequence of steps	Relatively lesser steps
Use semiconductor based gates	Use quantum gates
Bit is used to encode information.	Qubit is used to encode information.
2 distinct states (0 or 1).	3 distinct states.
No state of superposition.	It exhibit state of superposition that is to exist as 1 and 0 at the same time.

9.21 Wi-Fi 7 and Fixed Wireless Access (FWA)

Recently, Qualcomm announced that fiber and fixed wireless access are central to India's broadband expansion as it expects 10 Gbps to be the average speed by 2028.

- Wi-Fi is a wireless networking technology that allows electronic devices to interface with the Internet.
- **Wi-Fi 7** – Also known as *IEEE 802.11be Extremely High Throughput (EHT)*.
- It has better reliability and enhanced privacy and security.
- **Features** – *4.8× faster than Wi-Fi 6* and accelerates up to 46 Gbps
- *100× lower latency* (60% lesser than Wi-Fi 6)
- *5× network capacity* with 320 MHz and Multi-Link Operation (MLO - Enables devices to simultaneously send and receive data across different frequency bands and channels)
- *Works across all 3 bands* (2.4 GHz, 5 GHz, and 6 GHz)
- *Supports 4000 Quadrature Amplitude Modulation* (QAM- a method to transmit and receive data in radio-frequency waves).

Fixed Wireless Access (FWA)

- It is a *type of 5G or 4G LTE wireless technology* which provide wireless broadband connectivity between 2 fixed points.
- It transmits data *using radio frequencies instead of cables*.
- It is available for both licensed and unlicensed spectrum.
- **Advantage** - As FWA does not need a physical connection into a building, *new geographies* can be covered, and *new customers* can be connected, much more *quickly and cheaply* than with fiber.
- **Disadvantages** – It has *limited transmission distance* and environmental factors can impact its performance.
- A digital desert is an area where there is little or no access to high speed internet.

9.22 MIKA

- It is the ***world's 1st ever AI humanoid robot CEO*** of Polish rum company Dictador.
- It is developed by Dictador and Hanson Robotics, a Hong Kong-based engineering and robotics company which is behind the renowned AI robot Sophia.
- Mika is a more advanced version of her sister prototype, ***Sophia,*** who was activated in 2015.

9.23 Acoustic Side Channel Attacks (ASCA)

This AI model can steal passwords by 'listening' to the keyboard.

- **ASCA –** In an ASCA, the ***sound of clicks generated by a keyboard*** is used to analyse keystrokes and interpret what is being typed to leak sensitive information.
- Though the sound of keyboard clicks has become less profound, the technology with which the acoustics can be accessed and processed has also improved drastically.
- Additionally, the use of laptops has increased the scope of ASCAs as laptop models have the same keyboard making it easier for AI-enabled deep learning models to pick up and interpret the acoustics.

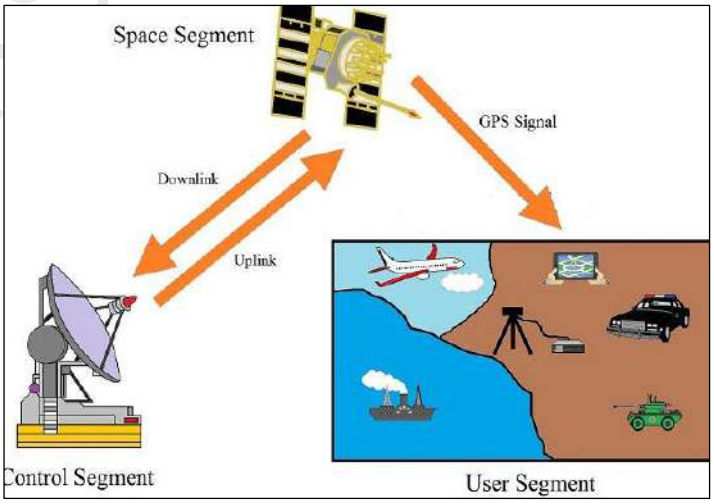
9.24 Dark Patterns

Department of Consumer Affairs seeks public comments on Draft Guidelines for Prevention and Regulation of Dark Patterns recently.

- Also known as ***Deceptive Patterns,*** a dark pattern is a user interface that has been carefully crafted to trick users into doing things, such as buying overpriced insurance with their purchase or signing up for recurring bills.
- **Examples -** Sponsored video ads scattered between reels and stories in Instagram that users originally opted to view, pop-ups and thumbnails of other videos in the final seconds of a video in YouTube.
- By using them, digital platforms take away a user's right to full information about the services they are using, and reduce their control over their browsing experience.

9.25 GPS Tracker

Recently, a prisoner in Jammu and Kashmir was released on bail after he was tagged with a Global Positioning System (GPS) tracking device to monitor his movements.

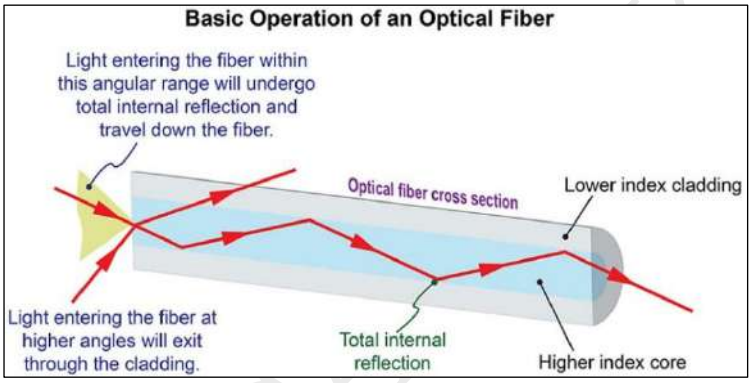


- GPS trackers are a precondition for bail in several countries including the United States, the United Kingdom, and Malaysia. It is the 1st time this technology has been used in India for this purpose.
- **GPS Tracker** – It is a small, portable unit that allows users to monitor and track its location.
- It connects to a series of satellites to determine location and consists of 3 segments.
- The **GPS,** originally Navstar GPS, is a satellite-based radio navigation system owned by USA.
- **Global Navigation Satellite System (GNSS)** refers to a constellation of satellites providing signals from space that transmit positioning and timing data to GNSS receivers. It typically includes GPS, GLONASS, Baidu, Galileo, and any other constellation system.
- **Space Segment** – GPS consists of ***27 satellites*** that orbit the Earth (24 are operational, and 3 are backup satellites) and orbit the earth *every 12 hours*.
- **User Segment** – It has GPS receivers to receive the signals sent by GPS satellites and use them to determine the user's position in space and time.
- **Control segment** - Different tracking stations are located around the globe which pick up microwave carrier signals transmitted by the satellites.
- **Working principle** – The tracker uses a process called *trilateration* which uses the position of 3 or more satellites from GPS satellites and its distance from them to determine latitude, longitude, elevation, and time.
- In geometry, **trilateration** is defined as the process of determining absolute or relative locations of points by measurement of distances, using the geometry of circles, spheres or triangles.

9.26 Fibre Optic Network

During the unprecedented COVID-19 pandemic, the one thing that connected us virtually was high-speed internet connections through the fibre optic network.

- **Optical fibres** – They are ***thin cylindrical strands of glass*** whose diameter is close to the *diameter of a human hair.*
- They are surrounded by protectives to make them strong, light, and flexible and thus durable.
- It can carry information like text, images, voices, telephone calls across large distances almost ***at the speed of light***.
- **Working** – A beam of light falling on a glass surface passes through partially while the rest is reflected away.
- When it passes through, its path bends because the ***refractive index*** of glass is different from that of air.
- When the beam travels from glass to air medium, it will be completely reflected back within the glass and this is called as ***total internal reflection***.



- This is how signals encoded as electromagnetic waves can be fed into one end of an optical fibre.
- **Refractive index** is a measure of the bending of a ray of light when passing from one medium into another that determines how fast light can travel in it.
- **Total internal reflection** is the basis of guiding light across long distances without a significant loss of optical power.

> *Physicist Charles Kao was the 1st to suggest that glass fibres could be a superior medium for telecom than copper wires for which he received Nobel Prize in Physics in 2009.*

- **3 parts of a fibre optic communication system**
  - **Transmitter** – It encodes information into optical signals (A form of rapidly blinking light pulses of o's and 1's).
  - **Optical fibre** – It carries the signal to its destination.
  - **Receiver** – It is placed at destination which reproduces the information from the encoded signal.
- **Advantages**
  - Optical waves *allow a high data-transmission rate*, up to several terabits per second in a single fibre.
  - They are *insensitive to external perturbations* like lightning and bad weather.
  - They are *ideal to be buried underground, drawn underwater*, or bent around a spool.

9.27 AI Voice Clones (Deepfake audios)

The creation a cloned voice of anyone holds significant implications as India approach the upcoming elections, a period particularly susceptible to the proliferation of misinformation.

- A deep fake audio closely mimics a real person's voice.
- **Technology** – It particularly uses ***deep learning algorithms,*** a form of generative AI and aims to ***generate synthetic or manipulated voice recordings*** that mimic the voice of a specific individual.

> ***Generative AI*** *refers to the capability of AI-enabled machines to use existing text, audio files, or images to create new content.*

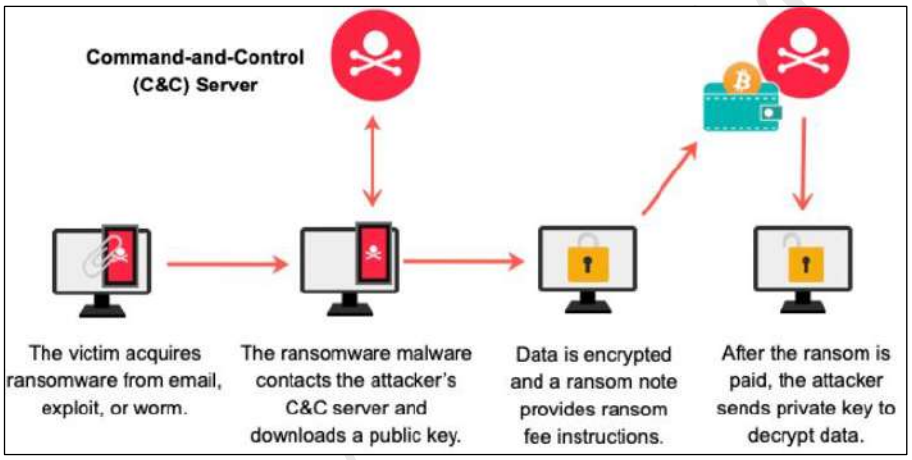
- **Threat** – It is now possible to create highly realistic and convincing *audio forgeries*.
- It can *produce misinformation* at a significantly faster rate compared to the time required by fact checkers to debunk it
- **Control measures** – ***Digitally signed videos*** can be a way to verify that content can be trusted.
- Advancing the development of ***AI voice clone detectors*** and promoting its active usage. Cracking down social media platforms to control the spread.

9.28 CERT-In

- CERT-In, established in 2004, is the national nodal agency for responding to computer security incidents as and when they occur, it functions under the Ministry of Electronics and Information Technology.
- With this, there are 27 other intelligence and security organisations such as the IB, R&AW, Directorate of Enforcement, National Technical Research Organisation that are exempt under RTI.
- It is *exempted from the ambit of the Right to Information Act (RTI), 2005.*

9.29 Ransomware attacks on Indian IT Firms

IT service provider HCL Technologies has shared that it was hit by a ransomware incident within a restricted cloud environment.



- **Ransomware** – It is an extortion software designed to lock or encrypt a device or data on a system and then demand a ransom (money) for its release.
- Attackers usually leave behind a message with instructions on the ransom amount, mode of transfer, or instructions on how to contact them for further guidance.
- **Working**
  - Originates from a malicious link, email attachment, exploited vulnerability, attack campaign, or worm.
  - Installs in victim's machine.
  - Spreads to other devices on a network and connects to a command-and-control server controlled by the attacker.
- **Impact** - It can lead to data loss, productivity losses, and reputational damage.

Ransomware-as-a-service business models promote new generation of smaller and smarter gangs are likely to become more prevalent

Malware	Ransomware
Malware is a computer virus designed to replicate and copies itself from file to file or program to program.	Ransomware is a sub-type of malware from cryptovirology that blocks access to the system unless ransom is paid.
Malware typically piggybacks on malicious links, fraudulent email attachements, social media messages, etc.	Ransomware are spread through phishing emails containing malicious attachments or web-based messaging applications.
Malware is also referred to as virus, worm, Trojan horses, spyware, adware, and ransomeware.	It's a new type of malware that presents itself in many ways to hold data to ransom.
The best way to protect the system from malware is to install antimalware programs.	The only way to protect your systems is to pay the ransom to the attackers.
It's a broad term that refers to all types of malicious programs.	Crypto and Locker are the two main types of ransomware.

9.30 Chameleon Trojan

- A ***malware that can disable biometric authentication methods*** like fingerprint and face unlock to steal the phone's PIN in Android operating systems.
- The malware collects information on app usage habits to determine when the user is using their device and launch attacks when they are least likely to use it.

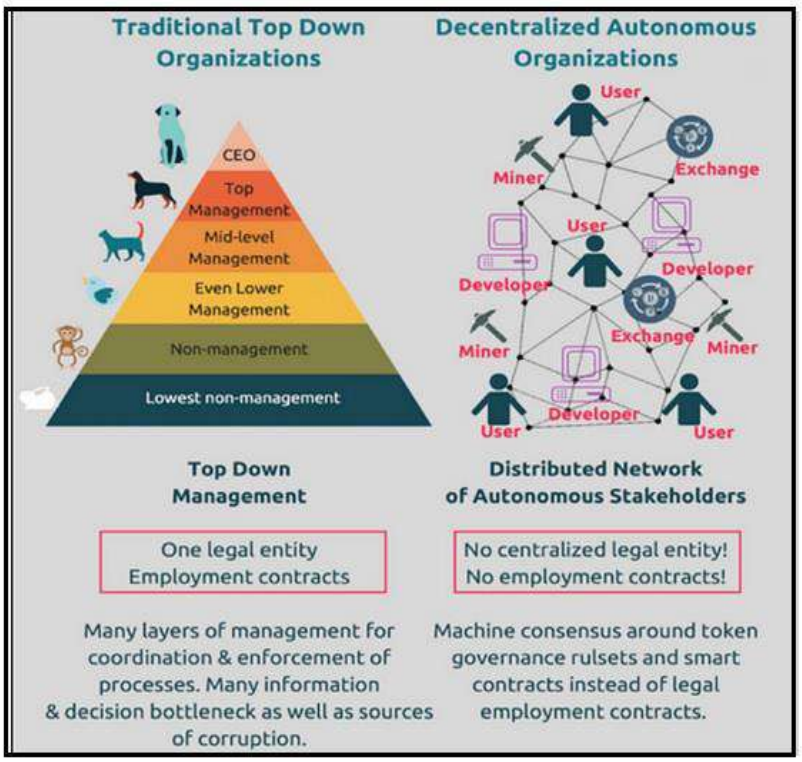
9.31 Decentralized Autonomous Organizations

Decentralized Autonomous Organizations (DAOs) represent a groundbreaking innovation at the intersection of blockchain technology and governance.

- It operates without centralized control and is governed by smart contracts and the consensus of its members.
- **Decision making**- It uses *blockchain technology* and smart contract to take decisions in a *bottom-up management approach*.
- **Community driven**-It is represented by rules encoded as a computer program that is transparent, controlled by the respective organization members, and not influenced by a government.

Blockchain is a type of shared database that differs from a typical database in the way it stores information, it store data in blocks linked together via cryptography.

- **Smart contracts**- It executes predefined rules without the need for intermediaries, ensuring trust through code rather than traditional authorities.
- **Enhanced cooperation**- They enable global, borderless cooperation on an unprecedented scale.
- **Constructive engagement**-Participants, often referred to as token holders, can propose and vote on decisions related to the organization's goals and resources.
- **Self-executing systems**- This decentralized decision-making process ensures that no single entity holds undue influence.



Applications of DAOs

- **Finance-** Platforms like Compound and Maker DAO have introduced lending and borrowing services, enabling users to participate in the global financial ecosystem without relying on traditional banks.
- **Intellectual property protection**- In the art world, artists are tokenizing their creations and utilizing DAOs to manage royalties and maintain control over their intellectual property.
- **Supply chain management**- DAOs offer transparency and traceability in global supply chains, ensuring the authenticity and quality of products.
- **Online governance**- DAOs have emerged as tools for decision-making, with platforms like DAO stack facilitating decentralized governance structures for internet communities.

9.32 Graph Networks for Materials Exploration (GNoME)

GNoME, an AI tool, is accelerating the materials discovery using artificial intelligence (AI).

- It is a state-of-the-art ***graph neural network (GNN)*** model that uses ***'active learning'*** to enhance its performance, allowing it to predict the stability of new materials.
- **Launched by** – ***Google DeepMind***
- **Aim** - To generate novel candidate crystals and to predict their stability.

Deep learning *is a method of artificial intelligence (AI) where it is taught to process data in a way that is inspired by a human computer.*

- **Working** – GnoME can generate predictions for the structures of novel, stable crystals which were then tested, resulting in high-quality training data fed back into model training.

- The final step in their approach exploits ***Density Functional Theory (DFT)***, a method to verify the stability of the new structures, which are then used as new training datasets for the tool.
- ***The Materials Project*** is the original datasheet for GNoME.
- **Significance** – It has boosted the precision rate for predicting materials stability from 50% to around 80%.
- It increases the number of stable materials by 10-fold.

> ***The Materials Project*** *is a multi-institution, multi-national endeavour to compute the properties of all inorganic materials and provide the data for every materials researcher free of charge.*

9.33 Touchscreen

Between 2007 and 2013, capacitive touchscreens overtook resistive touchscreens in the consumer electronics market.

- **Invention** – The 1st touch screen was invented in ***1965 by E.A. Johnson*** of U.K, a capacitive device.
- **Function** –Receive inputs for a computer (tapping on an app) and display the output (launching the app).
- **Working** – It consists of 3 main components
    - **A touch sensor** – It has an *electrical current* going through it and touching the screen *causes a voltage or signal changes* which are used to determine the location of the touch.
    - Main technology used in sensors are
        - Resistive
        - Capacitive
        - Surface Acoustic Wave(SAW)
        - Infrared LED or Optical
    - **A controller** – It takes information's from the touch sensor and translates it into information the PC can understand.
    - **A software Driver** – It allows the touch screen and computers to work together.
- **Applications** – Smartphones, ATM machines, TVs, refrigerators, e-readers, billing systems, and electronic voting machines (EVMs).

9.34 Lockbit 3.0

- Also known as "LockBit Black", LockBit 3.0 is a ***ransomware,*** a type of malware that locks a victim's data or device unless the victim pays a ransom to the attacker.
- It operates under the business model of "ransomware-as-a-service".
- Recently, the US arm of the China's Industrial and Commercial Bank of China (ICBC), world's largest lender in terms of assets, was hit by Lockbit 3.0.

10. AWARDS

10.1 Rashtriya Vigyan Puraskar (RVP)

The Government of India has come out with a new set of National Awards in the field of Science, Technology and Innovation known as Rashtriya Vigyan Puraskar.

- **Aim -** To recognize the contribution made by the scientists, technologists, and innovators individually or in teams in various fields of science, technology and technology led innovation.
- **Eligibility**
    1. **Persons -** Scientists/ technologists/innovators working in government, private sector organizations or any individual working outside any organization.
    2. **Field -** Science, technology, or technology- led innovation.

3. **Residence -** People of Indian Origin staying abroad with exceptional contributions benefiting the Indian communities shall also be eligible.

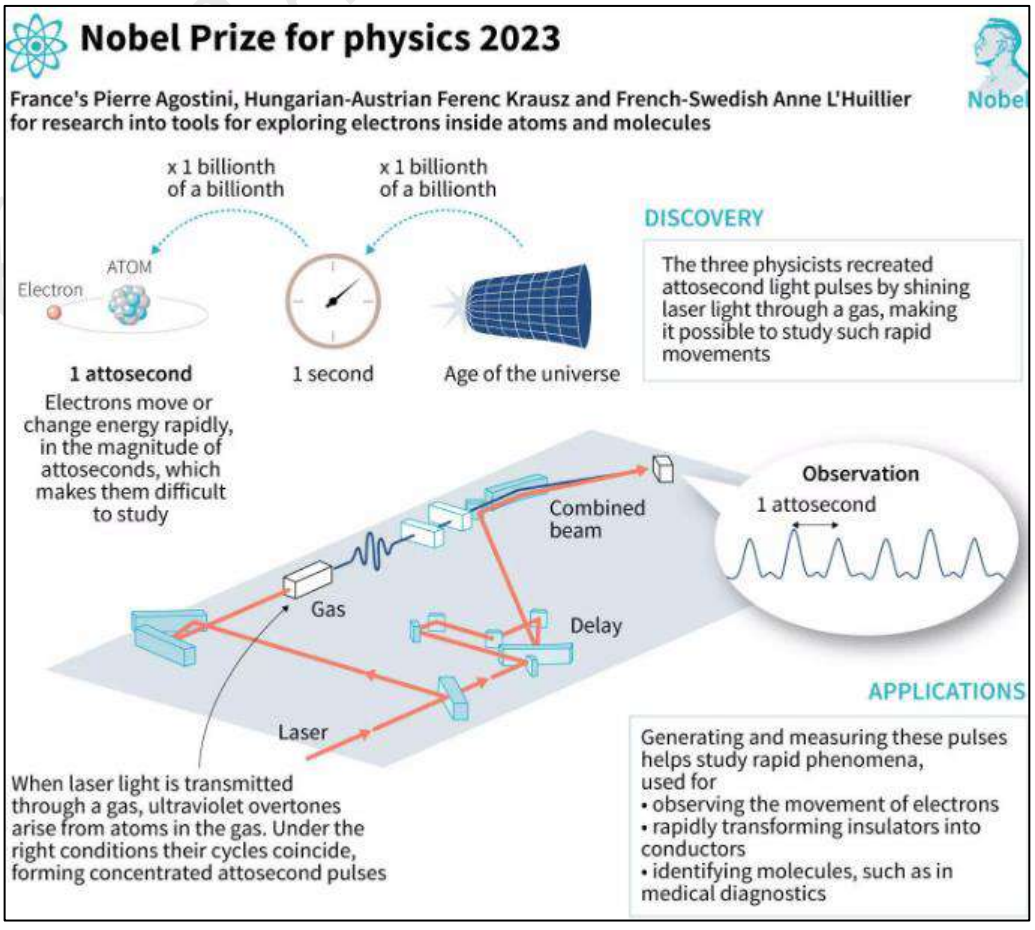
Categories	Recognition
Vigyan Ratna	Lifetime achievements & contributions made in any field of science and technology.
Vigyan Shri	Distinguished contributions in any field of science and technology.
Vigyan Yuva-Shanti Swarup Bhatnagar	Recognize & encourage young scientists up to the age of 45 years who made an exceptional contribution in any field of science and technology.
Vigyan Team	Team comprising of three or more scientists/researchers/innovators who have made an exceptional contribution working in a team in any field of science and technology.

- **Selection Committee -** Rashtriya Vigyan Puraskar Committee (RVPC) e headed by the Principal Scientific Adviser (PSA) to Government of India and comprising Secretaries.
- **Announcement -** ***11th May (National Technology Day)*** every year.
- **Award Ceremony -** Held on ***23rd August (National Space Day)***, Chandrayaan – 3's soft landing on moon.

10.2 Nobel Prize for Physics 2023

2023 Nobel Prize for Physics was awarded to Anne L'Huillier, Pierre Agostini, and Ferenc Krausz for experimental methods that generate attosecond pulses of light for the study of electron dynamics in matter.

- **Attosecond-** It is *one quintillionth of a second or* ***10 -18 seconds*****,** the timescale at which the properties of an electron change.
- These pulses are used to unravel dynamical processes in matter with unprecedented time resolution.
- **Attosecond science-** It is a branch of physics that deals with *light-matter interaction* phenomena, production of extremely short light pulses and using them to study superfast processes.



Applications of attophysics

- **Atomic and molecular physics** - With these attosecond pulses, scientists can "freeze" the motion of electrons within atoms and molecules, providing a real-time view of electron movement during chemical reactions.
- **Create and manipulate extreme ultraviolet (XUV) and X-ray pulses** - These are vital for imaging ultrafast processes

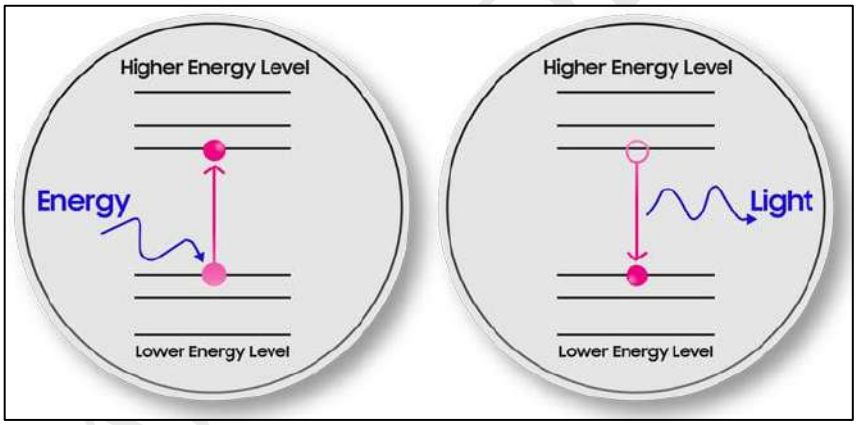
at the atomic and molecular scale. These pulses are produced using high-intensity laser systems that generate attosecond bursts of light.

- **Electronic gadgets**- A better understanding of how electrons move and transmit energy can also help in creating more efficient electronic gadgets.
- **Development of new tech** - They allow scientists to observe the quantum mechanical nature of electrons and the intricate dance they perform when interacting with one another and with atomic nuclei.
- This knowledge has profound implications for fields such as chemistry, materials science, and even the development of new technologies.
- **Solar power**- Photoelectric effect is the core of solar power and by refining the theoretical understanding it will make big strides in renewable energy production.

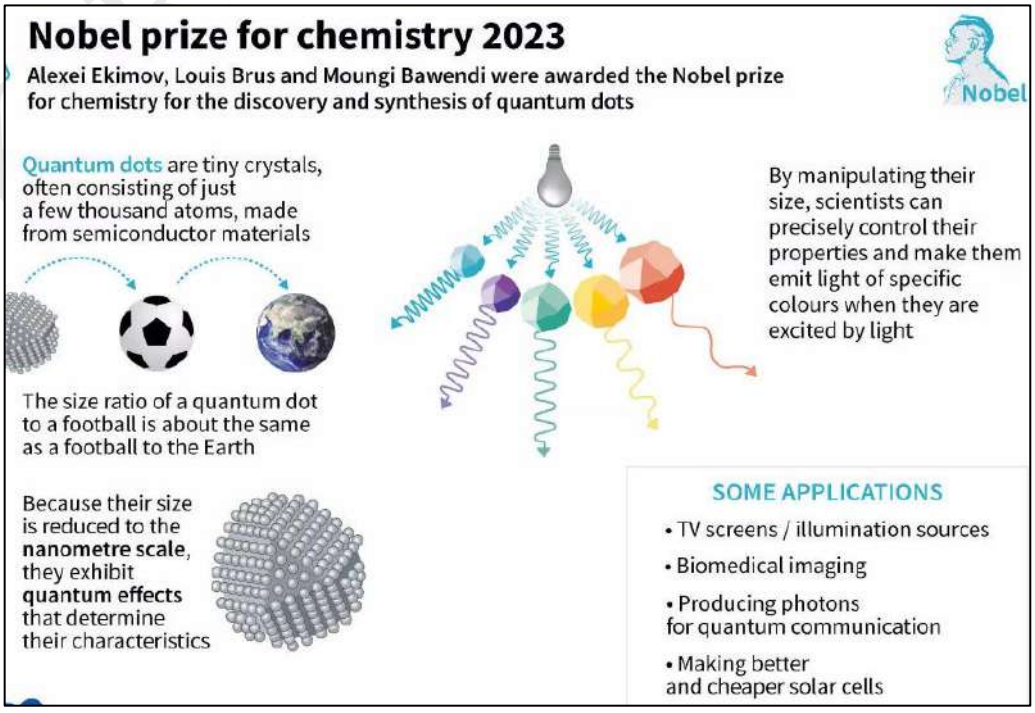
10.3 Nobel Prize for Chemistry 2023

Nobel Prize for Chemistry 2023 has been awarded to Alexei I. Ekimov, Louis E. Brus, and Moungi G. Bawendi for the discovery and synthesis of quantum dots.

- **Quantum dots-** Quantum dots are man-made nanoscale crystals that exhibit unique optical and electronic properties, including the ability to transport electrons and emit light of various colors when exposed to UV light.



- The quantum dot change based on the nature of their properties.
- **Quantum theory**- The motion and behaviour of very small particles are radically different, and strange, when compared with any familiar object in normal human experience.
- Such strange behaviour at the sub-atomic level is described by the hugely successful Quantum Theory.
- **Nanoparticles-** They are much larger compared with atoms.
- It was theorised in the 1930s that when the size of particles was reduced to nanoscale, it could give rise to quantum effects.
- **Effect of light on a quantum dot** - When light is shined on a quantum dot, it absorbs and then re-emits it at a different frequency.
    - **Smaller dots**- Emits bluer light
    - **Larger dots-** Emits redder light



- This happens because light shone on the dot energises some electrons to jump from one energy level to a higher one, before jumping back and releasing the energy at a different frequency.

Applications of quantum dot

- **Display**- An array of quantum dots can be a TV screen by receiving electric signals and emitting light of different colours.
- **Semiconductor**- If one of the energy levels an electron jumps between in a quantum-dot atom is the conduction band, the dot can operate like a semiconductor.
- **Photovoltaics**- The solar cells made with quantum dots are expected to have a thermodynamic efficiency as high as 66%.
- **Light Emitting Diodes (LEDs)-** Visible quantum dots-based LED is considered as a next generation display technology after OLED-displays (Organic LEDs) as it exhibits high colour purity, high luminance and lower power consumption.
- **Photodetectors-** They can be used in photodetectors for detecting both infrared and visible light.
    - **IR Photodetectors-** It finds application in night vision cameras, atmospheric spectroscopy for gas detection, biomedical imaging, quality control and product inspection.
    - **Visible light photodetectors**- They are used in image sensors for transforming the incoming light into electronic signals.
    - Quantum dots can also be used in surveillance, machine vision, industrial inspection, spectroscopy, and fluorescent biomedical imaging.
- **Medical diagnostics**- It can highlight a tumour that needs to be removed, for targeted drug delivery and other therapeutic measures.
- It is also used in DNA hybridization, receptor mediated endocytosis, monitoring of parasite metabolism, real time visualization of tissue and cellular structures, and diagnostics application.
- **Biological tissues-**They are also used to map biological tissues by biochemists.
- **Markers-** It can be used as security markers on currency and documents as an anti-counterfeit measure.
- It can be used as fluorescent markers to tag and track objects.

10.4 Nobel Prize in Literature, 2023

The Nobel Prize in Literature 2023 is awarded to the Norwegian author Jon Fosse for his innovative plays and prose which give voice to the unsayable.

- ***Fosse*** was born in 1959 in Norway and writes in ***Norwegian Nynorsk***. (*Bokmal and Nynorsk are the two different standards of writing in Norwegian language.)*
- His writings spans a variety of genres consisting of plays, novels, poetry collections, essays, children's books and translations.
- His style of writing novels famously known as *'Fosse minimalism*'.
- His work has been *translated into more than 40 languages*.
- **Notable works of Jon Fosse**
    - I Am the Wind
    - Melancholy
    - Boathouse
    - The Dead Dogs
    - A New Name: Septology VI-VII (finalist of the International Booker Prize, 2022)

*Last year, the Literature Nobel was awarded to French author **Annie Ernaux** for the courage and clinical acuity with which she uncovers the roots, estrangements and collective restraints of personal memory.*

10.5 Nobel Prize for Peace, 2023

The 2023 Nobel Peace Prize has been awarded to Iranian activist Narges Mohammadi "for her fight against the oppression of women in Iran and her fight to promote human rights and freedom for all".

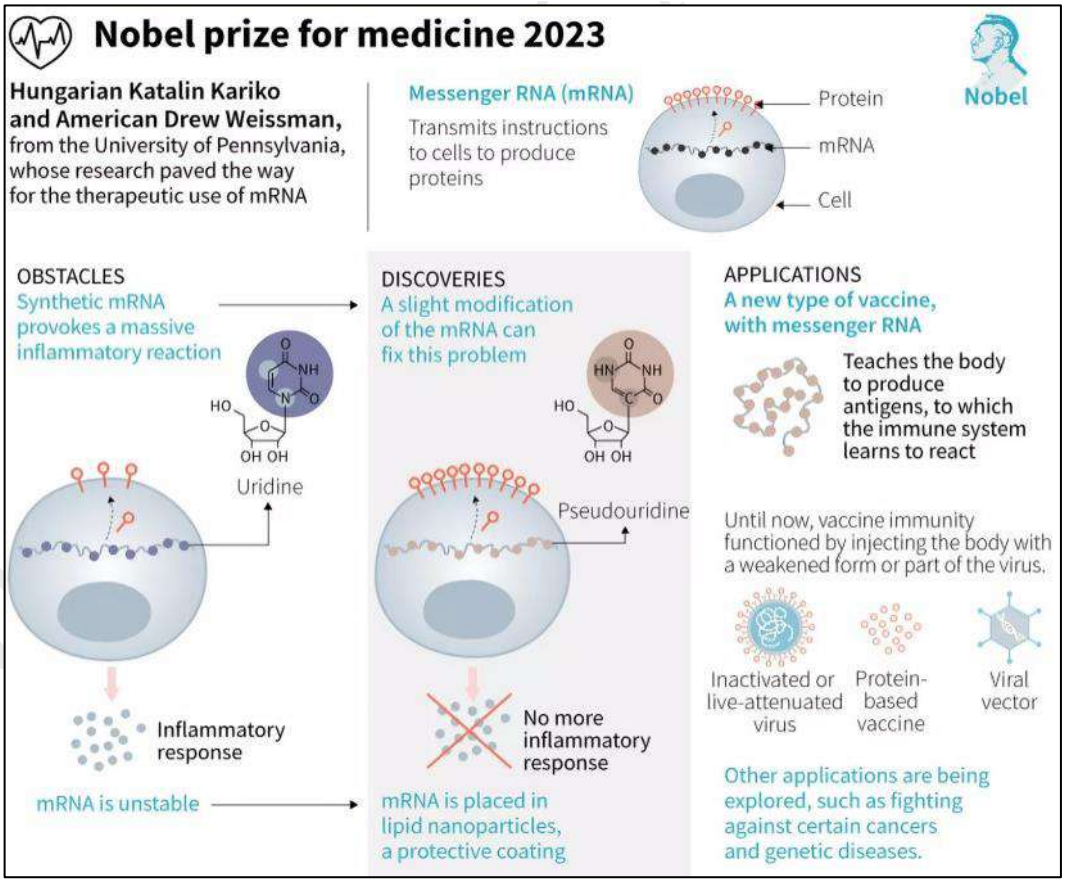
- **Narges Mohammadi** – An engineer-turned-activist and a human right advocate.
- She became the 2nd Iranian women after Shirin Ebadi in 2003 and 19th women to receive peace prize.

- **Contribution** – Mohammadi has long campaigned for women's rights and for the abolition of the death penalty.
- She *opposed the use of torture and sexualized violence* against women political prisoners in Iran.
- She is currently in a detention facility under the charges of spreading anti-state propaganda and defamation and was sentenced to a total of 31 years in prison.
- **Honours/Awards** – She was featured in the *BBC's list of 100* inspiring and influential women from around the world.
- Inspired from her work, "*Women Life Freedom*" was adopted as motto by the demonstrators for their struggle.
- Awards received by her include
    - 2023 UNESCO/Guillermo Cano World Press Freedom Prize
    - 2023 PEN/Barbey Freedom to Write Award

Some of the previous Nobel Peace laureates include Mother Teresa, Kailash Satyarthi, Malala Yousafzai, Nelson Mandela, Martin Luther King, Barack Obama & the European Union.

10.6 Nobel Prize in Medicine 2023

The Nobel Prize in Physiology or Medicine 2023 was awarded jointly to Katalin Karikó and Drew Weissman "for their discoveries concerning nucleoside base modifications that enabled the development of effective mRNA vaccines against COVID-19".



- **Contribution of Kariko and Weissman** – In human cells, genetic information encoded in DNA is transferred to messenger RNA (mRNA), which is used as a template for *protein production.*
- In the 1980s, researchers were able to produce mRNA "in vitro", which was highly unstable and triggered the immune system, leading to *inflammatory responses* in the body.
- Kariko and Weissman found out that mRNA with *chemically modified bases* did not lead to inflammatory reactions.
- They also found that using mRNA with altered bases significantly increased protein production.
- Their discovery helped to develop *Pfizer-BioNTech and Moderna's vaccine* at record speed.

The Nobel Prize in Physiology or Medicine has been awarded 114 times since 1901. There have been 227 recipients including this year's winners, but Kariko is only the 13th woman to receive the accolade.

10.7 The Indira Gandhi Prize for Peace, Disarmament and Development

Activist Ali Abu Awwad and pianist Daniel Barenboim win Indira Gandhi Peace Prize.

- It was instituted in the memory of the former prime minister by the Indira Gandhi Memorial Trust in 1986.
- It is given to ***individuals or organisations*** who work towards ensuring international peace and development.
- It consists of a monetary award of Rs 25 lakh along with a citation.

Barenboim	Awwad
• He is a distinguished ***classical pianist, and conductor,*** renowned for performing with and directing some of the leading orchestras in the world.	• Mr. Awwad is an eminent ***Palestinian peace activist*** who has been working tirelessly with the people of Palestine and Israel for a peaceful resolution of the ongoing conflict in the Middle East.

10.8 Sahitya Akademi Awards for 2023

- **Established in** – 1954 **by Sahitya Akademi**
- **Awarded to** – The most *outstanding books of literary merit*
- It is in the form of a casket containing an engraved copper-plaque, a shawl, and Rs.1,00,000 (since 2009).

Sahitya Akademi *- India's National Academy of Letters was founded in 1954 as an autonomous body under Ministry of Culture and registered as a society under the Societies Registration Act, 1860.*

Language	Author	Type	Book
Tamil	Rajasekaran (Devibharathi)	Novel	Neervazhi Padooum
Telugu	Patanjali Sastry	Short story collection	Rameshwaram Kaakulu Marikonni Kathalu
Malayalam	E.V. Ramakrishnan	Literary study	Malayala Novelinte Deshakalangal
Kannada	Lakshmisha Tolpadi	Essay collections	Mahabharatha Anusandhanada Bharathayatre
Bengali	Swapnamay Chakrabarti	Novel	Jaler Upar Pani
English	Neelum Saran Gour	Novel	Requim in Raga Janaki
Hindi	Sanjeev	Novel	Mujhe Pahachaano.

- **Languages recognised – 24** including 22 languages listed in 8th schedule of Indian constitution along with ***English and Rajasthani.***
- **Criteria** – Books published during the 5 years immediately preceding the year of award.
- **2023 Awards** – 9 books of poetry, 6 novels, 5 short story collections, 3 essays and 1 literary study.
- Some authors who will receive the honour for their poetry collections are Vijay Verma in Dogri, Vinod Joshi in Gujarati, Manshoor Banihali in Kashmiri, Ashutosh Parida in Odia, and Arun Ranjan Mishra in Sanskrit.

10.9 United Earth Amazonia prize

- The United Earth Amazonia prize is a "***Green Nobel" prize*** that recognizes environmental work in the Amazon rainforest.
- The prize was instituted by ***Marcus Nobel,*** a Swedish-American businessman based in Portland, Oregon.

10.10 Grandmaster Title

R. Vaishali became India's third female chess Grandmaster after Koneru Humpy and Harika Dronavalli.

- Grandmaster is the highest title or ranking that a chess player can achieve that is awarded by the ***International Chess Federation.***
- The title is valid for ***lifetime*** unless a player is stripped of the title for a proven offence such as cheating.
- **Qualifications for Grandmaster** – Currently, it is awarded to a player who is able to achieve a *FIDE Classical or Standard rating of 2,500, plus 3 Grandmaster norms.*
- In chess, a ***grandmaster norm (GM norm)*** is a high-level performance in a tournament.

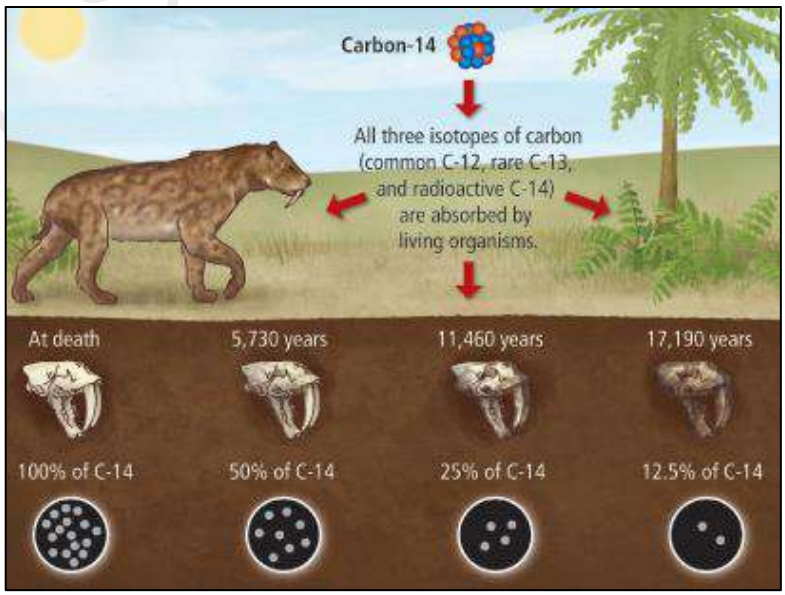
Qualified Titles	
GM	Grandmaster
WGM	Woman Grandmaster
IM	International Master
WIM	Woman International Master
FM	FIDE Master
WFM	Woman FIDE Master
NM	National Master
CM	FIDE Candidate Master
WCM	FIDE Woman Candidate Master
WNM	Woman National Master

11. OTHERS

11.1 Carbon Dating

The Allahabad High Court ordered a 'scientific survey', including carbon dating, of a 'Shivling' said to have been found at the Gyanvapi mosque complex in Varanasi.

- Carbon dating is a widely-used method to establish the age of dead organic materials.
- **Isotopes -** Carbon occurs naturally in 3 isotopes: ***carbon 12, carbon 13 and carbon 14.***
- The most abundant isotope of carbon in the atmosphere is C-12.
- The dating method uses Carbon-14 (C-14) which is radioactive and decays at a well-known rate.
- **Half-life -** The radioactive C-14 reduces to one half of itself in about 5,730 years, known as its 'half-life'.
- **Carbon dating -** Living things have carbon in them in various forms. Plants and animals get their carbon from the atmosphere.
- When they die, C-14 decay and the ratio of C-12 and C-14 changes.
- The changing ratio of C-12 to C-14 in the remains of a plant or animal after it dies is measured to deduce its approximate age.
- **Exceptions to carbon dating -** It cannot be used to determine the ***age of non-living things*** like rocks, for example.



- Also, the age of things that are ***more than 40,000-50,000 years old*** cannot be arrived at through carbon dating. This is because after 8-10 cycles of half-lives, the amount of C-14 becomes almost very small and is almost undetectable.

Alternate methods

- ***Radiometric dating methods*** which involve elements with half-lives of billions of years are used to determine age of very old objects.
- ***Potassium-argon dating*** - The radioactive isotope of potassium decays into argon, and their ratios can give a clue about the age of rocks.
- ***Uranium-thorium-lead dating*** - Uranium and thorium have several radioactive isotopes, and all of them decay into the stable lead atom.
- ***Cosmogenic nuclide dating (CRN)*** - It is applied to study the age of ice cores in Polar Regions.

11.2 Role of Calcium-41 in Radiometric Dating

Recent study shows that Calcium-41 can be used the same way as Carbon-14 in carbon dating, but with several advantages.

- **Radiocarbon dating** – It is a method that provides objective age estimates for carbon-based materials that originated from *living organisms.*
- Plants and animals assimilate Carbon 14 from carbon dioxide throughout their lifetimes.
- When they die, they stop exchanging carbon with the biosphere and their carbon 14 content then starts to decrease at a rate determined by the law of radioactive decay.
- An age could be estimated by measuring the amount of carbon-14 present in the sample.
- There are 3 principal techniques used to measure carbon 14 content of any given sample.
    1. Gas proportional counting
    2. Liquid scintillation counting
    3. Accelerator mass spectrometry (Advanced method)
- The method was developed 1940s by ***Willard Libby***, who received the ***Nobel Prize in Chemistry*** to this work in ***1960***.
- The issue with carbon dating was to detect carbon-14 atoms, which occur *once in around 10^{12} carbon atoms.*
- **Calcium-41** – It is a rare long-lived *radio-isotope of Calcium* that has a half-life of ***99,400 years.***
- Calcium-41 is called a ***cosmogenic nuclide,*** because it is produced when cosmic rays from space smash into calcium atoms in the soil in a fission reaction, called ***spallation***.
- It is found in the earth's crust, opening the door to dating fossilized bones and rock.
- The issue is Calcium-41 is rarer, occurring once in around 10^{15} Calcium atoms.
- **Atom Trap Trace Analysis (ATTA)** - ATTA is both extremely sensitive and selective, and is based on the laser manipulation and detection of neutral atoms.

11.3 Vapes

Electronic Nicotine Delivery Systems-ENDS (e-cigarettes) are 95% less harmful than tobacco cigarettes claimed by a study is a myth.

- Vaping consists of inhaling the vapour of a heated liquid inside e-cigarettes.
- The liquid inside e-cigarettes normally contains ***nicotine,*** the highly addictive substance present in regular tobacco.
- E-cigarette devices belong to a category of vapour-based nicotine products called ***Electronic nicotine delivery systems (ENDS)***
- **Effects -** E-cigarette has toxic substances and is associated with poisoning, lung injury and burns.
- Nicotine e-cigarettes can cause dependence or addiction in non-smokers. Young non-smokers who use e-cigarettes are more likely than non-users to initiate smoking and become regular smokers.
- E-cigarettes do not result in reduced harm if users continue to smoke.
- Since 2019, the production, manufacture, import and export, transport, sale, distribution, storage and advertisement of ***vapes has been banned in India.***

11.4 Clethodim

New study raises concerns on use of common herbicide Clethodim, which is posing a silent threat to male reproductive health.

- Clethodim is used as a selective post emergence ***herbicide*** for the control of annual and perennial grasses in numerous crops.
- **Effects –** Can significantly impact male reproductive function and early embryonic development.

11.5 Chiral Bose-liquid State

A recent research shows that the chiral Bose-liquid state may be an entirely new state of matter.

- **States of matter -** There are 3 classical states of matter - solid, liquid and gas.
- But, exotic or quantum states of matter, such as plasma, time crystals, and Bose-Einstein condensate also exist at the atomic scale, and at extremely low temperatures approaching absolute zero.
- **Chiral Bose-liquid state** - The chiral Bose-liquid state is a new phase discovered by physicists in a ***frustrated quantum system***, where infinite possibilities result from the interaction of particles.
- **Significance** - In this state,
    - Electrons can be frozen into *predictable patterns.*
    - Electrons can be made *resilient to changes in spin* (a defining characteristic of subatomic particles)
    - Electrons can even *synchronise their movements.*

11.6 Nano Knife

Recently a patient suffering from non-alcoholic steatohepatitis associated with renal cancer has been treated with nanoknife technology.

- Also known as ***electroporation***, nanoknife is a surgical procedure developed to help *treat certain cancerous tumours*, including cancer of the prostate using pulses of electricity.
- **Process** - The needles are placed in or around a tumour and *very high voltage electricity* between any two needles at a time.
- This process punctures very small holes into the cell membranes because of which the cells die while the peripheral tissues are left intact.
- Since it is high voltage electricity, the procedure has to be done under ***full general anaesthesia***.
- **Treatment** - It is mostly used for treating pancreatic cancer, tumours of the liver and kidney.
- **Advantages**
    - It's very precise and targeted. The success rate has been around 95%.
    - It will not harm the blood vessels even if they are in close vicinity of the tumour or even sometimes within the tumour.
- **Other methods -** ***Radio frequency ablation or microwave ablation*** require heating of the tissues and effectively burning them whereas ***cryoablation*** requires freezing the tumour to death.

11.7 All about 3D Printing

Recently India inaugurated its first 3D-printed post office in Bengaluru.

- **Additive Manufacturing (AM)** – It is the industrial production name for 3D printing.
- It is an additive process, in which layers of a material like plastic, composites or bio-materials are built up to construct objects that range in shape, size, rigidity and colour.
- It differs from the traditional ***subtractive manufacturing*** techniques involving cutting large blocks of material to form the desired object.

Applications of 3D printing

- **Prosthetics-** It has revolutionized how prosthetics are created. As 3D printing processes and techniques are refined, the creation of custom, tailored prosthetics becomes more straightforward.

Initiatives taken to promote 3D printing

- **Atal Innovation Mission (AIM) -** Flagship initiative to create and promote entrepreneurship and innovation across the country.
- **Atal Tinkering Labs -** Launched under AIM.
- Dedicated workspaces have been set up with do-it-yourself (DIY) kits including 3D printers, robotics and miniaturised electronics are installed.
- **National Strategy on Additive Manufacturing**- The strategy aims to increase India's share in global AM to 5% with a target to add nearly US 1$bn to the GDP by 2025.

- **Replacement Parts-** It has the ability to fabricate replacement parts easily. 3D printing enables consumers and businesses to maximize the value of their purchases.
- **Implants-** It allows the construction of more specialized products for patients.
    - Example- Tooth implants, heart valves, knee replacements etc.,
- **Pharmaceuticals-** 3D-printed drugs to have special delivery profiles that can be tailored to patients' specific needs.
- **Emergency structures-** 3D printing can help alleviate the hardships of affected families by building houses, hospitals, and other structures much faster than by traditional means.
- **Automotive-** Testing and production of lightweight, high strength parts.
- **Electronics-** Production of light weight, impact resistant structures with multiple functionality.
- **Example-** Wearable devices, soft robots etc.,
- **Consumer goods-** Fabrication of complex structures compels innovative product design.
- **Aerospace**- Relativity Space launched a test rocket made entirely from 3D-printed parts, measuring 100 feet tall and 7.5 feet wide.
- **Healthcare industry**- During Covid-19 pandemic the healthcare industry used 3D printers to make much-needed medical equipment, like swabs, face shields, and masks.

Concerns of 3D printing

- **Scalability-** In conventional techniques, once a design has been set, multiple copies can be made much faster. But 3D printing is slow.
- **High cost-** The initial set up of 3d printing and pre and post processing in healthcare is costly.
- **Job loss-** Due to automation it may have impact on employment opportunities.
- **Limited materials-** Raw materials is not exhaustive in 3d printing, it poses a serious challenge.
- **Skilled labour-** It needs talented individuals to work with additive manufacturing.

11.8 Namoh 108

Science Minister unveiled a variety of lotus called 'Namoh 108'.

- The ***lotus has 108 petals*** and was discovered several years ago in Manipur/
- This is the only lotus variety in India to have had its genome sequenced.
- It was only after the number of petals was discovered that the ***National Botanical Research Institute (NBRI)*** cloned and worked on improving its germplasm and modifying its characteristics.
- CSIR-NBRI would be initiating a 'Lotus Mission' as part of a larger ongoing horticultural mission to have more of the 108 Namo flowers grow in other parts of India.

11.9 Langlands Program

Langlands program, the world's biggest Math project provides a beautifully intricate set of connections between various areas of mathematics, pointing the way toward novel solutions for old problems.

- It is a mathematical exercise to find connections between two far-flung areas of mathematics - *number theory and harmonic analysis, launched in 1967.*
- **Significance** – It could be crucial to prove the ***Ramanujan conjectures*** (speculations), many of which remain unsolved. It has also *evolved into its own field of mathematics*,
- One offshoot, ***Geometric Langlands*** investigates connections between algebraic geometry and representation theory.

*Dr. Langlands was awarded the **Abel Prize,** one of the highest honours for mathematicians in 2018 for his visionary program connecting representation theory to number theory.*

11.10 India's 1st Solar City

Sanchi, the historic home of the Stupa, has become India's first 'solar city'.

- **Features** - The 5,572 solar panels spread over an area of 4.98 hectares ensure supply from 9 am to 4 pm.
- It currently includes a 3 MW solar plant that caters to the city's energy needs.
- A 5 MW plant for agricultural requirements is also under construction.
- Another similar facility in Gulgaon village, which will house a 5 MW solar facility equipped with 11,722 solar panels is about to come up.
- Madhya Pradesh has also initiated the construction of a 600 MW electricity-producing solar plant on the dam water in Omkareshwar.
- Once completed, Sanchi will become *energy surplus*.

Solar City Programme

- A total of 24 states and union territories have identified cities to be developed as solar cities.
- It comes under the ***Ministry of New and Renewable Energy (MNRE).***
- Each State /Union Territory shall *select at-least one city* under this.
- There is *no separate fund allocation* as funds available under the different existing schemes can be utilized for development of solar cities.

11.11 Tantalum

Researchers from the Indian Institute of Technology (IIT), Ropar has detected the presence of tantalum, a rare metal, in the Sutlej river sand in Punjab.

- **Tantalum** – A chemical element with symbol Ta and atomic number 73 in the periodic table.
- It is very ***hard, ductile, lustrous, bluish-grey transition metal*** that is highl y corrosion resistant.
- It has a melting point of 5,463 °F (2,996 °C), the 4th highest of all metals.
- It is one of the 12 ***critical and strategic minerals*** according to the annual report of the Union Ministry of Mines for 2020-21.
- Critical mineral is a metallic or non-metallic element that is essential for the functioning of our modern technologies, economies or national security. They are 30 in number in India.
- **Uses**
  - Production of electronic components
  - In the making of surgical implants
  - Can replace bone, connect torn nerves and bind abdominal muscle
  - As electrodes for neon lights and in glass for special lenses
  - High-temperature applications, such as aircraft engines

11.12 1st Night Sky Sanctuary

- South East Asia's 1st Night Sky Sanctuary will be setup in ***Ladakh*** with the help of ***Indian Institute of Astrophysics, Bengaluru.***
- It will be located within the ***Changthang Wildlife Sanctuary*** and adjacent to the ***Indian Astronomical Observatory*** (2nd-highest optical telescope in the world).

11.13 MAITRI – II Station in Antarctica

- India aims to set up a new research station in ***Antarctica*** near the Maitri station ***by 2029.***
- The existing Indian research station, Maitri is very old, is imperative to build a new research station.
- ***Dakshin Gangotri,*** India's 1st research station in Antarctica, was commissioned in 1983 had to be abandoned in 1989 after being submerged in snow.

11.14 Message in a Bottle Campaign

- Message in a bottle campaign is a campaign done by ***NASA, U.S.***
- It invites people around the world to sign their names to a poem written by the U.S. Poet Laureate Ada Limón.
- The names will be on a microchip that will ride aboard ***NASA's Europa Clipper mission*** as it explores Jupiter's moon (Europa).

11.15 Ketamine

- Ketamine is an ***illegal recreational anaesthetic drug*** that has been listed as a hallucinogen by the US Drug Enforcement Administration.
- It is used to treat mental health treatments like depression and Post-Traumatic Stress Disorder (PTSD).
- **India** – It included the drug in the stringent ***Schedule X*** of the Drug and Cosmetics act, 1940.
- The drugs in schedule X, cannot be purchased over the counter without a valid prescription of a Registered Medical Practitioner (RMP).

11.16 Polar Science and Cryosphere Research (PACER)

India's 1st winter scientific expedition to the Arctic has been flagged off from the MoES headquarters in New Delhi.

- It is a ***Central Sector*** umbrella scheme.
- **Implemented by** – Ministry of Earth Sciences (MoES) through National Centre for Polar and Ocean Research (NCPOR), Goa.
- **Objectives** – To promote long-term scientific programmes in the polar region and the surrounding oceans
- To implement annual expeditions and to maintain Indian research bases at Antarctica, Arctic and Himalaya.

Sub-schemes under PACER	
Indian Antarctic Program	• It was conceived in 1981 initiated under the Department of Ocean Development (DOD) attached to Prime Minister's Office (PMO). • 3 permanent Indian research bases, ***Dakshin Gangotri-1983, Maitri-1988 and Bharati-2012*** have been built.
Indian Arctic Program	• Its foundation was laid in 2007 and it established its Arctic research station, ***Himadri in 2008.***
Indian Scientific Expeditions to the Southern Ocean (ISESO)	• It was initiated to pursue multi-disciplinary, multi-institutional research activities addressing key scientific components like Air-sea interactions, lower atmospheric processes, hydrodynamics, biogeochemistry, biodiversity, etc.
Cryosphere and Climate	• It was initiated during 12th 5-year plan that have enhanced our understanding of the Antarctic cryosphere and the climate variability.

11.17 Sparsh Bharati

- After introducing the ***Bharati script*** V. Srinivasa Chakravarthy, a professor in IIT Madras has developed a script for persons with visual impairment named as Sparsh Bharati.
- This '***Indian Braille'*** can be used across Indian languages.
- Bharati is a simple and unified script which can be used to write most major Indian languages.
- It is designed using simple shapes, borrowing simple characters from various Indian languages and English.

11.18 Gyrocopters

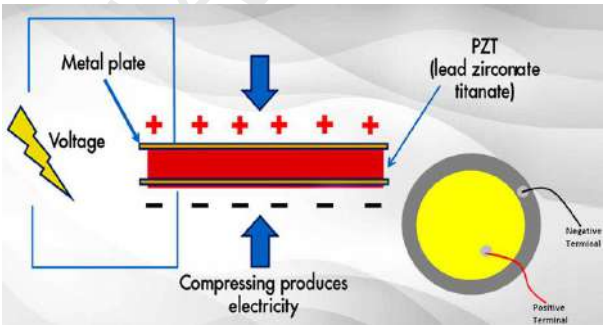
Uttarakhand is all set to launch India's first-ever gyrocopter safari by the year's end to redefine the concept of adventure tourism in the state.

> *A rotorcraft or rotary-wing aircraft is a heavier-than-air aircraft with rotary wings, which generate lift by rotating around a vertical mast.*

- It is a ***type of rotorcraft***, uses a rotor that is not powered to generate lift.
- The rotor looks ***similar to that of a helicopter***, but it requires air flowing upwards across it to rotate.
- **Economical** – The operating cost of a Gyrocopter is one-tenth that of a helicopter, so it is ***comparatively cheaper***, with an estimated cost of INR 200 per minute.
- **Safer transport** - As the engine is not connected to the rotors, it is not seriously affected if the engine stops in flight.
- It can ***fly lower and slower more safely*** than most other forms of flying machines and are also capable of flying in harsh weather conditions.

11.19 Piezoelectricity

- Piezoelectricity was discovered in 1880 by ***Pierre and Paul-Jacques Curie.***
- It is a phenomenon in which certain materials generate an electric charge in response to mechanical stress.
- Piezoelectric materials includes ***quartz, ceramics, lead zirconate titanate a nd biological substances like bone and tendons.***
- **Application** – Used in pressure sensors, accelerometers, and acoustic devices, where their ability to convert mechanical signals into electrical signals is crucial.



- The piezoelectric effect is also what made quartz watches so common and over time, affordable.

****