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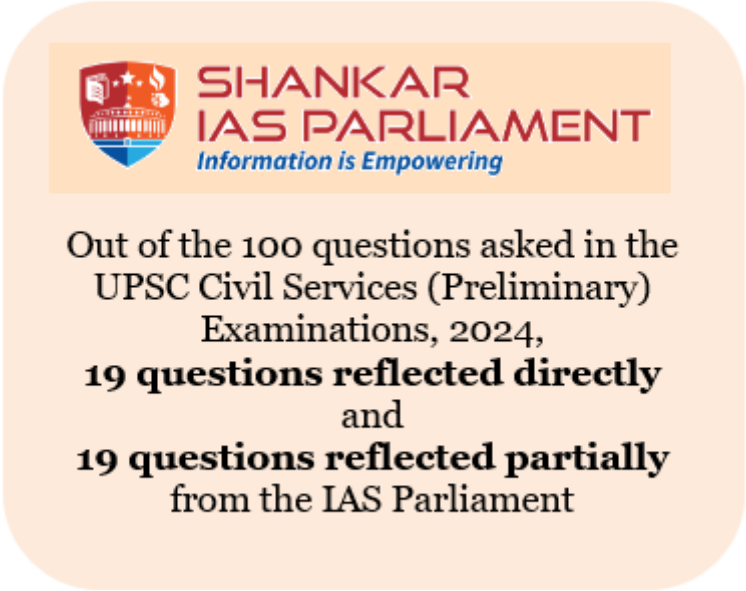

Total number of questions directly reflected from IAS Parliament (including Target 2024 series)	19
Number of questions directly reflected from the Target Series 2024	14
Total number of questions partially reflected from IAS Parliament	19

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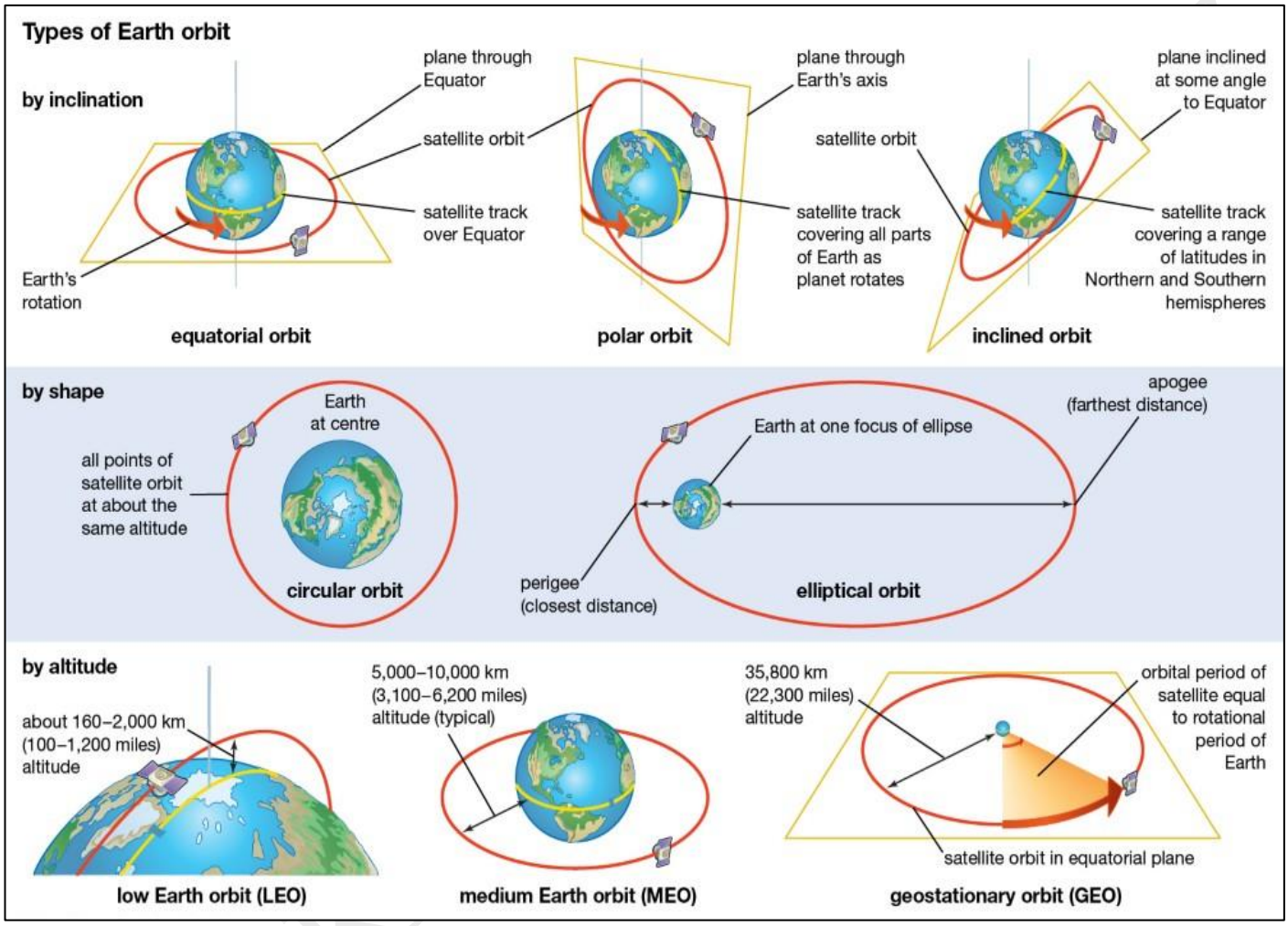
1. SPACE TECHNOLOGY

INTRODUCTION

1.1 Types of Orbits

- There are different satellite orbits that can be used d*epending upon satellite's functions and area it is to serve*.



- Most satellites, the International Space Station, the Space Shuttle, and the Hubble Space Telescope are all in Low Earth Orbit.

Orbit	About	Observation	Application
Polar Orbit	They have an inclination of about *90 degrees to the equator* and travels *north-south over the poles* at lower altitudes.	They 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.

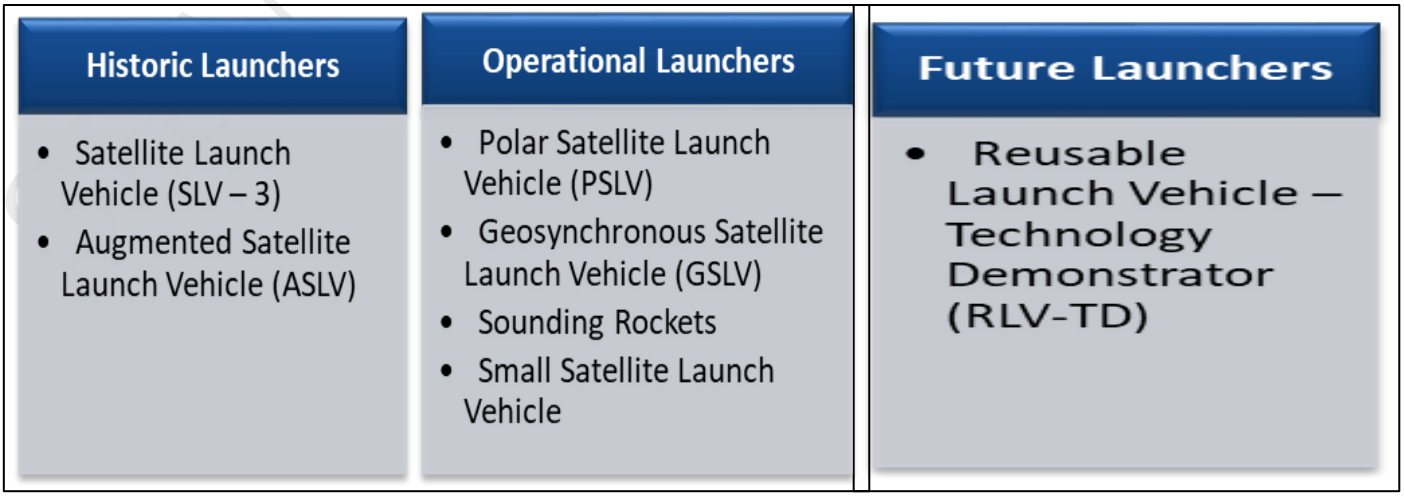
1.2 Types of Satellites

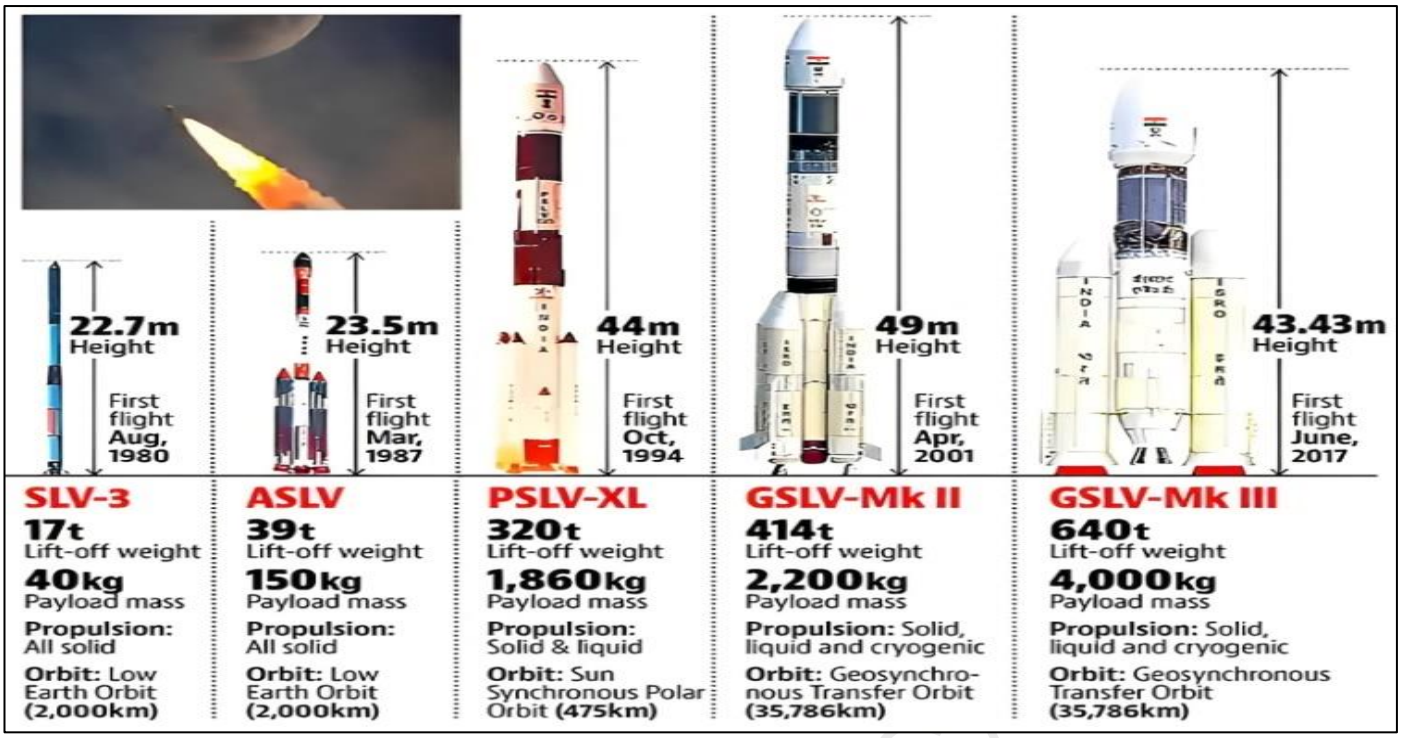
Satellite Type	Applications	Examples
Communication Satellites	Provide services to telecommunications, television broadcasting, satellite newsgathering, societal applications, weather forecasting, disaster warning and Search and Rescue operations.	The Indian National Satellite (INSAT) series (INSAT-3A, 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) –** It is implemented jointly by ISRO and Airport Authority of India (AAI).
- The main objective is to provide Satellite-based Navigation services with accuracy and integrity required for civil aviation applications and to provide better Air Traffic Management over Indian Airspace.
- The GAGAN Signal-In-Space (SIS) is available through GSAT-8 and GSAT-10.
- **Indian Regional Navigation Satellite System (IRNSS), NavIC**– It is an independent regional navigation satellite system to provide accurate position information service.

1.3 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.





Satellite Launch Vehicle (SLV – 3)

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

Augmented Satellite Launch Vehicle (ASLV)

- Developedin ***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.
- **Stage I**: It uses ***solid rocket*** motor with 4 liquid strap-ons.
- **Stage II**: It uses ***liquid rocket*** engine (similar to vikas engine of PSLV stage II).

- **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.
- The configuration of RLV-TD is similar to that of an aircraft and combines the complexity of both launch vehicles and aircraft.
- The winged RLV-TD has been configured to act as a flying test bed to evaluate various technologies, namely, hypersonic flight, autonomous landing and powered cruise flight.
- In future, this vehicle will be scaled up to become the first stage of India's reusable two stage orbital launch vehicle.

The Human rated LVM3 (HRLV) *is identified as the launch vehicle for Gaganyaan mission*

- **Objectives of RLV-TD -** Hypersonic aero thermodynamic characterisation of wing body, Evaluation of autonomous Navigation, Guidance and Control (NGC) schemes, Integrated flight management and Thermal Protection System Evaluation
- It was successfully flight tested in 2016 from Sriharikota.

Small Satellite Launch Vehicle

- 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

1.4 Propellants

- Propellant is the chemical mixture burned to produce thrust in rockets and consists of a ***fuel and an oxidizer***.
- A fuel is a substance which burns when combined with oxygen producing gas for propulsion.
- An oxidizer is an agent that releases oxygen for combination with a fuel.

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***, which is 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.
- 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.
- It is similar to *Viking rocket engines*.

Cryogenic Engine

- Cryogenic stage is technically a much more complexed system with respect to solid or liquid propellant stages due to the usage of propellants at extremely low temperatures.
- A cryogenic engine provides more force with each kilogram of cryogenic propellant it uses compared to other propellants, such as solid and liquid propellant rocket engines and is more efficient.
- 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.

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** (three 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),*** which is 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.

- *India is the 4th country* (after USA, Russia and European Space Agency) to demonstrate flight testing of Scramjet Engine.

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 Indian Space Situational Assessment Report (ISSAR), 2023 & IS4OM

Recently ISSAR for 2023 has revealed that more space objects were placed in orbit last year as compared to 2022.

- **Compiled by**- ISRO System for Safe and Sustainable Space Operations Management (IS4OM)
- **Global** - It indicates a *rise in the number of space objects placed in orbit in 2023* compared to 2022, suggests improved accessibility to space and the broadening applications of space technology in everyday life.

- **Indian scenario-** For India, the year saw the *successful launch of 7 ISRO missions*, placing 5 Indian satellites, 46 foreign satellites, and 8 rocket bodies into orbit.
- **Spacecraft decommissioning**- One of the major highlights of 2023 was the controlled *re-entry of Meghatropiques-1* into the Earth's atmosphere over an uninhabited area in the South Pacific Ocean.
- It outlined India's role in space operations, including the number of satellites re-entering the atmosphere and rocket bodies placed in orbit.
- **Close approach alerts**- ISRO receives close approach alerts from *USSPACECOM* and conducts assessments using accurate orbital data.
- While numerous close approaches were detected, coordination with international agencies helped mitigate risks, and no critical incidents warranted collision avoidance manoeuvres (CAM).
- There is an increasing trend in CAMs, reflecting the growing congestion in outer space.
- However, no concerning close approaches were detected for missions like Chandrayaan-3 and Aditya-L1.

ISRO System for Safe & Sustainable Operations Management (IS4OM)

- **Location-** Bengaluru
- **Aim**- To *ensure safety of India's space assets* and sustaining the utilization of outer space for national development.
- **Observation**- It observes and monitors space objects and the space environment.
- **Orbit determination-**It processes observations to determine the orbits of space objects.
- **Object characterization**- It characterizes and catalogs space objects.
- **Space environment analysis**- It analyzes the evolution of the space environment.
- **Risk assessment** - It assesses risks and implements mitigation strategies.
- **Data exchange**- It facilitates data exchange and collaboration.
- **Compliance with International guidelines**- IS4OM adheres to international guidelines on post-mission disposal and satellite end-of-life operations.

1.9 PS4 Engine

Indian Space research Organisation (ISRO) has successfully conducted a long-duration test of its '3D printed' PS4 rocket engine.

- It is a ***liquid rocket engine*** that uses
  - **Oxidiser** – The earth-storable bipropellant combinations of *Nitrogen Tetroxide*.
  - **Fuel** – *Mono Methyl Hydrazine* in pressure-fed mode.
- **Developed by** – ISRO's Liquid Propulsion Systems Centre (LPSC).
- LPSC redesigned the engine making it amenable to the Design for Additive Manufacturing (DfAM) concept thereby gaining considerable advantages.
- **Manufactured in** – Indian industry (M/s WIPRO 3D).
- **Technology** – It is manufactured through additive manufacturing (AM) technology for a duration of 665 seconds in the conventional machining and welding route.
- **Laser Powder Bed Fusion technique** – It has brought down the number of parts from 14 to a single-piece and eliminated 19 weld joints, saving significantly on the raw material usage per engine.
- **Hot tested at** – ISRO Propulsion Complex, Mahendragiri, Tamil Nadu.
- **Usage** – It has been in use *for the 4th stage of PSLV* which has a thrust of 7.33 kN in vacuum condition.
- It is also used in the *Reaction Control System (RCS) of the 1st stage (PS1) of PSLV*.

Rocket Engine testing

- **Cold flow tests & pressure tests** – The fuel and oxidiser are flowed through the engine without being ignited.
- **Hot fire tests** – When the engine is ignited, and its performance measured.

- **Significance -** It is a single piece engine, saves 97% of raw materials & reduces the production time by 60%.

1.10 Pushpak

Recently, the 3rd and final test success of the Reusable Launch Vehicle (RLV) Landing Experiment (LEX) or Pushpak is conducted.

- **Aim** – To carry *payloads into low earth orbits and return* to earth for reuse.
- **Agency-** Indian Space Research Organisation (ISRO).
- It is to undertake more difficult manoeuvres with dispersions, correct both cross-range and downrange.
- It demonstrated the ***autonomous landing capability*** of RLV from off-nominal initial conditions at release from helicopter.
- It landed at a velocity exceeding ***320 kmph***, due to its low lift-to-drag ratio aerodynamic configuration.
- It autonomously maintained a stable and precise ground roll along the runway using its rudder and nose wheel steering system during the ground roll phase.

1.11 PraVaHa Software

Recently, a Computational Fluid Dynamics (CFD) software named PraVaHa was developed.

- **PraVaHa Software -** Parallel RANS Solver for Aerospace Vehicle Aero-thermo-dynamic Analysis.
- It is a software tool designed to ***analyze the aerodynamics and thermodynamics of aerospace vehicles***.
- **Developed by-** Indian Space Research Organisation (ISRO).
- It simulates external and internal flows on launch vehicles, winged & nonwinged re-entry vehicles.
- **Usage**- It has been used extensively in the Gaganyaan program for aerodynamic analysis of human-rated launch vehicles, viz, HLVM3, Crew Escape System (CES), and CM.
- It is designed to make use of CPU as well as GPU architecture of available and upcoming supercomputing facilities.
- Currently, the PraVaHa code is operational to simulate airflow for Perfect Gas & Real Gas conditions.
- It soon will replace most of the CFD simulations for aero characterization, which is currently being carried out using commercial software.

Computational Fluid Dynamics (CFD)

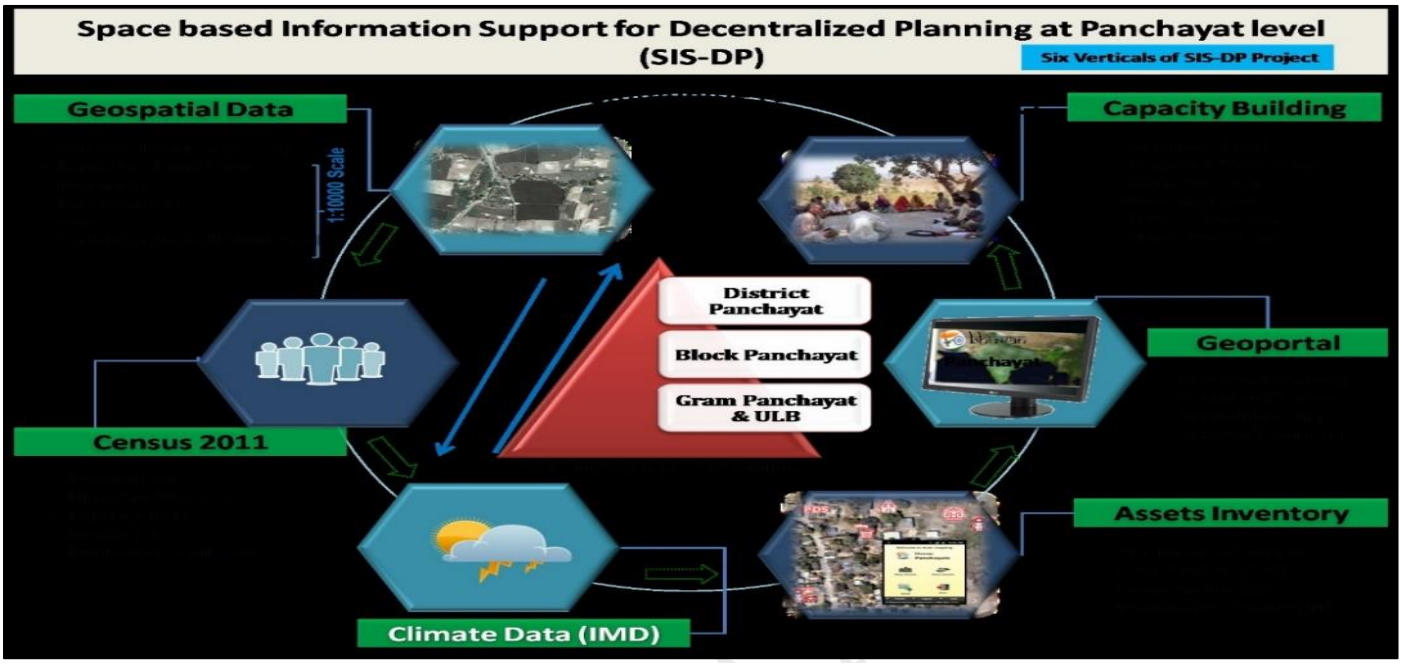
- CFD – It is the process of *mathematically predicting physical fluid flow* by solving the governing equations using computational power.
- In a CFD software analysis, fluid flow and its associated physical properties, such as velocity, pressure, viscosity, density, and temperature, are calculated based on defined operating conditions.
- In order to arrive at an accurate, physical solution, these quantities are calculated simultaneously.
- The most common CFD tools are based on the ***Navier-Stokes (N-S) equations.***

1.12 Bhuvan Panchayat portal & National Database for Emergency Management

Union Minister launches 2 Geoportals, "Bhuvan Panchayat (4.0)" portal and "National Database for Emergency Management (NDEM 5.0)" recently.

- **Bhuvan Panchayat Portal**– It is a Space based Information Support for Decentralised Planning at Panchyayat level (SIS-DP))
- It is a national initiative of preparing basic spatial layers useful in planning process at grass root levels.
- **Formulated by** – National Remote Sensing Centre, ISRO.
- **Implemented by -** In partnership with State Remote Sensing Application Centers in the country.

- **Aim -** Empowering Panchayati Raj Institutions (PRIs) and the Stakeholders with Space-based Information Support for Decentralized Planning and Governance.
- The project's main deliverables include
    - **Satellite images -** 2.5 m resolution satellite images of the entire country.
    - **Thematic maps -** 1:10K scale thematic maps on natural resources and infrastructure, such as land cover and settlements.



    - **Resource inventories -** Inventories of resources like water sources, road networks, drainage, and rail networks.
- These deliverables are useful for planning, development, implementation, and monitoring activities at the Panchayat or Village level.
- The project also integrates data from stakeholder departments into the spatial layer in a GIS environment.

National Database for Emergency Management

- **Aim** – To provide space-based inputs on natural disasters and aid in disaster risk reduction In India as well as neighboring countries.
- **Developed by** - National Remote Sensing Centre (NRSC), ISRO.
- **Nodal Ministry -** Ministry of Home Affairs (MHA).
- It acts as a geo-portal with the amalgamation of DSS tools and services of disaster forecasting organisations with value addition.
- It will also act as a ***Disaster Recovery and Data Provider node*** for the Integrated Control Room for Emergency Response (ICR-ER) being established by MHA, New Delhi.

1.13 Venus Orbiter Mission (VOM)

The Union Cabinet chaired by the PM has recently approved the development of Venus Orbiter Mission (VOM).

- **Launching agency -** Indian Space Research Organisation (ISRO).
- **Aim –** For scientific exploration and for better understanding of *Venusian atmosphere, geology* and generate large amount of science data probing into its thick atmosphere.
- It is expected to be accomplished during March 2028.
- **Significance** - By studying Venus, we can unlock answers to key questions about planetary evolution, particularly Venus, despite its similarities to Earth, developed so differently.

Venus

- It is the 2nd planet from the Sun and Earth's closest planetary neighbor.
- **Size -** It is the 6thlargest planet and is similar in size to Earth.
- Due to its similar size and composition, it is often referred to as ***Earth's "twin".***
- **Distance from the Sun** - It is said to orbit the Sun at an average distance of 67 million miles or ***0.72 astronomical units (AU).***
- At this range, sunlight takes about 6 minutes to reach Venus.
- **No Moon-** It does not have a moon in our solar system beside Mercury.
- But it have a *quasi-satellite called Zoozve.*
- **Features** –It has volcanic landscapes and distorted mountain ranges.
- It is believed to have once harbored conditions suitable for life.
- However, the planet underwent a dramatic transformation, evolving into an extremely hostile environment with surface temperatures***exceeding 450°C*** and an atmosphere filled with toxic gases.
- Venus's dense atmosphere creates an intense greenhouse effect, trapping heat and making it the ***hottest planet in the solar system.***
- NASA explained that its surface temperatures are so extreme that *they can melt lead.*

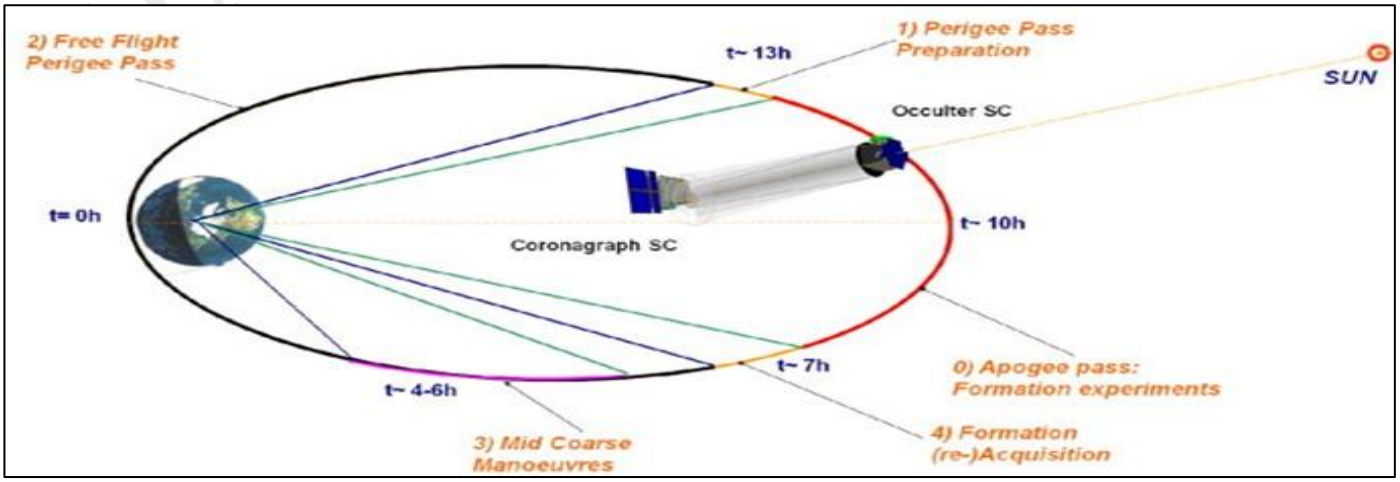
1 AU represents the distance between Earth and the Sun.

1.14 Proba-3 Mission

The Indian Space Research Organisation (ISRO) is all set to launch the European Space Agency's Proba-3 mission from Sriharikota, Andhra Pradesh.

- **Proba-3 –** It is the ***world's 1st precision formation flying mission***.
- Proba-3 will be the first mission to launch from India.
- **Mission life –** 2 years.
- **Launch vehicle -** Polar Satellite Launch Vehicle (PSLV) XL rocket.
- **Aim -** To *observe the Sun's corona* through an innovative satellite formation flight.
- To create an ***artificial eclipse*** by precisely coordinating two independent satellites.
- The 2 satellites will be launched together, and maintain a fixed configuration in space.
- It will be launched into a *highly elliptical orbit* measuring around 600 x 60,530 km with Orbital period - 19.7 hours.
- **2 satellites**
  - Coronagraph spacecraft (CSC) - 200 kg.
  - Occulter spacecraft (OSC) - 340 kg.

*The **Sun's corona** is the outermost part of the Sun's atmosphere, made up of hot, ionized gas called plasma. The corona is usually hidden by the bright light of the Sun's*



Instruments
• **The Association of Spacecraft for Polarimetric and Imaging Investigation of the Corona of the Sun (ASPIICS) or the Coronagraph** - Its field of view is between the Sun's outer and inner corona, a circular belt normally observable during solar eclipse events. • **The Digital Absolute Radiometer (DARA) -** Maintain a continuous measurement of the Sun's total energy output, known as the total solar irradiance. • **The 3D Energetic Electron Spectrometer (3DEES) -** Measure electron fluxes as it passes through Earth's radiation belts, providing data for space weather studies.

- **Working -** The 2 spacecraft will fly in formation, maintaining a distance of about 150 meters for 6 hours at a time.
- The OSC will cast its shadow onto the CSC's telescope, blocking the sun's direct light.
- This will allow the CSC to image the sun's corona in visible, ultraviolet, and polarized light.
- The CSC's coronagraph instrument will take images of the sun's corona. The mission will study the sun's corona.

1.15 Gaganyaan G1 mission

The Indian Space Research Organisation (ISRO) began the 'stacking,' or assembly, of HLVM3 at the Satish Dhawan Space Centre, Sriharikota.

- It is the *1st of 3 un-crewed test missions* that will lead up to India's maiden human spaceflight.
- **Aim** – To mimic - end to end - the actual flight and *validate critical technologies and capabilities* including the Human-rated Launch Vehicle Mark-3 (HLVM3).
- **Activity** – It will *place the orbital module* in a 170 km x 430 km elliptical orbit around the earth.
- Once the orbital module de-orbits, the crew module will separate for controlled re-entry into the earth's atmosphere and splashdown in the Bay of Bengal
- **HLVM3** – Human rated launch vehicle, HLVM3, is derived from LVM3 and designed with enhanced reliability to meet human safety considerations.
- It is ***a 3-stage vehicle*** with a payload capacity of about *10 tonnes to LEO*.

December 18, 2024 coincides with the 10th anniversary of the sub-orbital Crew Module Atmospheric Re-entry Experiment ***(CARE) mission*** *of 2014.*

- The vehicle is 53 meters tall and weighs 640 tonnes.
- **Orbital module components** – The service module and crew module together make up the **orbital module.**
- The crew module is progressing at the *Vikram Sarabhai Space Centre*, at Thumba in Kerala.
- Once the crew module is ready, it will be transferred to the *U.R. Rao Satellite Centre (URSC), Bengaluru*, for integration with the service module.

Orbital Module Components	Launch Vehicle components
• Service Module • Crew module	• S200 solid rocket boosters • L110 liquid stage • C32 cryogenic stage

- After a series of tests including thermo-vacuum tests at the URSC, the orbital module will be transported to Sriharikota to be placed aboard the launch vehicle.
- The crew module is connected to the c*rew escape system* which is placed at the very top.

1.16 SpaDeX MISSION

ISRO plans to launch SpaDeX (Space docking experiment) in December 2024.

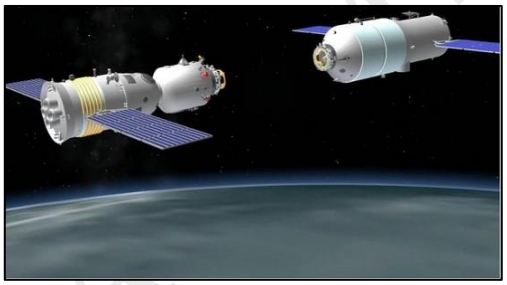
- **SpaDeX mission** – *2 satellites/spacecrafts will be launched* into low earth orbit, where they will demonstrate various technologies while in motion.
    - **Primary objective** – Demonstration of ***Dockingmanoeuvre***

Docking *specifically refers to joining of 2 separate free-flying space vehicles.*

- **Secondary objectives** – Demonstration of the ***transfer of electric power*** between the docked spacecraft.

- They were designed and realised by the *UR Rao Satellite Centre*.
- The full integration and testing of the satellite were carried out at Ananth Technologies, Bengaluru.
- **Launched by** – ***PSLV C-60***
- **Specifications** – Both spacecraft will be launched simultaneously but independently into a
  - 470-km wide circular orbit at 55° inclination
  - With a local time, cycle of about 66 days
- **Docking manoeuvre** – It is made up of *2 small spacecraft*
  - **Chaser** - SDX01
  - **Target**- SDX02.
- It involves various stages like
  - **Rendezvous** – Aligning orbits of 2 spacecraft
  - **Docking** – Connecting 2 spacecraft
  - **Undocking** – Disconnecting the 2 spacecraft.
- It requires very precise control of the spacecraft's attitude and velocity to ensure a safe connection.
- **Significance –** It is vital for
  - **Assembly and maintenance of the space stations** – Bharatiya Antariksh Station (BAS)
  - **Crew transfer** – Gaganyaan human space flight mission
  - **Suppling fuel to missions** – Chandrayaan-4 mission, for sample return from the Moon.
  - Cost-effective indigenous technology.

***Power transfer technology**, also known as wireless power transfer (WPT), is a technology that allows electrical energy to be transmitted without the use of physical wires or connectors.*

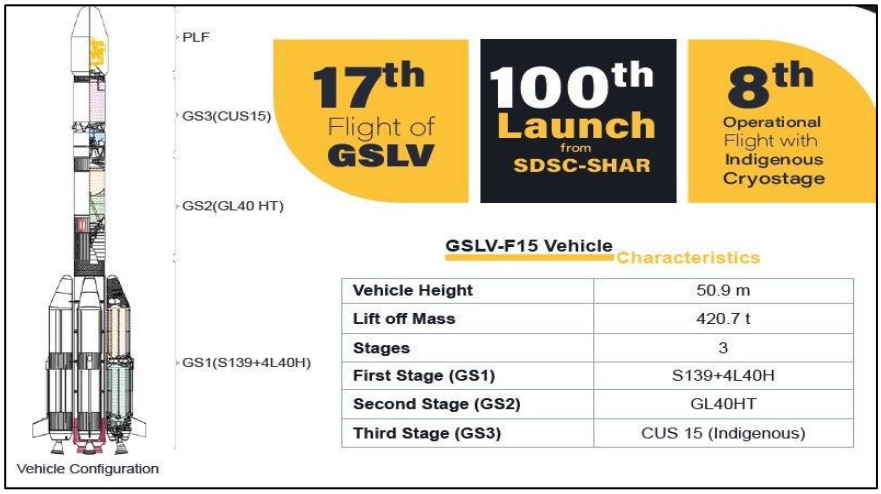


*India will be the **4th country in the world** to have space docking technology if the mission is successfully completed.*

1.17 GSLV-F15 NVS-02 Mission

GSLV-F15 NVS-02 mission is the 100th launch from the Satish Dhawan Space Centre in Sriharikot.

- **GSLV-F15 NVS-02** – Geosynchronous Satellite Launch Vehicle (GSLV) - F15/ Navigation with Indian Constellation-2 Satellite (NVS-2).
- **GSLV-F15 – 17th flight** of India's Geosynchronous Satellite Launch Vehicle (GSLV).
  - **11th flight with** – Indigenous Cryo stage.
  - **8th operational flight with** – Indigenous Cryogenic stage.



- **Payload** – Its fairing is a metallic version with a diameter of 3.4 meters.
- It will place NVS-02 satellite into a *Geosynchronous Transfer Orbit (GTO)*.
- **NVS-02 satellite** – It is the *2nd satellite* in the NVS series, a *part of NavIC.*
- **Designed, developed and integrated at** - *U.R. Satellite Centre (URSC)* with the support of other

***NAVIC** is India's independent regional navigation satellite system designed to provide accurate Position, Velocity and Timing (PVT) service to users in India. It extends to region of about 1500 km beyond*

satellite-based work centres.

- It operates in L1, L5, and S bands and employs ***Tri-band antenna***.
- **Rubidium Atomic Frequency Standard (RAFS)** – Is the main component of the navigation payload.
- RAFS is an ***atomic clock*** which acts as a stable frequency reference for the navigation payload.
- **Ranging Payloads** – It consists of ***C-band (CxC) transponder*** used for 2-way Code Division Multiple Access (CDMA) ranging to facilitate precise orbit determination.
- **Lift off mass** – 2,250 kg.
- **Power handling capability** – Approximately 3 kW.
- **Usage** – A combination of indigenous and procured atomic clocks for precise time estimation.

> ***Code Division Multiple Access (CDMA)*** *is a digital cellular technology that uuses spread spectrum techniques to allow multiple users to share the same frequency band simultaneously.*

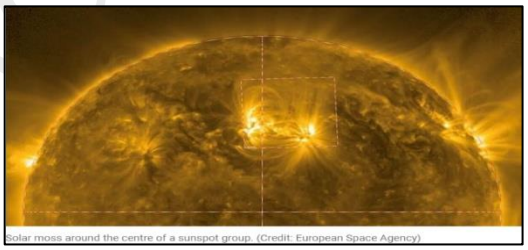
GLOBAL MISSIONS

NASA

1.18 Solar Moss

Indian-led NASA team traces what heats 'moss' on Sun.

- **Observations done by NASA's experiment**
  - High Resolution Coronal Imager (Hi-C) sounding rocket
  - Interface Region Imaging Spectrograph (IRIS)
- **Moss in Sun** –Sun, too, has an earth moss-like patchy structures *made of plasma in the solar atmosphere*.


Solar moss around the centre of a sunspot group. (Credit: European Space Agency)

- It is mainly due to *chromospheric jets or 'spicules'* interspersed with extreme ultraviolet emission elements.
- **Growth** – Under *strong magnetic conditions*, it grows and blossoms around the centre of a sunspot group.
- It is this magnetic field which primarily controls the dynamics of the solar atmosphere and it is present everywhere on the Sun.
- **Higher temperature** – It can go *as high as 5.5 lakh degree Celsius*, which is over a 100 times hotter than the immediate layer below as it is connected to the Sun's lower atmosphere.
- **Reason for high temperature** – It is dominated by a mess of *intertwined magnetic field* lines, and their interactions were *creating electrical currents*, which, in turn *dissipates as heat* the material upto 1 million degrees Fahrenheit.

> ***Sunspots*** *are dark patches on the solar surface where the magnetic field is abnormally strong — about 2,500 times stronger than that of Earth.*

- It can have a much stronger field than the average quiet-Sun , but they are slightly *weaker than the sunspots*.

Structure of Sun

- There are 7 layers in Sun.
- **Inner layers** – core, radiative zone, and convective zone.
- **Outer layers** –Photosphere, Chromosphere, Transition Region and Corona.
- **Corona** – The outermost peripheral part of the Sun's atmosphere, is extremely hot.
- Among the commonest features displayed by the solar corona are loops, streams, plumes and ejections.
- Any variations in the solar corona can affect the space weather and subsequently, the activities on Earth.

1.19 PREFIRE (Polar Radiant Energy in the Far-InfraRed Experiment)

The first of a pair of climate satellites designed to study heat emissions at Earth's poles was launched.

- **Developed by** – NASA & the University of Wisconsin-Madison.
- **Aim** – To measure far-infrared (IR) radiation from the Earth's pole.
- To gather data on the *amount of heat, the Arctic and Antarctica radiate* into space and their *influence on global climate*.
- It consists of ***2 shoebox-size cube satellites*** or CubeSats along with the spectrometer TIRS.
- Each of the PREFIRE satellites is a 6U CubeSat, measure around 90 cm in height and nearly 120 cm in width.
- They will be placed in a ***near-polar orbit*** (a type of low Earth orbit) at an altitude of about 525 kms.
- **Thermal Infrared Spectrometer (TIRS)** – It features specially shaped-*mirrors and detectors* for splitting and measuring IR light.

A lot of the heat radiated from the Arctic and Antarctica is emitted as far-IR radiation with wavelengths of 3 µm to 1,000 µm within the IR range of electromagnetic radiation.

- **Significance** – It will help us understand the fundamentals of *Earth's heat balance* and will provide a detailed picture of how Earth's Polar Regions influence Earth's capacity to absorb and release energies.
- The data can be used to predict how Earth's ice, seas, and weather will change in a warming world and in *prediction of sea ice loss, ice sheet melt*, and sea level rise.
- It provides crucial *information to farmers* tracking changes in weather and water, fishing fleets working in changing seas, and coastal communities building resilience.

Earth's energy budget *is the balance between incoming heat energy from the Sun and the outgoing heat given off by the planet. The water vapour content of the atmosphere, along with the presence, structure, and composition of clouds, influences the amount of far-IR radiation that escapes into space from Earth's poles.*

1.20 Rivers of lava on Venus

A new analysis of data from Magellan spacecraft finds signs of fresh lava flows occurring on the Venusian surface between 1990 and 1992.

- **Rivers of lava** - 2 vast, *sinuous lava flows* oozing from 2 different corners of Venus.
  - **Sif Mons** – It has a large shield volcano on its western slopes.
  - **Niobe Planitia** – A flat region studded with volcanic vents.
- Volcanic eruptions tinker with planetary atmospheres and thus creating opaque clouds.
- **Causes** – Venus *lacks the plate tectonics* of Earth but its *similarly rocky constitution* and comparable size suggests that something must still be cooking inside and it should be volcanically active.
- **Indirect evidence** – Volcanic gases linger in Venus' skies, and the planet glow suggests lava flows in the recent geologic past.
- **Direct evidence** – In 2023, researchers found a volcanic vent doubling in size & possibly filling with lava in old Magellan data.

Venus

- It is the 2nd planet from the Sun, and the *6th largest planet*.
- It is the *hottest planet* in our solar system.
- **Twin sister** – It is similar in size to Earth.
- **Long days** – Its day is longer than its year.
- **Features** – It has volcanic plains and rifts.
- **Runaway Greenhouse** – Its thick atmosphere traps heat.
- **Foul clouds** – Its sulphuric acid clouds smell like rotten eggs.
- **Science hotspot** – More than 40 spacecraft have visited.
- **Backward sunrise** – The Sun *rises in the west* & sets in the East.

Magellan

Magellan was the 1st spacecraft to image the entire surface of Venus and the 1st deep space probe launched by a space shuttle.

- **Aim** – To image the entire surface of Venus.
- **Launched by** – *NASA*, in 1989.
- It used cloud-penetrating radar to survey most of the planet.
- **Findings** – At least 85% of the surface is with volcanic flows.
- Despite the high surface temperatures (475 degrees Celsius) and high atmospheric pressures (92 atmospheres), the complete lack of water makes erosion an extremely slow process on the planet.

NASA's DAVINCI and VERITAS *probes, expected to launch next decade, will map the Venusian surface in far more detail manner.*

1.21 JADES-GS-z14-0 & JADES Program

A new study has detected the 2 earliest and most distant galaxies.

- **JADES-GS-z14-0 –** It is estimated to have *formed about 290 million years after the Big Bang*, making it the earliest-known galaxy.
- **Observed by** – *NASA's* James Webb Space Telescope
- **Umbrella programme** – ***JADES program*** (JWST Advanced Deep Extragalactic Survey).
- **Location** – It measures about 1,700-light years across.
- **Mass** – It is equivalent to 500 million stars the size of our Sun and is rapidly forming new stars, about 20 every year.
- **Size** – It is significantly larger than other galaxies that the JADES team has measured at these distances.
- **Luminous** – It is brighter.
- **JADES-GS-z14-1 –** It is smaller with a mass equal to about 100 million sun-sized stars, measures roughly 1,000 light years across and forms about 2 new stars per year.

The Big Bang theory *proposes that the universe began from an infinitely hot and dense single point, known as a singularity, around 13.7 billion years ago.*

A light year *is the distance light travels in a year, which is 9.5 trillion km.*

JADES Program

- **JADES** – JWST Advanced Deep Extragalactic Survey.
- **Partnership** – An international collaboration of more than 80 astronomers from 10 countries.
- It is conducting an ambitious program of deep infrared imaging and multi-object spectroscopy.
- **Technique** – It uses 3 JWST instruments, in the 2 most famous deep fields on the sky
  - The Hubble Deep Field (GOODS-N)
  - The Hubble Ultra Deep Field (GOODS-S)
- **3 scientific instruments**
  - NIRCam – Near-Infrared Camera
  - NIRSpec – Near-Infrared Spectrograph
  - MIRI – Mid-Infrared Instrument.

Galaxies *tend to grow larger as the universe evolves, thus it would potentially get significantly brighter in the next many 100 million years.*

1.22 Boeing starliner

A team of 2 astronauts sitting inside a crew capsule called Starliner is scheduled to be launched on 7th May 2024.

- **Starliner** – It is a spacecraft more than 4 m wide and can house up to 7 astronauts.
- It is a *partially reusable crew capsule*, officially known as ***CST-100 (crew space transportation).***
- **Built by** – Boeing, global aerospace company.

Starliner *is the 6th US-built spaceship to carry NASA astronauts, following Mercury, Gemini, Apollo, the Space Shuttle, and SpaceX's Crew Dragon.*

- **Launch by** – Atlas V rocket, operated by United Launch Alliance, a joint venture between Boeing and Lockheed Martin.
- **Crew capsule** – It houses the astronauts which will be able to survive re-entry and return to the ground.
- **2 crew members** – Astronauts *Barry Wilmore and Sunita Williams*.
- **Service module** – It provides *air and temperature control, water supply, sanitation*, etc., for the survival of astronauts plus the engines and fuel required to manoeuvre the spacecraft.
- This module won't be reusable.
- **Mission** – It will carry the astronauts *to the International Space Station* (ISS) in low earth orbit, where the duo will stay *for 8 days*.
- The capsule will return and descend to the ground, probably at a location in New Mexico.
- **Significance** – It is capsule's 3rd test flight and the 1st with astronauts on board.
- If successful, U.S. will for the *1st time in its history have 2 spacecraft (SpaceX and Boeing)to launch astronauts* to space.

NASA shut its Space Shuttle programme in 2011 and before SpaceX's Dragon capsule got ready in 2020. Each crew's expedition lasts up to 6 months, until the ISS is decommissioned next decade.

*SpaceX launched astronauts into orbit in 2020, becoming the 1st private business to achieve only in 3 countries — **Russia, the U.S. and China.***

1.23 Lunar Gateway Programme

India and the US have finalized the Strategic Framework for exploring the opportunities to participate in the Lunar Gateway Programme.

- It is an international collaborative project aimed at *establishing a space station in orbit around the Moon.*
- It is part of ***NASA's Artemis program,*** to support long-term human exploration of the Moon and beyond.
- **Launch -** No earlier than 2025.
- **Polar orbit** - Near-rectilinear halo orbit.
- **Objectives-** To facilitate regular missions to the lunar surface and serve as a base for astronauts.
- **Agencies -** It is a collaborative effort spearheaded by NASA, includes several international partners:
    - European Space Agency (ESA)
    - Canadian Space Agency (CSA)
    - Japan Aerospace Exploration Agency (JAXA)
    - Mohammed Bin Rashid Space Centre (MBRSC), UAE
- The Gateway Station is similar to the International Space Station currently in low Earth orbit, but the Gateway will orbit the Moon.
- Incidentally, the Gateway will be the ***1st space station ever to exist outside of low Earth orbit*** or LEO.

***Artemis programme** is to return humans to the moon by 2025, with the ultimate goal of expanding space exploration to Mars and beyond.*

1.24 CHAPEA project

Recently, 4 volunteer crew members of NASA's Mars simulation mission emerged after a year of living in a habitat replicating the Red Planet.

- **CHAPEA-** Crew Health and Performance Exploration Analogproject.
- It was the first of 3 planned simulations to understand the challenges Mars poses for space explorers.
- **Organization** - NASA.

*The **first CHAPEA mission** focused on nutrition, and the next two are planned for 2025 and 2026.NASA hopes to send astronauts to Mars by the 2030s.*

- **Mars simulation** - A ***3D printed airlocked habitat*** of 1,700 sq feet was created and set up at the Johnson Space Center in Houston, Texas, called "***Mars Dune Alpha***".
- Simulated Martian soil and a backdrop of red, rocky cliffs were provided for an immersive experience.
- **Aim** –To collect data for insight into the potential impacts of long-duration missions to Mars on crew health and performance.
- To understand and counter the physical and mental challenges astronauts will face.
- The data will also help them prepare for long-term presence on the Moon as part of its Artemis programme.
- **Significance** - Mars remains NASA's horizon goal for human exploration because it is one of the only other places we know where life may have existed in the solar system.
- **India's plans for a Mars mission** - In 2014, India tasted success with its Mars Orbiter Mission (MOM) or Mangalyaan, becoming the first nation to reach Martian orbit in its first attempt.

Quick facts

- The temperature on Mars ranges between 20 degrees Celsius and -153 degrees Celsius.
- The planet has a rocky surface with, volcanoes, dry lake beds, and craters, all covered in red dust.
- Winds can create dust storms, with tiny ones resembling tornadoes and large ones occasionally enveloping the entire planet.
- It has about one-third the gravity of Earth the atmosphere is much thinner than Earth's, containing more than 95% carbon dioxide and less than 1% oxygen.
- The planet turns on its axis more slowly than Earth, and being farther from the Sun, takes longer to revolve around the Sun.
- A day on Mars is 24.6 hours and a year is 687 Earth days long.

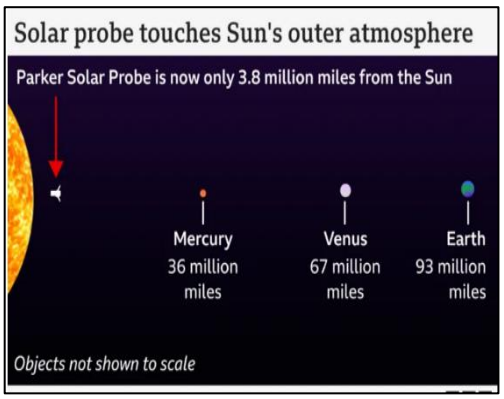
1.25 Parker Solar Probe

Recently, Parker Solar Probe made history by surviving the closest-ever approach to the Sun.

- **Launched in –** *2018*, by NASA.
- **Mission** – To "Touch the Sun".
- It is designed to fly *within about 4 million miles* (6.5 million kilometers) of the Sun's surface.

*It became the **1st spacecraft** to fly through the corona, the Sun's upper atmosphere in 2021.*

- **Aim** – To make observations of the ***outer corona of the Sun***.
- To *trace the energy flow*, to study magnetic fields, plasma, energetic particles, and to image the solar wind.
- **Movement** – It gradually circling closer towards the sun, using flybys of Venus to gravitationally pull it into a tighter orbit with the sun.
- Every orbit bringing it closer, the probe faces brutal heat and radiation.
- **4 Instruments**
  - Fields Experiment (FIELDS)
  - Integrated Science Investigation of the Sun (ISIS)
  - Wide Field Imager for Solar Probe (WISPR)
  - Solar Wind Electrons Alphas and Protons (SWEAP)
- **Thermal protector** – An 11.5cm thick carbon-composite shield protect from temperatures of nearly 2,500 degrees Fahrenheit.
- **Speed** – It moves *faster than any human-made object*, up to 430,000 mph.



- **Significance** – It flies more than 7 times closer to the Sun than any spacecraft and over 7 years, it will complete 24 orbits around the Sun.

OTHER SPACE AGENCIES

1.26 Chang'e 6

Recently, China launches lunar probe mission Chang'e 6.

- **Launched by** – China National Space Administration (CNSA).
- **Carried by** – Long March-5 Y8 rocket from Wenchang Space Launch Site, on the coast of southern island province of Hainan.
- **4 components** – An orbiter, a lander, an ascender and a re-entry module.

> ***Chang'e 6** is the 1st endeavour to collect and then return samples in the history of human lunar exploration.*

- **Mission** – It is tasked with collecting and then returning samples from the moon's far side to Earth.
- After collecting dust and rocks on the moon, the ascender will transport the samples to the lunar orbiter for transfer to the re-entry module, which will carry them back to Earth.
- The probe will carry out scientific exploration of the landing zone.
- **Key technologies** – Automatic sample collection, take-off and ascent from the far side of the moon.
- **International collaborations** – Scientific instruments from France, Italy and the European Space Agency/Sweden will be on board the lander and a Pakistani payload on the orbiter.

> *India became the 1st country in 2023 to land near lunar South Pole region with its Chandrayaan-3's lander, carrying the **Pragyaan rover** successfully landed there.*

Quick facts

- **Chang'e 4** – It landed in the Von Karman crater in the South Pole-Aitkin Basin in 2019 whose rover Yutu-2 became the 1st rover to successfully soft-land on the moon's far side.
- **Chang'e 5** – Its descender along with the lander landed on Mons Rumker, a vast volcanic plain on the moon.

1.27 ICUBE-Q

Pakistan in collaboration with China launched its first-ever lunar mission iCube-Qamar recently.

- It is a compact lunar cube *remote sensing satellite* that orbit the moon as part of Beijing's Chang'e-6 mission.
- **Developed by –** Pakistan's Institute of Space Technology (IST) in collaboration with Pakistan's national space agency SUPARCO, and China's Shanghai Jiao Tong University (SJTU).
- **Scientific instruments** – Two optical cameras designed to capture various images of the moon's surface.
- It will enable Pakistan to have its own satellite-based research imagery of the moon.
- **On-board Chang'e 6** – In 2022, the China National Space Administration (CNSA) invited member states via the Asia Pacific Space Cooperation Organization (APSCO) to include a student-built payload on the Chang'e 6 mission.
- Pakistan's ICUBE-Q was chosen for the above mentioned programme.

CubeSats

- They are diminutive satellites known for their compact dimensions and uniform design.
- **Basic design** – A 10 cm x 10 cm x 10 cm (which makes up for "one unit" or "1U") cube — just a little bigger than a Rubik's cube & weight not more than 1.33 kg.
- They are built in a cubic form, comprising modular components adhering to precise size limitations.
- **Features** – It typically weigh only a few kilograms and serve various purposes in space exploration, primarily aiding scientific research, technological advancement, and educational endeavours.
- Additionally, they support a broad spectrum of missions such as Earth observation, remote sensing, atmospheric studies, communication, astronomy, and technology testing.

1.28 Claude 3.5 Sonnet

Anthropic, U.S.-based artificial intelligence start-up has recently launched its latest AI model, Claude 3.5 Sonnet.

Feature	Claude 3.5 Sonnet	GPT-4	Gemini-1.5 Pro
About	It can independently write, edit, and execute code with sophisticated reasoning and troubleshooting capabilities.	GPT-4 is a type of deep learning model used for natural language processing and text generation.	Gemini 1.5 Pro can process text, images, audio and video.
Developer	Anthropic AI	OpenAI	Google
Core Model	Claude	GPT-4	Gemini-1.5
Text Generation Quality	High	High	High
Unique Strengths	Leading in creative content, superior performance in benchmarks, advanced conversational skills	Renowned for accuracy, reliability, and technical capabilities	Strong in integration, context understanding, and balanced performance across tasks.

1.29 Space Variable Objects Monitor (SVOM)

Recently, the Space Variable Objects Monitor spacecraft is launched from the Xichang Satellite Launch Center.

- The Space Variable Objects Monitor spacecraft is a combination of small telescopes.
- The primary objective of satellite is to look for ***gamma-ray bursts across the universe.***
- It is a ***1st astronomical satellite*** jointly developed by ***China and France.***
- **Carrier rocket-** It was placed in a ***low-Earth orbit*** by a Chinese Long March 2C carrier rocket.
- **Payload of SVOM-** It consists of 4 payloads, two developed by the France and two by the China.
    - **France-** ECLAIRs and MXT telescopes, which will detect and capture the GRBs.
    - **China-** The Gamma Ray Burst Monitor (GRB), measure the spectrum of GRBs and Visible Telescope (VT), will detect and observe visible emissions produced immediately after a GRB.
- The satellite will measure and study their electromagnetic radiation properties.

Gamma-ray bursts

- GRBs are bursts of highly energetic gamma rays, which last from less than a second to several minutes.
- They are known to occur in distant realms of the universe, and can erupt with a quintillion (a 10 followed by 18 zeros) times the luminosity of the Sun.
- There are two types of GRBs, short GRBs and long GRBs.
    - **Short GRBs-** Gamma-ray bursts (GRBs) with durations typically *less than 2 seconds.*
    - **Long GRBs-** Gamma-ray bursts (GRBs) with durations typically greater than 2 seconds, often lasting up to several minutes.

1.30 Moonlight program

Moonlight Lunar Communications and Navigation Services (LCNS) program was launched recently.

- **Launched by** - *The European Space Agency (ESA).*
- It is the ***Europe's first-ever dedicated satellite constellation*** for telecommunication and navigation services for the Moon.
- **Aim -** To offer coverage at the Moon's South Pole, an area suitable for future operations.
- **Partnership project between**
    - ESA and an industry consortium led by space systems developer Telespazio, with support from the UK and Italian Space Agencies.

- **Features -** It will have a constellation of about 5 lunar satellites (1 for high data rate communications and 4 for navigation) that allow accurate autonomous landings, high-speed communication, and surface mobility.
- These satellites will reportedly enable data transfer over 4,00,000 kilometres between the Earth and the Moon.
- The first step will be the *launch of Lunar Pathfinder*, a communications relay satellite built by Surrey Satellite Technology LTD, in 2026.
- The initial services of the programme will reportedly begin by the end of 2028, and the system is said to be fully operational by 2030.
- Moonlight will comply with LunaNet's standards and undergo the first-ever lunar navigation interoperability tests, scheduled for 2029.

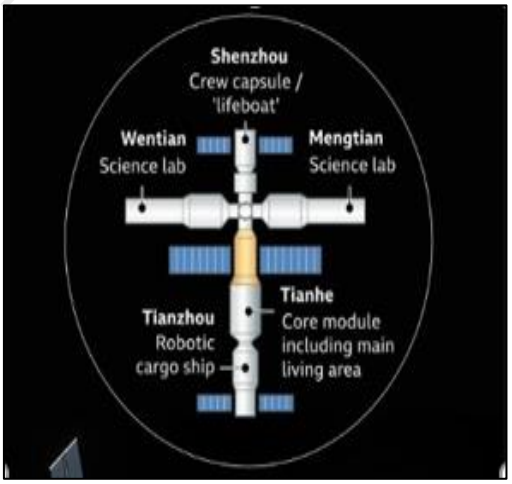
*The ESA is working with NASA and the Japanese space Agency JAXA on **LunaNet,** which is essentially a framework to standardise communication and navigation for the Moon.*

1.31 Shenzhou-19

A Chinese spaceship, Shenzhou-19 carrying a 3-person crew docked with its orbiting space station recently.

- It is a ***Chinese spacecraft*** carrying a 3-member crew to the ***Tiangong space station.***
- **Aim -** To focus on scientific research, technological innovation, and crew safety.
- It was China's 14th crewed spaceflight and the 19th flight of the Shenzhou program.
- **Agency -** China Manned Space Agency.
- **Areas of study** - Space life science, microgravity physics, and space material science.
- **Launching Rocket** - It is launched using Long March-2F rocket.
- **Orbit** - Low-Earth orbit.
- **Duration** – The crew remained on the station until April or May 2025.

*China launched its first crewed mission in 2003, becoming only the **3rd** nation to do so after the former Soviet Union and the United States.*



Tiangong space station

- It is a *permanently crewed space station in T-shape* constructed by China and operated by China Manned Space Agency.
- It is the ***first space station of China***.
- It is expected to be operational until 2028.
- It is a 3-module space station in low-Earth orbit.
    - The core module Tianhe launched in April 2021, followed by the Wentian and Mengtian experiment modules in 2022.
- The station typically hosts 3 astronauts at a time for six-month stays. It can support 6 astronauts at a time during crew handovers.
- It is significantly smaller and lighter compared to International Space Station (ISS).

ISS is a large space station assembled and maintained in low Earth orbit by 5 space agencies and their contractors - NASA (United States), Roscosmos (Russia), JAXA (Japan), ESA (Europe), and CSA (Canada).

1.32 Lignosat

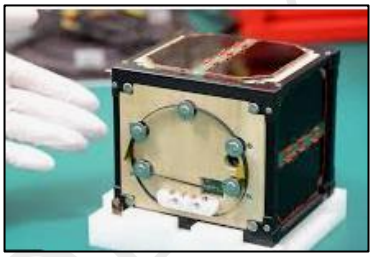
Recently, the world's first wood-panelled satellite was launched into space by the Japanese spacecraft.

- **Aim -** To test the durability of wood in extreme temperatures.
- To test the reliability of timber as a renewable building material for future space travel.
- **Developed by -** Kyoto University and logging firm Sumitomo Forestry.
- **Duration -** It will be released into orbit above the Earth, and will remain in orbit for six months.

- **Properties** - It is a small, palm-sized satellite, measures just 4 inches (10 centimeters) on each side, and weighs 900 grams.
- It is made from ***Honoki Wood***, a type of magnolia tree native to Japan.
- It is *not entirely made of wood*
- Aluminium structures and electronic components are also used in a wood panel casing.

> ***Magnolia wood*** *is a highly sought-after timber, known for its striking colouration and fine grain.*

- **Launched by -** Space X's Falcon 9 Block 5 rocket.
- **Tests to be conducted**
  - Durability of wood in the extreme environment of space where temperatures fluctuate from 100 to 100 degrees Celsius every 45 minutes.
  - Timber's ability to reduce the impact of space radiation on semiconductors.
  - Changes in the wood's structure, integrity, and resilience.



- **Benefits of Wooden Satellite** - Wood is more durable in space than on Earth because there's no water or oxygen that would rot or inflame it.
- It is a renewable solution for a long-term and it wouldn't introduce any damaging pollutants like aluminum oxides into the atmosphere when it falls back to Earth.
- It will be minimising the risk to active satellites, space stations, and astronauts.

PRIVATE SECTOR IN SPACE

1.33 Steps taken by India to support private sector in space

- **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.
- 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.

Agnibaan

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

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** - It laid down the regulations of privatizing space missions, and denoted clear guidelines of operations for NSIL, ISRO's commercial arm ANTRIX and IN-SPACe.

2. PLANETARY SYSTEMS

2.1 Cosmic Glitch

A group of researchers from Canada have discovered a potential "cosmic glitch" in the universe's gravity, explaining its strange behaviour on a cosmic scale.

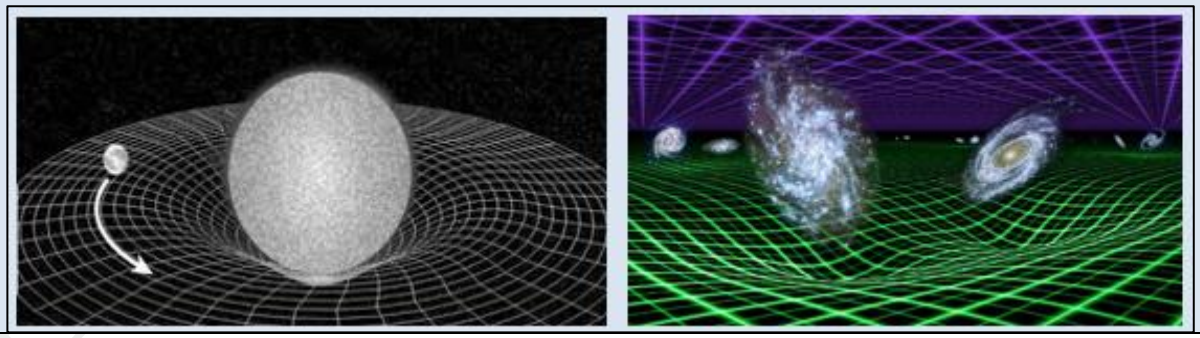
- **Challenges** – The theory of gravity, general relativity still has inconsistencies when it comes to calculating its effect on vast distances.
- **Cosmic glitch** – It is the apparent *inconsistencies* that occur *with the predictions of general relativity* in understanding gravity on a cosmic scale, *at the scale of galaxy cluster and beyond*.
- The ***gravity becomes around 1% weaker*** when dealing with distances in the billions of light years.

*The **Particle horizon or superhorizon** is the maximum distance light could have travelled since the origin of the universe.*

- **Cosmic glitch model** – It modifies and extends Einstein's mathematical formulas by adding a single extension to the standard cosmological model.
- This model is known as the *lambda cold dark matter model*.
- This should clear up inconsistencies in measurements at cosmological scales without affecting the existing successful uses of general relativity.

Albert Einstein's Theory of Gravity & General Relativity

- **Theory** – It posited that gravity arises from the curvature of the very fabric of space and time, united as a single entity called "spacetime."
- This curvature is said to have been shaped by objects with mass.
- It also suggests that gravity impacts not simply 3 physical dimensions but also a 4th dimension: time.
- **Curved Spacetime** - When a smaller mass passes near a larger mass, it curves toward the larger mass because spacetime itself is curved toward the larger mass.
- The smaller mass follows the structure of curved spacetime near the larger mass.
- Moons have less mass than planets, planets less than stars, and stars less than galaxies — thus, the gravitational influences of these celestial bodies increases respectively.
- **Significance** – It has been essential in theorizing the Big Bang, the existence of black holes, the gravitational lensing of light and tiny ripples in spacetime called gravitational waves.



2.2 55 Cancri e

Astronomers finally detect a rocky planet with an atmosphere based on infrared measurements done by James Webb Space Telescope.

- **55 Cancri e** – It is an *exoplanet*, also called *Janssen*.
- **Location** – It is located in our Milky Way galaxy about 41 light-years from Earth, in the constellation Cancer.

***A light year** is the distance light travels in a year, 5.9 trillion miles (9.5 trillion km).*

- **Features** – It *orbits its star* at one-25th the distance between our solar system's innermost planet Mercury and the sun.
- Thus, its surface temperature is about *3,140 degrees Fahrenheit* (1,725 degrees Celsius/2,000 degrees Kelvin).

- Its star is dimmer and slightly less massive than our sun, and it can rapidly complete *an orbit every 18 hours.*
- **A Super earth** – It is *about 8.8 times more massive* than Earth, with a diameter about twice that of Earth but smaller than Neptune.
- It has an atmosphere but the current observations *cannot pinpoint the exact composition and its thickness*.
- It is likely rich in carbon dioxide or carbon monoxide, but can also have other gases such as water vapour and sulphur dioxide.
- Being so close to its star, any atmosphere should be stripped away by stellar irradiation and winds but gases dissolved in the vast lava ocean thought to cover the planet replenish their atmosphere.

On Earth, the atmosphere warms the planet, contains the oxygen people breathe, protects against solar radiation and creates the pressure needed for liquid water to remain on the planet's surface.

- **No habitability** – It is apparently with a *surface of molten rock* and also *too hot to have liquid water*.
- **Significance** – All of the previous exoplanets found to have atmospheres were gaseous planets, not rocky ones.

2.3 Craters on Mars

Recently, scientists at the Physical Research Laboratory (PRL) discovered 3 craters on Mars.

- The 3 craters situated in the ***Tharsis volcanic region*** have been named for
  - Renowned cosmic ray physicist late Devendra Lal
  - The towns of Mursan, Uttar Pradesh and
  - Hilsa, Bihar.
- The naming is approved by ***International Astronomical Union (IAU)***.

Tharsis *is a vast volcanic plateau centered near the equator in the western hemisphere of Mars. The region is home to the largest volcanoes in the Solar System.*

- The discovery was made within the Mangala crater of Mars using ***SHARAD (Mars SHAllow RADar sounder)***.
- The discovery of the craters provided compelling evidence that water moved large volumes of sediment into the newly discovered Lal crater.
- It also confirmed that Mars was once wet and water has flown on its surface.

SHARAD *is a subsurface sounding radar mounted on the Mars Reconnaissance Orbiter (MRO) probe.*

- **Lal crater –** It is the biggest among the 3 craters, entire area is covered with lava.
- **Mursan crater-** It is superimposed on the ***eastern side*** of the rim of the Lal crater.
- **Hilsa crater-** It is superimposed on the ***western side*** of the rim of the Lal crater.

International Astronomical Union (IAU)

- The IAU is an apex governing international professional astronomical activities worldwide.
- **Established-** 1919.
- **Headquarters-** Paris, France.
- **Objective-** To promote and safeguard astronomy in all its aspects (including research, communication, education and development) through international cooperation.
- **Member-** 92 countries, ***India is a member*** of the International Astronomical Union.

2.4 Gigantic jets

Gigantic jets were recently witnessed over the Himalayan Mountains by National Aeronautics and Space Administration (NASA).

- Gigantic jets are a ***rare and powerful type of lightning*** that can extend from the top of a cloud to the edge of space.

- They are relatively a recent discovery in the field of atmospheric phenomena, having been documented only in the 21st century.
- It is different from regular cloud-to-cloud and cloud-to-ground lightning.
- The bottoms of Gigantic Jets look similar to blue jets, while the tops look similar to red sprites.
- It occurs between some thunderstorms and the Earth's ionosphere high above them.
- It pack ***50 times*** the power of a regular lightning strike and can travel as high as 80 kilometres above the Earth's surface.
- Unlike familiar cloud-to-cloud and cloud-to-ground lightning, gigantic jets bridge the gap between thunderstorms and the Earth's ionosphere, soaring high above the storm clouds.

2.5 Quarks

Scientists have reported that the insides of most massive neutron stars is most likely made of an unusual state of matter called quark matter.

- **Background** – All atoms are made of protons and neutrons inside the nucleus and electrons outside.
- Unlike electrons, *protons and neutrons are composite particles* because they are further *made up of quarks*.
- **Quarks** – They are called *strongly interacting particles* because they are bound by the strong force.
- **Properties** – They *can't exist in isolation*, even in the vacuum of empty space and can only be found in groups, such clumps of quarks are called ***hadrons.***
- Clumps can of heavier quarks or lighter quarks like in protons and neutrons.
- As 3-quark clumps are more likely to form than 2-quark clumps, the consolidation of quarks is dependent of the particle environment.
- **6 types** – Up, down, top, bottom, strange, and charm and each quark can have one of 3 types of colour charge.
- **Antiquarks** – It is an antimatter versions.
- **Meson** – It is a quark-antiquark clump.
- **Baryons** – They are 3-quark clumps.
- **Gluons** – A set of particles that also held quarks together.
- **Quantum chromodynamics** – A theory that explains how the nuclear force holds quarks together.
- When lead ions were smashed against each other at very high energies, a state of matter called a *quark-gluon plasma* exists for a brief moment, suggest that the quarks are independent.

Large Hadron Collider (LHC) is the world's largest science experiment.

*According to the **Big Bang theory**, the universe was filled with this plasma before the particles clumped and formed the first blobs of matter.*

Life of a Star

- **The force of gravity** – It arises from the star's mass, encourages the star to collapse under its own weight and implode.
- **The nuclear force** – It is released by fusion reactions at its core, pushes the star to blow up and outwards.
- **Star shines** - Normally, these 2 forces are equally matched.
- **Death of a star** – Once a star runs out of material to fuse, nuclear fusion weakens and gravity starts to gain the upper hand thus the star will 'die' and implode.
- **Afterlife of a star** – Depending on its size when it lived, it becomes a white dwarf, a neutron star or a black hole.
- **Neutron stars** – It will fuse all protons and electrons inside into neutrons, thus its name.
- A research suggest that insides of most massive neutron stars have an 80-90% chance of being made of quark matter.

2.6 Blaze Star

NASA predicts that the Blaze Star will become visible to the naked eye by September 2024.

- It is officially named as ***T Coronae Borealis (T CrB***), is actually ***2 stars binary system***.
- **Binary system**
  - **A white dwarf** – An Earth-sized remnant of a dead star with a mass comparable to that of our Sun.
  - **An ancient red giant** – It is being stripped of hydrogen by the relentless gravitational pull of its hungry neighbour.
- **Located in** – The Constellation *Corona Borealis, the "Northern Crown,"* between the constellations of Boötes and Hercules.
- It is 3,000 light-years away from our solar system.
- **Magnitude -** +10 (beyond naked-eye visibility) to magnitude +2 (visible).

T Coronae Borealis (T CrB) *will be visible for the 1st time in 2024 since 1946 due to possible eruptions. It will be as bright as Polaris, the North Star, the 48th-brightest star in the night sky.*

- **Reason for eruption** - The hydrogen from the red giant accretes on the surface of the white dwarf, building up of pressure and heat.
- Eventually, it triggers a *thermonuclear explosion* big enough to blast away that accreted material.
- This event appears to reoccur, on average, ***every 80 years***
- **Significance** – The Blaze Star is a rare example of a recurrent nova, which means "new star" in Latin.

T Coronae Borealis (T CrB) have erupted previously in the years 1946 and 1866, with earlier documented observations dating ack to 1787 and 1217.

2.7 Asteroid 2011 UL21

Mountain-sized asteroid, 2011 UL21 made a close approach to Earth recently.

- It is a ***giant space rock*** first discovered in 2011 and orbits the sun every ***3 years.***
- It is larger than 99% of known near-Earth asteroids.
- It is dubbed as the ***Planet Killer*** and one of the closest asteroids to approach the Earth.
- The asteroid is estimated to have a diameter of 2.5 kilometres.
- The asteroid is also one of the brightest, as it has an absolute magnitude of 15.8.
- Despite its size, it poses no threat and not projected to collide with Earth.

Near Earth Objects (NEO)

- It is an *asteroid or comet* that orbits the sun and passes close to Earth's orbit.
- NEOs are nudged into their orbits by the gravitational pull of nearby planets.
- Technically, a NEO is defined as having a trajectory that brings it within 1.3 astronomical units of the sun, and therefore within 0.3 astronomical units, or about 45 million kilometers, of Earth's orbit.
- NEOs that cross Earth's path are categorized as
  - **Atens** - Have a semimajor axis smaller than Earth's orbit around the sun.
  - **Apollos** - Have a semimajor axis larger than Earth's orbit.
- Asteroids as small as 20 meters in diameter can cause significant damage to the local environment and human populations.
- Larger asteroids can penetrate Earth's atmosphere and surface, creating craters or tsunamis depending on where they land.
- NEOs that are larger than 140 meters across and cross Earth's orbit are considered potentially hazardous objects (PHOs).

2.8 Astrophysical jets

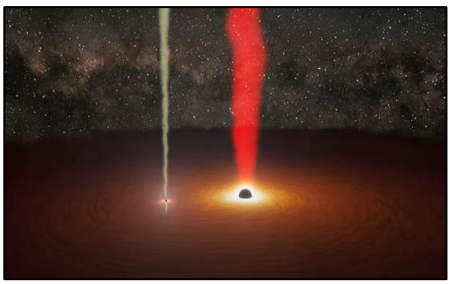
Recently, a team of scientists have traced the effect of plasma composition on dynamics of astrophysical jets from celestial bodies.

- It is an astronomical phenomenon where ***outflows of ionised matter are emitted*** as extended beams along the axis of rotation.
- **Formation-** They are believed to form due to complex interactions involving ***magnetic fields and the accretion disks*** around compact objects.
- **Composition-** It consist of *charged particles (plasma),* which can include electrons, protons, and other atomic nuclei.
- These particles are accelerated to *relativistic speeds, approaching the speed of light.*
- **Velocity-** Jets associated with stars are composed of ***ionized gas*** moving away from the star with velocities of a few hundred kilometres per second.
- **Recent findings-** Scientists have studied how the plasma composition of astrophysical jets are streams of ionized matter from celestial objects like ***black holes, neutron stars, and pulsars*** affects their behaviour.
- The study demonstrated that altering plasma composition affects jet propagation ***velocities, despite identical initial parameters.***

2.9 OJ 287 and Black Hole Pairs

A recent study has spotted the smaller black hole in a pair, marking the first confirmed sighting of an orbiting black hole.

- **OJ 287** – It is a distant galaxy, four billion light years away.
- **Black holes in OJ 287** – NASA's TESS satellite have confirmed the theory that there are *two black holes at the centre of OJ 287*.
- Researchers have found indirect evidence that a very *massive black hole in OJ 287 is orbiting a giant black hole* 100 times its size.
- **Discovery** - TESS monitored the brightness of the primary black hole and the jet associated with it.
- **Observation of black hole orbiting another** - Direct observation of the smaller black hole orbiting the larger one is very difficult, but its presence was revealed *by a sudden burst of brightness.*
- **Fast burst of brightness** - It occurs *when the smaller black hole "swallows" a large slice of the accretion disk* surrounding the larger black hole, turning it into an outward jet of gas.
- The jet of the *smaller black hole is then brighter than that of the larger* black hole for about twelve hours.
- **Color changes** – This event *makes the colour of OJ287 less reddish, or "yellow"*, instead of the normal red and after the burst, the red colour returns.
- The "yellow" colour indicates that for the 12-hour period, we are seeing the light from the smaller black hole.



Both black holes have jets associated with them, the larger one with reddish colour, and the smaller one with a yellowish colour jet.

Transiting Exoplanet Survey Satellite (TESS)

- **TESS** – It is an Astrophysics Explorer mission.
- **Launched by**- NASA, led and operated by MIT in Cambridge and Massachusetts.
- **Aim**- To discover thousands of exoplanets orbit around the brightest dwarf stars in the sky.
- **Findings** – It is finding planets ranging from small, rocky worlds to giant planets, showcasing the diversity of planets in our galaxy.
- **Significance**- It has so far found 410 confirmed exoplanets or new worlds circling stars other than the Sun.

2.10 Asteroid 2011 MW1

Recently, NASA predicted that a large asteroid, 2011 MW1, made a close approach to Earth.

- It is as an ***Apollo-class asteroid*** due to its orbit intersecting Earth's path.
- It is classified as a ***Near Earth Asteroid (NEA)***, a term for celestial bodies that pass relatively close to our planet.**Measurement**- 380 feet in diameter.
- **Speed**- 28,946 kilometres per hour.
- **Passage**- The asteroid will pass within 2.4 million miles of Earth, a distance considered safe.
- **Non-Hazardous**- It does not meet the criteria for being labeled a Potentially Hazardous Asteroid.
- **Significance**- These celestial bodies provide valuable insights into the conditions and processes that shaped our solar system billions of years ago.

*NASA's **Center for Near Earth Object Studies (CNEOS)** is responsible for characterizing the orbits of all Near Earth Objects.*

***Apollo asteroids** are a category of near-Earth asteroids named after 1862 Apollo, the first discovered by German astronomer Karl Reinmuth.*

Asteroids larger than 140 metres and within 4.6 million miles of Earth's orbit are considered potentially hazardous.

Asteroids

- They are often called minor planets.
- These are relatively small, inactive bodies orbiting the Sun.
- Asteroids are remnants of the early solar system and provide invaluable scientific information about the conditions that existed billions of years ago.
- They are typically composed of rocky, dusty, and metallic materials.
- Most of them reside in the asteroid belt between Mars and Jupiter.
- To date, scientists have identified over 1.3million of these space rocks.

2.11 Planetary Protection

Planetary protection ensures that Earth and other celestial bodies are shielded from cross-contamination by microbial life during space missions.

- It is the principle of *preserving the biospheres* of both Earth and other planetary bodies from contamination by microbial life during space missions.
- **Planetary Protection Policy** – It's an important principle of interplanetary missions, such as from the earth to the moon or Mars.
- It has been formulated by various agencies
  - The Committee on Space Research (COSPAR)
  - Committee of the International Science Council (ISC)
- This principle is grounded in ***Article IX*** of the ***Outer Space Treaty (1967)***.
- **Compliance-** The spacecraft are sterilized by assembling them fully and baking them in a dry room ***at 120°C for 3 days*** to prevent contamination.
- **Applications-** ***NASA's Viking 1*** (the 1st spacecraft to land on Mars in 1976) and China's upcoming ***Tianwen-3 Mars*** sample-return mission (planned for 2028).

Outer Space Treaty

- It is formally the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.
- It is a ***multilateral treaty*** that forms the basis of international space law in 1967.
- **Adopted by** - *United Nations General Assembly* in 1966

Outer Space Treaty	
Adopted in	1966
Members	As of June 2024, 115 nations ratified 23 countries have signed but yet to ratify it.
India	Signed in **1967** and ratified it in 1982.

- **Entered into force in** - 1967.
- **Establishes rules** – For the peaceful use of space & prohibits the stationing of weapons of mass destruction in space.
- It also defines the rights of nations to the moon and other celestial bodies.
- **Peaceful use -** The treaty establishes legally binding rules for the peaceful exploration and use of space.
- **No weapons of mass destruction** - It prohibits the stationing of weapons of mass destruction in space.
- **No military activities** - The treaty prohibits military activities on celestial bodies.
- **Free exploration** - The treaty declares that space is an area for free use and exploration by all.
- **Sharing of knowledge** - The treaty enshrines the principle of sharing scientific findings and knowledge.

2.12 Asteroid/ Mini-moon 2024 PT5

The Earth is about to have a temporary Asteroid or mini-moon named 2024 PT5.

***Mini moons** are temporary satellites that are difficult to detect due to their small size and speed, often being mistaken for space debris. However, astronomers are confident that 2024 PT5 is a natural object.*

- **Discovered by –** The ***Asteroid Terrestrial-impact Last Alert System (ATLAS)*** in 2024.
- **Size** – It is a *small asteroid*, about ***33 feet*** in size, due to this size it is only be visible through special telescopes.
- **Revolution** – It will be captured temporarily by Earth's gravity but it will only make a half-revolution in a ***horseshoe-shaped orbit*** around Earth.
- It will stay in Earth's orbit for about 56 days, from September 29 to November 25, before continuing its journey.
- It is rare for an asteroid to be temporarily captured by Earth's gravity without burning up or missing Earth.

*An **asteroid** is a small rocky body that orbits the Sun, primarily found in the asteroid belt between Mars and Jupiter.*

2.13 Saturn-like ring on Earth

A study suggested that earth may have once had a Saturn-like ring formed from the debris of a destroyed asteroid around 466 million years ago.

- The ring persisted for tens of millions of years during the ***Ordovician period.***
- **Formation** – When an asteroid passed too close to Earth, was stretched by its gravity to the point it broke down into lots of small and large pieces.
- These pieces jostled around and gradually evolved into a ***debris-laden ring*** orbiting Earth's equator.
- **Transformation** - Over time, the material from the ring was pulled towards Earth, once again courtesy gravity.
- While most of the smaller pieces would have been burnt up in the planet's atmosphere, the larger pieces would have formed impact craters on Earth surface, close to the equator.
- Analysis of 21 crater sites dated to between 488 million and 443 million years ago to the Ordovician period, found that the impacts all occurred close to the equator.
- **Earth's ancient ring** – It may have contributed to significant climate changes.

*The **Ordovician period** was a geologic period that occurred between 485.4 and 443.8 million years ago.*

Impact of Ring on Earth

- A ring over Earth's equator would have had a profound impact on the planet.
- **Giant Parasol**- It would *shade both the hemispheres during winter* while slightly increasing solar flux, amount of solar energy to reach Earth during the summer period.

- It could accentuate winter cooling while slightly increasing summer heating.
- Overall, scientists theorise that a ring would lead to *global cooling* by effectively acting as a giant parasol.
- **Dramatic Cooling** - The period in which the ring existed Earth did witness dramatic cooling.
- By 445 million years ago Earth was seeing the peak of the Hirnantian Ice Age, the coldest period in the past half a billion years.

2.14 Palomar 5

Astrophysicists suggests in a recent study that a stellar cluster known as Palomar 5 may harbor a hidden swarm of over 100 stellar-mass black holes.

- **A globular cluster**- It is a dense and spherical, containing between 100,000 and 1 million ancient stars.
- These clusters are often regarded as '*fossils' from the early Universe*.
- **Discovered by-** Walter Baade in 1950 and independently by Albert George Wilson in 1955.
- **Age-** It is estimated to be around 11.5 billion years old.
- **Location**- It is located in the *constellation Serpens*, about 65,000 light-years from Earth.
- **2 Tidal tails-** They stretch across more than 20 degrees of the sky and they contain more mass than the cluster itself that's shows evidence of stellar density gaps and clumps.
- **Black holes**-It has *more than 100 black holes*, which is about three times more than expected for a globular cluster. Each black hole has a mass of about 20 times the mass of the sun.
- **Density** –It has a relatively low mass and density among the lowest of all globular clusters in the Milky Way.
- **Disruption** - It is being disrupted by the Milky Way's gravity, and many stars are leaving the cluster in the form of a *stellar stream*.
- Recent study reveals that it will dissolve in approximately 1 billion years, leaving behind a trail of black holes orbiting the Milky Way's center.

Globular clusters

- They are associated with all types of galaxies and are much larger than open clusters.
- They are far more densely populated, with populations ranging from tens of thousands to millions of stars.
- They are populated by older, redder stars than open clusters (which might disperse before their stars can become really old).
- The intense gravitational attraction between the closely packed stars gives globular clusters their regular, spherical shape and also makes them very stable.
- Thus, they can be extremely long-lived, surviving to be billions of years old.

2.15 Sun's chromosphere

Astronomers from the Indian Institute of Astrophysics (IIA), have mapped the variation in the rotation speed of the Sun's chromosphere using 100 years of daily records at the Kodaikanal Solar Observatory.

Sun's Atmosphere

- Sun is a ball of gas with no solid form, different regions rotate at different rates.
- The sun's equatorial regions rotate in about 24 days, while the Polar Regions take more than 30 days to make a complete rotation.
- It is made up of several layers, mainly the photosphere, the chromosphere and the corona.
- **Photosphere**–It means "sphere of light", the layer where most of the sun's energy is emitted.
- **Chromosphere –** The layer above the photosphere is the chromosphere.
- **Corona** - The 3rdlayer of the sun's atmosphere is the corona.

- Like the chromosphere, it can only be seen during a total solar eclipse (or with NASA's Solar Dynamics Observatory).

- **Chromosphere -** The word "chromo" means color, thus chromosphere means sphere of color.
- It contains both hydrogen and calcium. The chromosphere has several important features, such as spicules, filaments, and other anomalies.
- The chromosphere emits a reddish glow as ***super-heated hydrogen*** burns off. But the red rim can only be seen during a total solar eclipse.
- At other times, light from the chromosphere is usually too weak to be seen against the brighter photosphere.
- **Temperature**
    - Minimum – around 6700 degrees Farenheit or 3700 degree Celsius.
    - Maximum – 14,000 degrees Farenheit or 7760 degree Celsius.
- The chromosphere play a role in conducting heat from the interior of the sun to its outermost layer, the corona.
- **Recent Findings –**It revealed a picture of the Sun's differential rotation faster at the equator (13.98 degrees per day) and slower towards the poles (10.5 degrees per day at 80 degrees latitude).

2.16 Earth's Future after Red Giant Phase of Sun

The recent discovery of earth like planet orbiting a white dwarf is giving a sneak peek at the future of the Solar System, and the fate of Earth.

- **Rocky planet** – It comes in at *around 1.9 times the mass of Earth*, orbiting its star at around twice Earth's distance from the Sun.
- The star is a white dwarf which means any life that might have been on the exoplanet was probably obliterated before or during the star's red giant death throes.
- White dwarf began as an ordinary star *1 or 2 times the mass of the sun* and its current mass is about half the sun.
- Before its host star's death, it orbited at a distance, possibly placing it in the habitable zone.
- Following its star's demise, it is at *2.1 times that distance*.
- **Current state** - It's *currently a freezing world* because the white dwarf, which is in fact smaller than the planet, is extremely faint compared to when it was a normal star.
- **Significance of the finding** – It offers insight into Earth's potential survival after sun's death.

Red Giant Phase of Sun

- The sun, roughly four and a half billion years old, is destined to become a white dwarf.
- **Red Giant phase** – It is the ***end of our sun's life*** when it will puff up to enormous size.
- It is estimated to occur 7 billion years from now and will become a white dwarf a billion years after that.
- It gently *blows off its outer layers in a wind*.
- As our sun loses mass, the planets' orbits will expand to larger sizes.
- Eventually, the s*tar will eject its outer material completely*, and the core will collapse under gravity to form a dense object whose bright light not generated by fusion, but the residual heat of its collapse process.
- That h*ot core is the white dwarf,* and it will take trillions of years to cool to complete darkness.

- Research shows that this planet very likely had a similar orbit to Earth before its host star became a red giant.
- It implies that *Earth's chances for survival may be higher* than currently thought.

2.17 White Dwarf

A recent study using Hawaii-based telescopes, found the 1st rocky planet that is orbiting the white dwarf about 4,200 light years away from our solar system near the bulge at the center of the Milky Way galaxy.

- **White Dwarf** – It is the *stellar core left behind after a dying star* has exhausted its nuclear fuel and expelled its outer layers to form a planetary nebula.
- It is the last observable stage of evolution for low- and medium-mass stars.
- **Conditions for formation** – Stars with a ***mass less than 8 times the sun.***
- **Formation** – It is formed when a low-mass star like our sun *exhausts most of its nuclear fuel*.
- **Composition** - Compared to our sun, it has a *similar carbon and oxygen mass* though it is much smaller in size.
- **Features** - It is about as massive as the Sun, yet only slightly bigger than the Earth.
- It is *one of the densest forms* of matter, surpassed only by neutron stars and black holes.
- **Temperatures** - It can *exceed 100,000 Kelvin* according to NASA.
- They no longer support nuclear fusion reactions that generate energy, but they are still extremely hot.
- **Luminosity** - Despite having too high a temperature, they have a ***low luminosity*** as they're so small in size.
- It luminosity can be used by astronomers to measure how long ago star formation began in a particular region.

*Stars having a larger mass may end their lives as **black holes or neutron stars.***

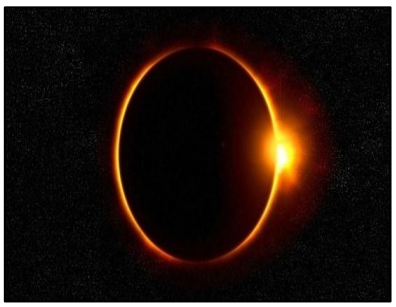
*White Dwarfs cool over time, and it is predicted that they would ultimately form **'black dwarfs'**, although the Universe is likely not old enough for any black dwarfs to exist yet.*

***Hubble** was the 1st telescope to directly observe white dwarfs in globular star clusters in 2003, which astronomers reported as the dimmest stars ever seen in a globular star cluster.*

2.18 Solar Eclipse

The recent annual solar eclipse created a rare ring of fire phenomenon visible in parts of South America because the Moon is farther from the Earth than usual.

- It occurs when the ***moon is positioned between Earth and the sun*** and casts a shadow over Earth.
- It is witnessed only during the new moon when the Moon and Sun are aligned on the same side of Earth where a new moon occurs about 29.5 days because that is how long it takes the Moon to orbit Earth.
- This, however, does not mean that a solar eclipse happens every month.
- **Frequency** – It takes place ***only between two to five times annually***.
- It is because the Moon does not orbit Earth in the same plane as the Earth orbits the Sun.
- In fact, the Moon is tilted by about five degrees with respect to Earth.
- As a result, most of the time when the Moon is in between the Sun and Earth, its shadow is either too high or too low to fall on the Earth.
- **Types of solar eclipse** - Depends on how the sun, moon and Earth are aligned at the time of the event
- **Total solar eclipse -** The sun is fully obscured by the moon.
- **Partial solar eclipse -** The moon doesn't fully block the sun so only a portion of the sun is obscured.
    - Here the moon appears to take a "bite" out of the sun and it is the most common type of solar eclipse.
- **Annular solar eclipse -** The moon is centered in front of the sun but doesn't cover the entirety of the surface (as seen in a total solar eclipse). A *"ring of fire" shines around the moon*.
- **Hybrid solar eclipse -** The rarest solar eclipse is a combination of a total and annular eclipse (sometimes known as an A-T eclipse) and is produced when the moon's shadow moves across Earth.
- These begin as one type of eclipse and transition to another.



***A "ring of fire"** occurs when the Moon lines up between the Sun and the Earth to create a solar eclipse but does not block out the Sun's light entirely.*

2.19 C/2023 A3 (Tsuchinshan–Atlas)

C/2023 A3 (Tsuchinshan–Atlas) reached its closest approach to the Sun (perihelion) becoming increasingly visible to observers on Earth recently.

- The comet is currently between the orbits of *Jupiter and Saturn.*
- It is approximately 129.6 million kilometres away from Earth and is currently located in the *Sextans constellation.*
- It is thought to orbit the sun about every 80,000 years on a highly elongated path.
- **Discovered by** - Purple Mountain Observatory; ATLAS South Africa.
- **Discovered** - 9 January 2023.
- It is a *non-periodic* comet. Unlike more familiar comets, such as Halley's Comet, this one is unpredictable in its appearance.

Asteroid Terrestrial-impact Last Alert System (ATLAS)

- ATLAS is a NASA-funded early warning system.
- **Developed by** - The University of Hawaii.
- It consists of 4 telescopes located in Hawaii and Chile.
- It is designed to detect smaller near-Earth objects days to weeks before they potentially impact Earth.
- ATLAS can survey the entire dark sky every 24 hours, making it a crucial tool for monitoring and tracking potential asteroid threats.

2.20 Charon

Researchers recently discovered Carbon dioxide, hydrogen peroxide on Pluto's largest moon 'Charon'.

- Charon is the ***largest of the 5 known moons of Pluto***.
- **Discovered by** - Charon was discovered in June 1978 by James Christy and Robert Harrington at the U.S. Naval Observatory in Flagstaff, Arizona.
- This moon is remarkably similar to Pluto, earning it the nickname ***"Pluto's smaller twin."***
- **Size -** Half the size of Pluto, Charon is the largest known satellite relative to its parent body.
- The same surfaces of Charon and Pluto always face each other, a phenomenon called ***mutual tidal locking.***
- **Orbit -** It's orbit around Pluto takes 6.4 Earth days, and one Pluto rotation (a Pluto day) takes 6.4 Earth days.
- It neither rises nor sets, but hovers over the same spot on Pluto's surface, and the same side of Charon always faces Pluto.
- It is tipped on its side, like Uranus.
- **Rotation -** Pluto's rotation is retrograde - it rotates backward, from east to west (Uranus and Venus also have retrograde rotations).
- **Possibility of life** - Being extremely cold, there's practically no chance for life to exist on Pluto and water, essential for life, is present as ice.

Recent Findings

- Hydrogen peroxide forms when ice is broken down by charged particles, releasing hydrogen and oxygen atoms that combine.
- The presence of the chemical suggests Charon's icy surface is altered by ultra-violet light and solar wind from the distant Sun.
- It sheds new light on Charon's composition and chemical processes, offering valuable insights into the Pluto system's mysterious and icy landscape.

Pluto

- It is the largest known dwarf planet in the solar system.
- Pluto was discovered in 1930 by astronomer Clyde Tombaugh.
- Pluto, once hailed as the ninth and final planet in our Solar System, underwent a reclassification in 2006.
- The International Astronomical Union (IAU) convened to establish a formal definition of a planet, resulting in Pluto's demotion to dwarf planet status.

2.21 Asteroids as Foods

A study published in The International Journal of Astrobiology suggests that astronauts could use asteroids to meet their nutritional needs.

> ***Asteroids** are remnants of planetary formation and they circle the Sun in a zone lying between Mars and Jupiter. The circular chain of asteroids is called the asteroid belt.*

> ***Pyrolysis** uses heat to break down combustible materials in the absence of oxygen, producing a mixture of combustible gases, liquids and solid residues.*

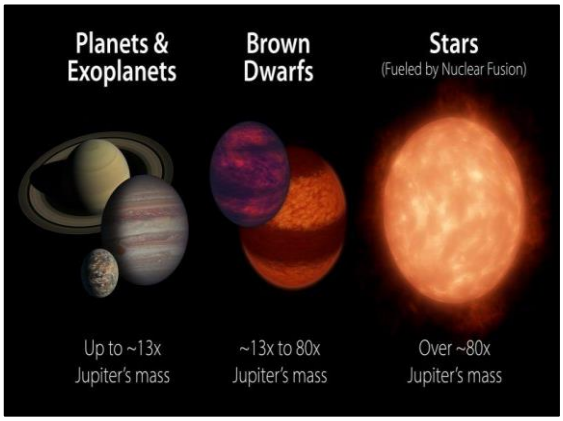
- **Concept** - The idea is to extract and convert the carbon from space rocks into something edible.
- **Principle** – *Asteroids share similarities with plastics* regarding how microbes interact with them.
- **Conversion of plastic into food** - Plastic wastes are broken down into solid, gas and oil through the process of *pyrolysis*.
- The *oil is then fed to bacteria* in a bioreactor, producing a nutritious biomass.
- **Microbes in meteorite** – It was observed that microbes thrived on the meteorite material.
- **Significance** – It addresses the limitations of the amount of dried food astronauts can carry.
    - Some astronauts have grown food in space, such as chillies and lettuce.
- It can also help in space farming that hasn't evolved yet.
- It is reported that asteroid Bennu when broken down by microbes, even inefficiently could sustain astronauts for up to 600 years.
- **Challenges** – Extensive toxicity testing is needed.

2.22 Brown Dwarfs

A new study confirms that brown dwarf twins, Gliese 229Ba and Gliese 229Bb discovered decades ago is actually twins orbiting each other at a much closer range, completing a full orbit every 12 days.

> *The mass required to sustain nuclear fusion is about 1/12th of a solar mass (or about 90 times the mass of Jupiter).*

- It is an astronomical object that is *intermediate between a planet and a star,* typically having a mass less than 0.075 times that of the Sun.
- **Features –** They are larger than giant planets like Jupiter but do not have enough mass to sustain hydrogen fusion reactions in cores.
- Thus, scientists have dubbed brown dwarfs *as "failed stars*".
- Rather, the small amount of energy emitted by these objects comes almost exclusively from the heat stored in them during the collapse of the parent gas cloud from which they formed.
- They gradually cool and fade with cosmological time.
- They accumulate material ***like a star,*** not like a planet.
- **Gravity** - They condense from a gaseous cloud and are higher in mass than planets and so ***have stronger gravity.***
- Thus, they *hold onto their lighter elements (hydrogen and helium)* more effectively than planets and have a relatively low metal content.
- **Orbit -** They have been found orbiting other suns at distances



> ***One AU** = one Earth-sun distance.*

of 1,000 astronomical units (AU) or more.

- However, not all brown dwarfs orbit far from their stars; some have been found orbiting at closer distances, and a few rogue brown dwarfs have been spotted not orbiting any star.
- **Luminosity -** Because of their low temperatures and small sizes, brown dwarfs have extremely low luminosities (about 1/100,000th of the solar luminosity).
- **Observation** – It is extremely difficult to observe even with modern telescopes because the brown dwarfs is more distant than two or three hundred light years.
- Consequently, it was only in 1995 that the first confirmed brown dwarf was observed.
- Due to their extremely low luminosities, brown dwarfs were one of the proposed candidates for ***baryonic dark matter.***

2.23 Comet C/2023 A3 (Tsuchinshan–ATLAS)

Thiruvananthapuram Astronomical Observatory has successfully captured images of the bright comet C/2023 A3 (Tsuchinshan–ATLAS) recently.

- It is in the ***constellation of Serpens*** and is currently traversing the Orion constellation.
- **Discovered by** - The Purple Mountain Observatory in China in 2023.
- The comet is currently between the ***orbits of Jupiter and Saturn***, a billion kilometers from Earth.
- **Orbit** – It is a long-period comet from the oort cloud, with an 80,000-year orbit around the sun.

> ***Oort Cloud*** *is a vast region of space thought to contain billions or trillions of icy objects, including comets, ranging in size from mountains to larger.*

- Its retrograde orbit, meaning it moves in the opposite direction to most major solar system objects.
- **Distance** - It is parabolic-like with a perihelion distance of 0.39 astronomical units (AU).
- **Brightness** - Though it has been described as the brightest comet in over a decade, it is not expected to reach the iconic brilliance of Comet Hale-Bopp, the 'Great Comet' which dazzled observers in 1997.

2.24 Recent Study on Space Rocks

New research shows most space rocks crashing into earth come from a single source, while some of these meteorites come from the Moon and Mars, the majority come from asteroid.

- **Meteorite -** When a fireball reaches Earth's surface is it called a meteorite.
- They are commonly designated as 3 types - stony meteorites, iron meteorites, and stony-iron meteorites.
- **Stony meteorites** – It comes in 2 types and the most common are the chondrites.
- **Chondrites –** It have round objects inside that appear to have formed as melt droplets.
- These comprise ***85% of all meteorites*** found on Earth and most are known as "ordinary chondrites".
- They are then divided into 3 broad classes – ***H, L and LL*** based on the iron content of the meteorites and the distribution of iron and magnesium in the major minerals olivine and pyroxene.
- These silicate minerals are the mineral building blocks of our Solar System and in Earth, present in basalt.
- Carbonaceous chondritesare a distinct group and contain high amounts of water in clay minerals, and organic materials such as amino acids.
- Chondrites have never been melted and are direct samples of the dust that originally formed the solar system.
- **Achondrites** - The less common of the two types of stony meteorites are "achondrites".
- These do not have the distinctive round particles of chondrites, because they experienced melting on planetary bodies.
- **The asteroid belt -** Asteroids are the primary sources of meteorites.
- Most asteroids reside in a dense belt between ***Mars and Jupiter.***
- The interactions with Jupiter can perturb asteroid orbits and cause collisions.

- This results in debris, which can aggregate into rubble pile asteroids. These then take on lives of their own.
    - S-class asteroids (akin to stony meteorites) are found on the inner regions of the belt, while
    - C-class carbonaceous asteroids (akin to carbonaceous chondrites) are more commonly found in the outer regions of the belt.

One family of asteroids

- The two new studies place the sources of ordinary chondrite types into specific asteroid families and most likely specific asteroids.
- The study reports that ordinary chondrites originate from collisions between asteroids larger than 30 kilometres in diameter that occurred less than 30 million years ago.
- The Koronis and Massalia asteroid families provide appropriate body sizes and are in a position that leads to material falling to Earth.
- Another study showed that the composition of L chondrite meteorites on Earth is very similar to that of the Massalia family of asteroids.
- In determining the source asteroid body, these reports provide the foundations for missions to visit the asteroids responsible for the most common outerspace visitors to Earth.

2.25 Black hole triple system

A new study says scientists have discovered a "black hole triple" in space for the first time.

- **Distance** - It is located about 8,000 light years away from Earth.
- **Constellation** - It is situated in the ***constellation of Cygnus.***
- **System**- It features one of the oldest known black holes, the V404 Cygni, which is ***9 times as big as the Sun*** in our solar system.
- It is at centre, currently in the process of consuming a small star spiralling close to it.
- There is also a second star, which appears to be circling the black hole but is actually far away.
- **The black hole Triplet** – The black hole triple not only has one star which orbits the black hole about every 6.5 days, but also a more far-off star which orbits it every 70,000 years.
- **Formation -** V404 Cygni has 2 stars around it as the black hole did not arise from a supernova, which typically kicks away outer stars in the explosion.
- It was formed through another process called ***"direct collapse",*** where the star caves in after expending all its fuel, but does not explode.
- These events are called as a 'failed supernova'.
- However, the black hole triple will not have 3 members forever, as V404 Cygni is consuming the nearer star.
- This suggests that some already discovered binary systems could have been triple systems at some point, with the black hole later devouring one of its members.

Black Hole

- It is a region in space where the pull of gravity is so strong that no matter or light can escape it.
- Astronomers believe most black holes are formed after massive stars explode at the end of their lives known as a supernova.
- However, the triple system suggests a gentler process.
- Many black holes discovered until now have been part of binary systems, consisting of a black hole and a secondary object (such as a star or another black hole).

> ***1 light year*** *is the distance light travels in a year, 9.5 trillion km.*

2.26 TOI-6651b, a new planet

An international team of scientists led by the Physical Research Laboratory (PRL), Ahmedabad, has discovered an exoplanet outside our solar system.

- It is a ***sub-Saturn class planet***, 5 times bigger and 60 times heavier than the Earth.

- **Discovered using** - The 2nd ***PRL Advanced Radial Velocity Abu Sky Search (PARAS-2)***, a high-end spectroscope mounted on PRL's 2.5m telescope at Mount Abu in Rajasthan.
- **Distance** - Located 690 light years away from the Sun.
- It is the *3rd most dense sub-Saturn class* located at the edge of the ***Neptunian desert*** (4th exoplanet within the rare Neptunian desert).

> ***Sub-Saturn class planets*** *have a size in between that of Neptune and Saturn.*

- **Orbit -** It orbits around its host star, a Sun-like star, in just ***5 days.***
- As the planet is revolving dangerously close to its parent star, this area receives strong irradiation from the star itself.
    - It means that the close-by planets will be unable to retain their gaseous atmosphere for long as they evaporate, leaving behind a rocky core, as in this case.

> ***Neptune desert*** *is a region of the known exoplanet population, where planets rotating close to the stars are rare.*

- The core of the exoplanet is massive (nearly 87%) composed of rich *metals like iron* and was found to be rocky whereas the rest mass consisted of a low-density envelope of *hydrogen and helium.*
- **Temperature -** 1,500 degrees Kelvin (about 1,200 degrees Celsius), thus *ruling out TOI-6651b from being habitable*.

2.27 Magnetic understanding of Uranus

Recently, the Scientists had uncovered a magnetic misunderstanding about Uranus.

Uranus

- It is a ***3rd largest planet*** in our solar system.
- **Discovered by** - William Herschel in 1781, the first planet discovered with the aid of a telescope.
- **Colour -** It is *blue-green in colour due to the methane* contained in the atmosphere comprised mostly of hydrogen and helium.
- **Orbit -** Its unusual tilt makes Uranus appear to orbit the sun like a rolling ball.
- **Size -** It has a diameter of about 31,500 miles.
- It has ***28 known moons and two sets of rings***.
    - 2 largest moons ***are*** *Titania and Oberon*.

- **Voyager 2 –** It is a space probe launched by NASA on August 20, 1977, as a part of the Voyager program.
- It is the only spacecraft to visit Uranus and Neptune and the probe is now in interstellar space, almost 13 billion miles (21 billion kilometers) from Earth.
- **Voyager 2 flyby of Uranus -** When NASA's Voyager 2 spacecraft flew by Uranus in 1986, it provided scientists' first — and, so far, only — close glimpse of this strange, sideways-rotating outer planet.
- **Misreading of Voyager -** The Voyager 2 observations had suggested that Uranus has
    - Small magnetosphere
    - No plasma in the atmosphere
    - Intense radiation belts
    - Its two largest moons - Titania and Oberon - orbit outside the magnetosphere.
- **Recent Findings –** Uranus has
    - Large magnetosphere
    - Plasma in the magnetosphere
    - Weak radiation belts
    - Titania and Oberon orbit within the magnetosphere

> ***Interstellar space*** *is the region outside the heliopause, or the bubble of energetic particles and magnetic fields from the Sun.*

- **Reason for the misreading** – Voyager 2 had visited the Uranus after the planet was hit by a strong solar storm which had striped its magnetosphere.

Solar Wind *is a high-speed flow of charged particles emanating from the sun.*

2.28 Solar Activity

Recently, 3 tiny Australian satellites from Curtin University's Binar Space Program burned up in Earth's atmosphere due to high solar activity.

- **Solar activity** – The sun is a ***magnetic variable star*** that fluctuates on times scales ranging from a fraction of a second to billions of years.
- It is a product of the Sun's ever-changing magnetic field, and approximately ***every 11 years***, it completely flips and at the midpoint of this cycle, solar activity is at its highest.
- It includes phenomena such as sunspots, solar flares and solar wind, the stream of charged particles that flows toward Earth.
- **High solar activity -** It means *more solar flares and stronger solar wind*, resulting in a higher flux of charged particles that can damage or disrupt electrical components on satellites.
- It also increase in ionising radiation, resulting in a higher dose for astronauts and pilots, and potential disruptions to long-distance radio communications.
- The presence of auroras which are far more intensely and closer to the equator than in the last 2 decades is due to this reason.
- **Impact on Satellites –** The satellite orbiting in Lower Earth Orbit at an altitudes up to 2,000 km, experiences *orbital decay, eventually re-entering and burning up* in the atmosphere.

Binar Space Program

- It is a satellite research program operating out of Curtin University.
- Binar (BIN-ah) is the Noongar word for "fireball".
- **Aim** - To advance our understanding of the Solar System and lower the barrier for operating in space.
- **Program Missions - Binar-1 -** First satellite mission, launched to the International Space Station (ISS) on August 29, 2021.
- It was deployed into its own orbit and operated in orbit for almost a year in space.
- It was intact and powered up, included beacon messages and some data about the spacecraft's systems.
- **Follow-Up Mission -** Binar-2, 3, & 4, launched on August 4, 2024.
- They comprised 3 1U CubeSats hosting scientific experiments, in-house developed technology validation and

industry payloads.

- They were deployed into a naturally decaying orbit below the ISS at an altitude of 400km above sea-level, and circled Earth every 90 minutes for just 2 months.
- They were expected to last approximately 6 months but managed only 2 months due to unexpected high solar activity.

2.29 WOH G64

European Southern Observatory's Very Large Telescope Interferometer (ESO's VLTI) recently observed WOH G64, which revealed some crucial details about its activity and surrounding layers.

- WOH 64 – It is a ***giant star that dwells in the Large Magellanic Cloud***, a dwarf or satellite galaxy that orbits Milky Way.
- **Discovered by -** Bengt Westerlunds, Olander, and Hedin in the 1970s.
- Incidentally, the WOH in its name is the acronym for the names of its 3 discoverers.
- **Imaging** – In 2005 and 2007, the team reportedly used European Southern Observatory's Very Large Telescope Interferometer (ESO's VLTI) in the Atacama Desert of Chile to ascertain the features of the star.
- To get an accurate image, the team had to wait for the development of GRAVITY, a set of VLTI's second-generation instruments.
- **Features** – The star is believed to be around *1,60,000 light years away* from Earth.
- It is classified as a ***red supergiant*** owing to its size, which is roughly 2,000 times that of the Sun.
- Red super-giants like WOH G64 shed their outer layers, which are mainly gas and dust, in the final stages of their lifecycles.
- This process can continue for thousands of years.
- This star is one of the most extreme of its kind, and any drastic change may bring it closer to an explosive end.
- According to the team, the materials that are being shed could be responsible for the dimming of the star and the unusual shape of the dust cocoon around it.

2.30 Far Ultra Violet (FUV) Emissions from Novae

Astronomers from the Indian Institute of Astrophysics (IIA) have recently spotted Far Ultraviolet (FUV) emissions from novae for the first time in the neighbouring Andromeda galaxy.

- **Novae** – A ***transient astronomical event*** that causes the sudden appearance of a bright, apparently new star that slowly fades over weeks or months.
- All observed novae involve *white dwarfs in close binary systems*.
- It occurs in binary star systems where a white dwarf and a companion star (such as a Sun-like star or its evolved form) orbit closely.
- **Novae Eruption** – The white dwarf's intense gravity pulls matter from the companion star, accumulating it on the white dwarf's surface.

> *A **binary star** is a system of two gravitationally bound stars that orbit a common centre of mass called a barycentre.*

- The piling up of matter creates the pressure and temperature increase, that triggering a fusion reaction that causes a ***Bright Nova Eruption.***
- This accretion process is through the presence of a disc-like structure around the White Dwarf, known as the *Accretion Disk*.
- These disks are very hot and emit electromagnetic waves in the Ultra Violet (UV) and blue regions of the spectrum.
- **Far Ultraviolet (FUV) emission** – It is a radiation that refers to the wave band of ultraviolet radiation with *wavelengths ranging from around 200 to 280 Nano-meters.*
- AstroSat is the *first dedicated Indian astronomy mission*, aimed at studying celestial sources in X-ray, optical and UV spectral bands simultaneously.

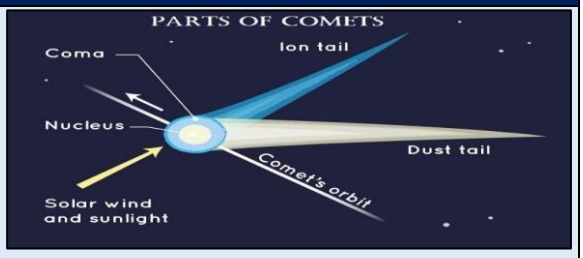
Ultraviolet Imaging Telescope (UVIT)

- It is primarily an imaging instrument and a *part of AstroSat multi-wavelength space observatory*, operational since 2015.
- Its fine spatial resolution and unique capability to observe simultaneously in far UV and near UV.
- It led to the detection of accretion disks which is 2.5 million light years away.

2.31 Dark Comets

The National Aeronautics and Space Administration (NASA) researchers are closely studying a new class of celestial objects known as "dark comets".

Comets

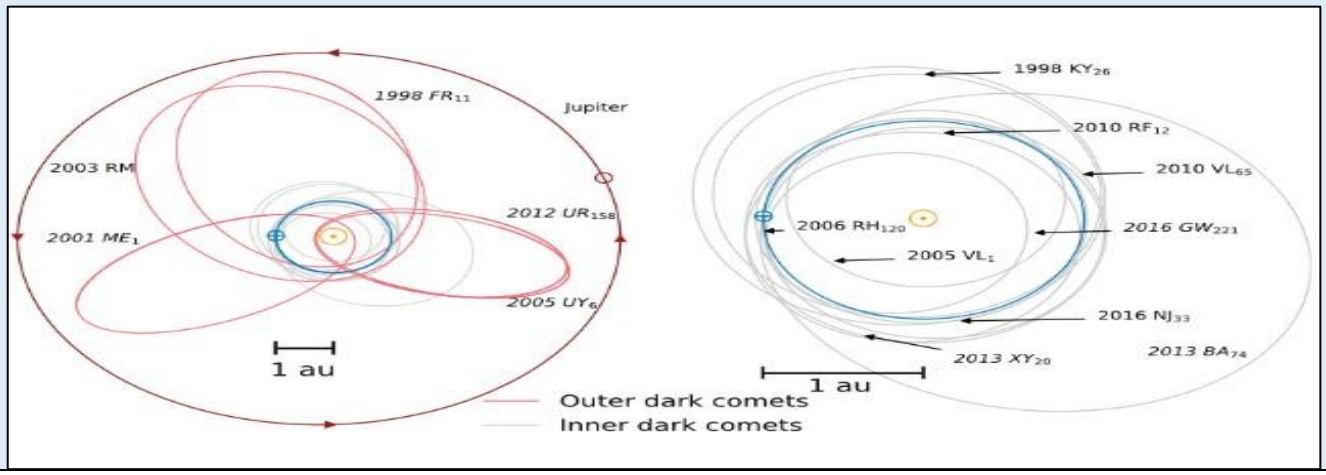


- These are ***large celestial objects made of rock, dust and ice*** that orbit the Sun.
- These ancient objects are leftovers from the formation of the solar system *4.6 billion years ago.*
- They are mostly found out in the solar system, which is described as "dirty snowballs".
- It is known for its ***long-haired stars and streaming tails***.
- **Short-period comets** – It come from a wide disk beyond the orbit of Neptune called the *Kuiper Belt*.
- It take *less than 200 years* to orbit the Sun.
- **Long-period comets** – It comes from the *Oort cloud* which is beyond the orbit of Kuiper Belt.
- It takes *more than 250,000 years* to orbit the Sun.

- **Dark comets** – A celestial object that looks like an asteroid but *moves through space like a comet*.
- It appears as faint points of light in space, with ***no visible signs of gas or dust trails***.
- **Discovered in** – The first indication of dark comets came in 2016.
- **Size** – They are *often small*, just a few metres to a few hundred metres wide.
- **Rapid Spin** – They often disperse escaping gas & dust in all directions, making them less visible.
- **Composition/Age** – It result in weaker or no gas loss, as the materials that go into the tails.

2 Types of Dark Comets

- **Outer dark comets** – They have similar characteristics to Jupiter-family comets.
- They reside in the outer solar system and have highly eccentric (or elliptical) orbits and are on the larger side (100s of meters or more across).
- **Inner dark comets** – They reside in the inner solar system (includes Mercury, Venus, Earth, and Mars) travel in nearly circular orbits and are on the smaller side (10s of meters or less).



Bright Comets	Dark Comets
Their brilliant tails form as sunlight vaporises their icy surfaces.	They are more elusive than their bright siblings.
They have the glowing tails.	They *lack the glowing tails* instead resemble asteroids, appearing as a faint point of light against the vast darkness of space.

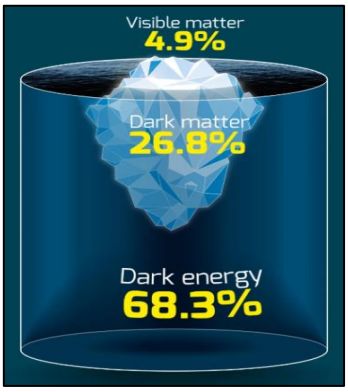
Oumuamua

- It is a *dark Comet racing toward the outskirts of our solar system* in 2017.
- Oumuamua is the Hawaiian word for scout.
- It is the first interstellar object to pass through our solar system.
- Its speed and path around the Sun don't match a typical asteroid.
- It has no bright tail or nucleus (icy core) normally associate with comets.

2.32 Dark Matter

Physicists have revised the minimum possible mass of a dark matter particle.

- **Dark matter** – It is an enigmatic *invisible substance* supplying five-sixths of the matter of the universe.
- It is said to be *everywhere in the universe*.
- **Coverage** – It seems to outweigh visible matter roughly 6 to 1, making up *about 27% of the universe.*
- **Properties** – Unlike normal matter, it *does not interact with the electromagnetic radiation* (heat, light, radio, etc,).
- **Hard to spot** - It does *not absorb, reflect or emit light.*
- **Exploration** – The existence of dark matter was inferred *only from the gravitational effect* it seems to have on visible matter.
- The evidence emerged when astronomers found an unusual pattern in the rate at which stars in a galaxy rotated the farther, they were from the centre.
- **Non-Zero mass** – The particles of dark matter need to have non-zero mass or else the dense and intricate structure of matter on cosmic scales will not form.



- **Minimum mass** – For decades scientists thought this minimum mass was about 10^{-31} times the mass of a proton.
- In 2024, theoretical physicists revised the limit and pushed it up by an order of magnitude, to ***2.3 × 10⁻³⁰ proton masses***.
- In this case, the wavelength is 200 light years, about the size of a dwarf galaxy.
- **R&D** - Experiments at the Large Hadron Collider (LHC) may provide more direct clues about dark matter.
- Dark matter might be newer particles like
  - WIMPS (Weakly Interacting Massive Particle)
  - AXIONS
  - Gravitinos

*In 1922, Dutch astronomer Jacobus Kapteyn studied the motion of stars neighbouring the Sun and concluded the **density of "dark matter"** (using that term for one of the first times) must be 0.0003 solar masses per cubic light year.*

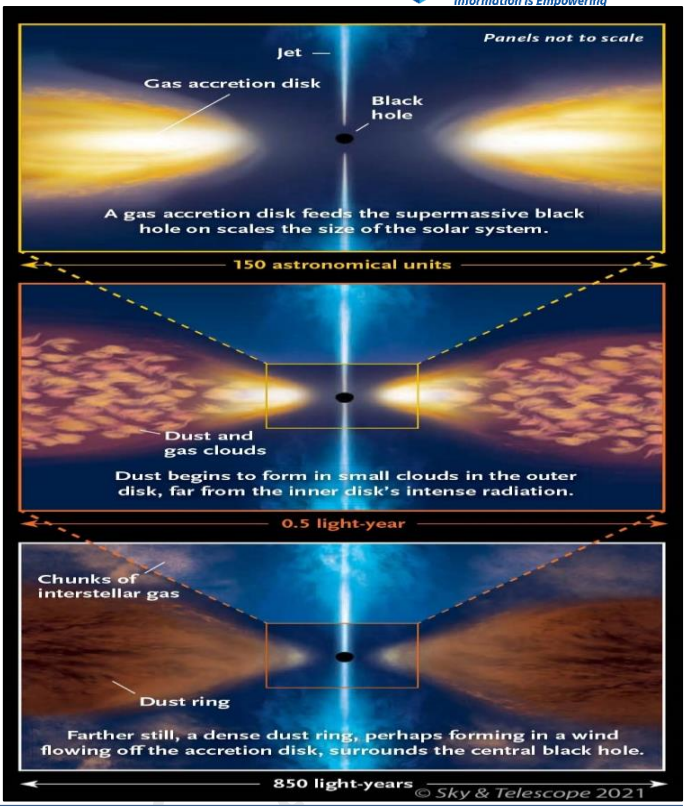
***Leo II** is a dwarf galaxy orbiting the Milky Way.*

2.33 Quasar

Recently, the astronomers have identified a remarkable water reservoir circling a quasar over 12 billion light-years away.

- **Quasar** – It is a *subclass of Active Galactic Nuclei (AGNs)*, extremely luminous galactic cores where gas and dust falling into a supermassive black hole.

- **Formation** – It occur when immense amounts of matter fall into a supermassive black hole, *spiraling around it in the form of a disk* before entering.
- **Luminous object** – The accretion disk is subjected to *extreme gravitational and frictional forces,* causing the gas and dust to heat up to millions of degrees.
- Thus, it *become luminous*, blasting out dazzling jets of material into the universe.
- Together, the jets and glowing disk outshine their host galaxies.
- **Features** – Though they *aren't much bigger than Earth's solar system*, they emit 100 to 1,000 times as much light as an entire galaxy.
- **Discovery** – They were 1st found in the 1950s and 60s and *labeled "quasi-stellar radio sources*," because they looked like stars but emitted radio waves.
- The closest quasars to Earth are 100s of millions of light-years away.



Hubble telescope found ***quasars in both spiral and elliptical galaxies****, colliding and undisturbed, which may indicate a subtler mechanism for feeding a supermassive black hole than galaxy collision.*

Quasar APM 08279 5255

- **Size** - It surrounds a supermassive black hole that is *20 billion times more massive than our Sun*.
- **Energy** – It pumps out as much *energy as a 1000 trillion suns*.
- **Water reservoir** – It contains water vapour equating to 140 trillion times the volume of Earth's oceans.
- It is the farthest and *largest known reservoir of water source* in the universe.
- **Features** – It is *emitting hydrogen-rich gases* like water vapour and carbon monoxide, and creating a region 100s of light-years wide.
- The gas is warm and dense compared to typical galactic conditions.
- The intense radiation from the quasar keeps the surrounding gas active.
- It primed for star formation or feeding the black hole, potentially increasing its mass 6-fold.

2.34 Quandrantid Meteor Shower

The world is all set to witness the 1st Quadrantid meteor shower of the year 2025.

Meteor shower

- It is a celestial event in which a *number of meteors* are observed to radiate, or originate, from one point in the night sky called Radiant.
- **Caused by** – *Streams of cosmic debris called meteoroids* entering Earth's atmosphere at extremely high speeds on parallel trajectories.

- **Name Quadrantids** – It comes from the obsolete *constellation Quadrans Muralis*, which was named in 1975 by French astronomer JJ Lalande.
- **Origin** – It possibly emerged from *asteroid 2003 EH1*.

Quadrans Muralis *is located between the constellations of Bootes and Draco (near the end of the handle of the "Big Dipper").*

- **Observation** – It was *1st seen in 1825* by Belgian astronomer Adolphe Quetelet.
- **Fireball meteors** – These meteors usually lack persistent trains but often *produce bright fireballs*.
- They are known for their larger explosions of light and color with *magnitudes brighter than -3*.
- It persists longer than an average meteor streak due to the fireballs which originate from larger particles of material.
- **Speed** – They enter the Earth's atmosphere at high speed, typically *around 40km per second*.
- **Visibility** - In its peak activity, observers can spot ***60 to 120 meteors per hour*** and the visibility depends mainly on location and timing.
- **Quadrantid Meteor Shower in 2025** favour the western regions of North America during pre-dawn hours.
- They are likely to shine bright as Earth's forward-facing side hits them at high speed.

Asteroid 2003 EH1 *is believed to be a fragment of an extinct comet that broke down in 1490-91, which takes 5.52 years to orbit the Sun once.*

Asteroid	A relatively small, inactive, rocky body *orbiting the Sun*.
Comet	A relatively small, at times active, object whose ices can vaporize in sunlight forming an atmosphere (coma) of dust and gas and, sometimes, a *tail of dust and/or gas*.
Meteoroid	A small particle *from a comet or asteroid* orbiting the Sun.
Meteor	The light phenomena which results when a meteoroid enters the Earth's atmosphere and vaporizes; *a shooting star*.
Meteorite	A meteoroid that survives its passage through the Earth's atmosphere and *lands upon the Earth's surface*.

2.35 WASP-127b

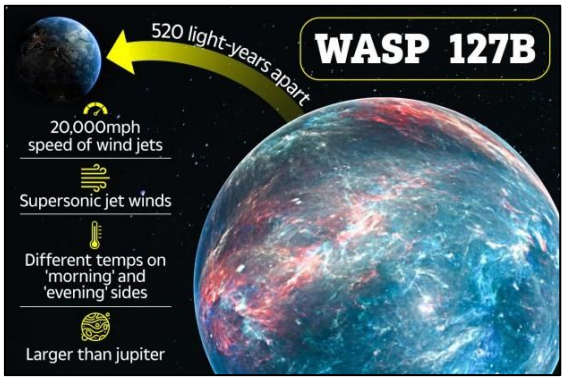
Recently, the astronomers have detected winds howling on large gaseous planet, WASP-127b.

- **Discovered in** – *2016*.
- **Located in** – Milky Way galaxy approximately 520 lightyears from the earth in a tight orbit around a star.
- **WASP-127b** – It is a ***gas giant exoplanet***, which means that it has no rocky or solid surface beneath its atmospheric layers.
- Instead, below the observed atmosphere lies gas that becomes denser and more pressurized the deeper one goes into the planet.
- **Type** – *Hot Jupiter*, that orbits very close to its host star.
- **Diameter** – About 30% larger than Jupiter.
- **Mass** – Only 16% (0.1647) of Jupiters, making it one of the puffiest planets ever observed.
- **Orbital Period** – It takes *4.2 days* to complete 1 orbit of its star.
- **Position** – One side of WASP-127b faces its star, the day side and other side always faces away, the night side.
- **Temperature** – 2,060 degrees Fahrenheit, its polar regions less hot than the rest.
- **Composition** – Mainly of hydrogen and helium.

*An **Exoplanet** is any planet beyond our solar system. Most of them orbit other stars, but some free-floating exoplanets, called **Rogue Planets**.*

Research Findings

- The wind circling at its equator are the fastest of their kind on any known planet.
- Its atmosphere also contains traces of more complex molecules such as ***carbon monoxide and water***.
- The primary source of energy for these winds is the ***intense irradiation*** from the host star.
- Higher atmospheric wind speeds have been detected on 2 other exoplanets, in winds from their day side to night side.



2.36 Einstein Ring

Recently, the Euclid space mission of the European Space Agency (ESA) spotted an Einstein ring in the galaxy NGC 6505, just 590 million light-years from the earth.

- Bruno Altieri 1st noticed the Einstein ring (Nicknamed as Alteri's Ring) in galaxy NGC 6505 in 2023 in a blurry image captured by Euclid mission of European Space Agency.
- **Einstein Ring -** An Einstein ring is a ring-shaped image that occurs when light from a distant galaxy is bent around a massive object in the foreground.
- This phenomenon is called ***gravitational lensing.***
- Albert Einstein's general ***theory of relativity*** predicted this phenomenon.
- The gravity of the foreground object bends light rays, similar to how a magnifying lens bends light.
- If the background galaxy, the lensing galaxy, and the telescope are perfectly aligned, the image appears as a ring.
- **Significance** - They are a valuable tool to study the expansion of the universe, dark matter, and dark energy.
- They also help scientists learn about the background source of the light that is bent by dark matter.
- An Einstein ring is also known as an ***Einstein–Chwolson ring or Chwolson ring.***
- Astronomers discovered the first Einstein ring in 1998.
- The largest and one of the most complete Einstein rings ever discovered is GAL-CLUS-022058s.

> ***NGC 6505*** *is an elliptical galaxy in the Draco constellation, about 608 million light years away from the Milky Way, discovered in 1884 bu Lewis A. Swift.*

> ***General relativity*** *predicts that the path of light will follow the curvature of space time as it passes near a massive object.*

2.37 Asteroid 2024 YR4

National Aeronautics and Space Administration (NASA) officials said that 2024 YR4 has slightly more than 1% chance of crashing into Earth in 2032.

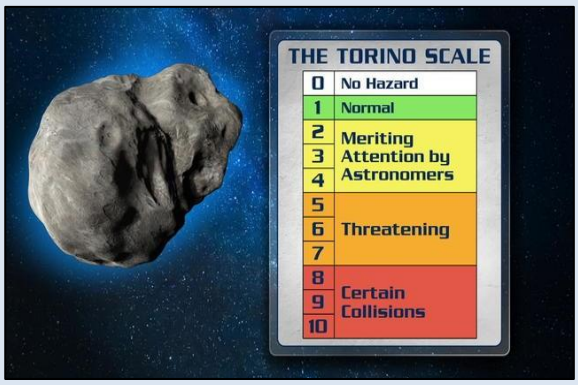
- It is a ***near-Earth asteroid*** recently discovered by a telescope in Chile.
- **Size** – Measuring 40 to 100 metres across, as big as a football field.
- Size measurement is based on estimates from its reflected light.
- **Features** – Asteroids do not emit a light of their own, they only reflect sunlight.
- It brightness depends on how reflective the asteroid's surface.
- Currently, it is moving away from the planet at 13.26 kilometres (8.24 miles) per second.
- It passing within roughly 800,000 kilometres of Earth, about twice the distance of the moon.
- It will eventually fade from view over the next few months, and will not be visible again until it passes Earth's way again in 2028.
- **Destruction potential** – Categorized by - ***Torino Scale.***
- The NASA JPL Center for Near-Earth Object Studies (CNEOS) has currently rated the 2024 YR4 a 3 on a scale from 0 to 10.
- **Rating –** Scale 3 - When the object is larger than 20 metres (65 feet) and has an impact probability of 1% or higher.
- It is expected to release 8 to 10 megatons of energy in case of a crash.
- The European Space Agency (ESA) has stated that the asteroid will safely pass through Earth with a 99% chance of no collision.

> ***Apophis asteroid****, which was discovered in 2004, was initially rated 4 on the scale but was later downgraded as observations showed that it posed no threat for at least 100 years.*

Torino Scale

- It is a rating system that helps astronomers and the public understand the risk of a near-Earth object (NEO) colliding with Earth.

- It is named after Turin, Italy, where it was first presented at an international conference in 1999.
- It is used to categorize the likelihood and consequences of a potential impact.
- It uses a number from 0 to 10, with higher numbers indicating a greater risk.
- It is based on the probability of a collision and the estimated kinetic energy of the impact.
- It is color-coded to help convey the level of risk.
- **Usage**
  - To communicate the seriousness of collision predictions.
  - To help the public understand the potential impact of a NEO.
  - To help determine the level of public concern that is warranted.



2.38 Gaia BH3

Recently, the astronomers have discovered a gigantic black hole, Gaia BH3.

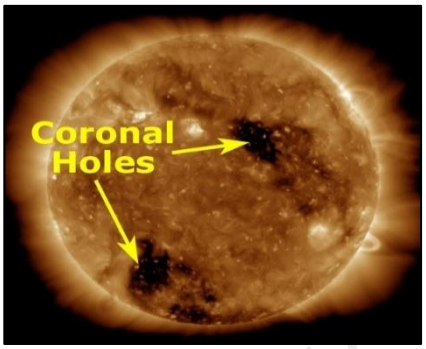
- **Gaia BH3** – It is a ***dormant black hole***, and it is the 3rd kind of Gaia Black Hole.
- It is the ***1st black hole*** found in the Milky Way galaxy's outer reaches and the largest known stellar-mass black hole in the galaxy.
- **Discovered in** – ***2024*** by European Space Agency's Gaia telescope.
- **Distance** – 1,926 light-years from Earth, which makes it the ***2nd closest black hole to the Earth.***
- **Located in** – About 2,000 light years away in the constellation.
- **Constellation** – *Aquila* and appears to be a passive black hole.
- **Solar Mass** – Nearly 33 times the mass of the Sun.
- **Features** – It isn't actively pulling material from its surroundings due to lacks of significant supply of matter in its neighborhood.
- It doesn't have associated X-ray emissions either.

Gaiatelescope *has been constantly monitoring the motions of billions of stars in the galaxy since 2013 under European Space Agency's astrometry mission.*

2.39 Solar Coronal Holes

Astronomers from the Indian Institute of Astrophysics (IIA) recently accurately characterised the latitude dependence of temperature and magnetic field strengths within the coronal holes.

- **Coronal holes -** They are large, dark areas on the sun that are cooler and less dense than the surrounding plasma.
- They are regions of open magnetic fields that allow solar wind to escape into space.
- These phenomena are intense sources of fast solar wind, streams of charged particles escaping the sun at high speeds.
- They may appear at any time of the solar cycle but they are most common during the declining phase of the cycle.



Solar and Heliosphere Observatory (SOHO), *a joint project between NASA and the European Space Agency (ESA) is a spacecraft that orbits the Sun, studying the Sun's interior, atmosphere, and solar wind.*

- **First discovered in** - 1970s by X-ray satellites.

Key findings of the study

- **Uniform Temperature -** There is no significant variation in the temperature structure of coronal holes across different latitudes.
- **Magnetic field structure -** The strength of the magnetic field structure within coronal holes *varies with latitude*, increasing from the solar equator to the poles.
- These results suggest that coronal holes likely ***originate from the deep solar interior*** and may form from the superposition of *Alfven wave perturbations*, respectively.
- Understanding the thermal structure, estimate the depths of origin of coronal holes, while radiative flux and energy estimations help quantify the thermal energy input into interplanetary space.
- **Significance of the Findings -** Improved monsoon predictions which benefit agriculture and disaster management.
- Deepen the knowledge of how solar phenomena influence Earth's weather systems.

3. TELESCOPES & OBSERVAIONS

3.1 Low-Frequency Array (LOFAR)

Recently, Astronomers discover new radio galaxy, J0011+3217 using LOw-Frequency ARray (LOFAR).

- **LOFAR** – It is currently ***the largest radio telescope*** operating at the *lowest frequencies (30–300 kHz)* that can be observed from Earth.
- **Developed by -** Dutch Institute for Radio Astronomy (ASTRON) in 2012.
- **Location-** Thousands of small antennas spread across Europe, with the core located in the Netherlands.
- **Directions -** It is the 1st telescope that consists of a vast array of ***omnidirectional antennas,*** can observe in several directions simultaneously.
- **Utility**
  - The observation of ***cosmic rays***,
  - The mapping of the universe's ***large-scale structure***, and
  - The study of ***transient astronomical phenomena***.
- It is a powerful tool for exploring the early universe and the formation of galaxies, stars, and black holes.
- **Recent Findings-** The research revealed that the newfound galaxy, showcases peculiar features, including a one-sided secondary lobe.
- The finding noted that radio galaxy cores emit significant radio waves due to black holes accreting gas and dust, producing high-energy jets that accelerate charged particles, visible in radio wavelengths.

Radio galaxy

- Radio galaxies are a type of *active galaxy that emit more radio waves* than visible light.
- They are also known as ***radio-luminous or radio-loud galaxies***.
- **Powered by** – Jets from supermassive black holes at the center of the galaxy, which interact with charged particles and strong magnetic fields to create radio emissions.
- These emissions form giant regions called radio lobes that extend beyond the visible structure of the galaxy, often in pairs and can be up to 15 million light-years across.
- They are much larger than most other galaxies and are *almost always large elliptical galaxies*.
- **Examples**
  - **Cygnus A**– 1st discovered, known for its large, bright and powerful radio lobes.
  - **Centaurus A** -A nearby radio galaxy that is also a source of X-rays and gamma rays.

3.2 SPHEREx Telescope

A new telescope SPHEREx is set to launch on February 27, 2025.

- **SPHEREx** – Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer.
- It is an *infrared telescope* designed to take spectroscopic images.
- **Launch agency** – NASA.
- **Objective** – To *map the whole sky*, covering 1 billion galaxies, 100 million stars, and 10,000 asteroids.
- **Working** – It *divides cosmic light into 96 distinct spectral bands* and will generate 8 million new spectroscopic images of life-bearing molecules.
- **Usage** – Spectroscopic images will be able to tell us about the
  - **Formation of the universe** – Growth of all galaxies across cosmic history
  - **Cosmic inflation** – Rapid expansion of the universe after the Big Bang
  - **Biogenic molecules** – Location of water & life-forming molecules in our own galaxy.
- **Significance** – It complements high-resolution telescopes like James Webb and Hubble, which focus on small sky patches.

> ***Spectroscopy*** *is the separation of light into its component colors (or wavelengths) to reveal information about the chemical content, temperature and motion of planets, comets, stars, interstellar gas and galaxies.*

> ***Biogenic molecules*** *are organic compounds essential for life, such as water (H_2O), carbon dioxide (CO_2), and methanol (CH_3OH).*

4. DEFENCE

4.1 SMART System

DRDO successfully flight tested the Supersonic Missile-Assisted Release of Torpedo (SMART) system from Dr APJ Abdul Kalam Island off the coast of Odisha.

- It is a *next generation missile*, canister-based, *long-range* ***supersonic anti-submarine missile***.
- **Developed by**- Defence Research and Development Organization ***(DRDO)*** for Indian Navy.
- **Objective**- To enhance the anti-submarine warfare capability of the Indian Navy far beyond the conventional range of lightweight torpedo.
- **Features-** The missile consists of *2-stage solid propulsion system*, an electromechanical actuator system and a precision inertial navigation system.
- **Launch**- It can be launched from surface ship or a truck-based coastal battery.

> ***Canister-based missiles*** *are a type of missile system where the missiles are stored and launched from canisters or tubes*

- **Propellant-** Solid fuel and silver zinc battery.
- **Range-** 643 km carrying a light weight torpedo of range 20 km with 50 kg high explosive warhead.
    - It is light weight torpedo delivery system that extends the conventional range of torpedoes.
- **Sea skimming**- It is a technique used by the missile to avoid radar, infrared detection, and to lower probability of being shot down during their approach to the target.
- **Acoustic huming**- It is the process in which a system uses the *sound or acoustic signals* of a target or destination to guide a moving object.
- **Guidance system**- The missile uses a inertial navigation system (INS), and allows real-time course correction and target updating via datalink.
- **Testing**- The missile is successfully tested by DRDO from a ground based launcher at Integrated Test Range, Balasore, Odisha.

4.2 Igla-S

Army set to receive Igla-S air defence systems partly assembled in India.

- It is a ***Man-portable air defence missile system*** (MANPADS), which is known in the West as *SA-24 Grinch*.
- **Developed by** – ***Russia***
- It is an advanced version of the Igla MANPADS.
- In combat effectiveness, it *exceeds the Igla from 2 to 5 times*, especially when firing at cruise missiles and pinpoint targets.
- **Features** – It has a *combat equipment, maintenance equipment, training facilities & night firing devices* and this can be fired by an individual or crew to bring down an enemy aircraft.
- It is a high-explosive fragmentation (HE-FRAG) & weighs 2.5 kg.
- It is heavier & powerful to maximize damage capabilities, as well as contact and timed fuzes for increased attack range.
- Guidance is homing via infrared.
- **Range** – Very short range air defence system (VSHORAD)
- **Capacity** – It can engage *all types of visually observable aircraft* and helicopters.
- It can *pinpoint air targets* like cruise missiles and unmanned air vehicles, both head-on and receding, *at any time of day*, against background clutter and decoy flares (jamming).
- **Contract with India** –They are being *assembled by Adani Defence Systems and Technologies Limited (ADSTL)* in India under technology transfer from Rocoboronexport.
- The missile will be imported and some parts like sights, launcher, and the battery will be assembled/ manufactured by Adani defence.

> ***Air Defence (AD)*** *functions in 3 levels, gun/missile system, medium range and high range. AD Gun Missile system and AD self-propelled guns are the 2 types.*

> *India is also set to receive Israeli Hermes-900 Medium Altitude Long Endurance Unmanned Aerial Vehicle (UAV) assembled by ADSTL in Hyderabad.*

> ***A VSHORAD*** *is the soldier's last line of defence against enemy combat aircraft, helicopters and UAVs in the multilayered air defence network.*

4.3 50 years of Operation Smiling Buddha

On May 18, 1974, India conducted its 1st nuclear test in Pokhran, code-named Operation Smiling Buddha.

- The year 2024 marks 50 years of India's 1st nuclear test.
- **Operation** – It is an ***underground test with plutonium device*** in 10-15 kiloton range.
- **Location** – Pokhran in Rajasthan, thus known as *Pokhran-I*.
- **Aim** – To develop its own technology for peaceful use of nuclear energy.
- **Background** – The groundwork for testing nuclear energy was laid down by Homi J Bhabha and Vikram Sarabhai.

- In 1954, the Department of Atomic Energy was founded, with Bhabha as director.
- It had no intention of developing nuclear weapons.
- **Course of action** – On *11th May in 1998*, India conducted a series of nuclear tests in Pokhran, code-named **Operation Shakti, also known as Pokhran-II**
- With this test, India declared itself a *full-fledged nuclear state*.
- **Nuclear-weapon States** – They are defined under the Nuclear Non-proliferation Treaty (NPT) as those that manufactured and exploded a nuclear weapon or other nuclear explosive devices before January 1, 1967, effectively meaning the P-5 countries.
- After India's nuclear test in 1974, it became the first nation to conduct a nuclear test apart from the P-5 countries.

*May 11 is celebrated as **National Technology Day** in India.*

4.4 RudraM-II Missile

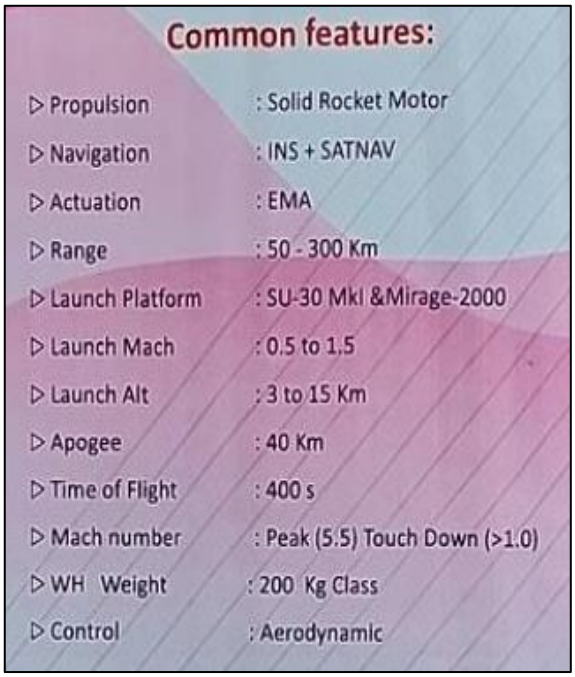
India successfully test-fires RudraM-II missile from a Su-30 fighter jet of the Indian Air Force (IAF) off the coast of Odisha.

- It is India's 1st indigenously developed ***air-launched ballistic missile*** (ALBM).
- **Developed by** – Defence Research and Development Organisation (DRDO).
- **Aim** – To neutralise several types of enemy assets.
- **Mode** – It is a ***solid-propelled, air-to-surface missile***.
- **Significance** – They are *ideal weapons to target Chinese static infrastructure,* which have mushroomed in Tibet largely since the standoff at the Line of Actual Control (LAC) began in 2020.

***Air-launched ballistic missile (ALBMs)** are cheaper than cruise missiles and easier to manufacture. Their high speeds, terminal velocity, high manoeuvrability, and quasi-ballistic trajectory make them extremely difficult to intercept by air defence systems.*

RudraM

- **Role** – It is a series of *anti-radiation & land-attack missiles* developed by DRDO.
- **Anti-radiation missiles** – They target enemy equipment that emits electromagnetic radiation, ie, radars and active jammers.
- **RudraM-I** – It will only be used in anti-radiation roles and has a range of 180 kilometres.
- **RudraM-II and RudraM-III** – They both will be ALBMs, with ranges of 300 kms & more than 600 kms, respectively.
- **2 different variants**
  - An *anti-radiation seeker* to destroy air defence radars.
  - An IIR seeker to destroy heavily fortified bunkers.
- **Terminal velocity** – More than a Mach, making them very hard to defend against.



4.5 North Korea's Spy SatelliteMalligyong-1-1

Malligyong-1-1 satellite launch failed as the rocket exploded and fell into the Yellow Sea shortly after lift-off.

- It is a ***military reconnaissance satellite***.
- **Launched by** – *North Korea*.
- **Russia's assistance** – Russian experts have

***Malligyong-1 satellite** which was launched successfully in 2023 is North Korea's 1st spy satellite.*

visited North Korea to help with the satellite and space rocket program.

- **Reason for failure** – Due to the failure of newly developed *liquid-fuel rocket motor*, which is the 1st stage.
- It uses a combination of ***liquid oxygen and petroleum engine***.

  Challenges – Liquid oxygen engines require specialised storage and handling due to extremely *low boiling points* ***(-183 degree Celsius)***.

- It is quite difficult to solve combustion instability problems of this fuel system and apply materials and parts that can withstand extremely low temperatures.
- **Significance** – Using different engines might allow North Korea to differentiate its civilian space program from its missile program, which is banned by the UN Security Council.

North Korea's ***Chollima-1 satellite*** *uses hypergolic fuels, substances that can be stored at room temperature but ignite on contact each other, thus require careful handling. It is used in nuclear ballistic missiles.*
Hypergolic fuels *include hydrazine (N_2H_4) and its derivatives including: monomethylhydrazine (MMH), unsymmetrical dimethylhydrazine (UDMH), and Aerozine 50 (A-50).*

Yellow Sea

- It is a large *inlet of the western Pacific Ocean*.
- **Yellow colour** – It was named so as the yellowish sand particles originating from the Gobi Desert that descend on the surface of the sea, thereby giving it a golden yellow colour.
- Also known as *Huang Hai or Hwanghae*.
- **Location** – It is lying between mainland China on the west and north, the Korean peninsula on the east and the Shandong Peninsula & Liaodong Peninsula to the south.
- **Boundaries** – It is to the north of the *East China Sea* while the *Bo Hai Sea* is the north-western extension of the Yellow Sea.
- It is dotted with numerous islands, some of which are
  - Jeju Island (South Korea), Shandong Peninsula islands (China), and Ganghwa Island (South Korea).

4.6 Standard Missile 6 (SM-6)

The US Navy's F/A-18 Super Hornet was recently spotted carrying an air-launched version of the SM-6 (RIM-174) missile.

- The Standard Missile-6 (SM-6) is also known as ***RIM-174.***
- **Capability -** It is the first missile of its kind, with *anti-air, anti-surface and sea-based* terminal defence capabilities, which enable it to intercept ballistic and cruise missiles.
- **Technology -** It is an extended range active missile (ERAM) that uses the sophisticated signal processing and guidance technologies of the ***AMRAAM (Advanced Medium-Range Air-to-Air Missile).***
- **Guidance -** The interceptor uses semi-active homing and active homing guidance to achieve accurate engagement of the assigned targets.

Features	
Developed by	Raytheon, a United States company.

Basing	Ship-launched
Class	Surface-to-air and surface-to-surface missile
Range	370 km
In service	2013-Present

4.7 Javelin anti-tank missiles

Recently, India and the US discussed co-producing Javelin missiles in India.

- It is a ***3rd generation*** man-portable fire ***anti-tank guided missile (ATGMs).***
- It is developed and produced jointly by U.S. defence majors, *Raytheon and Lockheed Martin.*
- It employs a ***top-down attack mode***, striking tanks from above where the armour is the thinnest.
- It is a highly lethal *medium-range missile* has been in full-rate production since 1994.
- It is capable of defeating all known and projected armour, as well as soft and irregular targets.
- **Range-** 2,500 metres to 4,750 meters.
- **Technology-** It uses *"fire-and-forget" technology* with automatic infrared guidance.
- It is designed to defeat heavily armoured vehicles like main battle tanks, lighter military vehicles, fortifications, bunkers, and helicopters.
- It's reload and reacquire time is about one minute.

> ***Fire-and-forget missiles*** *require no further guidance after launch, allowing them to hit their target without needing the launcher to maintain line-of-sight or provide ongoing direction.*

Anti-Tank Guided Missile (ATGM)

- It is a precision weapon designed to destroy armoured vehicles such as tanks.
- It is primarily designed to hit and destroy heavily armoured military vehicles.
- These are "fire-and-forget" missiles.
- They rely on an electro-optical imager (IIR) seeker, a laser, or a W-band radar seeker in the nose of the missile.

4.8 ABHYAS

DRDO has successfully completed developmental trials of High Speed Expendable Aerial Target (HEAT) 'ABHYAS'.

- The High-speed Expendable Aerial Target (HEAT) ABHYAS is a high-speed ***indigenously-designed target*** developed for the Indian Armed Forces.
- It is designed for autonomous flying with the help of an auto pilot made by the Aeronautical Development Establishment (ADE) of the Defence Research and Development Organisation (DRDO).
- It is equipped with ***MEMS (Micro-Electro-Mechanical Systems)*** based Inertial Navigation System (INS) for navigation.
- It has a Flight Control Computer (FCC) for guidance and control.
- It has a radar cross section, visual and infrared augmentation system required for weapon practice.
- It has pre-flight checks, data recording during the flight, replay after the flight and post-flight analysis can be carried out.

Defence Research and Development Organisation (DRDO)

- It is an agency under the Department of Defence Research and Development in Ministry of Defence.

- It is India's largest research organisation.
- **Role-** Military's research and development
- **Headquarters-** New Delhi.
- **Formed in –** 1958.
- It is formed by the merger of the
    - Technical Development Establishment.
    - Directorate of Technical Development and Production of the Indian Ordinance Factories
    - Defence Science Organisation
- Defence Research & Development Service (DRDS) is constituted in 1979.
- **Motto-** "Balasya Mulam Vigyanam" – "The source of strength is science".
- The ***Integrated Guided Missile Development Programme (IGMDP)*** under A P J Abdul Kalam is the most prominent success of DRDO.

4.9 Maritime Partnership Exercise (MPX)

Recently, Indian Navy successfully conducted the Maritime Partnership Exercise (MPX) at Baltic Sea.

- **MPX** – A multilateral event *conducted by Indian Navy* in which *naval forces of foreign countries* participate.
- **Aim** – To enhance Indian Navy's operational capabilities and strengthen its partnerships with friendly nations.
- **Importance** – It enhances the ability of different naval forces to *operate together seamlessly*, which is crucial in times of crisis or conflict.
- It *strengthens diplomatic and military ties* between participating nations, fostering greater regional and global stability.
- It also allows participating navies to *train and refine their tactics*, techniques, and procedures, leading to improved operational effectiveness.
- **MPX 2024 –** It is ***between India and Russia***, which involved naval ships from both nations
    - **India**- INS Tabar, was built in Russia and was commissioned into the Indian Navy, on April 19, 2004.
    - **Russia**- Soobrazitelny
- **Activities**
    - Communication drills
    - Search-and-rescue tactics
    - Replenishment at sea procedures

In 2023, Indian Naval ships INS Rana and INS Sumedha undertook a Maritime Partnership Exercise (MPX) with French Navy ship FS Surcouf, in the Bay of Bengal on 30 June 2023.

- **Significance –** The Indian Navy's participation in the 328th Russian Navy Day Parade and MPX highlights a key step in maritime cooperation for regional peace and security.

4.10 Su-30MKI Fighter Aircraft

The Cabinet Committee on Security approved the procurement of aero engines for the Sukhoi Su-30 MKI fighter jets under the 'Buy (Indian)' category from Hindustan Aeronautics Limited (HAL) recently.

The "Buy (Indian)" category is a category in the Defence Procurement Procedure that refers to the purchase of products from

- It is a ***2-seater, twinjet multirole combat fighter aircraft*** for the Indian Air Force (IAF).
- **Developed by -** The Sukhoi Design Bureau, Russia and Hindustan Aeronautics Limited (HAL).
- It is equipped with thrust vectoring control and canards.
- Its maiden flight was in 2000 and its *service entry was in 2002*.
- **Maximum Speed-** Mach 2.

- **Range-** 3,000 km.
- It supports **all-weather, air-to-air and air-to-surface** deep interdiction missions.

Features	Su-30MKI	Rafale
Design and Role	• It performs roles like air-to-ground and maritime strike missions. • It has a larger airframe and is designed for long-range missions and heavy payloads.	• It performs missions like air superiority, ground attack, reconnaissance, and nuclear deterrence. • It is known for its advanced avionics and sensor suite, making it a highly capable multirole aircraft.
Weaponry	• *Air-to-air and air-to-ground* missiles, rockets, bombs, and even anti-ship missiles, giving it considerable firepower.	• Meteor beyond-visual-range *air-to-air missiles, Scalp cruise missile*s for long-range strike capability, and various precision-guided munitions.
Maximum speed	• 2,120 km/h (Mach 2.0)	• 1,912 km/h (Mach 1.8)
Armament capacity	• Up to 8,130 kg	• Up to 9,500 kg
Generation	• 4th -generation fighter aircraft	• 4.5-generation fighter aircraft
Range	3,000 km at a high altitude 1,270 km at low altitude	1,850 km on penetration mission (combat range)
Hard points	12 hardpoints	14 hardpoints
Ferry range	8,000 km	3,700 km
Service ceiling	17,300 m (56,800 ft)	15,835 m (51,952 ft)
Rate of climb	300 m/s (59,000 ft/min)	304.8 m/s (60,000 ft/min)

4.11 New Defence Procurements

Recently, the Defence Acquisition Council has approved 10 capital acquisition proposals.

The Defence Acquisition Council (DAC), *chaired by the Minister of Defence, is responsible for formulating new policies and approving capital acquisitions for the Army, Navy, Air Force. and the Indian Coast Guard.*

- **Objective-** Modernizing India's defence capabilities of Army, Navy and Indian Coast Guards.
- **Future Ready Combat Vehicles**– FRCVs are futuristic main battle tanks to replace the ageing Soviet-origin T-92 tanks.
- **Air Defence Fire Control Radars** – It can detect and track aerial targets, and provide firing solutions.
- ADFCR in conjunction with Anti-Aircraft Guns forms a Ground Based Air Defence system
- It is against air threats at short and very short ranges during day and night under all weather conditions.
- **Forward Repair Team (Tracked)** – It has suitable cross-country mobility for carrying out in-situ repair during mechanised operations.
    - **Developed by** - Armoured Vehicles Nigam Ltd

- **Dornier-228 aircraft** – It is a most advanced high-wing aircraft with capabilities of long range, high utilization rates and high payload.
- **Next Generation Fast Patrol Vessels** – High operational features in rough weather conditions.
- **Next Generation Offshore Patrol Vessels** – It can be operated in both deep waters and coastal areas.

- It is equipped with a sophisticated electronic warfare (EW) suite.
- **Stealth Frigates** – These are a class of stealth guided-missile frigates developed under *Project-17 Bravo frigates (P-17B)* or Next Generation Frigates (NGF).
    - **Developed by** - Garden Reach Shipbuilders and Engineers (GRSE) and Mazagaon Dock Shipbuilders Limited (MDL).
- **Mode of Procurement-** 99% of the procurement cost will be sourced from indigenous manufacturers under the "Buy (Indian)" and "Buy (Indian-Indigenously Designed Developed and Manufactured)" categories.

4.12 Vertical Launch Short Range Surface-to-Air Missile (VLSRSAM)

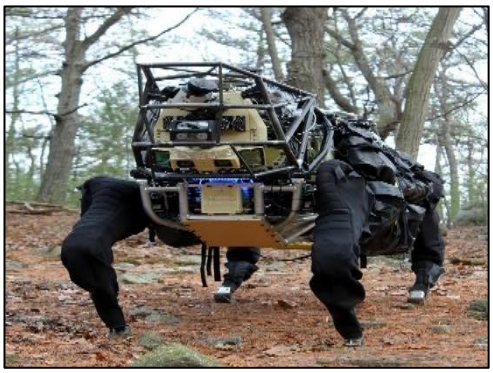
DRDO and the Indian Navy successfully conducted back-to-back flight tests of the Vertical Launch Short Range Surface-to-Air Missile (VLSRSAM).

- **VL SRSAM** – It is the indigenously built ***short-range*** surface-to-air missile.
- It is designed to neutralise various ***aerial threats*** at close ranges, including sea-skimming targets.
- **Missile Developed by** - Defence Research and Development Organisation (DRDO).
- **Operational range** – 80 Km
- **Flight altitude** - 16 km (52,000 ft)
- **Maximum speed** - Mach 4.5
- **Guidance Technology**- During mid-course flight, the missile uses ***fibre-optic gyroscope*** based inertial guidance mechanism while in terminal phase uses ***active radar homing***.
- **VLS** - Each Vertical Launch System (VLS) can hold forty missiles in a twin quad-pack canister configuration.
- **Replacing Barak** - VL-SRSAM intended to replace older Barak 1 surface to air missile system onboard Indian Navy warships.
- **Flight Test** - The flight test was carried out from a land-based vertical launcher, targeting a high-speed aerial target flying at a low altitude.
- The missile system successfully tracked and engaged the target.
- **Testing site** - Integrated Test Range (ITR) in Chandipur, off the coast of Odisha.

4.13 Robotic mule

The Army has procured and inducted 100 robotic mules in forward areas under the fourth trance of emergency procurements (EP) recently.

- It isa ***Multi-Utility Legged Equipment (MULE),*** a *dog-shaped robot* that can be used for surveillance and transporting light loads across difficult terrain.
- **Features** – It can climb stairs, steep hills and other hurdles.
- It is a high-endurance, agile and durable all-weather ground robot.
- **Operating temperature -** It can operate in extreme temperatures, ranging from -40 to +55 degrees Celsius.
- **Payload -** It carry a payload of 15kg.
- **Durability** - It can able to walk up to 3 years.
- **Water proof -** It can go inside water and cross rivers.
- **Sensing -** It has the ability to recognise objects around as there are electro-optics, infrared.
- **Control –** It is controlled by an easy-to-use remote control and can also be operated using Wi-Fi or Long-Term Evolution (LTE).



- **Pre-fed missions -** It can be programmed to complete missions using waypoints or recorded missions.
- **Integration with small arms -** It can be integrated with small arms for combat purposes.

4.14 Peak Pods

DTECH 360 Innovations announced the field launch of its Peak Pods.

- It is a ***high-altitude habitat (tent)*** designed for sub-zero temperature regions.
- **Temperature control –** It aims to achieve 15° C inside the shelter in sub-zero temperatures, even when the outside temperature is touching minus 40° C.
- **Bio-toilets** – It is equipped with bio-toilet and overhead warm water tank.
- **High portability** – 100% modular, relocatable, easy to install and dismantle.
- **Endurance** – It can withstand winds upto 90km/h
- **Pure air quality** – It can maintain optimum CO2, O2 and humidity levels for safe ambience.
- **Eco-friendly** – Solar powered and has zero carbon emissions.
- **Fuel** - No fuel or electricity needed.
- It is ideal for high-altitude military bases, research stations, adventure tourism destinations, fast-track hospitals, disaster relief camps among others.

4.15 Very Short-Range Air Defence System (VSHORAD)

The Defence Research and Development Organisation (DRDO) recently announced the completion of the development trials of the ingeniously developed 4th Generation miniaturised VSHORAD.

- The VSHORAD is a ***Man Portable Air Defence System (MANPADS)*** aims to provide effective protection against aerial threats at short ranges.
- **Developed by -** DRDO's Research Centre Imarat (RCI) with other DRDO laboratories and DcPPs.
- **Range** - 1 to 15 kilometers.
- **Altitude -** It can engage targets at altitudes up to around 3,000 meters.
- **Novel Technologies -** The VSHORADS missile is equipped with advanced features including a miniaturized Reaction Control System (RCS) and integrated avionics.
- **Propulsion system -** It is powered by a dual-thrust solid motor, making it capable of effectively neutralizing low-altitude aerial threats at short ranges.
- **Features -** It can engage multiple targets simultaneously.
- It is designed to protect ground forces and critical assets from low-flying aerial threats such as drones, helicopters, and fast-moving aircraft.
- These systems fill a vital gap between short-range and close-in air defense solutions, providing quick response capabilities to counter immediate threats.
- VSHORAD systems are often mounted on mobile platforms, such as vehicles or trailers, enabling them to be repositioned quickly in response to changing battlefield conditions.

4.16 INS Nirdeshak

Recently, a survey vessel Nirdeshak (Yard 3026) was delivered to the Indian Navy.

- It is ***2nd of 4 Survey Vessel (Large) ships***, steered by the Indian Navy's Warship Design Bureau.
- **Built at** – Garden Reach Shipbuilders & Engineers (GRSE), Kolkata
- **Aim** – It aims for full scale ***coastal and deep-water hydrographic survey*** of port/ harbour approaches and determination of navigational channels/ routes.
- **Features** – It displaces about 3400 tons and overall length is 110 meters and is powered by 2 *diesel engines*.
- It can achieve *speeds in excess of 18 knots*.
- It is fitted with state-of-the art hydrographic equipment such as

> *The 1st ship of the class,* ***INS Sandhayak*** *was commissioned early in 2024.*

- Data acquisition and processing system
- Autonomous underwater vehicle
- Remotely operated vehicle
- Digital side scan sonar, etc.

- **Role** – It will collect *oceanographic and geophysical data* for *defence and civil applications*.
- **Importance** – It has an *indigenous content of over 80% by cost*.

4.17 Dragon drones

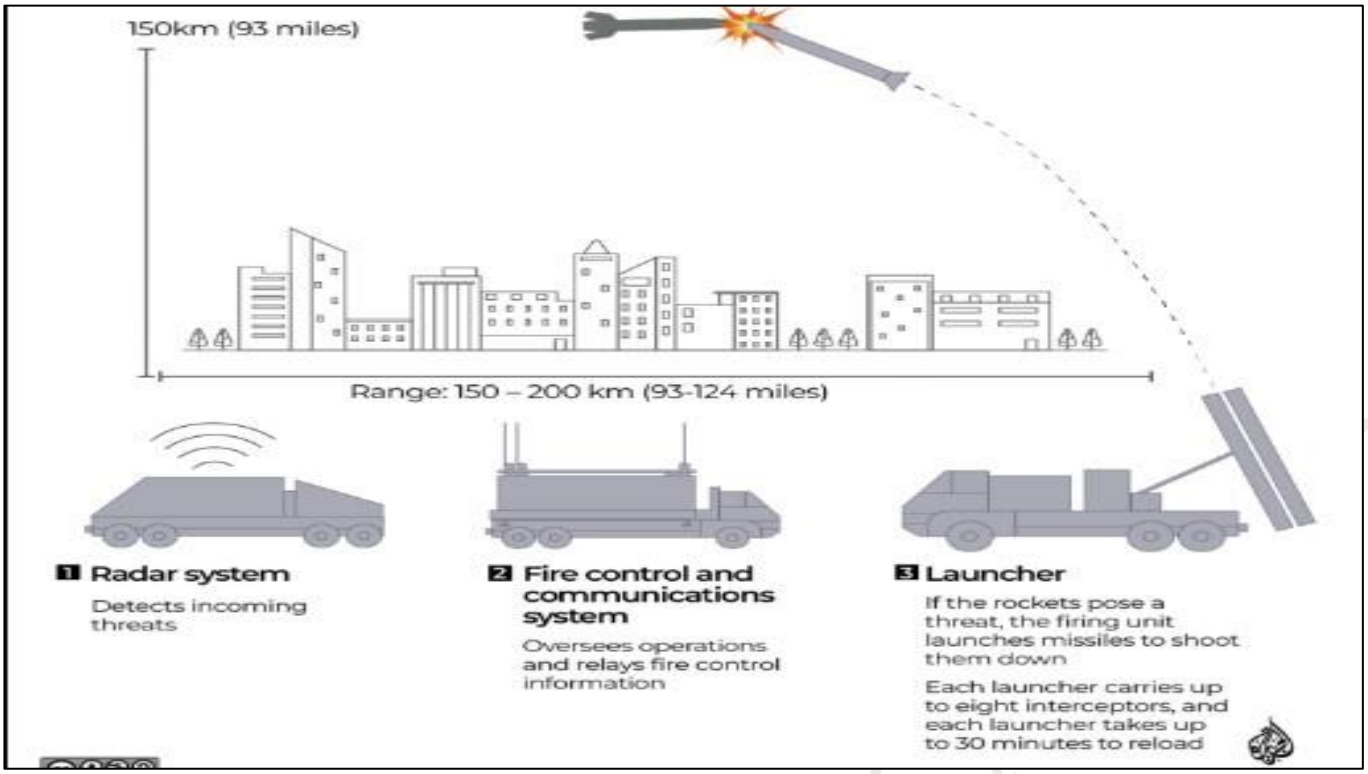
Dragon drones have been used in the recent Russia-Ukraine War.

- Dragon drones *essentially release a substance called* ***thermite,*** a mixture of *aluminium and iron oxide.*
  - Thermite is just one type ***of 'incendiary weapon***,' with others including napalm and white phosphorous.
- When ignited (usually with the help of an electrical fuse), thermite triggers a self-sustaining reaction that is quite difficult to extinguish.
- These are known to emit a molten metal that burns at 2,427 degree Celsius and can even burn underwater.
- As it comes down, the mixture resembles the fire spewed by the mythical dragon.
- **Discovered in –** 1890s by a German Chemist and ***originally used to weld railway tracks.***
- On humans, it causes severe, ***possibly fatal***, burns and bone damage.
- There is little protection against thermite as it can burn through almost everything, including even metals.
- Dragon drones tend to be ***low-flying*** because thermite is more effective when it's in close contact with the target.
- Under international law, thermite is not banned for military combat, but its use on civilian targets is prohibited.

4.18 THAAD Antimissile System

A recent press release by the US department of defence said that they are going to send THAAD battery system to Israel.

- **THAAD -** Terminal High-Altitude Area Defense.
- It is a ***defense battery system*** used to intercept and destroy enemy missiles.
- **Developed by** - Lockheed Martin Corporation.
- **Components -** It consists of *95 soldiers, 6 truck-mounted launchers, 48 interceptors* (eight per launcher), radar surveillance and radar, and a tactical fire component.
- Deployable capability against
  - Short-range (up to 1,000 km),
  - Medium-range (1,000–3,000 km), and
  - Limited intermediate-range (3,000–5,000 km) ballistic missile threats inside or outside the atmosphere during their final (terminal) phase of flight.
- **Technology** - It employs ***"hit-to-kill" technology*** to destroy threat missiles, can defend a larger area than the older Patriot Air and Missile Defense System.
- It is so accurate because the radar system that supplies its targeting information, the Army Navy/Transportable Radar Surveillance radar, or AN/TPY-2.
- **2 ways of detecting missiles -** In forward-based mode it is configured to acquire and track targets at ranges of up to 3,000 kilometers, and in its terminal mode it is aimed upward to acquire targets during their descent.
- Its interceptors use kinetic energy (energy generated through its mass being in motion) to set off the missile.



4.19 C295 aircraft

Indian Prime Minister recently inaugurated a plant in Vadodara, where Tata Advanced Systems Ltd (TASL) will manufacture the C-295 aircraft for the Indian Air Force (IAF).

- It is a tactical transport aircraft *originally produced by a Spanish aircraft* manufacturer named Construcciones Aeronauticas SA.
- **Manufactured by -** Airbus Defence and Space.
- **Capacity** - 5 to 10-tonnes.
- **Maximum speed** - 480 kmph.
- **Features**
    - **Range and Endurance** - 5,000 km range and 11 hours of endurance.
    - **Payload Capacity -** Up to 9,250 kg.
    - **Short Takeoff and Landing (STOL)** -Enabling operations from short, unpaved runways.
    - **Advanced Avionics** - State-of-the-art cockpit and navigation systems.
    - **Multi-Mission Capability** - Easily configurable for various roles.
- It has a rear ramp door for quick reaction and para-dropping of troops and cargo.
- The aircraft has the longest unobstructed cabin in its class and can accommodate 71 seats.
- C295 can carry troops and logistical supplies from main airfields to forward operating airfields of the country.
- The aircraft can additionally be used for casualty or medical evacuation, performing special missions, disaster response and maritime patrol duties.
- **Usage** - It operates in the Brazilian jungles and Columbian mountains in South America, the deserts of Algeria and Jordan in the Middle East and the cold climates of Poland and Finland in Europe.
- The aircraft has also flown in military operations in Chad, Iraq and Afghanistan.

4.20 Pinaka Multi-Barrel Rocket Launcher (MBRL)

France is considering India's Pinaka Multi-Barrel Rocket Launch (MBRL) system for its requirements.

- It is a battle-proven an all-weather, indirect area *fire Artillery Weapon System*.
- **Designed by** - Defence Research and Development Organisation.
- The system consists of Rocket, Multi Barrel Rocket launcher, Battery Command Post, Loader cum Replenishment Vehicle, Replenishment Vehicle and Digicora MET Radar.

- **Characteristics**
  - **Maximum Range**
    - Mark-I Enhance - 45 km
    - Mark-II ER version - 90
  - Shoot & Scoot Capability with Auto Levelling / Stabilisation
  - Salvo of 12 Rockets in 44 Seconds
  - Position accuracy of one milliradian for AZ and EL
  - Programming all 12 Rockets in max. 20 seconds
  - Onboard Inertial Navigation System for Accurate and Speedy Laying
  - It can fire a variety of ammunition
- It is capable of firing in ***salvo mode*** within 48 sec neutralizing the area of 700 x 500 m.
- The Indian Army has *4 Pinaka regiments in service* and six more are on order.
- *Armenia became the first export customer* for the indigenously developed Pinaka.

4.21 Antariksha Abhyas, 2024

Antariksha Abhyas, 2024, a tri-service 3 day Exercise hosted by Defence Space Agency begins in New Delhi.

- It is the ***1st Ever Space Exercise*** to help secure national strategic objectives in space.
- It is a first of its kind exercise being conducted and is expected to integrate India's space capability in military operations.
- **Aim -** To war-game the growing threats from and to Space Based Assets and Services.
- **Conducted by -** The Defence Space Agency of Headquarters Integrated Defence Staff.
- **Participants -** Specialist branches under Headquarters Integrated Defence Staff namely Defence Cyber Agency, Defence Intelligence Agency and Strategic Forces Command.
- In addition, the exercise intends to identify vulnerabilities in conduct of operations in the event of denial or disruptions of space-based services.

4.22 Dhruv-NG (Next Generation)

Recently, the Pawan Hans Limited has secured a 10-year contract for Rs. 2,141 crore to deliver 4 Dhruv-NG helicopters to the Oil and Natural Gas Corporation (ONGC).

Dhruv

- It is an *Advanced Light Helicopter (ALH).*
- **Developed by** – Hindustan Aeronautics Limited (HAL)
- It was initially *designed with Germany's assistance*.
- **In service** – It was *1st flown in 1992* but entered service after certification in 2002.
- **Type certified by**
  - For military operations - Centre for Military Airworthiness Certification (CEMILAC)
  - For civil operation - Directorate General of Civil Aviation (DGCA)
- **4 military variants** - Dhruv Mk-I, Mk-II, Mk-III & Mk-IV.

- *Over 335 military helicopters* are operational as on date and have logged over 3, 75,000 cumulative flight hours.
- **Civilian version** – It has been *in service since 2003*.

- **Dhruv-NG (Next Generation)** – It is a multi-role, multi-mission helicopter.
- It is the ***civil variant of the Dhruv Mk III***, which is widely employed by Indian defense forces.
- **Developed by** – Hindustan Aeronautics Limited (HAL).
- **Weight** – 5.5 tonne.
- **Powered by** – *2 indigenous Shakti engines* with Cat 'A' performance.
- **Specialty** – It is capable of *day and night operations*.
- It is also fitted with *AS4 (Applicability Statement)* compliant systems.
- It received a restricted type certificate from the European Aviation Safety Agency (EASA) in June 2023.
- **For ONGC operation** – This will be the *1st time the chopper will be deployed in offshore operations* like transporting staff to and from duty stations on oil and gas rigs.
- **Significance** - It is a "reliable and cost-effective product' for service provider Pawan Hans Limited.

***Pawan Hans** has been a key industry player in the Indian offshore industry, providing helicopter services to ONGC, British Gas, HOECL, Petro Gas, and others.*

These helicopters are scheduled to go into service in 2025, largely to meet Oil and Natural Gas Corporation (ONGC) crew change requirements.

4.23 Nag Mk 2

Field Evaluation Trials of Nag Mk 2 Anti-Tank Missile, were successfully conducted recently.

- It is an indigenously-developed ***third-generation Anti-Tank Fire-and-Forget Guided Missile***.
- **Characteristics** – It is an all-weather, fire-and-forget, lock-on after launch, anti-tank guided missile (ATGM).
- It is estimated to have a range of 7 to 10 kilometers.
- It also boasts a tandem *high-explosive anti-tank (HEAT) warhead* for increased destructive power.
- **Launch vehicle** - From the NAMICA, an armoured vehicle based on the Indian-made BMP-2 Sarath.
- **Sarath** – It is based off a Russian-origin BMP-II based system with amphibious capability.
- **NAMICA** – It provides a robust and mobile platform for the Nag missile system, allowing it to be deployed quickly and effectively across various terrains.
- **Effectiveness** – It is effective against modern armoured vehicles, including those equipped with Explosive Reactor Armour.

*Its predecessor the **Nag Mark 1**, which had a 4-kilometre range.*

4.24 Major Defence Exercises

Defence Exercises	
MPX 2024	Maritime Partnership Exercise ***between India and Russia***, which involved naval ships from both nations
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.***

4.25 Important Operations

Operation Smiling Buddha	India's 1st nuclear test in Pokhran in 1974.
Operation Shakti	On 11th May in 1998, India conducted a series of nuclear tests in Pokhran and is also known as Pokhran-II
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 FLiRT

New COVD-19 strains KP.2 and KP1.1 known as FLiRT variants causing a surge in cases in the U.S., U.K., South Korea and New Zealand.

- **FLiRT group of variants**- KP.2 and KP1.1 are recent descendants of the JN.1 variant of the SARS-CoV-2 virus. These mutations confer greater invasive properties to the virus.
- **Symptoms-** It is similar to other Omicron subvariants, including sore throat, cough, nausea, congestion, fatigue, headache, muscle or body ache, loss of taste or smell.'
- **KP.2-** It is considered the 'great-grandson' of JN.1 and is more prevalent across countries which accounts for about 25% of new cases in the U.S. and U.K.
- **JN.1-** It is a descendant of the Pirola variant (BA.2.86), which itself stems from the Omicron sub-variant. It was classified as Variant of Interest.
- **Immunity evasion**- Research indicates that the FLiRT variants, especially KP.2, can evade immunity from vaccines and previous infections, posing challenges for COVID-19 management.
- **India's status-** INSACOG has detected cases of FLiRT variants in India with a rise in COVID-19 cases, emphasizing the need for updated vaccinations and continued precautions.
- **Cyclical disease**- COVID-19 is described as a cyclical disease with periodic spikes, rather than an endemic one, necessitating sustained surveillance and universal protection measures.

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

KP.2

- **KP.2** – A ***subset of COVID variants***, nicknamed "FLiRT," drawn from the letters in the names of their mutations.
- **Direct descendant of JN.1** – KP.2 has *3 substitutions in the S protein* and additional *1 substitution in non-S protein*.
- This might make it better at *evading our immune defenses* and slightly more infectious than JN.1.
- **Infection** – There are possibility of getting *reinfected with KP.2* even if one had been infected earlier with JN.1, particularly if it's been several months or longer since your last bout of COVID.
- KP.2 could *infect even people who got the most updated vaccine*.
- **Virulence** – There isn't enough evidence yet that KP.2 would cause more severe illness than other strains.
- But people who are *age 65 and older, pregnant or immunocompromised* remain at higher risk of serious complications.
- **Symptoms** – Mostly *similar to those seen with other variants* that include sore throat, runny nose, coughing, head and body aches, fever, congestion, fatigue and, in severe cases, shortness of breath.
- Many individuals might also have symptoms like *diarrhea, nausea and vomiting.*
- **In India** – As per reports, 91 cases of the new Covid-19 Omicron subvariant KP.2 has been recorded in Maharashtra.

5.2 Mice study on COVID's True Cause

A recent study suggests that fibrin, a key player in blood clotting, may be the primary driver of long COVID symptoms, rather than just a consequence of the disease.

- COVID – It is an infectious disease caused by the ***SARS-CoV-2 virus.***
- It is well-known as a vasculopathic agent, a damager of blood vessels.
- The dominant respiratory symptoms associated with COVID-19 are largely ***due to clotting and inflammation in the blood vessels*** of the lungs (rather than the direct involvement of the airways).
- Its more severe complications, including neurological ones like stroke, are rooted in vasculopathy as well.

Recent findings

- **Role of fibrin-** *Fibrinogen* binds with the SARS-CoV-2 spike protein, forming fibrin, which causes inflammation and complications in the lungs and brain.
- This contradicts the earlier view that inflammation due to the virus was responsible for clotting.
- The *spike protein binds with fibrinogen* in the lungs, altering the clot structure and triggering an immune response.
- This interaction may drive long COVID symptoms even after active infection is gone.
- **Implications for treatment-** A ***monoclonal antibody*** was found to block the interaction between the spike protein and fibrinogen without affecting normal clotting functions.
    - Monoclonal antibodies are proteins made in a lab that bind to one antigen only.
- **Limitations-** It is a ***preliminary mouse model***, not long-term human studies, and require further research for confirmation.

> ***Fibrinogen*** *is a glycoprotein complex, produced in the liver that circulates in the blood of all vertebrates.*

> *A* ***spike protein*** *is a protein that forms a large structure known as a spike or peplomer projecting from the surface of an enveloped virus.*

DISEASES IN NEWS

VIRAL DISEASES

5.3 H5N1 Infection

Scientists believe that the H5N1 virus can be transmitted to humans via an infected cow's milk that has not been pasteurised.

- **H5N1** – It causes a highly *infectious respiratory disease* in birds called avian influenza or bird flu.
- **Transmitted by** – Wild birds to domestic poultry and other bird and animal species through *bird droppings*.

> ***Highly Pathogenic Avian Influenza (HPAI)*** *is a disease that is highly contagious and often deadly in poultry, caused by HPAI A (H5) and A (H7) viruses. It is 1st identified in domestic waterfowl in 1996 in China.*

- New research shows a sub variant of H5N1 can transmit *through Air* while another study shows that some birds (poultry) as well as cats do show susceptibility to influenza virus infections via oral route.
- **Affected population** – Both *land and sea mammals* have been affected and there are few instance of infection in *humans* as well.

H5N1 in humans

- So far, close to 900 human infections have been reported since 2003, of which more than half were fatal.
- **Transmission** – Almost all of those infected were farm workers who had come in *close contact with infected animals*.
- **Symptoms** – Primarily respiratory, but conjunctivitis and other

> *Almost all human influenza virus infections are primarily respiratory infections unlike in some other mammals where gut infections have been reported.*

non-respiratory symptoms have also been reported.

- From mild to severe and in some cases, it can even be fatal.
- **India** – It reported its first and only case of human avian influenza A (H5N1) in Haryana in 2021.
- **Vaccines** – Current seasonal influenza vaccines do not protect against human infection with animal influenza A viruses.

FAO noted that H5N1 virus was detected in high concentrations in milk from infected dairy cattle, still no reports of viable H5N1 virus being found in raw milk samples.

- **Misconception** - The notion of immunity against H5N1 virus can be developed by drinking raw milk containing viable viruses.

5.4 Increased Risk H5N1 Virus in Humans

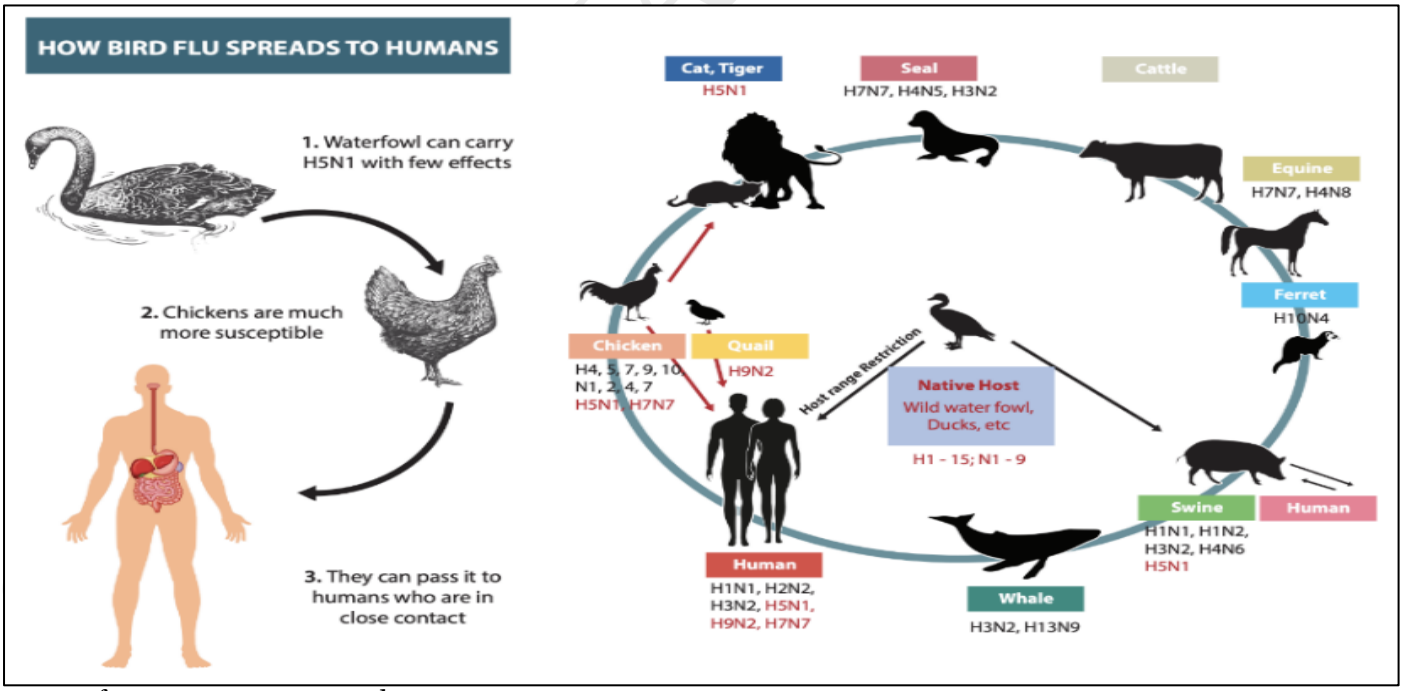
Recently, the researchers found that circulating the H5N1 clade virus attached better in the human respiratory tract.

- **Avian influenza** – It is highly contagious and spreads through direct contact with infected birds or their secretions, including saliva, feathers, and faeces.
    - Avian influenza is a zoonotic disease, meaning it can spread from animals to humans.
- **H5N1** – It is a subtype of Avian Influenza A, was 1st detected in geese, China on 1996 and causing outbreaks in birds since then.
- **Key causes of spread**
    - Wildlife spillover
    - Large-scale poultry farming and poor biosecurity measures
    - Improper cooking practices

***A clade**, in biology, is a group of organisms that consists of a common ancestor and all of its descendants.*

H5N1 in Humans

- **H5N1 clade 2.3.4.4b** – Influenza A **virus *cross the species barrier and infect humans*** and spread



from one person to another.

- It ***infects the cells in the respiratory epithelium*** of the upper respiratory tract.
- It is endowed with the ability to attach to and replicate in the upper respiratory tract led to infection and transmission of the virus.
- The ability to attach to cells in the lower respiratory tract is associated with its ability to cause severe respiratory disease.

- **Increased risk** – The receptor binding repertoire of H5N1 virus has expanded to attach to receptors in the human upper and lower respiratory tracts.
    - There have been *64 confirmed human cases* of H5N1 clade 2.3.4.4b in the U.S. as of December 2024.
- The H5N1 virus has now established its presence in ***108 countries across 5 continents***, impacting even endangered species like the ***California condor and polar bears***.

H5N1 Clade	
Clade 2.3.2.1a	• *Detected in a child* traveler returning to Australia from India, 2024.
Clade 2.3.4.4b	• Identified in dead migratory birds in China, November 2021. • It is *affecting wild and domestic birds and mammals* worldwide. • Since 2020, it led to an unprecedented number of deaths in wild birds and poultry in many countries. • In 2021, spread to North America and in 2022 to Central and South America.

5.5 Virus-like Particles (VLPs)

Scientists had recently developed a novel method to generate non-infectious virus-like particles (VLPs) that mimic the Nipah virus (NiV).

Nipah Virus

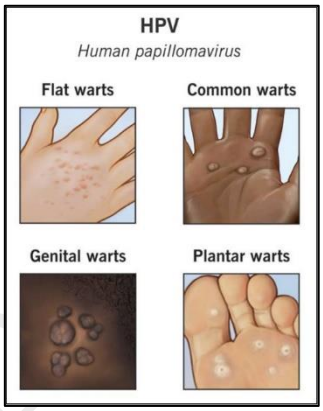
- It is a ***zoonotic disease*** that spreads primarily between animals and humans.
- Nipah is a highly ***pathogenic paramyxovirus***, with a fatality rate of up to 80% in affected humans.
- The genome of the NiV encodes 6 major proteins:
    - Glycoprotein (G), Fusion protein (F), Matrix (M), Nucleocapsid (N), Long polymerase (L), and Phosphoprotein (P)

- **Virus-like Particles (VLPs) –** VLPs are molecules that closely resemble viruses, but are non-infectious because they contain ***no viral genetic material.***
- **Characteristics -** VLPs carry most of the characteristics of the virus, except their ability to replicate (because it lacks the viral genome).
- The advent of NanoBiT technology and "HiBiT-tagged" VLP (HiBiT is an 11 amino acid peptide) makes it far more sophisticated.
- Scientists at the Institute of Advanced Virology (IAV) have generated "HiBiT-tagged" Nipah virus-like particles (NiV-VLPs).
- Highly sensitive and quantitative HiBiT-tagged Nipah virus-like particles is a platform for rapid antibody neutralisation studies.
- It was generated using plasmid-based expression systems, encoding the NiV structural proteins G, F, and M.
- The VLPs produced are morphologically and functionally identical to the native virus.
- The inclusion of a highly sensitive HiBiT tag on these VLPs accelerates their potential in antiviral drug screening and vaccine development.
- **Virus neutralisation assays –** These are critical for the development and evaluation of vaccines and immune-therapeutics,
- They are also used for conducting basic research into the immune response and pathogenesis of NiV.
- These tests, which traditionally require to be done in high security labs (BSL-4) with the infectious organism, can now be done safely in BSL-2 labs in the country using the NiV-VLPs.
- Biosafety level 4 (BSL-4) laboratories are designed to handle pathogens that are highly contagious and can cause fatal diseases.

- These pathogens are known as Risk Group 4 pathogens and include viruses like Ebola, Lassa, Nipah, Marburg and Crimean-Congo hemorrhagic fever.

5.6 Human Papilloma Virus (HPV)

India's public health sphere recently saw a one-sided discussion on how HPV vaccination prevents cervical cancer and reduces related deaths.



- It is a ***viral infection***.
- There are more than 100 varieties of human papillomavirus (HPV).
- **Infection** - It cause *skin or mucous membrane growths (warts)*.
- Most HPV infections ***don't lead to cancer*** but some types of genital HPV can cause cancer of the lower part of the uterus that connects to the vagina (cervix).
- Other types of cancers, including cancers of the ***anus, penis, vagina, vulva, and back of the throat (oropharyngeal)***, have been linked to HPV infection.
- **Symptoms** - Genital warts, Common warts, Plantar warts, Flat warts.
- **Transmission** - Often transmitted sexually or through skin-to-skin contact.
- **Vaccine** - It can help protect against the strains of HPV most likely to cause genital warts or cervical cancer.
- ***Gardasil 9*** is an HPV vaccine approved by the U.S. Food and Drug Administration and can be used for males and females to protect against cervical cancer and genital warts**.**

Quick fact

- **Cervical cancer** - Nearly all cervical cancers are caused by HPV infections, but cervical cancer may take 20 years or longer to develop after an HPV infection.
- Cervical cancer ***doesn't cause symptoms***.
- Getting ***vaccinated against HPV infection*** is your best protection from cervical cancer.
- The Serum Institute of India (SII) has developed '***Cervavac***', a *vaccine against cervical cancer*.
- It uses similar techniques, deploying virus-like particles ***(VLPs)*** produced using recombinant deoxyribose nucleic acid ***(rDNA)*** techniques to generate an immune response against HPV infections.
- It is only the ***second rDNA vaccine in the world*** using the techniques of the early 1970s, the first being the vaccine against ***Hepatitis-B***.

5.7 Chandipura virus

Recently 6 children have died due to suspected Chandipura virus Infection (CHPV) in Gujarat.

- Chandipura vesiculovirus (CHPV), is an ***RNA virus.***
- It is a ***noncontagious*** disease.
- **Virus Family-** Rhabdoviridae family.
- **First identified-** In 1965 in Chandipura, Maharashtra.
- **Transmission-** Primarilythrough the ***bite of infected sandflies*** (genus Phlebotomus).
- It primarily affects children and has been associated with outbreaks of acute encephalitis in India.
- It is a serious pathogen with a rapid onset of severe symptoms, primarily affecting children in certain regions.
- The virus resides in the salivary gland of these insects, and can be transmitted to humans or other vertebrates like domestic animals through bites.
    - **Vector-borne transmission-** The primary mode of transmission is through sandfly bites.

RNA virus *is a virus that has single-stranded as well as double-stranded RNA as its genetic material.*

The ***Rhabdoviridae family*** *are bullet-shaped, negative-sense single-stranded RNA (ssRNA) viruses which also includes the rabies virus.*

- **Animal reservoirs-** Certain animal species may act as reservoirs for the virus, though this is still under investigation.
- **Environmental factors-** Outbreaks have been linked to specific environmental conditions that favor the breeding of sandflies.

- **Symptoms -** Fever, Headache, Vomiting, Convulsions, Coma.
- **Treatment-** There is ***no specific antiviral treatment*** or vaccine for Chandipura virus infection.
- **Prevalance of Disease in India-** Significant outbreaks of the disease in India were seen in 2003-04 in states such as *Maharashtra, northern Gujarat and Andhra Pradesh*.
- Ithas largely remained endemic to the central part of India, where the population of CHPV infection-spreading sandflies and mosquitoes is higher.

5.8 Measles and its vaccines

According to WHO-UNICEF, India has the highest number of unvaccinated children for measles in 2023, with 1.6 million cases.

- It is a highly ***contagious viral disease*** caused by the measles virus, which is a *single-stranded RNA virus* of the genus Morbillivirus within the family Paramyxoviridae.
- **Symptoms-** High fever, Cough, Runny nose, Diarrhea and Pneumonia.
- **Transmission-** It is an ***airborne disease,*** spreads through person-to-person contact.
- **Vulnerables** - Unvaccinated young children and pregnant persons are at highest risk of severe measles complications.
- **Prevalent Regions -** Measles is still common, particularly in parts of Africa, the Middle East and Asia.
- **Treatment -** There is *no specific treatment* for measles.
- **Prevention -** The primary method for preventing measles is vaccination.
  - **MMR Vaccine-** MMR stands for Measles, Mumps, and Rubella.
  - **MMRV Vaccine-** MMRV stands for Measles, Mumps, Rubella, and Varicella (chickenpox).
- In some regions, a single measles vaccine may be available, but it is less commonly used compared to the MMR and MMRV vaccines.
- **Immunisation Agenda 2030-** The Immunization Agenda 2030 (IA2030) sets an ambitious, overarching global vision and strategy for vaccines and immunization for the decade 2021–2030.
- A key goal is to reduce the number of ***zero-dose children by half by 2030.***

> ***zero-dose children*** *is a children who don't receive a single dose of diphtheria, tetanus and pertussis containing vaccine.*

Recent Findings of WHO-UNICEF

- *In 2023, India was one of the top 10 countries* globally where 55% of children lacked measles vaccination, despite 90-94% of its children being vaccinated for measles.
- India has recorded more ***'measles zero dose'*** children in 2023 than in 2022.
- India logs 3rd highest number of children not vaccinated against measles after Nigeria and Congo.
- The latest finding noted that measles outbreak in at least 5 Indian states in 2022, driven by reduced vaccination during the COVID-19 pandemic.
- *Maharashtra* reported the most cases and deaths in India.

5.9 Respiratory Syncytial Virus Infection (RSV)

The World Health Organization recently recommended vaccinating pregnant women and administering infants with an antibody to prevent severe respiratory synctial virus (RSV) infection in newborns.

- It typically causes ***cold-like symptoms,*** a leading cause of severe infection & death in babies and older adults.

- **Symptoms –** Cough, Runny nose, Congestion, Sneezing, Sore throat, Mild headache, Lack of energy, Fever, Decreased appetite, Lack of interest in playing (in babies and young children).
- A severe infection leads to ***pneumonia and bronchiolitis.***
- **Transmission -** It can spread in close contact with someone with the infection or by touching a contaminated object and then touching your eyes, nose or mouth.
- People with RSV are usually contagious for ***3 to 8 days*** and may become contagious a day or two before they start showing signs of illness.
- However, some infants and people with weakened immune systems can continue to spread the virus for ***4 weeks or longer***, even after they stop showing symptoms.
- RSV symptoms make it difficult to distinguish it from the common cold or other respiratory viruses (like the flu or COVID-19).
- In most regions of the United States and other areas with similar climates, RSV season generally starts during fall and peaks in the winter.
- **Vulnerables -** Premature babies, young infants and older adults, with heart or lung disease or a weakened immune system are at higher risk of severe infection.
- **Vaccines**
  - **For infants** – Nirsevimab (Beyfortus).
  - **For Adults -** Two vaccines are available - Abrysvo and Arexvy.

According to the WHO, majority of RSV-related deaths occur in low- and middle-income countries, with about 101,400 annual deaths in children under the age of five.

5.10 Marburg virus

Rwanda recently reported that the Marburg disease infected at least 46 individuals and 12 Marburg deaths.

- It is a rare but ***severe hemorrhagic fever*** that can cause serious illness and death.
- It belongs to the *filovirus family*, like Ebola and both pathogens are clinically similar, and rare.
- **Discovered in -** The first outbreak occurred in Marburg, Germany, in 1967.
- **Caused by -** *Prolonged exposure to mines or caves* inhabited by colonies of ***Rousettus bats***, most notably the ***Egyptian fruit bat.***
- Marburg also spreads through human-to-human transition both
  - Directly (through contact with blood and other bodily fluids of infected people) and
  - Indirectly (through surfaces and materials like bedding, clothing, etc. Contaminated with these fluids).
- **Symptoms -** High fever, severe headache, muscle ache, severe watery diarrhoea, abdominal pain and cramping, and vomiting.
- Many patients develop haemorrhagic symptoms (bleeding), often in many places including the digestive system (faeces and vomit often come with fresh blood), the nose, gums, and vagina.
- Haemmorage leads to most MVD fatalities, with death in fatal cases occurring 8 to 9 days after the onset of symptoms, usually of severe blood loss and shock.
- **Treatment -** Currently, there are *no approved vaccines or specific treatments*.
- **Fatality -** Its*fatality rates ranging from 24% to 88%* in past outbreaks, depending on virus strain and case management.

5.11 Vaccine-derived poliovirus

A recent report says that World Health Organization's database on polio, like wild poliovirus and vaccine-derived poliovirus cases hides more than it reveals.

- VDPV stands for vaccine-derived poliovirus, a ***rare and weakened strain of poliovirus*** used in the oral polio vaccine (OPV) mutates and regains the ability to cause paralysis.
- OPV contains a *live, attenuated virus* that is used for immunization against the disease.

- This weakened virus triggers an immune response when administered, thus protecting people from the disease.
- **Transmission** - The attenuated virus replicates in the intestines for a limited period and is excreted in the stool.
- In rare cases, the virus can mutate enough to cause the disease again, and circulate in areas where
    - Either immunization is low, or
    - Where immunocompromised persons reside, or
    - Regions with poor sanitation and hygiene.

India was declared polio-free in 2014 by the World Health Organization (WHO).

- If it spreads in populations that aren't immunized or in people with compromised immune systems.
- **Symptoms** - Acute flaccid paralysis (AFP) and includes muscle pain, loss of muscle reflexes, and floppy limbs.
- **Risk** –It poses a similar risk as wild poliovirus, and can spread to others who aren't vaccinated.
- If VDPV is detected in at least 2 different sources that are genetically linked, it's considered "circulating".
- **Prevention** - The inactivated poliovirus vaccine (IPV) protects against VDPV and is given as an injection in the arm or leg. The United States has used IPV exclusively since 2000.

5.12 Lassa fever

Lassa fever has come into prominence after a recent case in Iowa, United States, involving the death of a traveler from West Africa.

- **Caused by -** Lassa virus.
- It is a ***zoonotic disease***, part of the Arenaviridae family, with the ***Mastomys rat*** as its primary reservoir.
- **Identified in –** The town of Lassa in Nigeria in 1969
- **Symptoms -** Gradual onset of fever, general weakness, and malaise, followed after a few days by
    - More severe manifestations such as headache, sore throat, muscle and chest pain, nausea, vomiting, diarrhoea, cough, and abdominal pain.
- While approximately ***80% of infections are asymptomatic*** or mild, severe cases can present with high fever, severe headaches, and haemorrhage, potentially leading to organ failure.
- **Human Transmission** - Humans usually contract the virus through contact with food or items contaminated by the the Mastomys rat's urine or faeces.
- Secondary human-to-human transmission occurs through exposure to bodily fluids, raising significant risks, particularly in healthcare settings.
- **Vulnerable population -** Pregnant women and infants.
- Infected pregnant women, especially those in their 3rd trimester, face an increased maternal mortality rate of over 30%.
- The disease's impact on the foetus is devastating, with a foetal death rate ***exceeding 85%.***
- For children up to 2 years old, Lassa fever can manifest as "swollen baby syndrome, "characterized by extensive swelling and associated with a higher fatality rate than that of adults.
- Vertical transmission has been reported from the mother to the foetus in the transmission of Lassa fever.
- **Prevention** - *Minimising rat-to-human transmission* is vital to controlling Lassa fever.
- **Fatality -** Lassa fever has a case fatality rate (CFR) of approximately 1% overall and it can escalate to as high as 15-20% among hospitalised patients.
- Notable issue include varying degrees of deafness in nearly 25-50% of patients one to 3 months after recovery.
- Estimated 1,00,000 to 3,00,000 individuals annually, with around 5,000 deaths each year.
- **Cases in India -** India's Ministry of Health and Family Welfare, has classified Lassa fever as a disease of international significance.
- India has ***not recorded any documented cases*** until now (officially, no case reported till 2022).

5.13 Infectious Disease among Bees

A recent research paper explores the presence of some virus species in wild bee and hoverfly species across different landscapes in Switzerland.

- **Virus in Bees** – Recent study found the presence of ***deformed wing virus and black queen virus*** in 19 wild bee and hoverfly species across different landscapes in Switzerland.
- They found *higher loads of these pathogens in wild pollinators* that used floral resources the honey bees accessed as well.
- **Causes** – *Western honey bees are often viral reservoirs* and can infect wild species when they share habitats.
- **Pathogen spillover** – A process of the transmission of pathogens between managed honey bees and wild pollinators.
- The loads were 10-times higher among the wild pollinators in these shared habitats.
- **Pathogen spillback** – The less virulent virus could *mutate in the wild pollinators and then spill back* to honeybees in a more virulent form, being more detrimental to honeybees.
- **Habitat loss** – It could force pollinators into smaller suitable habitats and increase the risk of disease transmission.
    - A recent estimate showed that 40% of bumblebee species in the Indian Himalaya could lose more than 90% of their habitat by 2050, raising concerns about the competition for resources with western honey bees.

> *More than 75% of food crops, fruits, and flowering plants need bees, wasps, beetles, flies, moths, and butterflies to yield successful harvests.*

- **Control mechanism** – *Diverse pollinator-friendly habitats* with more floral resources lowered the chance pathogen spillover & spillback between wild pollinators and managed western honey bees.
- More research and surveillance are required to monitor emerging diseases in bees and other pollinators.
- **Impact** – It threatens world's economies.

Bees in India

- It hosts *more than 700 bee species*, including ***4 indigenous honey*** bees - Asiatic honey bee (*Apis cerana indica*), Giant rock bee (*Apis dorsata*), Dwarf honey bee (*Apis florea*), Stingless bee (sp. *Trigona*).
- **Introduction of Western honey bees in India** - In 1983 to increase the country's honey yield.
- **Infection** - In 1991-1992, a *Thai sacbrood virus* outbreak devastated around 90% of Asiatic honey bee colonies in South India and *reemerged in 2021 in Telangana*.

5.14 Japanese Encephalitis Virus (JEV)

Recently, a suspected case of Japanese Encephalitis Virus was reported in Bindapur, New Delhi.

- **JEV** – It is a ***mosquito-borne flavivirus*** that belongs to the *same genus as dengue, Zika, yellow fever and West Nile viruses.*
- **Transmission** – Through the bite of an infected mosquito especially a mosquitoes called *Culex tritaeniorhynchus*.
- It circulates in the environment between mosquitoes and other animals, namely wading birds and pigs.
- It is ***not transmitted from person-to-person***, except rarely by blood transfusion.
- **First case** – Reported on 1871 in Japan.
- **Symptoms** – It doesn't have any symptoms or have only mild symptoms in most of the people.
    - **Initial** – Includes fever, headache, Seizures, gastrointestinal pain and vomiting.

- **Severe** – High fever, headache, neck stiffness, disorientation, weakness, coma, seizures, spastic paralysis and ultimately death.

- **Signs** – The time from infection until illness onset is ***typically 5–15 days***.
- **Region** – In temperate areas of Asia, transmitted mainly during the warm season.
- In tropics and subtropics, transmission intensifies during the rainy season.
- **Risk Factors** – Majorly occur to children ***below 15 years of age***.
  - **Less than 1%** - Develop neurologic illness.
  - **20–30%** - Die due to inflammation in the brain.
  - **30%-50%** - Suffer permanent cognitive, behavioural illness such as seizures, hearing or vision loss, speech, language, memory, and communication problems or weakness of the limbs.

*24 countries in the World Health Organisation (WHO) South-East Asia and Western Pacific Regions have **endemic JEV transmission,** exposing more than 3 billion people to risks of infection.*

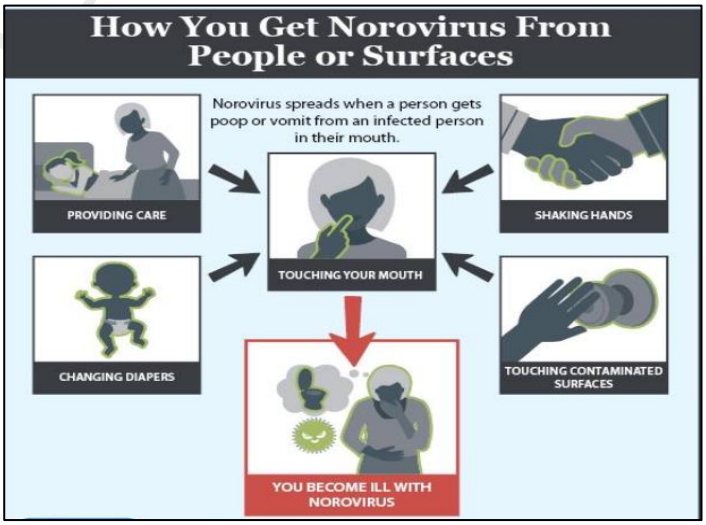
- *Vaccine is available* to prevent disease.
- **Treatment –** There is ***no antiviral treatment***.
- It is focused on relieving severe signs and supporting the patients to overcome the infection.
- Rest, fluids, and counter pain medicine relieve some symptoms.

5.15 Norovirus Infection

Recently, the norovirus cases are raising in the United States (US).

*Norovirus is also called as **Stomach Flu** or Stomach Bug owing to its common symptoms associated with stomach.*

- **Norovirus** – It is a highly contagious virus, an influenza virus.
- **Winter vomiting bug** – Since it is most common during winter, it is called as *Winter Vomiting Bug*.
- **Risk factors –** All age groups get infected but more vulnerable are children younger than 5 years old, older adults, and people with weakened immune systems.
- **Transmitted through** – *Contaminated food* due to consumption of raw, oysters and other filter-feeding shellfish, water and surfaces
- **Primary transmission route** – O*ral-faecal*.
- **Incubation period** – It develops in *1 or 2 days* after exposure.
- **Symptoms –** Diarrhea, vomiting, nausea and stomach pain and dehydration (loss of body fluids).



  - **Other symptoms** – Fever, headache and body aches.
- Norovirus were previously known as **Norwalk virus**, was 1st identified in stool specimens collected during an outbreak of gastroenteritis in Norwalk city, United States.
- **No treatment** – There are n*o vaccines available* for the disease and even antibiotic drugs do not help to treat norovirus infections.
- **Precautions** - *Washing hands repeatedly* with soap after using the lavatory or changing diapers.

5.16 Human Metapneumovirus (HMPV) Infection

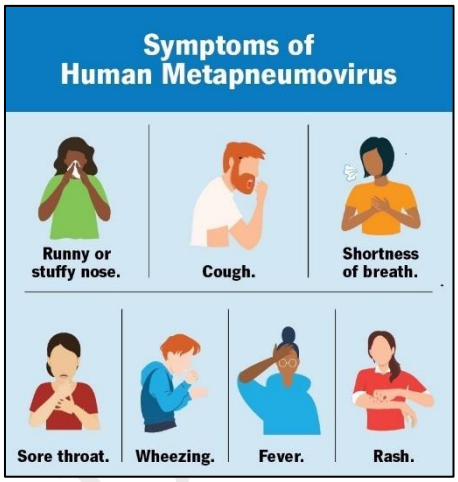
An outbreak of Human Metapneumovirus (HMPV) in China has raised alarm globally.

- **HMPV** – It is a common *respiratory virus* that causes lower and upper respiratory infections (like a cold).

- It falls in the Pneumoviridae family along with RSV.
- **Seasonal disease** – It usually *occurs in the winter and early spring*, similar to Respiratory Syncytial Virus (RSV) and the flu.

***Pneumoviridae family** includes Respiratory Syncytial Virus (RSV), measles and mumps.*

- **Risk factors** – ***All age groups***, especially among young children under the age of 14, older adults, & people with weakened immune systems.
    - Lung conditions such as *Asthma or Chronic Obstructive Pulmonary Disease (COPD)* should be extra cautious.
- **Transmission –** Through bodily secretions from coughs, sneezes
- Close contact with an infected person such as shaking hands, hugging.
- Touching a doorknob or a phone or a keyboard that may be contaminated with the virus & then touching the mouth, nose or eyes.
- **Incubation period** – *3 to 6 days.*
- **Symptoms** – Cough, runny or blocked nose, sore, throat, fever and wheezing which progress to *bronchitis or pneumonia*.
- **Treatment** – There is *currently no vaccine*, and antiviral treatment is not recommended.
- **Precautions** – *Wash hands often* with soap and water for at least 20 seconds.



***India** hadn't registered any unusual spike in winter respiratory diseases.*

5.17 Bluetongue Disease

The presence of multiple Culicoides species responsible for the larger number of bluetongue virus transmission in the Andaman and Nicobar Islands.

- Bluetongue is a ***viral disease*** that affects ruminants like sheep, cattle, and goats.
- **Symptoms –** Fever, Swelling of the face, lips, tongue, nose, jaw, and eyelids, Excessive salivation, Congestion and nasal discharge, Ulcers in the mouth and nose, Lameness, Respiratory problems, Hemorrhages in the skin and other tissues.
- **Transmission –**By the bite of a *Culicoides midge*.
- The midge takes blood from an infected animal and spreads the disease to other animals when it bites them again.
- It is ***not contagious*** between animals.
- **Affected animals -** Sheep are usually the most affected.

*The **Indian Culicoides fauna** now includes 93 valid species, many of which are recognised as confirmed or potential vectors of important pathogens of animal health.*

- Cattle and goats can carry the virus for a period of time and transmit it to other animals.
- Other ruminants like deer, camels, llamas, giraffes, bison, buffalo, wildebeest, and antelope can also be affected.
- **Geographic distribution -** Bluetongue is found in tropical and subtropical regions, between 53°N and 35°S.
- It has been found in Africa, the Americas, Australia, the Middle East, and some countries of southern Asia and Oceania.
- **Vaccination –** Vaccination is used as the most effective and practical measure to minimize losses related to the disease.
- European Medical Agency has recently recommended the approval of the vaccines *Bluevac-3 and Syvazul BTV 3* to protect sheep against bluetongue disease.
- **Treatment -** There is no specific treatment for animals with bluetongue apart from rest, provision of soft food, and good husbandry.
- Bluetongue is listed by the World Organization for Animal Health (OIE) as a *notifiable disease.*

5.18 Henipavirus

First case of deadly henipavirus found in North America.

- It is a ***zoonotic,*** negative-sense RNA Virus belong to Paramyxoviridae family.
- **Natural Hosts –** Pteropid fruit bats (flying foxes)
- **Symptoms -** Dizziness, headache, fever, and myalgias.
- Respiratory symptoms also may be present.
- Relapsing or late-onset encephalitis can occur months or years after acute illness.
- **Infection** - These inhibit the cell's response to viral infection, and allow viral replication.
- These thus act as virulence factors, blocking the interferon-stimulated antiviral defense mechanisms from kicking in inside the infected cells.
- It causes destruction of small blood vessels in many major organs, such as the brain, liver and kidney, causing organ failure. This is associated with microinfarction, infection, and organ failure.
- **Fatality -** Fatality often occurs when the disease progresses to severe encephalitis and symptoms like confusion, abnormal reflexes, seizures, and coma occur.
- **Prevention** - By ensuring *HeV vaccination* of all horses in risk situations, as well as minimal human contact with fruit bats, isolation of sick animals.
- **Treatment** - Symptomatic, and ***no vaccine or antiviral drug*** has been developed so far to treat the disease.

> ***Camp Hill virus****, a type of henipavirus has been found in the northern short-tailed shrews, a small mammal commonly found in Canada and the US.*

5.19 Influenza & VaxiFlu-4

Zydus Lifesciences recently introduced India's First Flu Vaccine for New Influenza Strains.

- Influenza, or the flu, is a ***contagious viral infection*** that affects the respiratory system.
- **Types -** A, B, C, and D. Only influenza A, B, and C affect humans.
- Influenza viruses are constantly changing, with new strains appearing often.
- **Symptoms –** Fever, Runny nose, Sore throat, Muscle pain, Headache, Coughing, Fatigue, Diarrhea and vomiting (especially in children).
- **Transmission** - Spreads through droplets from coughs, sneezes, or talking.
- Can also spread by touching something with the virus on it and then touching your eyes, mouth, or nose.
- It causes illnesses that range in severity and at times lead to hospitalization or even death, mainly in high-risk groups.
- **High-risk groups -** Under-5 children, the elderly, and people with immunosuppressive and chronic medical conditions.
- **Treatment**
  - Flu is primarily treated with rest and fluid intake to allow the body to fight the infection on its own.
  - Drink plenty of fluids, like water, juice, and warm soups
  - Rest and get more sleep
  - Antiviral drugs can help shorten the duration of the illness and prevent complications.

> *According to the World Health Organization,* ***seasonal influenza*** *results in 2.9 lakh to 6.5 lakh deaths every year.*

Prevention (VaxiFlu-4)

- **VaxiFlu-4** - It is a ***Quadrivalent Inactivated Influenza*** virus vaccine made as per World Health Organization (WHO) recommended composition.
- **Developed by** – Zydus's Vaccine Technology Centre (VTC) in Ahmedabad
- The vaccine has been cleared by the Central Drug Laboratory (CDL).

> ***A quadrivalent influenza (flu) vaccine*** *is designed to protect against four different flu viruses, including 2 influenza A viruses and 2 influenza B viruses.*

BACTERIAL DISEASES

5.20 Fusobacterium nucleatum

A new study finds that a mouth bacteria has starring role in colorectal cancer (CRC) tumours.

- It is a *Gram-negative, anaerobic oral bacterium*, commensal to the human oral cavity that plays a role in periodontal disease.
- It lives in the human mouth and are rarely found elsewhere.
- **Types** – It has *4 subspecies*.
- Among the 4 subspecies, only ***Fusobacterium nucleatum animalis (Fna)*** subspecies was associated with CRC tumours.
- **Role in colorectal cancer** – They are found in tumours in the gut, where they *help cancer cells escape from the immune* system and spread to other parts of the body.
- **Genetic adaptation** – There are 2 different clades of Fna, namely Fna C1 and Fna C2, where Fna C2 bacteria are significantly associated with CRC tumours with their extra genetic factors.
- **Mouth to gut** – It could go from the mouth to the gut by infecting the *bloodstream or* could have descended *through the gastrointestinal tract to reach the colon*.
    - Bacteria don't usually take gastrointestinal tract as they can't survive the highly acidic environment of the stomach.
- It was found Fna C2 could *grow in more acidic conditions* than Fna C1.

*Research showed that when a mice infected with Fna type of Fusobacterium, their intestines developed precancerous formations called **adenomas**.*

***A clade** is a group of life-forms belonging to one evolutionary lineage. The pangenome contains all genes encoded by a species, with the core genome present in all strains and the accessory genome in only a subset.*

Colorectal cancer (CRC)

- It is the *7th most common type of cancer* in India, where the number of cases rose by 20% from 2004 to 2014.
- Its overall incidence has declined worldwide but the incidence of age-adjusted early-onset CRC has risen at an alarming rate of 2-4% in many countries, with even sharper increases in individuals younger than 30 years.

5.21 Extra-Pulmonary TB (EPTB)

Many challenges are associated in tackling extra-pulmonary Tuberculosis.

- **TB** – Tuberculosis, is an infectious disease caused by a type of bacteria called Mycobacterium tuberculosis.
- **EPTB** – Extra-Pulmonary TB refers to the TB infection that ***infects the organs apart from the lungs.***
- It includes TB infections that develop in the *lymph nodes, brain, gut, eyes or other organs.*
    - *20% of total TB infections are extra-pulmonary.*
- **Twin Challenges**
    - Lack of awareness, even among physicians
    - Lack of accurate diagnostic and treatment
- **Lack of accurate diagnosis** – EPTB is *often stain negative*, which means it is not detectable on regular TB stain tests.
- The infection may surface in any part of the body and present itself like other non-TB conditions.
- Another troubling aspect is the *prolonged presence of disease markers* even after the infection is resolved with treatment.

*The mycobacterium that causes TB was first isolated in the eye just a year after **Robert Koch** identified the organism.*

The World Health Organization (WHO) reports over 10 million new cases of TB every year and India alone accounts for 27% of the global TB burden.

- **Persistent infection** – Some EPTB patients who complete anti-TB therapy may still find themselves affected by the disease.
    - In the eye, an autoimmune response to antigens triggered by the original infection can lead to a persistent intraocular inflammation even after appropriate anti-TB therapy.
- **Measures** – In 2014, a group of health experts across India and the WHO came together to formulate ***INDEX-TB***, a set of *guidelines for EPTB management* in India.
- **Issues** – While a set of clinical practice points for 10 organs was released, but good quality evidence was available only for 5 of them.
- However, this work has remained dormant and more needs to be done to foster and build a common approach to EPTB management.

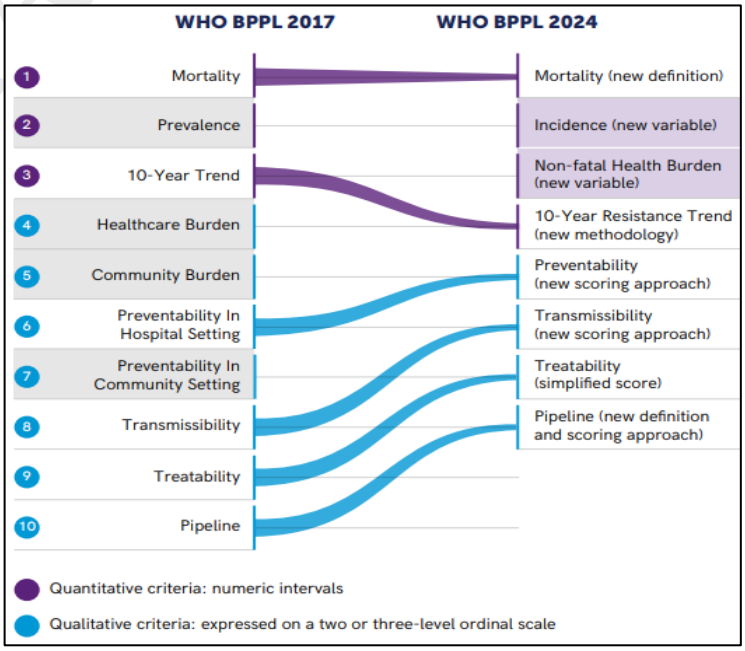
5.22 Bacterial Pathogens Priority List (BPPL)

The Bacterial Pathogens Priority List was updated as critical priority pathogens continue to present major global threat.

- **Developed by** – World Health Organisation (WHO).
- **Aim** – To list bacterial pathogens of public health importance to guide research, development and strategies to *prevent and control antimicrobial resistance.*
- **2024 edition** – Built on the *1st edition that was published in 2017*.
- It updates & refines the prioritization of antibiotic-resistant bacterial pathogens to address antibiotic resistance.
- **Categories** – *Critical, high, and medium* priority groups.

***Antimicrobial Resistance (AMR)** occurs when bacteria, viruses, fungi and parasites no longer respond to medicines. It is driven in large part by the misuse and overuse of antimicrobials.*

- **Coverage** – ***24 pathogens***, spanning ***15 families*** of antibiotic-resistant bacterial pathogens.
- **Notable pathogens**
    - *Gram-negative bacteria* resistant to last-resort antibiotics
    - Drug-resistant *mycobacterium tuberculosis*
    - **Other high-burden resistant pathogens** – Salmonella, Shigella, Neisseria gonorrhoeae, Pseudomonas aeruginosa, and Staphylococcus aureus.
- **Significance** – Act as a guide for *prioritizing R&D & investments in AMR,* emphasizing the need for regionally tailored strategies.
- It also targets policy-makers responsible for developing and implementing AMR policies and programs.



5.23 Diphtheria, Tetanus and Pertussis (DTaP)

Recently, WHO and UNICEF estimates of national immunization coverage (WUENIC) for 2023 indicate a slight decline in childhood immunization compared to 2022.

Diseases	Diptheria	Tetanus	Pertussis(Whooping Cough / Black Cough)

Caused by	Bacteria		
Transmission	It can spread from person to person.	It enters the body through cuts or wounds.	It can spread from person to person.
Symptoms	It causes a *thick covering in the back of the throat*. Breathing problems, paralysis, heart failure and even death at times.	It causes painful *tightening of the muscles* usually all over the body. Unable to open the mouth, having trouble swallowing and breathing, or death.	It causes can cause *uncontrollable, violent coughing* that makes it hard to breathe, eat, or drink. Extremely serious especially in babies & young children, causing pneumonia, convulsions, brain damage, or death. In teens and adults, it can cause weight loss, loss of bladder control and rib fractures from severe coughing.
Prevention	Through Vaccines		

- **DTaP Vaccine-** It contains ***inactivated toxins (toxoids)*** from the bacteria that cause diphtheria and tetanus, along with whole-cell pertussis bacteria or parts of it.
- Typically administered to infants and children in a series of doses starting at 2 months old, with booster shots given at intervals to maintain immunity.
- **Findings-** WHO and UNICEF estimates noted that, in 2023, India had 2.04 million under-vaccinated children, down from 2.11 million in 2019.
- Vaccine coverage fell to 85% during the first two years of the pandemic, down from 91% in 2019.
- India saw DPT vaccine coverage drop from ***95% in 2022 to 93% in 2023.***
- This decline suggests an increase in children receiving no routine immunizations.
- India's DPT coverage in 2023 was higher than the global average of 89%, and significantly above 2020 and 2022 figures of 87% and 88% respectively.

National Immunization Coverage

- The World Health Organization (WHO) and UNICEF jointly monitor national immunization coverage through the WHO-UNICEF Estimates of National Immunization Coverage (WUENIC).
- **Aim-** WUENIC aims to track and report immunization coverage globally to assess progress towards immunization goals, such as those set out in the Global Vaccine Action Plan (GVAP).
- **Vaccination Coverage-** In 2023, India had 1.6 million zero-dose children, up from 1.1 million in 2022 but down from 2.73 million in 2021.
- During the pandemic's early years, coverage dropped to 85% from 91% in 2019.
- In 2023, 2.04 million children were under-vaccinated, slightly fewer than the 2.11 million in 2019.
- **Significance-** These estimates are used to monitor progress towards immunization targets, identify gaps in coverage, and guide immunization strategies and interventions to improve coverage rates.

5.24 Strain MCC0200

Scientists have discovered a new strain of lactic acid bacterium with potential for broader probiotic use through collaborative genome analysis.

- It is identified as ***Streptococcus Thermophilus***, is a *probiotic bacterium* isolated from dairy products.

Recent Findings

- It demonstrates several health-promoting traits, such as surviving
  - Gastrointestinal transit,
  - Adhering to intestinal mucosa, and
  - Exhibiting ***antioxidant and anti-hypercholesterolemic***

Genome analysis*, also known as genomic analysis, is the study of an organism's genome, or complete set of genetic information.*

activities.

- **Probiotic efficacy –** It withstands the harsh conditions of the gastrointestinal tract and exhibits remarkable resilience against gastric juices and bile acids.
- **Gut health-** It can adhere to mucosal surfaces, crucial factor a in promoting gut health and immune function.
- **Mitigating oxidative stress-** Genome analysis reveals its ability to produce beneficial compounds like *folate and bacteriocins*, and enzymes that mitigate oxidative stress.
- **Production of essential vitamins-** It is considered to be a nutrient powerhouse including the production of essential vitamins like *folate (vitamin B9).*
- **Cardiovascular benefits-** MCC0200's *cholesterol-lowering properties* hold promise as a functional food ingredient with cardiovascular benefits.

5.25 Listeria and Listeriosis

Two separate outbreaks of listeria have been reported in the United States and Canada in recent weeks.

- **Listeria**- It is a type of ***bacteria (Listeria monocytogenes)*** found in soil, vegetation, water, sewage, and even the feces of animals and humans that can contaminate many foods.
- Listeria can *cause an intestinal illnes*s that is usually mild.
- **Listeriosis**- People who eat those foods can get infected with Listeria and this infection is called listeriosis.
- **Infected through** - Raw meat & seafood, Ready-to-eat processed meat & seafood, raw vegetables, refrigerated pates, prepared salads, Melons, Soft cheeses and Unpasteurized milk products.
- **People at risk-** It is most likely to sicken people who are pregnant and their newborns, adults aged 65 or older, and people with weakened immune systems.
- **Symptoms**- Most do not fall sick or develop symptoms, but some may develop fever and flu-like symptoms like muscle aches, fatigue, Headache, Stiff neck, Confusion, Loss of balance, Seizures, Diarrhea, and Vomiting.
- **Treatment**- A routine stomach infection and could require antibiotics.

*Pregnant Hispanic women are 24 times more likely than the general population to get **Listeria infection**.*

5.26 Cellulitis Disease

There has been an upsurge in number of cellulitis cases in Karimnagar, Telangana.

- **Cellulitis-** It is a common, potentially serious ***bacterial skin infection.***
- It is caused by ***Streptococcus and Staphylococcus bacteria***, which live on the skin's surface.
- In some cases, *Methicillin-resistant Staphylococcus aureus (MRSA)*can cause cellulitis.
- **Infection –** It can occur anywhere on the body, but it most *often affects the lower legs*.
- It typically affects the skin's deeper layers, including the dermis and subcutaneous tissue.
- The affected skin is swollen and inflamed and is typically painful and warm to the touch.
- **Symptoms-** Redness, swelling, warmth, Pain, Fever and blisters.
- Left untreated, the infection can spread to the lymph nodes and bloodstream and rapidly become life-threatening. It isn't usually spread from person to person.
- **Affected Population-** Common among those working in agriculture, construction, and people prone to cuts, bruises, and other injuries.
- People who are overweight, have a weakened immune system, or have other skin diseases are at higher risk for developing cellulitis.
- **Primary treatment** – *Antibiotics,* and most people recover fully within 24 hours.

SHANKAR IAS ACADEMY

5.27 Trachoma Free India

World Health Organisation (*WHO) declares that India has eliminated Trachoma as a public health problem in 2024.*

- **Trachoma** – It is a bacterial infection that ***affects the eyes***.
- WHO has termed it as a *neglected tropical disease*.
- **Caused by** – Bacterium ***Chlamydia Trachomatis***.
- **Transmission** – It is *contagious*, spreading through contact with the eyes, eyelids, nose or throat secretions of infected people.
- **Infection** – Repeated infections in childhood lead to *scarring of the inner side* of the upper eyelids, resulting in *inward turning of the eyelid margin*, with the eyelashes touching the eyeball.
- If left untreated it causes *irreversible blindness*.
- **Spread** – Globally, 150 million people are affected and 6 million of them are blind or at risk of visually disabling complications.
- **Susceptible population** – Underprivileged communities living in poor environmental conditions.

Elimination in India

- **India** – It was amongst the leading cause of blindness in the country during 1950-60.
- **Measures by India**
  - **NTCP** – National Trachoma Control Program in 1963
  - **NPCB** –National Program for Control of Blindness
  - **NPCBVI** – National Programme for Control of Blindness & Visual Impairment in 1976
  - **WASH** - water, sanitation and hygiene
- In 1971, blindness due to Trachoma was 5% and today, it has come down to less than 1%.
- **WHO SAFE strategy** – It stands for adoption of *surgery, antibiotics, facial hygiene, environmental cleanliness* etc.
  - Swachh Bharat Mission and Jal Jeevan Mission
- **Elimination** –
  - In *2017*, India was declared free from infective Trachoma
  - In 2024, India has eliminated Trachoma as a public health problem.
- India becomes the 3*rd country in the South-East Asia Region*.
- **Recognition** – An *official Certification* was handed over to Ministry of Health and Family Welfare by the WHO.

*The **National Trachomatous Trichiasis (TT only) Survey** was carried out in 200 endemic districts of the country under NPCBVI from 2021-24, which was a mandate set by WHO in order to declare that India has eliminated Trachoma as a public health problem.*

***India joins Nepal and Myanmar** in the WHO South-East Asia Region and 19 other countries globally that have previously achieved this feat.*

5.28 Murine Typhus

A 75-year-old man from Kerala who recently travelled to Vietnam and Cambodia diagnosed with the bacterial disease murine typhus.

- It is an infectious bacterial disease caused by the ***flea-borne bacteria Rickettsia typhi.***
- The disease is also known as endemic typhus, flea-borne typhus or flea-borne spotted fever.

- **Host -** Rodents like rats, mice and mongoose, are known to be reservoirs of the disease. The fleas can also live on other small mammals, including pets such as cats and dogs.
- Once a flea is infected, it can spread the disease ***for the rest of its life.***
- **Transmission -** When infected flea faeces come into contact with cuts or scrapes in the skin.
- It can also happen through exposure of mucous membranes to infected flea faeces.
- Murine typhus is *not spread from one person to another*, or from person to fleas.
- **Prevalent areas -** Reported in coastal ***tropical and subtropical regions***, where rats are prevalent.
- In India, cases of murine typhus have been reported in the Northeast, Madhya Pradesh and Kashmir.
- **Symptoms** - Usually appear 7 to 14 days after the exposure and include fever, headaches, body aches, joint pains, nausea, vomiting, and stomach aches.
- Some people may later develop rashes on the skin, days after the initial symptoms.

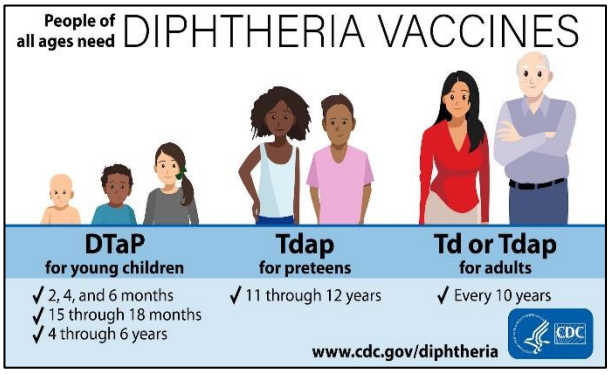
*Both **Murine and Scrub Typhus** share overlapping symptoms, while Scrub Typhus caused by Orientia tsutsugamushi is generally more severe and widespread in the Asia-Pacific region.*

- The illness seldom lasts longer than two weeks, but may last for months with complications if not treated.
- **Treatment** - There is ***no vaccine currently*** available against the disease.
- The antibiotic doxycycline is considered effective in therapy, but early diagnosis is vital for treatment.
- **Fatality** - Without timely treatment, the disease could turn severe in one or two weeks, and become fatal in rare cases.

5.29 Diphtheria

A 3-year-old girl died of suspected diphtheria in Punjab's Faridkot recently.

- It is a ***highly contagious*** but preventable bacterial disease.
- A toxin produced by some strains of the ***Corynebacterium diphtheria*** bacteria results in diphtheria.
- **2 Types -** Respiratory and cutaneous.
    - Respiratory diphtheria affects the nose, throat, and tonsils, while cutaneous diphtheria affects the skin.
- **Transmission** - Through the air or by contact with an infected person.
- It affects the respiratory tract and spreads throughout the body.
- **Symptoms** - Fever, chills, swelling in lymph nodes, fatigue, shortness of breath, etc.
- **Prevention -** Immunisation is the best prevention against it, with the full schedule requiring seven doses between 0-16 years.
- 3 doses are given before the child turns one, a booster Diphtheria, Pertussis and Tetanus (DPT) shot when the child is two, a 5thdose when the child turns six, and one each in years 10 and 16.



- **Treatment**
    - **Respiratory diphtheria** - Diphtheria antitoxin and antibiotics.
    - **Skin infections** - Antibiotics are used.
- **Prevalence –** In2023-24, almost *84% of cases in India were reported from 10 states*
    - Kerala, Assam, Delhi, Gujarat, Haryana, Karnataka, Nagaland, Maharashtra, Rajasthan and West Bengal.

According to the Ministry of Health and Family Welfare, 93.5% of Indian children in the one-year age bracket were immunised in 2023-24 while Punjab's numbers stood at 93.96%.

5.30 Escherichia coli (E.coli)

1 person has died and 10 have been hospitalized in the US due to an E.coli infection after eating McDonald's burgers.

- It is a *rod-shaped, gram-negative bacterium* typically resides in the intestines of humans and most mammals.
- While most strains are harmless and play a beneficial role in gut health, s*ome can cause serious foodborne illnesses.*
- **Transmission –** It spreads through contaminated food and water.
- Most diarrheagenic *E. coli* strains spread through fecal-oral transmission.
- Some forms, like Shiga toxin-producing E. coli (STEC), can also transmit through undercooked meat and unpasteurized beverages.
- E. coli can be *contagious (spread from person to person).*
- **Symptoms**
    - Fever of more than 102 degree F, persistent diarrhoea, bloody diarrhoea, and vomiting.
    - The main problem, however, is dehydration due to the inability of the patient to retain water and fluids.
    - In very few cases, people may get acute kidney injury.

Types of E. coli

- Enterotoxigenic Escherichia coli (ETEC)
- Enteropathogenic *Escherichia coli* (EPEC)
- Enteroaggregative *Escherichia coli* (EAEC)
- Enteroinvasive *Escherichia coli* (EIEC)
- Diffusely adherent *Escherichia coli* (DAEC)
- Enterohemorrhagic *Escherichia coli* (EHEC)

Enterohemorrhagic Escherichia coli (EHEC)

- **EHEC –** It produces a *poison called Shiga toxin*.
- EHEC strains cause bloody diarrhea and can sometimes damage the kidneys and progress to the potentially fatal hemolytic uremic syndrome (HUS).
- It has caused many large food-borne outbreaks worldwide, O157:H7 is the best known strain.
- This group is also known as ***STEC (Shigatoxin producing E. coli)*** and is the ***only group that is passed in animal feces.***
- **Treatment -** E.coli is a bacterial infection for which antibiotics are prescribed.
- Indiscriminate use of antibiotics leads to antimicrobial resistance and further difficulty in treating common infections.
    - For example, E.coli's susceptibility to even strong antibiotics, such as carbapenem, has been on the decline, reducing from 81.4% in 2017 to 62.7% in 2023 to one type of medicine in this category.
- **Severity** - E. coli sometimes causes life-threatening complications
- **Prevalence in India** - According to the National Centre for Disease Control, more than 500 outbreaks of diarrhoeal diseases were reported across India in 2023.
- According to the latest report of ICMR's Antimicrobial Surveillance Network, E.coli is the most common bacteria isolated from patient samples.
- The pathogen was found in ***23.19%*** of all types of patient samples from tertiary care hospitals across India.

5.31 Helicobacter pylori (H. pylori)

More research is needed to combat the global prevalence of Helicobacter pylori, with India having an infection rate of over 50% of its population.

- It is a type of bacteria that can cause an *infection in the stomach or duodenum* (first part of the small intestine).
- People usually get it as children, and it can stay in the body for years without causing problems.
- Even though the stomach has strong acid, H. pylori survives by making a substance that weakens the acid.
- Over time, this bacteria can harm the stomach's protective layer, leading to irritation and sometimes causing painful sores called ulcers.

- **Symptoms -**It don't have symptoms, but when they do, these may include *burning stomach pain, bloating, burping, nausea or vomiting.*
- Some may also lose their appetite and experience weight loss.
- While many are infected in childhood without symptoms, in some cases, symptoms don't appear until the late teens or adulthood, particularly if the infection causes ulcers or digestive problems.
- **Transmission -** H. Pylori from person to person, primarily through saliva, vomit or stool.
- It can also spread by contaminated food, water or poor hygiene especially in areas with crowded living conditions or limited access to clean water and sanitation.
- **Treatment -** A combination of antibiotics and medications to reduce stomach acid.
- **Prevalence** - It is almost *10 times more prevalent than diabetes* in the country and is a major cause of chronic gastritis, peptic ulcers and even stomach cancer.
- It affect an estimated *50% to 60% of the population in India* and constitute a significant public health challenge.
- **Nobel Prize -** Dr. Barry Marshall, along with Robin Warren, was awarded the 2005 Nobel Prize in Physiology or Medicine for discovering that ***H. pylori was the main cause of peptic ulcers.***

5.32 Walking pneumonia

In recent weeks, doctors have sudden increase in reported cases of walking pneumonia.

- It is most commonly caused by the ***bacteria Mycoplasma pneumonia.***
- It is also known *as atypical pneumonia*, is a less severe type of pneumonia.
- It is a mild yet persistent lung infection that can mimic symptoms of a common cold.
- The primary difference between them is that the common cold is usually caused by a viral infection while walking pneumonia is essentially a bacterial infection.
- Unlike typical pneumonia, which can lead to severe lung inflammation and difficulty breathing, walking pneumonia is ***often less intense,*** allowing people to carry on with their daily activities.
- It is also called ***'silent' pneumonia*** because sometimes people don't experience symptoms despite X-rays showing fluid-filled air sacs in the lungs.
- **Symptoms -** Fever, Runny nose, Cough, Sore throat, Headache, Tiredness, Ear pain, and Chest pain from coughing.
- **Transmission** - It is typically not as contagious as the flu or a viral cold, it can still spread through respiratory droplets when an infected person coughs or sneezes.
- **Vulnerable** - People who work or live in crowded spaces are at a higher risk of outbreaks.
- **Prevention -** There *aren't any vaccines available* that prevent walking pneumonia.
- **Treatment -** Walking pneumonia is often manageable with rest, fluids, and, in some cases, antibiotics.

5.33 Brucellosis

An 8-year-old girl from Kottakkal in Malappuram district of Kerala died at the Government Medical College Hospital, Kozhikode, recently after undergoing around two months of treatment for brucellosis.

- It is a bacterial infection caused by the consumption of ***unpasteurized milk.***
- **Caused by -** Various *Brucella species*.
- It is also known as ***undulant fever, Mediterranean fever, Malta fever.***
- It mainly infects cattle, swine, goats, sheep and dogs.
- **Transmission -** Humans acquire it through direct contact with infected animals, by eating or drinking contaminated animal products or by inhaling airborne agents.
- Most cases are caused by ingesting unpasteurized milk or cheese from infected goats or sheep.
- Human-to-human transmission is very rare.

- **Symptoms -** Fever, weakness, weight loss, and general a feeling of discomfort. In many patients, they can be mild and may not get diagnosed at all.
- **Incubation Period -** It can vary from one week to two months, but it usually lasts between two and four weeks.
- **Vulnerable age group -** It affects people of all ages. Transmission primarily affects farmers, butchers, hunters, veterinarians and laboratory personnel.
- **Treatment -** Treatment options include taking doxycycline 100 mg tablets twice a day for 45 days, and streptomycin 1 g daily for 15 days as per the advice of the doctors.
- **Prevention -** *Vaccination of cattle, goats and sheep* is among the prevention options.
- *Pasteurisation of milk* for direct consumption and for creating derivatives such as cheese is an important step to prevent its transmission from animals to humans.

5.34 Clostridioides difficile bacteria

Researchers are developing the 1st successful vaccine against Clostridioides difficile bacteria, using the technology behind the revolutionary mRNA vaccines that tackled COVID-19.

- It is a bacterium highly contagious and difficult-to-treat and can cause severe diarrhea and even deadly colon damage.
- **Symptoms**
  - **Common** - Watery diarrhea, fever, nausea, abdominal pain
  - **Severe -** Severe cramping, loss of appetite, weight loss, dehydration, rapid heart rate
  - **Life-threatening** - Pseudomembranous colitis, toxic megacolon with septic shock
- **Vulnerables** - It can affect anyone, but most cases occur after taking antibiotics or shortly after finishing them.
- **Transmission** - C. diff can also spread from patient to patient, or through contaminated hands or the environment.

> ***Clostridioides difficile bacteria*** *is the leading cause of antibiotic-associated diarrhea worldwide.*

- C. diff can live in the intestines of humans and animals, and in the environment, especially where infected people and animals live.
- It can enter the body through the mouth, and reproduce in the small intestine.
- In the colon, the bacteria can release toxins that damage tissues and cause diarrhea.
- Roughly one-third of infected individuals will have recurrent infections.
- **Treatment -** C. diff can usually be treated with another course of antibiotics.
- **Recent advancement in treatment -** Like the COVID vaccines, the ***C. difficile mRNA vaccine*** uses genetic material from the bacteria to train the immune system to recognize and respond in the event of future infections.
- Immune cell responses increased with vaccine dose and were significantly higher than with more traditional vaccines.
- Mice vaccinated with traditional-style vaccines all died within a day after being infected with the bacteria.
- Adding a booster to the old-style vaccines improved survival by 20%, but immunization with the mRNA vaccine improved survival to 100%.

DISEASES CAUSED BY PARASITES, PROTOZOANS

5.35 GM Mosquitoes

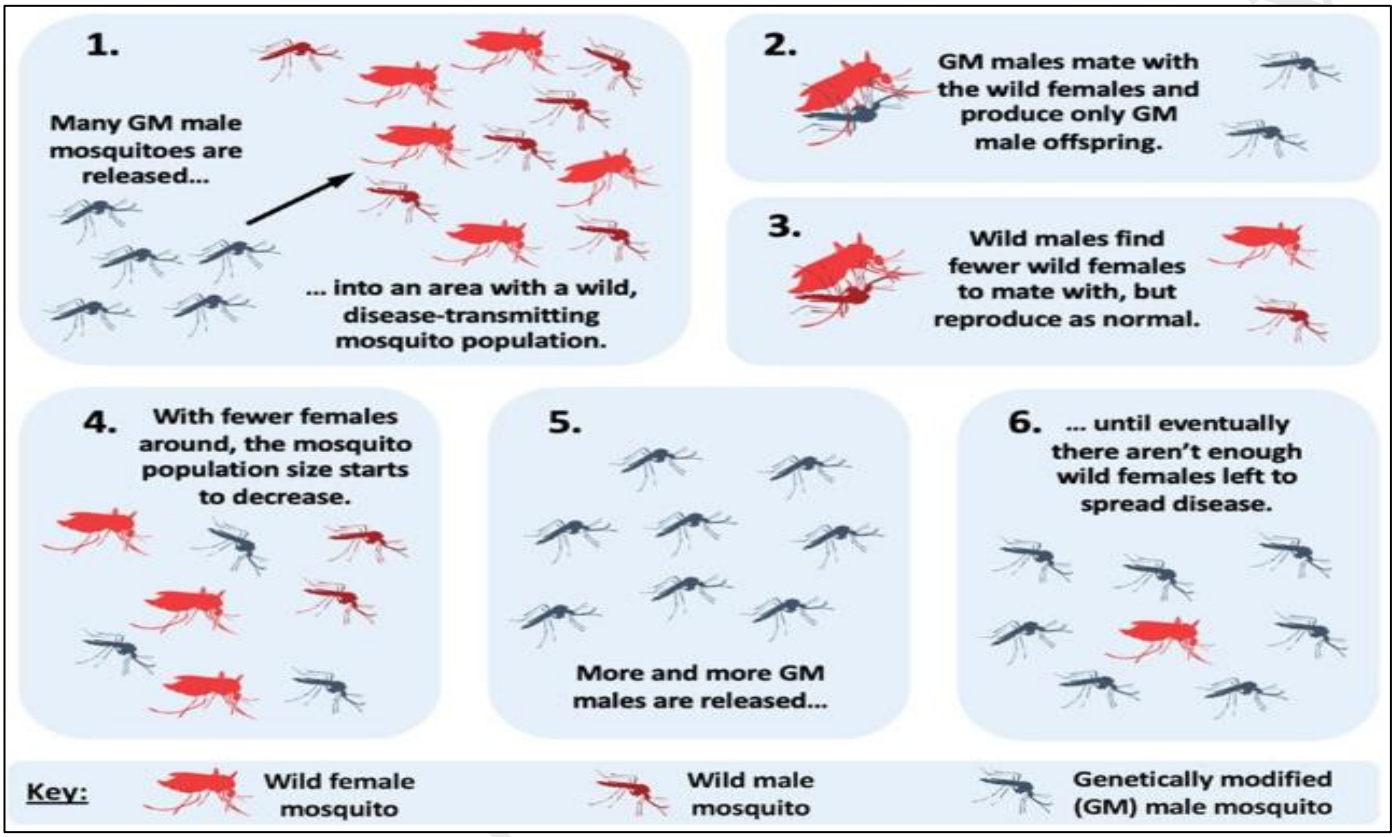
Djibouti releases GM mosquitoes to fight malaria as part of a pilot project.

- **Umbrella Programme** – *Djibouti Friendly Mosquito Programme*, that aims to *stop the spread of Anopheles stephensi*.

Anopheles stephensi

- It is an *invasive species of mosquito*.
- It was detected 1st detected in Africa in 2012 with 27 reported cases in Djibouti.
- **Invasiveness** – They had migrated to Africa from South Asia and the Arabian Peninsula.
- **Urban spread** - Unlike other malaria-carrying mosquitoes in Africa that primarily breed in rural areas, these are well *adapted to the urban environment*.

- **Production** – They are produced using a technique called *embryonic microinjection*.



- An engineered DNA often called a *transgene* when injected in mosquito eggs integrates into the mosquito genome and specifically activates or inactivates a target gene.
- GM mosquitoes are made to carry 2 types of genes
  - **A self-limiting gene** – It prevents female mosquito offspring from surviving to adulthood.
  - **A fluorescent marker gene** – It glows under a special red light, allowing the researchers to identify them in the wild.
- **Control method** – It ***targets female mosquitoes***, as male mosquitoes do not bite and therefore cannot transmit malaria.
- This method targets only the particular species of mosquitoes which was genetically modified, here it is Anopheles stephensi.
- **Previous release** – They have been successfully used in parts of Brazil, the Cayman Islands, Panama, and India to control Aedes aegypti mosquitoes.
- Since 2019, over 1 billion mosquitoes have been released.

This is the 1st time a GM mosquito has been released in East Africa and the 2nd time on the African continent.

5.36 Visceral Leishmaniasis (VL)

The World Health Organization (WHO) recently launched a framework to eradicate visceral leishmaniasis (VL) in eastern Africa.

- **Caused by** –Leishmania parasite.

- It is also known as ***kala-azar or black fever***.
- **Transmitted by -** Infected *female phlebotomine sandflies*.
- **Vulnerable -** It primarily affects infants and children, though adults can also be infected.
- **Symptoms -** Fever, weight loss, and enlargement of the spleen and liver.
- If the disease is not treated, the fatality rate can be as high as 100% within 2 years.
- It is the ***2nd deadliest parasitic disease*** in the world, only after malaria.
- **Endemic in -** 80 countries.
- In India, ***Leishmania donovani*** is the only parasite causing this disease.
- **Post Kala-azar Dermal Leishmaniasis (PKDL)** – It is a condition when Leishmania donovani invades skin cells, resides and develops there and manifests as dermal leisions.
- **WHO framework on VL Elimination**
    - Early diagnosis and treatment
    - Integrated vector management
    - Effective surveillance
    - Advocacy, social mobilisation and partnership-building and
    - Implementation and operational research.

In 2022, eastern Africa accounted for 73% of global VL caseload, 50% of which occurred in children aged under 15 years.

WHO has set the target date for the elimination of this disease in South-East Asia Region by 2026.

***Bangladesh** is the first country to eradicate VL in 2023.*

5.37 Human African Trypanosomiasis (HAT)

Recently, Chad became the 51st country to eliminate the gambiense form of human African trypanosomiasis (HAT) globally.

- It is also known as ***sleeping sickness***, is a *vector-borne parasitic disease.*
- **Caused by -** Protozoans of the genus Trypanosoma, transmitted to humans by bites of tsetse flies (glossina), acquired the parasites from infected humans or animals.
- Only *certain species of tsetse flies* transmit the disease.
- **2 Variants of HAT-** They are determined by the subspecies of the parasite involved
    - Trypanosoma brucei gambiens - It accounts for *92%* of reported cases.
    - Trypanosoma brucei rhodesiense – It is responsible for the remaining *8%.*
- **Endemic to -** Sub-Saharan Africa.
- **Symptoms -** A swollen, discolored (red, purple or brown) bump that may be painful, recurrent fever, Chills, Headache, Muscle pain, Joint pain and Skin rash.
- It is potentially a fatal disease if left untreated.
- **Treatment-** It depends on what type of protozoa caused the infection and whether the infection has spread to other areas of the body.
- Early diagnosis and treatment can cure this disease.

5.38 Zoonotic diseases

United Nations Environment Programme (UNEP) has issued a stark warning about emerging zoonotic diseases that may trigger another pandemic by 2030.

- **About-** Zoonotic diseases are infections that are *spread between people and animals.*
- **Different pathogens-** Many different pathogens can cause zoonoses. These include *Bacteria, Parasites (protozoa or parasitic worms), Viruses, Fungi, and Prions.*
    - **Examples** include rabies (from bites of infected animals), Ebola (through contact with infected animals), Lyme disease (from ticks), and COVID-19 (thought to originate from bats).

- **Symptoms-** Some common symptoms include Fever, Tiredness (fatigue), Headache, Body aches, Rash, Diarrhoea, and Vomiting.
- **Prevention-** Avoiding contact with wild animals, proper food handling and cooking, using insect repellents, and vaccination of animals.

- **Recommendations-** The UNEP report emphasizes the urgent need for proactive measures to address ecological disruptions and human-wildlife interactions, stressing that safeguarding planetary health is crucial in preventing future zoonotic outbreaks.
- Understanding zoonotic diseases is crucial for public health preparedness and managing outbreaks effectively.

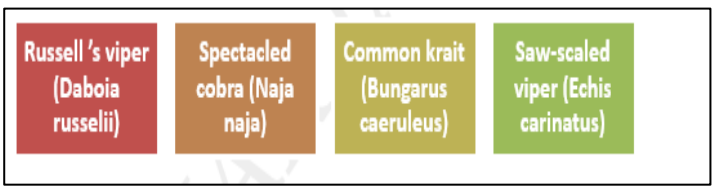
5.39 Snakebite Envenomation

The Tamil Nadu government has officially declared snakebite envenomation as a notifiable disease.

- It is a ***life-threatening medical condition*** caused by venomous snake bites.
- **Symptoms** - Severe paralysis, bleeding disorders that can lead to fatal hemorrhage, irreversible kidney failure and severe local tissue destruction.
- **Treatment** – High-quality snake *anti venom*, which can prevent or reverse toxic effects of the venom.
- Often preventable, it poses a risk to vulnerable populations like agricultural workers, children, and those living in tropical and subtropical areas.

An estimated 5.4 million people worldwide are bitten by snakes each year with 1.8 to 2.7 million cases of envenomings.

- It is a major health concern in rural and snake-endemic regions.
- **WHO response -** It has recognized snakebite as a *global public health issue* and launched a strategy to reduce snakebite-induced deaths and disabilities worldwide.
- **In India** – More than 310 species of snakes, mostly non-Venomous.
- However, there are *66 species that are labelled as venomous* or mildly venomous and majority of the snakebites result from 4 species, collectively named as "Big 4" species namely



- **Action plan in India -** National Action Plan for Prevention and Control of Snakebite Envenoming, which was published by the Ministry of Health and Family Welfare earlier this year.
- The plan aims to ***halve snakebite deaths by 2030*** through a 'One Health' approach, integrating human, animal, and environmental health interventions.

Tamil Nadu's Plan in Snake bite Prevention and Control

- It is declared as a *notifiable disease* under the ***Tamil Nadu Public Health Act, 1939***.
- To improve the collection of vital data, strengthen clinical infrastructure, and ensure the efficient distribution

of anti-snake venom.

- This move is expected to lead to better prevention strategies, reduce mortality rates, and enhance treatment facilities across the state.
- Authorities have noted that there has been a significant *underreporting of snakebite cases and deaths* in existing data, and the new system is designed to bridge this gap.
- Under the new directive, both government and private hospitals are now required to report cases of snakebites and related fatalities to the government.
- This mandatory reporting system will be integrated with the State's Integrated Health Information Platform under the *Integrated Disease Surveillance Program*.

5.40 Snakebites as a notifiable disease

The Union Health Ministry has urged states to make snakebites a notifiable disease, a disease that is legally required to be reported to the government by both private and public hospitals.

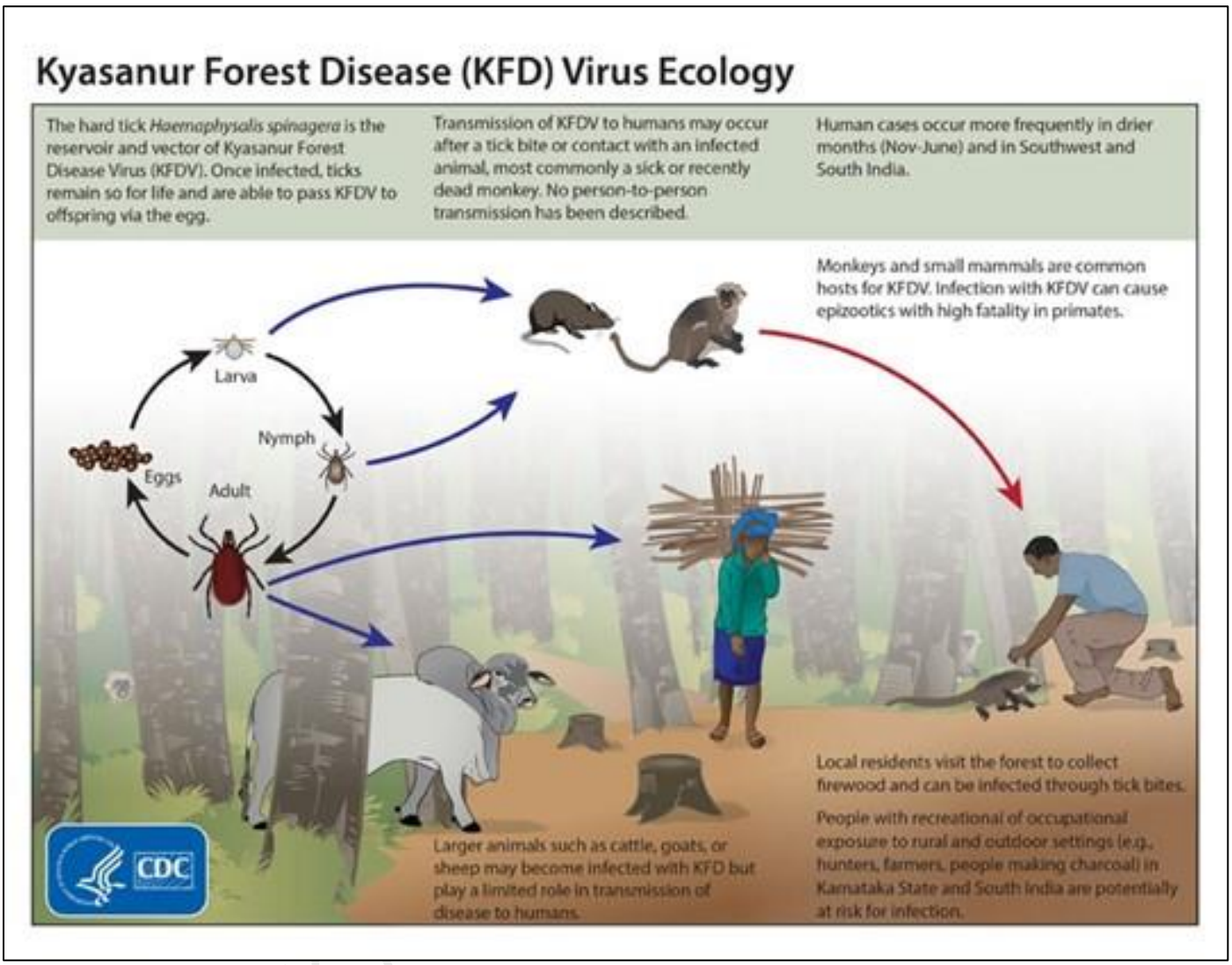
- **Notifiable diseases -** Infections that are likely to cause an outbreak, lead to deaths, and those that need to be investigated quickly to take appropriate public health measures.
- List of notifiable diseases differs from state to state, state governments are responsible for bringing out the notification.
- Most of them consider infections such as tuberculosis, HIV, cholera, malaria, dengue, and hepatitis among others to be notifiable.
- **Snakebites in India -** India accounts for more than half of all snakebite deaths in the world with an average of 58,000 deaths from snakebites annually.
- According to NAPSE, the most burden of snakebite deaths states are
    - Bihar, Jharkhand, Madhya Pradesh, Odisha, Uttar Pradesh, undivided Andhra Pradesh (which includes Telangana), Rajasthan and Gujarat.
- It accounts for more than 70% of deaths during the period between 2001 and 2014.
- The chance of an Indian dying from snakebite is about 1 in 250.
- World Health Organisation states that around ***90% of snakebites in India are caused by the 'big four'*** among the crawlers - common krait, Indian cobra, Russell's viper and saw scaled viper.
- The commercially available ***polyvalent antivenom*** contains venom from all 4species, and is effective against 80% of snakebites.
- National Action Plan for Prevention and Control of Snakebite Envenoming (NAPSE) with the aim of halving snakebite deaths by 2030.

5.41 Kyasanur Forest Disease (KFD)

Recently, Karnataka district health officials have created awareness on high alert to prevent Kyasanur Forest Disease (KFD).

- **KFD** – It is a ***tick-borne haemorrhagic fever*** of humans, caused by Kyasanur Forest Disease Virus (KFDV).
    - KFDV virus is a *single-stranded, positive-sense RNA virus* belonging to the family Flaviviridae.
- It is also known as ***"monkey fever"*** because monkeys are highly susceptible to the disease.
- KFD was *first discovered in 1957* in the Kyasanur forest area of Karnataka.
- *Hard ticks (Hemaphysalis spinigera) spread* the KFD virus to people and to animals, like monkeys and rodents.
- **Symptoms**
    - **1st Wave -** Sudden onset of chills, high fever, frontal headache, vomiting, diarrhea, coughing, and severe muscle pain, followed by bleeding from the nasal cavity.
    - **2nd Wave -** About 10 to 20% of patients experience including severe headache, mental disturbances, tremors, and vision problems.

- **Signs** - 3-8 days after being infected with the virus.
- **Transmission -** To people primarily occurs through tick bites or contact with infected animals.
- It can spread to livestock like cattle, goats, and sheep but livestock rarely spread tick bites to people.
- Human-to-human transmission has ***not been observed***.



- **Mortality rate** - Infected cases are estimated to be 3–10%.
- **Risk factors -** Hunters, herders, forest workers, and farmers in the Karnataka, Tamil Nadu, and Kerala states are at higher risk.
- **Treatment -** There is ***no specific treatment*** available.
- **Prevention**
  - **Vaccination –** It is an inactivated vaccine produced using formalin inactivation of the KFD virus grown in a chick embryo tissue culture.
  - About 70% of people who take this vaccine develop neutralizing antibodies.
  - **Tick bite avoidance -** It is an effective way of being safe when traveling in areas where this disease is transmitted.

5.42 Onchocerciasis

WHO verifies Niger as the 1st country in the African Region to eliminate Onchocerciasis.

- It is also known as ***river blindness***, is a *parasitic disease* that affects the skin and eyes.
- **Caused by -** Microscopic worm Onchocerca volvulus.
- **Symptoms –** Severe itching, bumps under ths kin, rashes, skin thickening & wrinkling and Blindness.

- **Transmitted to humans -** By the bites of ***infected black flies***, that breed in fast-flowing rivers.
- **Vulnerable** - More common in people who work in agriculture, especially those who live near rivers.
- Early exposure to *O. volvulus* infection is associated with epilepsy in children.
- Primarily affects rural populations in sub-Saharan Africa, and Yemen, with smaller endemic areas foci found in parts of Latin America.
- **Prevention** - Onchocerciasis was brought under control in West Africa through the work of the Onchocerciasis Control Programme (OCP).
- This was later supplemented by large-scale distribution of ivermectin since 1989.
- The African Programme for Onchocerciasis Control (APOC) was launched in 1995 with the objective of controlling onchocerciasis in the remaining endemic countries in Africa.
- It is closed at the end of 2015 after beginning the transition to onchocerciasis elimination.
- **Treatment -** Population-based treatment with ***Ivermectin*** is the current core strategy to eliminate onchocerciasis, with a minimum requirement of 80% therapeutic coverage.
- Ivermectin is donated by Merck under the brand name of Mectizan.

Status of Onchocerciasis

- **Global status -** More than 99% of infected people live in Africa and Yemen, the remaining 1% live on the border between Brazil and Venezuela (Bolivarian Republic of).
- In 2023 at least 249.5 million people required preventive treatment against onchocerciasis.
- **Onchocerciasis free countries -** *5 countries* have been verified by WHO as free of onchocerciasis after successfully implementing elimination activities for decades.
    - 4 in America - Colombia (2013), Ecuador (2014), Mexico (2015) and Guatemala (2016), and
    - 1 in Africa - Niger (2025).

5.43 Lymphatic Filariasis (LF)

Union Health Minister launched National Mass Drug Administration (MDA) campaign for the elimination of Lymphatic Filariasis (LF) across 13 identified LF endemic states.

- It is a ***Neglected Tropical Disease (NTD)***.
- **Caused by** – Parasites classified as nematodes (roundworms) of the family Filariodidea.
- There are 3 types of these thread-like filarial worms
    - *Wuchereria bancrofti*, which is responsible for 90% of the cases
    - Brugia malayi, which causes most of the remainder of the cases
    - Brugia timori, which also causes the disease.
- **Transmission** – It enters to human body through the bites of infected mosquitos to humans.
- **Transmitted by** – Different types of mosquitoes,
    - **Culex** – Widespread across urban and semi-urban areas.
    - **Anopheles** – Found in rural areas.
    - **Aedes** – Endemic in the islands of Pacific.
- **Symptoms –** Asymptomatic, acute and chronic conditions which leads to,
    - Lymphoedema (tissue swelling) or elephantiasis (skin/tissue thickening) of limbs and hydrocele (scrotal swelling).
- It is commonly known as ***Elephantiasis or Hathi Paon***.
- **Risk factors** – It is usually acquired in childhood.
- **Treatment –** It is possible to stop the spread of the infection through preventive *chemotherapy*.

- **WHO recommendation** – Chemotherapy strategy for lymphatic filariasis elimination is *Mass Drug Administration (MDA)*.
- 5-pronged strategy to ensure that Lymphatic Filariasis (LF) is eliminated much ahead of the Sustainable Development Goal of 2030.

***Mass Drug Administration (MDA)** involves administering an annual dose of medicines to the entire at-risk population.*

Mass Drug Administration (MDA) Campaign in India

- **Goal –** To reduce the spread of LF by eliminating the microscopic filarial parasites present in the bloodstream of infected individuals.
- **Coverage** – 111 endemic districts across *13 states*,
  - Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Uttar Pradesh, and West Bengal.
- **Medication regimen – Double Drug (DA) –** Diethylcarbamazine Citrate (DEC) and Albendazole.
- **Triple Drug (IDA)** – Ivermectin, Diethylcarbamazine Citrate (DEC), and Albendazole.

NON-COMMUNICABLE DISEASE

5.44 Naegleria fowleri

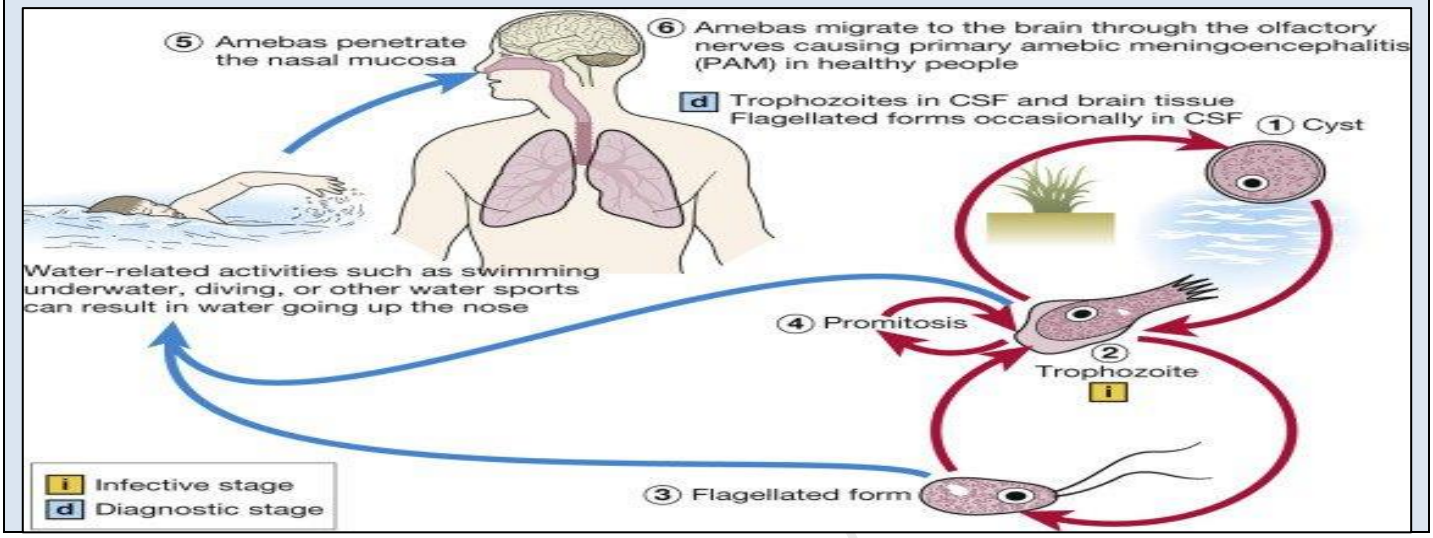
A five-year-old girl in Kerala died due to the infection caused by Naegleria fowleri.

- It is a free-living amoeba or a *single-celled* living organism.
- **Growing conditions** – *Higher temperatures* of up to 115°F (46°C) are conducive to its growth and it can survive for short periods in warm environments.
- **Occurrences** – It lives in *warm fresh water and soil* around the world.
- **Infection** – It enters the body *through the nose*, usually when people are swimming and then travels up to the brain, where it destroys the brain tissue and causes swelling.
- Thus it is also known as ***brain-eating amoeba***.
  - People cannot get infected with Naegleria fowleri from drinking water contaminated with the amoeba.

Primary amoebic meningoencephalitis (PAM)

- There have been 20 reported cases of PAM in India.

- It is a *rare brain infection*, caused by the amoeba ***Naegleria fowleri***.
- It is a *non-communicable disease*.
- **Symptoms** – Headache, fever, nausea and vomiting.
- Later on, the patient may have a stiff neck and experience confusion, seizures, hallucinations and slip into a *state of coma*.
- **Treatment** – Still scientists haven't been able to identify any effective treatments for the disease yet.
- At present, a combination of drugs, including amphotericin B, azithromycin, fluconazole, rifampin, miltefosine, and dexamethasone are used.



5.45 Huntington's Disease

Scientists develop new methods to detect Huntington's disease progression.

- It is a *genetic disorder* that causes the ***progressive breakdown of nerve cells in the brain***.
- It is caused by a ***mutation in the HTT gene*** that provides instructions for making a protein called huntingtin.

Huntington's disease affects an estimated 3 to 7 out of every 100,000 people, most often people of European ancestry.

  - **Adult onset -** This is the most common form and symptoms usually begin after age 30.
  - **Early onset (juvenile Huntington's disease)** –It affects children and teenagers but very rare.

Physical symptoms	Mental symptoms
• Uncontrolled movements like jerking or twitching (chorea). • Loss of coordination (ataxia). • Trouble walking. • Difficulty swallowing (dysphagia). • Slurred speech.	• Emotional changes like mood swings, depression and irritability. • Problems with memory, focus and multitasking. • Trouble learning new information. • Difficulty making decisions and reasoning.

- **Treatment-**Presently, there is ***no cure*** for Huntington's disease, but treatments can help manage symptoms.

5.46 Motor Neuron Diseases (MNDs)

The 3rd annual conference on MND 'Awareness, Care and Management' at Nimhans held recently in Bengaluru, stated that symptomatic and supportive treatments help manage the condition better.

- They are a group of ***progressive neurological diseases that destroy motor neurons,*** cells controlling skeletal muscular activities like walking, breathing, speaking and swallowing.

- In MND, these neurons degenerate and die.
- It is an uncommon disease and the average age that people are diagnosed with MND is 58 years.
- **Symptoms -** Usually start on one side of the body before spreading that include
    - Weakness in their hands and grip, and weakness in their legs, and a tendency to trip
    - Slurred speech, Cramps and muscles twitching
    - Weakness of their shoulder, making lifting difficult
- **Treatment -** There's ***no cure*** for motor neurone disease, but treatment can help reduce the impact the symptoms have on your life.

5.47 Down syndrome

A recent research study has discovered first Case of Down Syndrome in Neanderthals.

- It is a genetic disorder caused when ***abnormal cell division*** results in ***an extra full or partial copy of chromosome 21.***
- It typically occurs spontaneously during fetal development due to errors in cell division, rather than being inherited.

*Human cells normally contain **23 pairs of chromosomes**, One chromosome in each pair comes from father and mother.*

3 genetic variations can cause Down syndrome

- **Trisomy 21**- It causes about 95% of cases, where a person has *3 copies of chromosome 21* instead of the usual two, due to abnormal cell division during egg or sperm development.
- **Mosaic Down syndrome**- It is due to an *extra copy of chromosome 21* due to abnormal cell division after fertilization, leading to a mix of normal and abnormal cells.
- **Translocation Down syndrome**- A portion of chromosome 21 attaches to another chromosome before or at conception.
- These individuals have the usual 2 copies of chromosome 21, along with *extra genetic material from chromosome 21 attached* to another chromosome.

MND disease group

- Lou Gehrig's disease, also known as amyotrophic lateral sclerosis
- Progressive muscular atrophy
- Progressive bulbar palsy
- Primary lateral sclerosis
- Kennedy's disease, also known as spinal and bulbar muscular atrophy

- **Impact** - It is usually associated with *developmental delays*, mild to moderate intellectual disability, and characteristic physical features.
- **Symptoms-** At birth, babies with Down syndrome usually have certain characteristic signs, including:
    - flat facial features, small head and ears, short neck, bulging tongue, eyes that slant upward, atypically shaped ears and poor muscle tone
- **Treatment-** Presently, there's ***no cure***, but treatment can help people reach their full potential.

5.48 Kawasaki Disease

A Pediatric study recently revealed that Kawasaki disease cases among children have increased in India after COVID-19 pandemic.

- It is a ***rare disease*** that is sometimes called *mucocutaneous lymph node syndrome.*
- **Susceptible population** – It most often affects the *heart arteries in children* from 6 months to 5 years of age.
- Those arteries supply oxygen-rich blood to the heart.
- **Cause** –It is unknown, but it may be due to an immune system reaction to a virus or a genetic link.

- **Transmission** - It is *not contagious* and cannot be spread from one person to another
- **Symptoms -** A high fever, red eyes, swollen lymph nodes in the neck, a red rash on the middle of the body, a red tongue, and swollen hands and feet.
- Cardiovascular complications include aneurysm formation, heart failure, myocardial infarction, and valvulitis.
- **Prevention** - There is *no way to prevent* Kawasaki disease.
- **Treatment** - With early treatment, most children get better and have no long-lasting problems.

Multisystem inflammatory disease in children (MIS-C) vs Kawasaki Disease

- A recent study revealed that hyperinflammatory shock with clinical features similar to those of Kawasaki disease (KD) after COVID-19 infection in 2020.
- The clinical manifestations of MIS-C overlap with those of KD, including fever, skin rashes, conjunctivitis, and mucocutaneous manifestations.
- It is more commonly associated with ***left ventricular dysfunction (30%–40%)*** and shock, gastrointestinal abnormalities, and neurological manifestations than KD.
- It also revealed that KD following SARS-CoV-2 infection has clinically different characteristics from conventional KD.

5.49 Vitiligo

A new Kannada film, 'Bili Chukki, Halli Hakki' is attempting to take the veil of stigma off from Vitiligo, disease that is usually the subject of stereotypes and ignorance in India.

- It is a ***chronic auto-immune skin disorder*** that results in the *loss of pigment in patches*, causing white areas to appear on the skin.
- It arises due to the ***malfunction or destruction of melanocytes,*** the cells responsible for producing melanin, the pigment that gives skin its colour.
- **Symptoms -** Depigmented patches may occur anywhere on the body, including the skin, hair, and even the lining of the mouth.
- **Causes** - It ***is unknown***, but it may be related to immune system changes, genetic factors, stress, or sun exposure.
- Potential triggers could include oxidative stress, physical trauma, severe sunburn, or chemical exposure.

- **Impact -** Itaffects between o*.5% and 2% of the population* worldwide.
- It occurs with similar frequency in all ethnic groups, but may be more noticeable in dark-skinned people.
- **Risk factors** - A family history of certain autoimmune diseases have a higher risk of getting this disease.
- The pale areas of skin caused by vitiligo are more vulnerable to sunburn, so it's important to take extra care when in the sun and use a sunscreen with a high sun protection factor (SPF).
- **Treatment -** There is ***no cure*** for vitiligo, but treatments can help stop the progression and reverse its effects.
- Options include topical corticosteroids, calcineurin inhibitors, and phototherapy, which work to slow depigmentation and encourage the regeneration of melanocytes.
- In advanced cases surgical interventions like skin grafting or depigmentation therapy may be considered to even out skin tone.

5.50 Sjogren's Disease

Recently, the clinical immunologist offered an insight into the conditions prevalence and presentation of the Sjögren's Disease.

- It is a ***chronic long-lasting autoimmune disorder***.
- The immune system attacks the glands that make moisture such as your nose, throat, and skin.

- It also affect other parts of the body, including your joints, lungs, kidneys, blood vessels, digestive organs, and nerves.
- It is also known as ***Sjogren's and Sjogren's syndrome.***
- **Symptoms –** It have cycles of mild and then severe symptoms.
    - **Dry eyes -** Burn or itch or feel like sand in the eyes, the dryness causes blurry vision or sensitivity to bright light, and get irritated, itchy eyelids due to inflammation.
    - **Dry mouth -** Feel chalky, have trouble swallowing, speaking, and tasting, and develop mouth infections such as candidiasis.
- Its inflammation damages the glands, limiting their production of the fluids that normally keep the eyes and mouth moist.
- It also damages other organs and tissues and causing a range of other symptoms.
- **Risk factors**
    - **Age** - It is usually diagnosed in people older than 40.
    - **Sex -** It predominantly affects women.
    - **Rheumatic disease -** It's common for people who have this syndrome to also have a rheumatic disease such as rheumatoid arthritis or lupus.
- **Treatment -** There is ***no cure*** for this syndrome.
- It can be relieved depending on which parts of the body are affected.

> ***Autoimmune diseases*** *happen when the immune system mistakenly damages the body instead of protecting it.*

5.51 Depersonalization and Derealization Disorder (DPDR)

Recently, an article described about the Depersonalization and Derealization Disorder (DPDR).

- A state where individuals experience persistent *feelings of detachment from themselves* or their surroundings.

	Derealization	Depersonalization
Conditions	• A sense of feeling of detachment from environment, objects & people in it.	• A feeling of detachment from themselves.
Symptoms	• Distortion of the distance from the size or shape of objects • A heightened awareness of surroundings. • Feeling as recent events happened in the distant past.	• An inability to recognize or describe emotions. • Feeling unconnected to body, mind and feelings. • Sense of body and limbs are distorted and head is wrapped in cotton.

- **Susceptible population** – It *affects 1 to 2% of the global population*, predominantly youngsters.
- **Symptoms** – Sensation of being in a dream or fog.
    - The world appears flat, colourless or artificial.
    - *Distortions in visual perception*, with objects appearing either blurred or unusually sharp.
    - Sounds that seem either amplified or muted.
    - An altered perception of time, which may seem to move too fast or too slow.
- The above symptoms can last for hours, days, weeks or even months.
- **Treatment** – It is *treatable* by addressing the root cause, whether it is anxiety, trauma or depression.

5.52 Guillain-Barre Syndrome (GBS)

Union Health Ministry has recently sent a team to Pune to assess the situation following a reported outbreak of Guillain-Barré syndrome with 73 cases so far.

- It is an ***autoimmune neurological disorder*** in which a person's immune system attacks their ***peripheral nerves***, leading to muscle weakness that can progress to paralysis.
- **Spread** - It can develop over a few days or several weeks. People of any age can be affected, but it is more common in adults and males.
- The condition is rare, with an estimated incidence of 1/2 per 100,000 population.
- **Causes** –It istill not fully understood- in most cases, it occurs after a viral or bacterial infection.
- According to the World Health Organization (WHO), infection with the bacteria Campylobacter jejuni, which causes gastroenteritis is one of the most common risk factors for GBS.
- People can also develop GBS after having the flu or other viral infections including cytomegalovirus, Epstein-Barr virus, and the Zika virus.
- In rare instances, vaccinations may increase the risk of people getting GBS, but the chance of this occurring is extremely low.
- **Symptoms** – It starts usually with tingling and weakness in the feet and legs before spreading to the upper body, arms and face.
- It also includes a pins and needles feeling in the toes, fingers, ankles or wrists, back pain, pain in the legs, not being able to walk or climb stairs, trouble with facial movements and double vision.
- For some people this can lead to paralysis of the legs, arms or face.
- It can lead to life-threatening complications when it affects the autonomic nervous system which controls your blood pressure and heart rate.
- **Treatment -** No known cure but supportive care and some immunological therapies are administered.

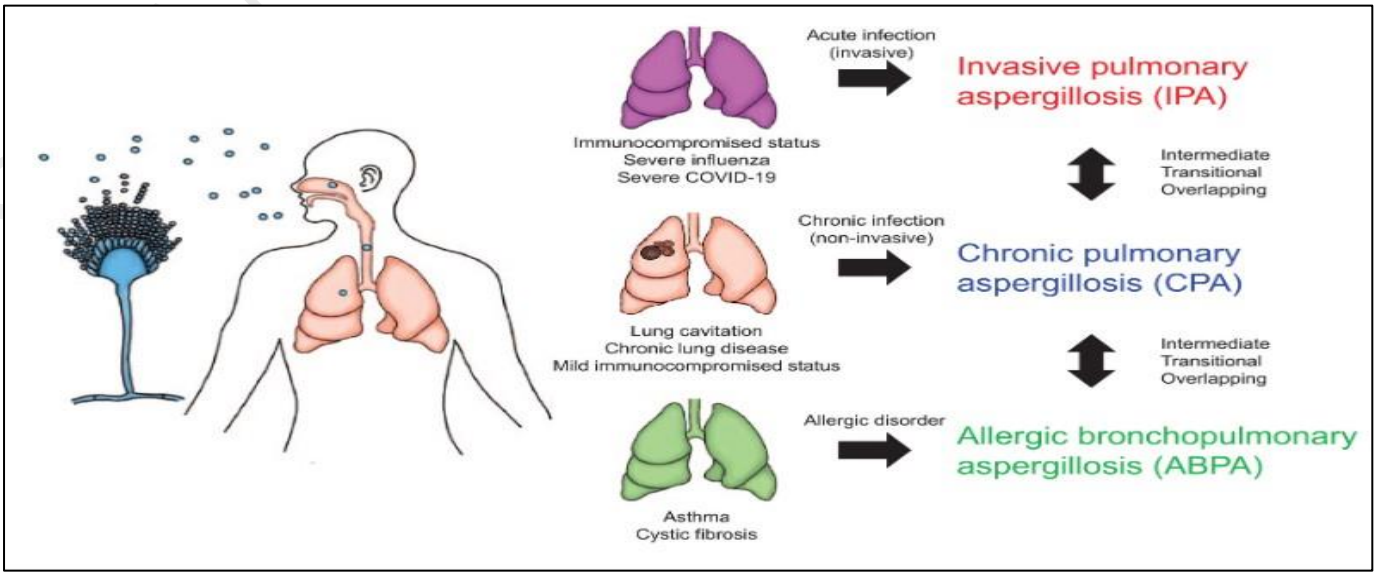
5.53 Chronic Pulmonary Aspergillosis (CPA)

Recently, a new research has identified a Chronic Pulmonary Aspergillosis (CPA) in tuberculosis survivors among Assam's tea plantation workers.

According to the National Tuberculosis (TB) Prevalence Survey 2019-2021, TB has been a major public health issue across the tea belts in Assam's Brahmaputra and Barak valleys, afflicting 217 per 1,00,000 population.

- **CPA** – It is a serious and ***long-term fungal infection*** that affects the lungs.
- **Caused by** – *Aspergillus fumigatus, a fungus* that strikes individuals with immunodeficiency.
- **Conditions** – It is a chronic lung disease that occurs commonly in ***pre-existing lung cavities***.
- Poverty, poor nutrition, kitchen smoke, close contact with smear-positive patients and living in congested environments.

Using advanced serological testing and radiological imaging, the researchers recorded a CPA prevalence of 17.18% in the year-long study and seropositivity was 18.5% in active TB patients but spiked to 48.9% in those who had completed treatment.



- **Risk factors** – It mostly occurs in,
    - Post-Tuberculosis (TB) or active TB patients.
    - People with weakened immune system or
    - Lung diseases.
- **Transmission** – It is not a contagious disease.
- It can't be passed from person to person.
- **Incubation period** – *3 months* or more.
- **Symptoms** – Chronic cough, haemoptysis (coughing blood), weight loss or fatigue and other respiratory.
- It causes severe bleeding in the lungs, which lead to be fatal.
- **Treatment** – It vary depending on the severity of symptoms and any underlying conditions.

5.54 Inherited Retinal Diseases (IRDs)

According to a recent study, there is a higher prevalence of Inherited Retinal Diseases (IRDs) situation in India.

- It is a ***genetic disorder***, a change or a variant, in one or more genes that contribute to proper retinal function.
- It stems from *mutations in more than 300 genes* responsible for the function of the retina, the light-sensitive tissue at the back of the eye.
- It varies significantly across different communities, and it is difficult to identify common mutations.
- **Impacts** – It ***affects the gene's ability*** to do its job properly.
- The mistake gene doesn't make a protein and cells in the retina degenerate and cause vision loss.
- **Vulnerables –** It affects individuals of *all ages*.
    - **Causes** – Lose sight shortly after birth, Gradual deterioration over time, Progressive vision loss and Often resulting in blindness.
- **Treatment - *Gene therapy*** for blindness caused by mutations in the *RPE65* genes and treat various inherited eye disorders.
- ***RNA-based therapies*** to restore protein production in retinal cells without altering the underlying DNA.
- Treat retinal degenerative diseases caused by single-point mutations.

According to the World Health Organization (WHO), more than 2.2 billion people worldwide experience some form of vision impairment.

Studies have revealed significantly higher prevalence, with 1 in 372 individuals in rural South India, 1 in 930 in urban South India, and 1 in 750 in rural Central India affected by these conditions.

5.55 Asperger's Syndrome

International Asperger Syndrome Day Celebrated recently.

- **Asperger's Syndrome** –It is a neurodevelopmental condition that falls under the umbrella of ***Autism Spectrum Disorder (ASD).***
- **Causes –** It is unknown but Genetics and brain differences may be involved.
- **Affecting age -** Most diagnoses happen between ages 5 and 9, although some people are adults before they get their diagnosis.
- Although the term "Asperger Syndrome" has been widely used for years, it was integrated into the ASD classification in the DSM-5 (Diagnostic and Statistical Manual of Mental Disorders) in 2013.
- However, many people still prefer the term because they identify with it.
- **Symptoms -** They have average or above average intelligence and usually started talking before age two.
    - **Intense and specific interests -** A deep focus on areas of particular interest.
    - **Preserved cognitive abilities -** Unlike other diagnoses on the spectrum, there is no significant impairment of language or intellectual development.

- **Social difficulties -** They may find it challenging to interpret facial expressions, body language, or implicit rules in social interactions.

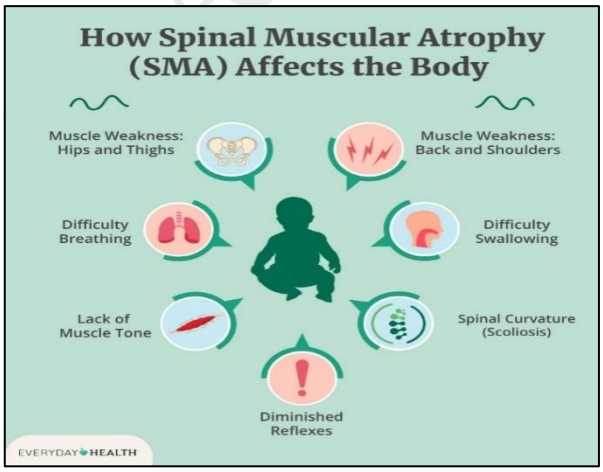
- No two people have the same symptoms.
- **Treatment -** Currently there is *no cure for ASD*.
- Social skills training, Speech-language therapy, Cognitive behavioral therapy (CBT), Applied behavior analysis, Medicine, Parent education and training help managing the condition.

International Asperger Syndrome Day

- It is celebrated in ***February 18,*** dedicated to raise awareness about this condition that is part of the autism spectrum and to broaden social understanding and promote the inclusion of people with Asperger's in all contexts of life.
- Established in honor of the birth of Hans Asperger, an Austrian doctor who first described the set of characteristics.

5.56 Spinal Muscular Atrophy (SMA)

A two-and-a-half-year-old girl has shown no signs of a genetic disorder, known as spinal muscular atrophy (SMA), becoming the first person in the world to be treated for the disease while in the womb.



- It is a debilitating ***genetic condition*** which affects *motor neurons* that control movement, and leads to progressive muscle weakening.
- **Caused by -** Mutations in the survival motor neuron gene (SMN1) which causes a deficiency of a protein crucial for the survival of motor neurons in the spinal cord.
- This prevents muscles from receiving signals from the brain, causing them to waste away.
- **Types of SMA**
  - **Type I** - Usually diagnosed before age 3
  - **Type II** -Begins to affect children between 6–18 months old
  - **Type III** - Also called ***Kugelberg-Welander syndrome*** or juvenile SMA, begins to affect kids as early as 18 months of age or as late as adolescence
  - **Type IV-** The adult form of SMA, symptoms usually begin after age 35.
- In its most severe form, SMA-1, motor skills decline rapidly and patients usually only live two to three years.
- **Prognosis** - About one in every 10,000 births have some form of the condition making it a leading genetic cause of death in infants and children.

Recent application in Treatment

- For the treatment, scientists used an oral drug called risdiplam, which is given to patients to slow the progression of SMA.
- *Risdiplam* is typically given to a patient soon after birth.
- The mother, who was 32 weeks pregnant, took Risdiplam daily for 6 weeks and thus the baby started taking the drug from roughly one week old, and will probably continue to take it for the rest of her life.
- The scientists found that the girl had higher levels of the SMN protein in her bloodstream, compared to those usually born with the condition.
- The girl seemed to have lower levels of nerve damage, and even after 30 months had normal muscle development with no sign of atrophy.

5.57 Foetus in foetu

Doctors at the Buldhana District Women's Hospital in Maharashtra recently detected a rare case of "foetus in foetu" in a pregnant woman.

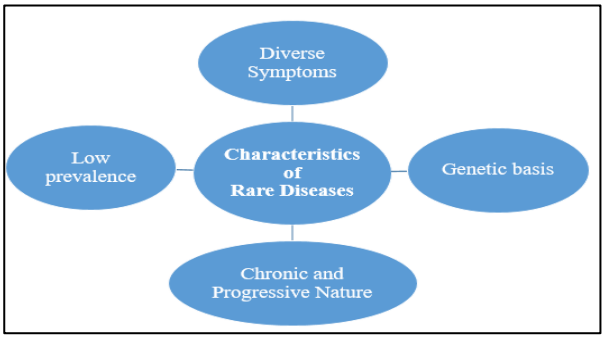
- It is a ***congenital disorder occurs when a malformed foetus*** develops inside another foetus.
- It is also known as cryptodidymus.
- **Causes** - It is not fully understood, but it's believed to result from an anomaly during the development of monozygotic or identical twins.
- **Condition** - A foetus-like mass developed within the body of the other foetus in a *monozygotic twin pregnancy*.
- Basically, one twin is very underdeveloped and enwrapped inside the body of the other twin, so much so that the pregnancy is considered a ***singleton pregnancy***.
- The presence of a twin inside the body of the other twin may go *undetected for years.*
- The ***trapped twin is considered "parasitic,"*** as it draws its blood supply and nutrients from the other "host" twin.
- The trapped or "parasitic twin" has some morphologic features of a normal foetus such as
    - An umbilical cord-like structure,
    - A bag of membranes surrounding it, and
    - Blood vessel connections to the host twin.
- It may have a vertebral column, limbs, and a few organs but *lacks vital organs like the brain, heart or gut*.
- Despite having "living tissue," the parasitic twin has no prospects of independent existence outside the host twin.
- It affects the health of the host twin, who has to "feed" the former from the nutrients received over a single umbilical cord.
- **Challenge** – Generally, the parasitic twin is found in the abdomen of the host twin and rarely, it may be found in other organs like the brain or chest.
- Most of the cases reported have presented in childhood as an abdominal mass causing gut obstructions and swelling.
- X-rays and CT scans have confirmed the presence of foetal structures like digits, limbs, a spine, etc., in the mass.
- **Treatment** - Surgical excision of the mass, the parasitic twin with special attention being given to the foetus' blood supply.
- **Prevalence** - It affects about one in 500,000 births. Less than 200 cases have been reported worldwide, with about 10 to 15 cases in India.

5.58 Rare Diseases in India

Recently, a 19-year-old child actress, Suhani Bhatnagar, died due to dermatomyositis, a rare disease

***Dermatomyositis** is an uncommon inflammatory disease marked by muscle weakness and a distinctive skin rash.It can affect adults and children, affects more females than males. And there's no cure for it.*

- **Definition** – According to WHO, Rare disease is a *lifelong disease* with a prevalence of ***10 or fewer per 10,000 population***.
- According to Organization of Rare Diseases India (ORDI) defined rare disease as a disease when it affects 1 in 5,000 people.
- **Spread** – It affect approximately 3.5% to 5.9% of the population.
- **Causes** – 72% of rare diseases are genetic, with over



7000 characterized by diverse disorders and symptoms.

Status of Rare Diseases in India

- India lacks a standard definition for rare diseases.
- Estimate suggests that *about 8 crore-10 crore Indians suffer* from one rare disease or another, over 75% are children.
- India accounts for one-third of the global rare disease incidence, with over 450 identified diseases.

***Rare Disease Day** was observed on the last day of February i.e., 28th February (or 29 in leap years).*

- These range from widely known ones such as Spinal Muscular Atrophy and Gaucher's disease to lesser-known ones such as Mucopolysaccharidosis type 1 and Whipple's disease.
- Currently, ***63 rare diseases*** are included under NPRD on recommendation of Central Technical Committee for Rare Diseases (CTCRD).

5.59 Breast cancer cases in India

According to a recent study the number of breast cancer cases in India is projected to rise by 50,000 annually this decade, with the economic burden estimated to an average $19.55 billion per year.

- **Breast Cancer** - Breast cancer is one of the most common cancers that affects women and people assigned female at birth (AFAB).
- It happens when cancerous cells in your breasts multiply and become tumors.
- About 80% of breast cancer cases are invasive, meaning a tumor may spread from your breast to other areas of your body.

Common types of breast cancer	Less common breast cancer types
• Invasive (infiltrating) ductal carcinoma (IDC)	• Triple-negative breast cancer (TNBC)
• Lobular breast cancer	• Inflammatory breast cancer (IBC)
• Ductal carcinoma in situ (DCIS)	• Paget's disease of the breast

- **Symptoms –** Lumps, Skin changes, Nipple changes, Nipple discharge, Pain and others.
- **Complications -** The most significant complication is metastatic breast cancer, spreads to other areas of your body, including your brain, bones, liver and lungs.
- **Treatment –** Breast cancer is treated with a combination of surgery, radiation therapy, chemotherapy, hormonal therapy, and targeted therapy.

Recent Study Findings of Breast Cancer

- **Cancer rate** - Cancer is now reported as the 5th-leading cause of death in India (5.7% of all deaths), as per the Medical Certification of Cause of Death (2018).
- The rise of around 11.5% in cancer incidence is recorded in India, along with a 13.8% increase in cancer-related deaths every year.
- **Breast cancer rate** - Over the past 26 years, the age-standardized incidence rate of breast cancer in females increased by 39.1% from 1990 to 2016, with the increase observed in every State.
- The number of breast cancer cases in India is projected to rise by 50,000 annually this decade.
- **Vulnerable** - Current trends point out that a higher proportion of the disease is occurring at a younger age in Indian women, as compared to the West.
- **Survival rate in India** - The survival rate of patients with breast cancer is poor in India as compared to Western countries.
- It is due to earlier age at onset, late stage of disease at presentation, delayed initiation of definitive management and inadequate/fragmented treatment.

- **Associating factors -** Firstly, breast cancer is associated with lower levels of physical activity, socioeconomic status, utilization of health facilities and health insurance.
- A survey showed that 14.2% of patients discontinued treatment, and only 9% of the patients were covered by any health insurance scheme.
- **Co-morbidity** - Breast cancer is also associated with high co-morbidity, with hypertension and diabetes being the most common co-morbidities, thus contributing to a high economic burden.

DRUGS, VACCINES AND MEDICINES

5.60 Hydroxyurea

The Indian Council of Medical Research (ICMR) has invited an Expression of Interest (EoI) for joint development and commercialization of paediatric oral formulation of hydroxyurea.

- **Hydroxyurea** – It is in a class of medications called *antimetabolites* and is also a *myelosuppressive agent*.
- **Application** – As an antimetabolites, they *treats cancer* by slowing or stopping the growth of cancer cells in your body.
- As a myelosuppressive agent, it is used for treating patients of *sickle cell disease, and thalassemia*.
- **Concerns** – *Lack of availability of paediatric doses* as well as the *fear of toxicity*.
    - Only high dosage hydroxyurea tablets are available, as 500 mg capsules or 200 mg tablets.
- **Paediatric formulation** – In children, the prescribed dose is 10-15 mg per kilogram of body weight after 2 years of age.
- **Usage in India** – As per National Health Mission's guidelines, healthcare providers initiate hydroxyurea therapy to only symptomatic sickle cell disease patients among children.
- Currently, the tablet has to be broken down appropriately to be administered in accordance with body weight, thereby risking the efficacy available with measured doses.

5.61 Ban of Antibiotics

The Drugs Consultative Committee (DCC) recommends banning the import, production, distribution, and sale of antibiotics.

The DCC functions as the advisory committee to the Central Drugs Standard Control Organization (CDSCO).

- **Antibiotics**- An antibiotic is a type of antimicrobial substance active against bacteria.
- **Banned Drugs -** Chloramphenicol and Nitrofurans.
- **Recommendation-** The DCC members noted that chloramphenicol and nitrofurans are often misused in poultry and other animal feed supplements.

Chloramphenicol	Nitrofurantoin
• It is an antibiotic useful for the treatment of a number of ***bacterial infections*** including superficial eye infections, enteric fever, typhoid fever and central nervous system infections. • It is recognised by the WHO as a ***Highly Important Antimicrobial (HIA).***	• It is an antibiotic medication that is used for the treatment of uncomplicated ***lower urinary tract infections.*** • It derivatives are classified as ***Important Antimicrobials (IA)*** by WHO.

- This misuse can lead to antibiotic-resistant bacteria and exacerbate the global health issue of ***antimicrobial resistance (AMR).***
- **AMR**- Anti-Microbial Resistance refer to the ability of microorganisms (such as bacteria, viruses, fungi, and parasites) to resist the effects of drugs designed to kill them or inhibit their growth.
- **Other banned antibiotics-** As per Coastal Aquaculture Authority (CAA) guidelines, ***20 antibiotics*** and other pharmacologically active substances are banned for use in shrimp aquaculture.

- This includes chloramphenicol and types of nitrofurans, including furaltadone, furazolidone, furylfuramide, nifuratel, nifuroxime, nifurprazine, nitrofurantoin and nitrofurazone.
- **Concerns-** In May 2023, Marine Products Export Development Authority (MPEDA) proposed a ban on the import and production of these drugs to the Department of Animal Husbandry and Dairying (DAHD).

Marine Products Export Development Authority (MPEDA), *the nodal agency for the development of the seafood industry in India, especially focusing on exports of marine products.*

Central Drugs Standard Control Organization

- The CDSCO is the Central Drug Authority for discharging functions assigned to the Central Government under the Drugs and Cosmetics Act.
- It is the National Regulatory Authority for the medical devices industry under the provisions of the Drugs & Cosmetics Rules.
- **Nodal Ministry-** Ministry of Health & Family Welfare.
- CDSCO, along with state regulators, is jointly responsible for the grant of licenses for certain specialized categories of critical Drugs.
- **Functions-** Regulatory control over the import of drugs, approval of new drugs and clinical trials.
- Approval of certain licences as Central Licence Approving Authority

5.62 Poliovirus & Vaccines

Vaccine hesitancy in major cities of Afghanistan and Pakistan is causing a resurgence of the poliovirus, posing a serious threat to the WHO's Global Polio Eradication Initiative.

- Polio is a ***highly infectious*** viral disease caused by a human enterovirus called the poliovirus.
- **Vulnerable-** It largely affects children ***under 5 years of age***.
- **Types of polio**
  - **Abortive poliomyelitis-** causes flu-like and intestinal symptoms. It only lasts a few days and doesn't cause long-lasting issues.
  - **Non-paralytic poliomyelitis-** cause aseptic meningitis, a swelling of the area around brain.
  - **Paralytic poliomyelitis-** The poliovirus attacks brain and spinal cord. It can paralyze the muscles that allow to breathe, speak, swallow and move your limbs.
  - **Polioencephalitis-** It is a rare type of polio that mostly affects infants. It causes brain swelling.
- **Symptoms-** Between 70% and 95% of people infected with poliovirus don't have symptoms.
- **2 types Vaccines -** *Inactivated polio vaccine (IPV) and oral polio vaccine (OPV).*
- The world has used both vaccines in the fight against polio.
- While some countries, such as ***Norway, Sweden, Finland, and Iceland,*** relied exclusively on the IPV, most countries have used a combination of the two.

Feature	Inactivated Polio Vaccine (IPV)	Oral Polio Vaccine (OPV)
Type	Inactivated virus	Live attenuated virus
Administration	Injectable	Oral drops
Immune Response	Induces primarily humoral immunity	Induces both humoral and mucosal immunity

Global Use	Used in countries where wild poliovirus is eradicated	Used in countries where polio is endemic or recently eradicated
Current Usage	Used in polio eradication campaigns in developed countries	Used extensively in polio eradication efforts globally

- **Potency of OPV-** OPV offered several advantages over IPV.
- Firstly, it induced protection at the gut, the viral entry site, providing stronger immunity compared to IPV.
- Secondly, OPV was administered orally, eliminating the need for syringes and trained personnel for its delivery.
- **Concerns-** Despite successful efforts in many regions, particularly in Africa, these countries continue to struggle with the virus.
- There are concerns that the WHO may not meet its goal of ***global polio eradication by the end of 2024.***

5.63 Vaccine for Shigella

The Indian Council of Medical Research (ICMR) has recently found an Indian partner to manufacture the breakthrough vaccine for the Shigella infection.

- It is an ***intestinal infection*** caused by ***bacterium*** that belongs to the ***enterobacter family***.
- **Four species of Shigella**
  - Shigella sonnei
  - Shigella flexneri
  - Shigella boydii
  - Shigella dysenteriae

Shigellosis *affects about 188 million cases per year that result in about 1 million deaths per year around the world.*

- The main sign of shigella infection is ***diarrhea***, which often is bloody.
- **Symptoms** - Diarrhea (often containing blood or mucus), Stomach pain or cramps, Fever, Nausea or vomiting.
- Some people have ***no symptoms*** after they've been infected with shigella but their feces may still be contagious up to a few weeks.
- **Transmission** - Shigella is ***very contagious***.
- People get infected with shigella when they come in contact with and swallow small amounts of bacteria from the stool of a person who is infected with shigella.
- Eating or drinking ***contaminated food or water***.
- It can also be spread during ***sexual activity*** with a sick person.
- **Vulnerable Age** - ***Children under age 5*** are most likely, but it can occur at any age.
- **Prevention** - Washing your hands frequently with soap.
- **Vaccine** - There is ***no vaccine*** or cure yet.

5.64 Tinzaparin for Snake bites

Recently, researchers discovered that tinzaparin significantly reduces damage to human cells caused by spitting cobra venom.

- **Tinzaparin**- Tinzaparin is a prescription drug used to treat deep vein thrombosis (DVT) and pulmonary embolism (PE).
- It is a Low Molecular Weight Heparin (LMWH) and a drug commonly used to ***prevent blood clots***.
- It is a potent inhibitor of activated coagulation factors, especially Factors Xa and IIa (thrombin).

Encounters with venomous snakes kill about 1.4 lakh people every year, especially in the tropical regions of Africa and Asia.

- It can also inhibit angiogenesis by binding to heparin-binding sites on endothelial cells, and by increasing the release of tissue factor pathway inhibitor (TFPI).
- It can also be used in conjunction with warfarin for the treatment of acute symptomatic Deep Venous Thrombosis (DVT) with or without PE.
- It could protect these cells even when it was introduced an hour after the cells had been exposed to the venom.
- **Highlights of the recent study -** If the venom's toxicity depended on the biological pathway that synthesised ***heparan sulphate***, artificially stopping this pathway could ameliorate the venom's toxic effects.
- Tinzaparin could protect these cells even when it was introduced an hour after the cells had been exposed to the venom and it worked by blocking the interaction between the venom and its receptor in the cell by binding to venom molecules.

5.65 PresVu Eye drop

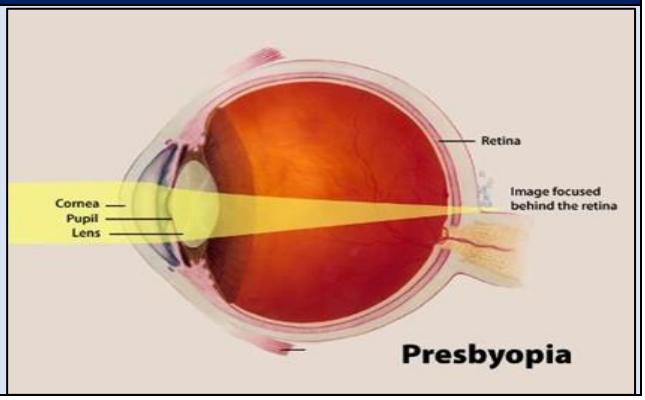
Recently, a Mumbai-based company has developed a new eye drop to reduce dependency on reading glasses for individuals affected by presbyopia.

- **PresVu** – It is a first of its kind eyedrop in India to ***treat presbyopia***.
- **Developed by** - Entod, Mumbai-based pharmaceuticals company.
- **Active Ingredient** – It contains 1.25% concentration of *Pilocarpine*.
- **Working** –It contracts the iris muscles, which control the size of the pupil, to focus better on nearby objects.
- It uses advanced dynamic buffer technology essentially, a base solution, to adapt to the pH level of tears.
- This ensures that the eye drop has consistent efficacy and safety for extended use.
- **Impact** - It is a prescription-only medicine and its impact is unlikely to last beyond four to six hours.
- Regular use may lead to itching and redness, eyebrow pain, and muscle spasms in the eyes.

In India, the government decides on the ceiling price of pilocarpine in 4% and 2%

Presbyopia

- It is an ***age-related farsightedness*** condition in which the eyes gradually ***lose the ability to focus on nearby objects***.
- It usually starts around the age of 40.
- **Symptoms** - Blurry close-up vision, headaches, and eye strain.
- **No Cure** - There's no cure for presbyopia, but there are several treatments, including corrective lenses, contact lenses, and surgery.



5.66 Lenacapavir, Potential Preventive HIV Drug

Patent applications for a drug called lenacapavir have shown to be capable of virtually eliminating new HIV infections through sex opposed in India.

- **Lenacapavir Drug –** It functions as a fusion capsid inhibitor.
- It disrupts the HIV capsid, which is the protein structure that safeguards the genetic material and enzymes essential for the virus's replication.
- This medication is delivered via subcutaneous injection, with a dosing schedule of once every 6 months.
- Administration – It is given through biannual injections as numerous clinical trials have shown it to be more effective than traditional oral preventive treatments, known as pre-exposure (PrEP).
- **PrEP, or pre-exposure prophylaxis-** It involves the administration of antiretroviral medications to reduce the risk of HIV infection in individuals who are considered to be at high risk.
- The primary medication utilized in PrEP is Truvada, which consists of a combination of two antiretroviral agents - Tenofovir disoproxil fumarate (TDF) and Emtricitabine.

- There are multiple forms of PrEP, including daily oral pills and a long-acting injectable form.
- **UNAIDS**- It could play a pivotal role in the global effort to eradicate AIDS, provided that it is accessible to all.

HIV/AIDS

- **HIV (human immunodeficiency virus**)- It is a virus that attacks the immune system, and AIDS (acquired immunodeficiency syndrome) is the most advanced stage of HIV infection.
- It is particularly targeting CD4 cells (T cells) that are essential for combating infections.
- **Transmission** – It can spread through sexual contact, illicit injection drug use or sharing needles, contact with infected blood, or from mother to child during pregnancy, childbirth or breastfeeding.
- **Treatment** – There is ***no vaccine*** to prevent HIV infection and no cure for HIV/AIDS.

UNAIDS
• It serves as a paradigm for reform within the United Nations and stands as the sole cosponsored Joint Programme in the UN framework. • It leverages the knowledge and skills of 11 Cosponsors from the United Nations system and uniquely includes civil society representation on its governing board. • UNAIDS is at the forefront of the international initiative to eliminate AIDS as a public health concern by the year 2030, aligning with the Sustainable Development Goals.

5.67 Semaglutide vs tirzepatide (Weight Loss Drugs)

India's drug regulator could soon approve the weight-loss drug tirzepatide.

- Semaglutide and tirzepatide are ***small proteins*** that increase levels of hormones like ***GLP-1,*** helping to control weight via the brain and digestive tract.
- **Manufacturer-** Eli Lilly, American pharmaceutical company.
- The United States Food and Drug Administration (FDA) has approved ***Wegovy (semaglutide) and Zepbound (tirzepatide)*** for chronic weight management in adults.
- **Prescription-** Prescribed to adults who are obese (BMI over 30) or overweight (BMI between 27 and 30) with at least one weight-related health condition, such as high blood pressure, high cholesterol, or type 2 diabetes.

Glucagon-like peptide 1 *(GLP-1) is a hormone most commonly known for stimulating insulin release following meal consumption.*

Feature	Semaglutide	Tirzepatide
Drug Class	Glucagon-like-peptide 1 (GLP-1) receptor agonist	Dual GIP and GLP-1 receptor agonist
Brand Names	Ozempic, Rybelsus, Wegovy	Mounjaro
Indications	Type 2 diabetes, chronic weight management	Type 2 diabetes, potentially for weight loss
Mechanism of Action	Mimics GLP-1 to increase insulin secretion, decrease glucagon release, and slow gastric emptying	Activates both GIP and GLP-1 receptors to enhance insulin secretion, inhibit glucagon release, and slow gastric emptying
Efficacy in HbA1c Reduction	Reduces HbA1c by approximately 1.0-1.5%	Reduces HbA1c by approximately 1.5-2.0%
Weight Loss	Significant weight loss observed (up to 15% body weight in trials for Wegovy)	Significant weight loss, potentially greater than Semaglutide (up to 22.5% in trials)
Side Effects	Nausea, vomiting, diarrhea, constipation, potential risk of thyroid C-cell tumors	Similar to Semaglutide: nausea, vomiting, diarrhea, potential risk of thyroid C-cell tumors, injection site reactions

Cardiovascular Benefits	Shown to reduce major cardiovascular events in patients with type 2 diabetes and cardiovascular disease	Shown to reduce major cardiovascular events in patients with type 2 diabetes (ongoing studies to further validate)
Approval Status	FDA approved for type 2 diabetes and chronic weight management	FDA approved for type 2 diabetes (weight management indications under investigation)

- **Global scenario-** The development of various weight loss drugs has been a game changer for obesity treatment in recent years, especially in the ***US and Europe***.

India's drug regulator could soon approve the weight-loss drug tirzepatide.

- Semaglutide vs tirzepatide drugs are ***yet to be*** commercially available in India.

5.68 Excipients in Drugs information

The Health Ministry initiated the process to amend the drug rules to mandate inclusion of details of excipients into the data stored in the label of drug formulation products.

- **Excipients**- Excipients are substances other than active pharmaceutical ingredients in finished pharmaceutical dosage forms.
- Almost all drug dosage forms include excipient to guarantee dosage, stability, and bioavailability.
- Currently, the other information that are stored in the label in bar code or QR Code include
    - The unique product identification code,Proper and generic name of the drug,
    - Brand name,Name and address of the manufacturer,
    - Batch number,Date of manufacturing andDate of expiry.
- There is no clear cut indication of composition of excipient on the strips of medicines available on retail medical shops and patients find it difficult to find paraben free antihypertensive medicines and others.
- **Recent consideration -** The listing of excipients was considered by the Ministry after multiple grievances about adverse related to parabens.
- The suggestion was to include the details of excipient or INS codes of the excipients on every strip of medicines.
- **Aim**- To help patients omit any adverse reactions causing ingredients while under treatment.
- It will amend the ***sub-rule (7) of Rule 96 of the Drugs Rules, 1945*** to include details of excipients.

5.69 Orphan drugs

Orphan drugs have increasingly gained attention in India following the implementation of the National Policy for Rare Diseases (NPRD) in 2021.

- Orphan drugs are critical in ***treating rare (orphan) diseases.***
- They are categorized ***based on the types of diseases*** they target and their regulatory status.

Orphanet *is a resource that allows users to search for orphan drugs by disease name or substance name.*

- Diseases such as genetic disorders, rare cancers, metabolic disorders, and autoimmune conditions frequently fall under the orphan disease category.
- **Examples** - Ivacaftor for cystic fibrosis, Alglucerase for Gaucher disease, Coagulation factor IX for hemophilia B, Imatinib for leukemia, and Rucaparib for ovarian cancer.
- **Criteria** - For a drug to receive orphan drug designation, it must meet certain criteria that vary across countries. Typically, the disease in question must have a ***low prevalence.***
- Additionally, the condition must lack approved treatments, or the orphan drug must provide significant benefits over current treatment options.
- **Approval** - Developers of orphan drugs must also provide scientific evidence that the drug has the potential to treat or alleviate the condition.
- This evidence can be presented at any stage of drug development, from preclinical research to late-phase clinical trials.

- **Incentives -** Once designated, it receive several incentives to encourage their development, including market exclusivity, tax credits for research and development expenses, and fee waivers for regulatory applications.

Rare Disease

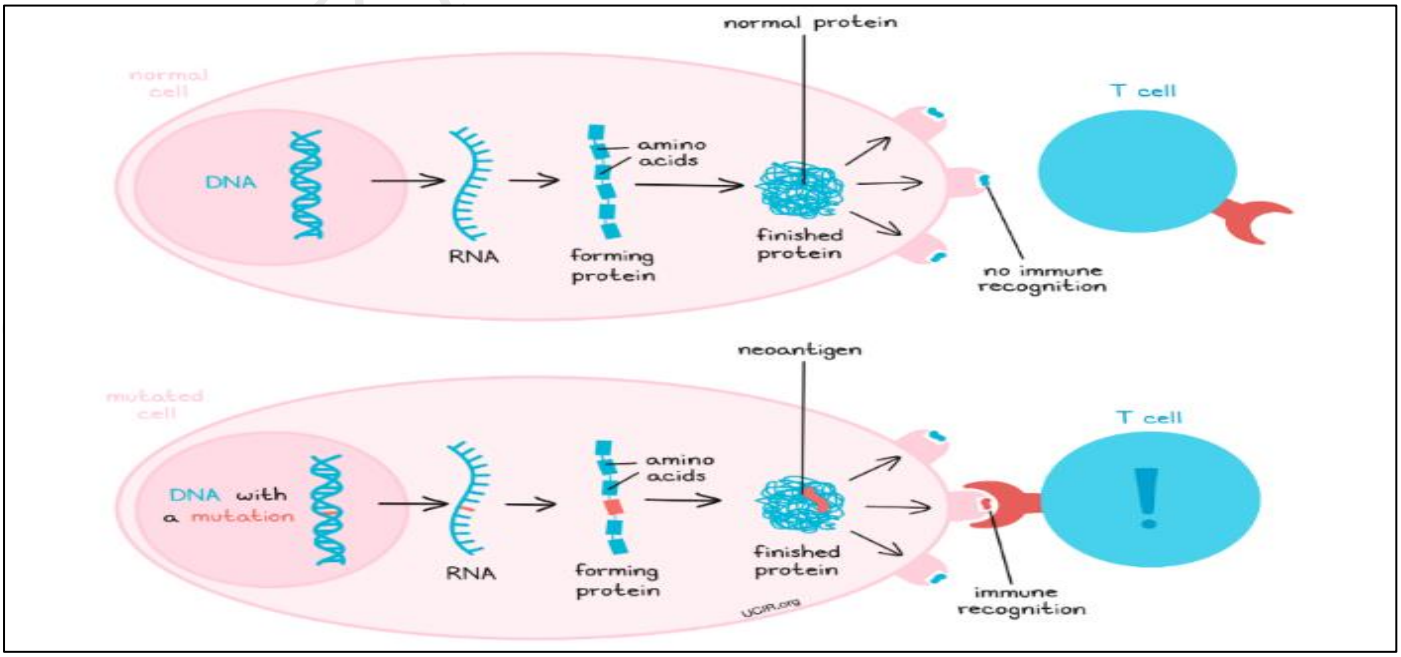
- A disease is considered rare if it affects fewer than 200,000 people in the U.S. and fewer than 1 in 10,000 people in the European Union.
- There is ***no formal prevalence-based*** definition in India, the NPRD of 2021 outlines a framework for diagnosing and treating rare diseases, with a low prevalence threshold expected.
- **Category** - Under India's NPRD, rare diseases are classified into 3 categories to facilitate treatment approaches.
    - Group 1 includes disorders that are curable through one-time interventions, such as Lysosomal Storage Disorders (LSDs) requiring Hematopoietic Stem Cell Transplantation (HSCT).
    - Group 2 encompasses diseases that need long-term or lifelong management but have relatively lower treatment costs, such as Phenylketonuria (PKU) and Maple Syrup Urine Disease (MSUD).
    - Group 3 covers conditions like Gaucher Disease and Pompe Disease, where treatment is available but complicated by high costs and the necessity for lifelong care.

5.70 Vaccine for Cancer & Neoantigens

Recent reports in Russia's state-run news agency claimed that Russian scientists have developed an mRNA vaccine that has shown the ability to suppress tumour development and metastasis in pre-clinical trials.

***Cancer** is a disease in which some of the body's cells grow uncontrollably and spread to other parts of the body.*

- **Vaccine** – A substance or group of substances meant to cause the immune system to respond to harmful pathogenic microorganisms.
- **Vaccination** - The process of using a vaccine to stimulate the immune system to provide protection against a disease.
- **Cancer vaccine** – Unlike vaccines for infections that are given to healthy individuals to protect them from disease, cancer vaccines are given to *those who already have certain types of cancers.*
- **Approach** — Vaccines can be given in combination with other treatments for better outcomes or they can be given for maintenance to prevent relapse.
- The personalised vaccine was developed by collecting the patients' immune cells, exposing it to a protein found in high levels in prostate cancer cells, and then giving it back to patients.
- However, it *extended the patient's survival by only 4 months*.



- **Vaccine preventable Cancers** – There are *at least 2 cancers* whose incidence can be reduced by vaccinating against 2 pathogens.
- Preventing chronic **hepatitis B infection** with vaccination can bring down the incidence
    - Cervical Cancer
    - Liver Cancer

> ***Cervavac*** *is India's 1st indigenous quadrivalent human papillomavirus vaccine (qHPV) vaccine, and intended to protect women against cervical cancer.*

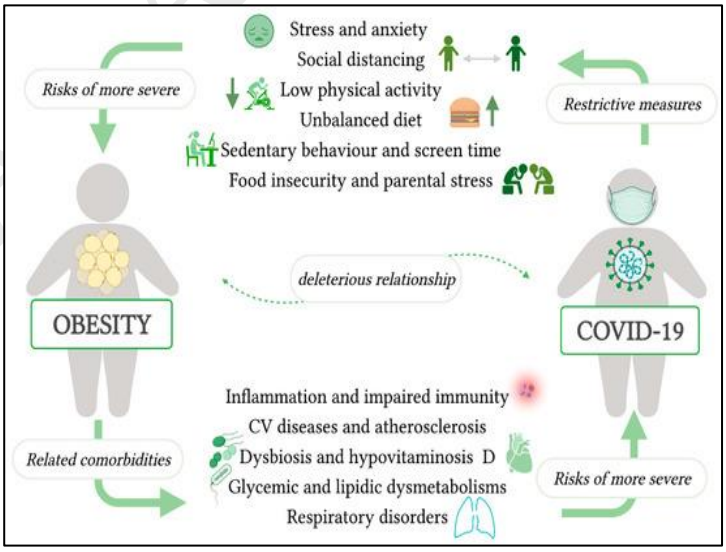
- **Existing vaccines** – The only cancer vaccine approved by the US Food and Drug Administration is Sipuleucel-T, for the treatment of prostate cancer.
- **Russian mRNA vaccine** – It can be "personalised" based on the genetic analysis of each person's tumour *to identify mutations called neoantigens.*
- **Neoantigens** – A new protein that *forms on cancer cells* when certain mutations occur in tumor DNA.
- **Significance** – They may play a role in helping the body make an immune response against cancer cells.

5.71 Obesity Pandemic & Weight Loss Drugs

Recently, the World Health Organisation (WHO) scientists have endorsed a weight loss drugs for controlling obesity.

> *World Health Organization (WHO) have endorsed a new class of medicines known as* ***GLP-1 receptor agonists.***

- **Obesity** – It is a chronic complex disease defined by ***excessive fat deposits*** that can impair health.
- **Diagnosis** – It is made by measuring people's weight and height by *calculating the Body Mass Index (BMI)*.
- **BMI categories** – For defining obesity vary by age and gender.
- Globally, *1 in 8 people* were living with obesity in 2022.
- In India, there were *44 million women and 26 million men* living with obesity in 2022.
- **Impacts** – It increase the risk of type 2 diabetes and heart disease.
- It affects bone health and reproduction and it increases the risk of certain cancers.
- **Globesity** – An escalating *global epidemic of overweight and obesity* called as "globesity" is taking over many parts of the world.
- It elevated to greater levels during the times of COVID Pandemic.



Glucagon-like peptide-1 (GLP-1) receptor agonists

- **Role** – A class of medications *utilized to treat type 2 diabetes mellitus (T2DM) and obesity*.
- **Composition** – It includes drugs such as *Semaglutide and Tirzepatide*, which have the potential to be transformative.
- **Working** – It mimics a hormone that regulates appetite and blood sugar levels.
- It lowers serum glucose levels and thereby manage metabolism in affected patients.

> *WHO is currently in the process of* ***drafting guidelines*** *for the use of GLP-1 receptor agonists in adults with obesity, likely to be published in July 2025.*

- **Objectives** – Identify the mechanism of action of GLP-1 receptor agonists.
- Assess the potential adverse effects of GLP-1 receptor agonists.
- Differentiate the proper administration techniques for GLP-1 analogs and the clinical monitoring necessary for patients prescribed GLP-1 receptor agonists.

5.72 Suzetrigne

Recently, United States Food and Drug Administration approved a new type of non-opioid painkiller, suzetrigne.

Opioids

- Opioids are a class of drugs that derive from, or mimic, natural substances found in the opium poppy plant.
- Some common opioids include oxycodone, morphine, codeine, heroin, and fentanyl.

According to the US Centers for Disease Control and Prevention There were 82,000 opioid-involved overdose deaths in 2022.

- Prescription opioids are primarily used for pain relief but they are quite addictive.
- They do so by getting attached to opioid receptors in the brain cells to release signals that block the perception of pain, and boost the feelings of pleasure or euphoria.

- **Suzetrigne -** Unlike opioids, which numb the sensation of pain in the brain, suzetrigne works by ***targeting pain signals*** before they reach the brain.
- Pain is essentially a signal from one's body to the brain that something potentially harmful has happened or is happening to the body.
- It is meant to prompt a reaction where one avoids further damage.
- **Working -** Several body parts are involved in the sensation of pain.
- First are specialized nerve endings or 'nocireceptors' which are widely distributed across the body.
- Any tissue damage activates these receptors which send electrical signals through the spinal cord to the brain, which then interprets these as pain.
- Suzitrigne interrupts that path, so even though the tissue injury exists, the brain does not know.
- Since suzetrigne does not produce any sensation of pleasure or euphoria, experts believe that the drug could not create addiction or dependence among users.
- **Dosage** - Suzetrigne is a 50-milligram prescription pill that is consumed every 12 hours after a larger starter dose.
- The pill is given in two dosages. In trials, participants got an initial dose of 100 milligrams, followed by 50 milligrams every 12 hours.

5.73 Intranasal vaccine

Recently, Indian Immunologicals Ltd (IIL) in collaboration with Griffith University has developed a live-attenuated needle-free intranasal booster vaccine targeting SARS-CoV-2.

- **Intranasal Vaccines** – These are vaccines that are administered through nasal pathways.
- **Features** - The nasal route has excellent potential for vaccination due to the organized immune systems of the nasal mucosa.
    - Non-invasive, Needle-free.
    - Ease of administration – does not require trained health care workers.
    - Elimination of needle-associated risks (injuries and infections).
    - High compliance
    - Scalable manufacturing – able to meet global demand.
- **Mucosal Immunity** – It helps prevent the virus from establishing an infection at its entry point in the nasal.
- It stimulates a broad immune response of neutralizing IgG, mucosal IgA, and T cell responses.
- **Localized Immunization** - It helps in blocking both infection and transmission of COVID-19.
- **Immunity Period** - It could offer protection for ***up to a year with just one dose.***
- **IIL's Vaccine** - It is a live-attenuated booster vaccine that utilises codon deoptimization technology.

- **Codon deoptimization technology** – It involves modifying the virus in such a way that it mimics a natural infection without causing harm.
- It is an efficient virus attenuation strategy, where the degree of attenuation can be regulated as required.
- It is extremely safe and takes less time than the conventional way of attenuating viruses which usually takes several years.

OTHERS IN HEALTH

5.74 Cancer Detection using Ultrasound

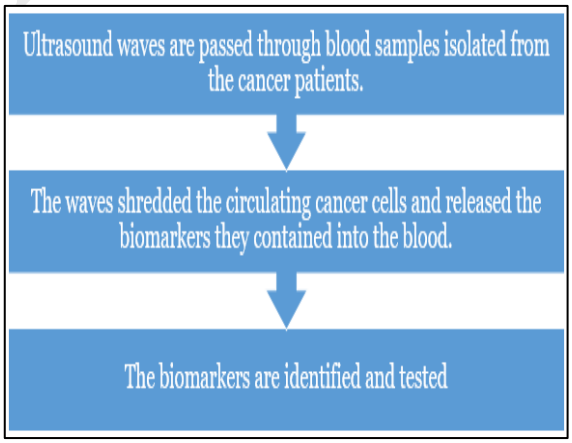
Scientists are working on a way to detect cancer with sound waves.

- **Traditional method** - The *gold standard is a biopsy*, where doctors extract a small piece of tissue or cells using a large needle from the part of the body where cancer is suspected to be present.
- In vitro tests can confirm if the tissue/cells are cancerous and, if so, what kind of cancer it is.

Normally, when cancer progresses and spreads, cancer cells move to parts of the body other than their original site via the blood. But it is difficult to spot these cells in blood because they're very small in number.

- **Ultrasound method** – Ultrasound waves are used in the blood sample of patients in detecting the presence of cancers in the body.
- **Principle** – High-energy ultrasound (at frequencies greater than those used in ultrasound scans) can *break off a small piece of cancerous* tissue into droplets.
- It release their *contents into the bloodstream*.
- The blood can be *tested for biomarkers*, biomolecules like DNA, RNA or proteins that are specific to cancer.
- **Advantages** - Ultrasound can enhance the levels of genetic and vesicle biomarkers in blood samples by over a 100-times.
- The blood samples can be used to *detect specific cancer types* and even the *mutations* they contain, which is currently undetectable in blood.
- **Significance** – The main advantage is its *non-invasiveness*, which will prevent patient discomfort.
- It could help clinicians *avoid nearly half of all biopsies*.
- It could be extended to monitoring cancer progression and treatment response.

***Ultrasound machines** are used to take pictures of internal organs. The technology converts the sound waves reflected by surfaces inside the body to an image, just the way bats use ultrasound to sense their surroundings.*



Biomarker

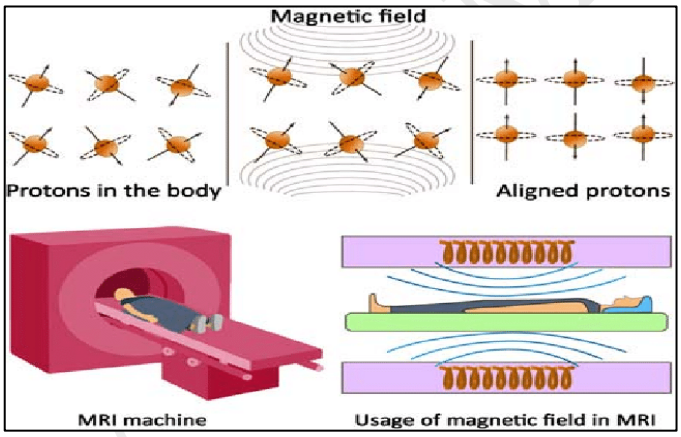
- A biological characteristic that can be measured to indicate a normal or abnormal biological process, or a response to a treatment.
- **Present in –** Blood, urine, tissues, or other body fluids.
- **Usage** – It can be used to diagnose diseases, identify potential treatments and also to track disease progression.

5.75 Magnetic Resonance Imaging (MRI)

An MRI procedure reveals an image of a body part using the hydrogen atoms in that part.

- **MRI** – It is a *non-invasive diagnostic* procedure, used to obtain *images of soft tissues* within the body (tissue that hasn't become harder through calcification).

- **Principle** – *Using the hydrogen atoms,* which are present almost throughout the body but abundant in fat and water.
- A hydrogen atom spin with axes pointing in random directions but in a magnetic field, its *spin axis* will point along the field's direction.
- **4 essential components** – *Bore*, a hole in the centre, where the person whose body is to be scanned is inserted.
    - A *superconducting magnet* inside the bore, which produce a powerful and stable magnetic field around the body.
    - A *radiofrequency pulse emitter* and a *detector* to receive the emissions from the atoms present in the scanned part.
- **Working** – The magnetic field is applied, such that the axes of roughly 50% of the Hydrogen atoms are pointing one way and the other 50% are pointing the other way.
- Only a handful remain unmatched — i.e. a *small population of 'excess' atoms pointing one way or the other*.
- When the pulse is on, a fraction of excess atoms absorb it and gets excited and return to lower energy state by *emitting radiations* when switched off, this emitted radiation is converted *as images*.
- At times, a contrast agent like *gadolinium-based compound* is injected to the person to improve their visibility in an MRI scan.
- **Application** – In the observation & treatment of certain *cancers* like prostate cancer and to track various *neurological conditions*.



- MRI scans of *changes in blood flow* is used to infer the way the activity of neurons is changing in the brain.
- **Pros** – It don't pose any threat on the body and it scan portions that are just a few millimetres wide.
- **Cons** – Machines are expensive and so the scan costs.
- The individual is actually expected to lie still for tens of minutes as their movement may distort the images.
- **Challenges** – Since it uses strong magnetic fields, individuals with metallic implants may not be able to undergo MRI scans and its effects on pregnant women aren't as well-studied.

During MRI scan, if the person have a credit card in their pocket, the magnetic fields will wipe its magnetic strip.

Paul Lauterbur & Peter Mansfield refined the MRI machine and were awarded the medicine Nobel Prize in 2003.

5.76 Timeline for Organ Transplants

Centre sets timeline for disposing living donor transplant applications.

- **Reason for changes** – In January 2024, *Delhi High Court directed* the Ministry of Health & Family Welfare to prescribe timelines in the process of the *living donor transplant applications*.
- **Timeline** – ***6 to 8 weeks***
- **Direction to Health Secretaries** – To follow the guidelines as mentioned to help in expediting the decision-making process.
- **Direction to Authorisation Committees**
    - To process applications *within 10 days*.
    - To give *1 week time* to the donor or recipient for responding to queries or deficiencies in the documents.
    - To hold *interview within 7 days* of the receipt of all required documents with the donor and recipient.
    - To publish their decision on the hospital's website *in 24 hours*.

Organ Donation in India is regulated by the Transplantation of Human Organs and Tissues Act, 1994, and Rules, 2014.

- **Appeal response time** – Any appeal under Rule 33 of the Act against the decision of the Authorisation Committee would have to be decided *within a maximum of 30 days*.
- **Mandate e-Aadhaar verification** – For identification of the donor and recipient and is applicable in the case of both near relative and other than near relative living donor.
- **Donation from a minor living donor** – It shall not be considered without the prior approval of the Appropriate Authority and the State Government concerned.
- **Restriction order** – No swap transplant between a pair of foreigner donor and recipient and a pair of Indian donor and recipient shall be considered by the Authorisation Committee.

The non-near relative living donor can donate only for the reasons of affection and attachment or for any other special reason and that too with the approval of the Authorisation Committee.

***Authorisation Committees** were constituted under the provisions of the Transplantation of Human Organs and Tissues Act, 1994.*

5.77 National Sickle Cell Anaemia Elimination Mission (NSCAEM)

A total of 3.85 crore people have been screened in 17 identified States for sickle cell anaemia as of July 31.

- **Launch in** – 2023, in Madhya Pradesh.

Sickle Cell Disease

- **Sickle cell disease** – A *genetic blood disease* affecting red blood cells.
- **Transmitted by** – Parents carrying a defective *'beta globin' gene*.
- **Spread** – It is more common in the *tribal population* of India.
- **Symptoms** – The disease *starts early in life* causing anemia, pain crises, reduced growth, low energy.
- It *affects many organs* like lungs, heart, kidney, eyes, bones and the brain.

- **Mission -** To improve care of all Sickle Cell Disease patients
- To lower the prevalence of the disease through multi-faced coordinated approach towards screening and awareness strategies.
- **Vision –** To eliminate sickle cell disease as a public health problem in India *before 2047*.
- **Objectives –** To reduce the prevalence of SCD and to provide affordable, accessible and quality care for SCD patients.
- **Target** – To cover 7 crore people in three and half years 17
- **Implementation** – Initially *focus is on high prevalence and tribal states/UT* and then to cover the *entire population from zero to 18 years of age* and incrementally covering population up to 40 years.

India has the highest prevalence of sickle cell disease in South Asia, and over 20 million sickle cell affected individuals reside in the country.

Gujarat, Maharashtra, Rajasthan, Madhya Pradesh, Jharkhand, Chhattisgarh, West Bengal, Odisha, Tamil Nadu, Telangana, Andhra Pradesh, Karnataka, Bihar and Uttarakhand are the high prevalent SCD states.

- **Implementation strategies** – It emphasizes on *3 pillars.*
    - **Health promotion**- Awareness generation & pre-marital genetic counselling
    - **Prevention** - Universal screening and early detection
    - **Holistic management & continuum of care** - Management of persons with sickle cell disease at primary, secondary and tertiary health care levels.
    - Treatment facilities at tertiary health care facilities.
    - Patient support system and Community adoption

- **Integrated approach** - Counselling through collaborative efforts of Central ministries and State governments.
- **Diagnosis** - ICMR-National Institute of Research In Tribal Health (NIRTH), Jabalpur provides training on diagnosis of SCD in States.

Hydroxyurea *has been included in the National Health Mission (NHM) Essential Drugs List at Sub-Health Centres thus making it available at Primary Health Centres (PHC) and Urban PHC, Community Health Centres (CHC) and District Hospitals.*

- **Treatment -** *Hydroxyurea treats SCD* by helping to prevent formation of sickle-shaped red blood cells.
- **Gene Therapy** - CSIR-Institute of Genomics and Integrative Biology (IGIB), Delhi has been working in gene editing therapies for advanced treatment options for SCD.

5.78 Digital Solutions for Universal Access to Healthcare

Recently, a National Conference on Universal Access to Healthcare was organized by National Human Rights Commission (NHRC) in collaboration with other stakeholders.

- **Objective-** To bring together practitioners, experts, policymakers, and innovators in the field of healthcare and digital healthcare technology.
- To discuss universal access to affordable and quality healthcare, particularly in rural, remote, and hilly areas.
- **Participants-** NHRC, Sankala Foundation, supported by NITI Aayog and the Ministry of Health & Family Welfare (MoHFW).

Digital Health Initiatives of India

- Universal access to healthcare has emerged as a basic human right.
- India has committed to achieve Universal Health Coverage by 2030, by utilizing digital health solutions to strengthen primary-level public health infrastructure.
- **Bridgital Model** - Ministry of Health and Family Welfare addressed overcrowding in AIIMS, New Delhi, by the Bridgital Model for registration and appointments.
- **Digital Nerve Centre (DiNC)** – A unique healthcare delivery model to enable quick access to primary health care and provide a well-coordinated continuum of care for citizens visiting government health facilities.
- **Global Initiative on Digital Health (GIDH)** - India launched along with the WHO during the 2023 G20 Health Ministerial Meeting.
- **National Digital Health Mission (NDHM)** – It is implemented by National Health Authority aims to make India Self-reliant in providing universal health coverage to all the citizens in the country.
- D**igital Health Incentive Scheme** – It aims at digitising patients' health records and linking them with the Ayushman Bharat Digital Health Account.

5.79 Central Drugs Standard Control Organisation (CDSCO)

The Central Drugs Standard Control Organisation (CDSCO) has met safety, efficacy, and quality indicators for a functional vaccine regulatory system by the World Health Organization (WHO).

- It is the Central Drug Authority for discharging functions under ***the Drugs and Cosmetics Act.***
- **Ministry** - Ministry of Health & Family Welfare.
- **Head Quarters** – New Delhi.
- It has 6 zonal offices, 4 sub zonal office, 13 Port offices and 7 laboratories.
- The ***Drugs Controller General of India (DCGI)*** is the head of the Central Drugs Standard Control Organization (CDSCO).
- **Vision -** To Protect and Promote public health in India.

- **Mission** - To safeguard and enhance the public health by assuring the safety, efficacy and quality of drugs, cosmetics and medical devices.
- **Functions**
  - Regulatory control over the import of drugs,
  - Approval of new drugs and clinical trials,
  - Meetings of drugs consultative committee (DCC) and drugs technical advisory board (DTAB),
  - Approval of certain licenses as central license approving authority
- It will also coordinate the activities of ***state drug control organizations.***
- It also plays a key role in drug surveillance and monitoring adverse drug reactions.

5.80 Centre of Excellence for Rare Disease

The Union Ministry of Health and Family Welfare is discussing adding more Centres of Excellence (CoEs) to its network of centres to improve access to diagnosis and treatment for patients suffering from rare diseases.

- **Centre of Excellence** – They are institutions *identified by the central government* under the National Policy for Rare Diseases (NPRD), 2021.
- **Aim** – To treat patients suffering from rare diseases actively.
- There are *12 such centres* covering 2,420 rare disease patients from 6 categories ***across 3 groups*.**

Categories of Rare Disease - NPRD

- **National Policy for Rare Diseases (NPRD)** – Launched by Ministry of Health & Family Welfare in *2021*.
- There are 3 groups *based on the type of treatment* they require.
- **Group 1** – Diseases that can be cured with a one-time treatment.
- **Group 2** – Diseases that require long-term or lifelong treatment, but are relatively inexpensive.
- **Group 3** – Diseases that have a definitive treatment, but are expensive and require lifelong therapy.

Most common rare disease in India

- Lysosomal Storage Disorders
- Pompe disease (Glycogen storage disease type II)
- Anderson–Fabry disease
- Mucopolysaccharidosis
- Severe Combined Immunodeficiency (SCID)
- Phenylketonuria
- Cystic Fibrosis
- Duchenne Muscular Dystrophy

- Currently, 63 rare diseases are included under NPRD on recommendation of Central Technical Committee for Rare Diseases (CTCRD).

- **Tax exemption** – GST and Basic Customs Duty on drugs imported for Rare Diseases for individual use and through CoE.
- **Challenges** – It has *lack of institutional care* at CoEs to the *exhaustion of the one-time fund* of Rs 50 lakh given to patients.
- It fails to support sustained treatment for chronic conditions like Lysosomal storage disorders (LSDs).

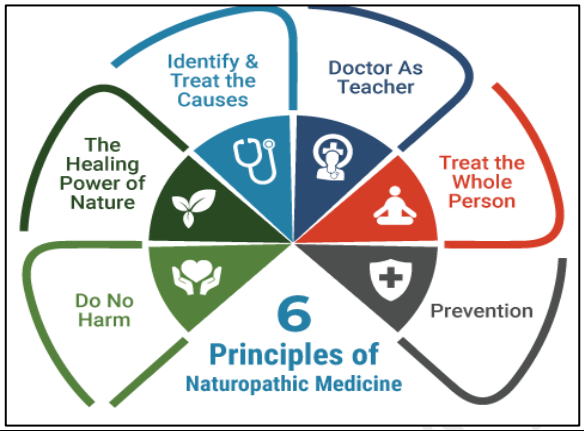
5.81 Naturopathy

The 7th Naturopathy Day was celebrated at the Central Research Institute of Yoga and Naturopathy (CRIYN) in Karnataka to promote better mental and physical health through natural, drug-free therapies.

- **Naturopathy** – It is a unique system of medicine that promotes health by aligning with nature.
- It focuses on the ***body's natural ability to heal***, emphasising treatments like diet, exercise, fasting, hydrotherapy, homoeopathy, botanical medicine, detoxification, and lifestyle counselling.
- It teaches us to eat, drink, act, and live in moderation.

*The term 'naturopathy' was 1st used by John Schell in 1895. **Benedict Lust** was known as the 'Father of Modern Naturopathy,' popularised it in the U.S.*

- It equips us with the *art of self-management*, enabling us to stay healthy for spiritual pursuits.
- **Origin** – It had its *roots in Germany*.
- **Introduction in India** – It gained prominence with the translation of 'The New Science of Healing' by German nutritionist into Telugu in 1894 and later into Hindi and Urdu in 1904.
- States like Andhra Pradesh, Gujarat, Bengal, Maharashtra, and Uttar Pradesh played an essential role in promoting naturopathy.



Naturopathy Day *is observed every year in India on 18th November since 2018, the day on which Mahatma Gandhi become a Life Member of the Nature Cure Foundation Trust and signed the deed in 1945.*

Gandhiji *is considered the founding figure of Naturopathy in India.*

- **Initiatives in India** – *Central Council for Research in Yoga & Naturopathy (CCRYN)*, Ministry of Ayush was inaugurated in Haryana in 2024.
- *National Institute of Naturopathy* (NIN) titled 'NISARG GRAM' was inaugurated in Pune, Maharashtra in 2024.
- India is going to create a chain of research and teaching institutes like *Central Research Institutes in Yoga and Naturopathy (CRIYN)* with 100 to 200 bed hospitals to conduct high-level research across various states.
    - 2 CRIYNs, one at Karnataka, and another in Haryana, are already operational.
- India aims to establish Yoga and Naturopathy Diet Centres (YNDCs) across the nation.

5.82 Unani Medicine

International Conference that was organised by Central Council for Research in Unani Medicine concluded recently.

- It is derived from the word IONIAN which indicates its genesis in the present day Greece (Unan) and TIBB means medicine.
- It is an extensive medical system that deals with *various states of the body (healthy and disease)*.
- It is integrated in nature and offers preventive, promotive, curative and rehabilitative healthcare.
- It is one of the oldest systems of medicine, based on the teachings of Hippocrates.
- **Hippocratic theory** – It postulates that a *perfect balance of "Arkan" (elements), "Akhlat" (humors) and "Mizaj" (temperament)* keeps the body and mind healthy.
- The theory presupposes the presence of *four humours* in human body, which are:
    - Dam
    - Balgham
    - Safra (Yellow bile)
    - Sauda (black bile)

Hippocrates *is known as the "Father of Medicine" because he established medicine on a scientific basis and raised ethical standards.*

- **Umure Tabiya** – In Unani system of medicine, human body is based on seven natural principles, known as "Umure Tabiya".
- These are the very factors responsible for the existence of the human body and are considered responsible for the maintenance of health.
- The loss of any one of these components could lead even to death of the individual.
- **Diagnosis** – The most important aspect for the diagnosis of diseases are three in number,and they are Nabz (pulse), examination of baul (urine) and Baraz (stool).
- The surroundings and the ecological conditions are very much responsible for the state of health of a person.
- ***World Health Organization (WHO) recognized it*** in 1976.

5.83 Cells of Endocrine Glands

Recent analysis at the Weizmann Institute in Rehovot, Israel shows the number of cells in an endocrine gland that secrete hormones.

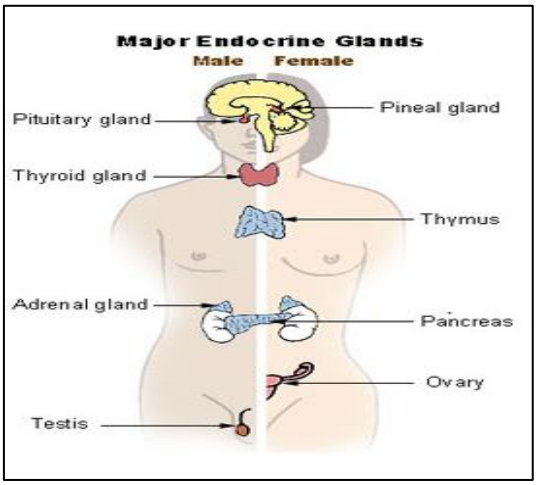
- **Endocrine Glands** – An organ that *makes hormones that are released directly into the blood* and travel to tissues and organs all over the body.

> ***Hormones*** *are signaling molecules found in most multicellular organisms which facilitate communication between organs and tissues in body that are far apart. The signals regulate a wide range of physiological and behavioral processes, such as growth and maturation, sleep, digestive functions, and stress responses.*

- **8 Major glands** – They are scattered *from head to toe*

Endocrine Glands			
	Location	**Shape &/ Size**	**Weight**
Pineal gland	Midline of the brain	A grain of rice	50-150 mg
Pituitary gland	Hypothalamus of the brain	A pea	0.5–1 gram
Thyroid gland	Neck	A butterfly in shape	25 grams
Parathyroid gland	4 of which are in the neck	Size of a lentil seed	120 mg
Thymus	Between the lungs	Pyramid-shaped lymphoid organ	Average of 20 grams
Adrenal glands	Found atop each kidney	Triangular-shaped glands	5-10 grams in adults
Pancreas	Behind the stomach	Tadpole-shaped gland	80-100 grams
Ovaries	On either side of uterus in female	Oval-shaped glands	-
Testis	Underneath penis in male	Round organs	-

- **Functions** – It controls many body functions, including *growth and development, metabolism, and fertility.*
- **Findings** – Every hormone producing cell has *about 2,000 target cells.*
- The number of hormone-secreting cells are in proportion to the number of cells that are targeted.
- Only *1-2% of cells in the pancreas produce insulin*, which targets the liver and muscle cells.
- Parathyroid gland has about 10 million cells that secrete the parathyroid hormone.
- Adrenal cortex over 5 grams has 4.5 billion cells that secrete cortisol.



- Thyroid hormones keep up metabolic balance throughout the body and Pancreas has a major role in secreting digestive enzymes.

5.84 Effects of Space Travel on Astronaut Health

Recent research published in 2024 reveals the effects on the health of astronauts who participated in SpaceX's Inspiration4 mission (2021), the first all-civilian team to orbit the Earth.

- **Physiological challenges -** High-energy radiation can damage DNA.
- **Increased cancer risk-** High-energy radiation can increase the risk of cancer.
- **Neurodegenerative effects-** Cosmic radiation may increase the risk of developing neurodegenerative diseases such as *Alzheimer's disease and Parkinson's disease.*
- **Gastrointestinal effects -** Without gravity to help move food through your GI tract, the intestinal system can decrease motility.
- **Vision changes -** Without gravity, bodily fluids shift upward, leading to facial swelling and increased intracranial pressure, which can affect vision.

The human body evolved over millions of years to function optimally in the earth's environment, includes its gravity, atmospheric composition and relatively low levels of radiation.

- It can attribute to a condition called *Spaceflight Associated Neuro-Ocular Syndrome (SANS).*
    - Dysfunction in subcellular structures called mitochondria plays a role in SANS.
- **Bone density loss -** The lack of mechanical loading on bones and muscles associated with the leads to bone density loss and muscle atrophy.

Astronauts can lose 1-2% of their bone mass every month they spend in space and up to 10% over a six-month period (on Earth, older men and women lose bone mass at a rate of 0.5%-1% every year).

- **Cardiovascular changes** – The heart and blood vessels struggle to adapt, complicating blood pressure regulation after return.
- **Orthostatic intolerance** - The changed gravity field can cause orthostatic intolerance.
- **Altered heart electrical rhythm -** The changed gravity field can alter heart electrical rhythm.
- **Psychological challenges** - The isolating nature of space travel can have profound effects on the mind.
- Long-duration missions in spaces with *limited natural stimuli* cause sleep disturbances, mood swings, cognitive decline and interpersonal conflicts.
- **Post-mission recovery** – Astronauts will *undergo physical rehabilitation* to help them regain strength, balance and coordination after returning from space.
- **Research needed areas -** While it is known that space radiation elevates cancer risk, accelerates aging and induces cellular damage, the precise biological mechanisms of following remain unclear.
    - Limited data on lung function in space
    - Role of Mitochondria in cellular energy production and repair.
    - Effects on long-term brain function and neuroplasticity unclear.
    - Reproduction in Space embryonic development and multi-generational effects on human in space unknown.
    - Critical gap for space colonization, a potential topic in geopolitics and future human survival.

5.85 Liquid Nitrogen in Food Products

The Tamil Nadu government issued an advisory banning the use of liquid nitrogen in food and warned of stringent action against violators.

- **Liquid Nitrogen** – An *inert, colourless, odourless cryogenic fluid* that has a very low ***boiling point of -196°C***, and is present as a *gas at room temperatures*.
- **Produced by** – Fractional distillation of liquid air.
- **Usage in food products** – To preserve food or to give a Smokey effect to foods.

***Dragon's breath** is a cereal puff infused with liquid nitrogen that produces smoke-like vapour from the nose and mouth after it is eaten.*

- **Preservation principle** – Since nitrogen's *volume expands 700-times* when it evaporates, it *displaces the oxygen* in the food pack, *preventing microbial action* and preserving the freshness.
- The technique was useful in packing coffee, potato crisps, peanuts and peanut butter, milk products, cheese, and dried potatoes.

- **Concerns** – Using liquid nitrogen at the point of sale poses a risk of accidental exposure to consumers.
- **Health Impacts** - Accidental contact exposure can cause *cryogenic burns or frostbite*.
- It can damage the lips, tongue, throat, lungs, and stomach.
- In the lungs, it could *produce CO_2* and the person could become unconscious.
- It could even prove fatal.
- **Government measures** – In 2017, Union Environment Ministry said that, it would investigate the addition of liquid nitrogen in food and drinks served in some restaurants.
- In 2024 The Tamil Nadu Food Safety Department issued a circular the substance can only be used to preserve packaged food.
    - It should be fully evaporated from the food or drinks before serving.
    - It also warned of stringent action, including fine and legal proceedings, if it is used for other purposes.

Cryotherapy – Liquid nitrogen in cancer care

- **Treatment** – It has been used in the management of many *benign pre-cancers and cancers* wherein conventional surgery is not possible or can be used as an adjunct to conventional surgery.
- **Applicability** – In many cancers, including those of skin, bone, breast, cervical, eye, kidney, liver, lung, and prostate.
- **Working principle** – It is used to *freeze and destroy cancer cells* due to formation of intracellular ice crystals, which will eventually swell, blister, and crust out.
- It is also used to *obtain biopsies from cancer tissues* for molecular analysis and as *cryo-adhesion to remove foreign bodies*.

5.86 The Dietary Guidelines for Indians

Indian Council of Medical Research (ICMR) released 17 dietary guidelines to meet the requirements of essential nutrients and prevent non-communicable diseases (NCDs) such as obesity and diabetes.

- **Issued by** - ***National Institute of Nutrition (NIN), Hyderabad***, which works under the Indian Council of Medical Research (ICMR).
- The guidelines has been drafted by a multi-disciplinary committee of experts led by *Dr Hemalatha R* (Director of ICMR-NIN).
- ***17 guidelines*** have been listed in the DGI.
- **Balanced diet** - A balanced diet should provide not more than 45% calories from cereals and millets and up to 15% of calories from pulses, beans and meat.
- Rest of the calories should come from nuts, vegetables, fruits and milk.

YOUNG & UNHEALTHY

	1-4 yrs	5-9 yrs	10-19 yrs
DISEASES OF OVERNUTRITION (%)			
Overweight		3.7	4.9
Obesity		1.3	1.1
Pre-diabetes		10.3	10.4
Diabetes		1.2	0.6
Hypertension			4.9
High total cholesterol		3.2	3.7
DISEASES OF UNDERNUTRITION (%)			
Anaemia	40.6	23.5	28.4
MICRONUTRIENT DEFICIENCIES (%)			
Iron	32.1	17.0	21.5
Vitamin D	13.7	18.2	23.9
Vitamin A	17.5	21.5	15.6
Vitamin B12	13.8	17.2	30.9
Zinc	19.0	16.8	31.7

Source: ICMR-National Institute of Nutrition Report on Dietary Guidelines for Indians

Disease burden in India

- Estimates show that 56.4% of the total disease burden in India is due to unhealthy diets.
- Healthy diets and physical activity can reduce a substantial proportion of coronary heart disease (CHD) and hypertension (HTN) and prevent up to 80% of type 2 diabetes.

5.87 Codex Committee on Nutrition and Foods for Special Dietary Uses (CCNFSDU)

India Participates in 44th Session of Codex Committee on Nutrition and Foods for Special Dietary Uses.

- **Codex Alimentarius** - It is the international food standards, guidelines and codes of practice for the safety, quality and fairness in international food trade.
- **Established in -** 1963
- **Functions of CCNFSDU -** To study specific nutritional problems assigned to it by the Commission and advise the Commission on general nutrition issues.
- To draft general provisions, as appropriate, concerning the nutritional aspects of all foods.
- To develop standards, guidelines or related texts for foods for special dietary uses, in cooperation with other committees where necessary.
- Endorse provisions on nutritional aspects proposed for inclusion Codex standards, guidelines and related text.
- **India's Representatives** - Food Safety and Standards Authority of India, the Ministry of Health and Family Welfare, and the Ministry of Women and Child Development
- **Matters Discussed** - Various food safety, consumer health, and trade-related issues.
- **India's Contribution** – It provided valuable insights on nutrient reference values for persons aged 6 to 36 months.
- India disagreed with the EU's proposal for sensory testing on assessing the relative sweetness of carbohydrate sources.
- **India's Demand** - Update Probiotic Guidelines for foods and food supplements and Nutrient Standards.
- During the adoption of the final report, India's suggestions were officially incorporated, marking a significant contribution to shaping global food safety and nutrition standards.
- **Joint Statement on Healthy Diet Principles** - During the session, FAO/WHO announced plans for a Joint Statement on Healthy Diet Principles.
- **Food and Diet domain** – This new domain was introduced by FAO on its FAOSTAT database.

5.88 India's First Diabetes Biobank

Recently, India sets up its first diabetes biobank.

- **Diabetes Biobank** – It is a ***repository of population-based biological samples.***
- **Aim** – To facilitate advanced research on diabetes, variations of the Indian type and related disorders.
- **Set up by** – It is a joint collaboration of
- Indian Council of Medical Research (ICMR)
- Madras Diabetes Research Foundation (MDRF)
- **Operated at** – ***Madras Diabetes Research Foundation*** (MDRF), Chennai.

> ***Biobanks*** *is a collection of biological samples (such as blood) and health information. It is critical in biomedical research, collecting, processing, storing and distributing biospecimens.*

- **Role** – It is designed to *collect, process, store, and distribute* biological samples to advance diabetes research.
- **Storage** – A plethora of blood samples of different types of diabetes in the young, such as ***Type 1, Type 2 and gestational diabetes***, have been stored for future studies and research.
- **Diabetes** – A *chronic metabolic disease* occurs when the blood glucose, also called Blood Sugar, is too high.
- **Symptoms** – Feeling very thirsty, Need to urinate more often than usual, Blurred vision, Feeling tired, Losing weight unintentionally.

Type 1 diabetes (Juvenile diabetes)	Type 2 diabetes	Gestational diabetes
It occurs in in *children* and young adults. (Insulin-dependent diabetes)	It occurs at *any age*, even during childhood.	It occurs *during pregnancy*.
The immune system attacks and *destroys the pancreas cells* that make insulin.	The pancreas *isn't making enough insulin* to keep the blood glucose level in the normal range.	It is hyperglycaemia with blood glucose values above normal but below those diagnostics of diabetes.

6. BIOTECHNOLOGY

6.1 Microbial Biosurfactants

Recent research has analyzed the potential of biosurfactants in the food industry.

- **Biosurfactants**-These are ***surface-active substances*** produced by microorganisms.
- This serves as a *healthier substitute for synthetic surfactants*in the food industry.
- They are produced using ***green substrates*** from agro-industrial waste.

> ***Surface active agents (SAAs)*** *are molecules with the capacity to adsorb to solid surfaces and/or fluid interfaces, a property that allows them to act as multifunctional ingredients.*

Types of Biosurfactants	
Glycolipids	Include rhamnolipids, sophorolipids, and trehalolipids, commonly used for their emulsifying properties.
Lipopeptides	Such as surfactin and iturin, known for their strong surface activity and antimicrobial properties.
Phospholipids and Fatty Acids	Derived from microbial sources, useful in food and cosmetic industries.
Polymeric Biosurfactants	Including emulsan and liposan, these are effective in stabilizing emulsions

- **Finding** - The study on biosurfactants in the food industry highlights the need for more research on their ***toxicity, dose effects, and interactions*** with other food components to secure regulatory approvals.
- The Cost-effective biosurfactants derived from agro-industrial waste offer a sustainable and healthier alternative to synthetic surfactants in the food industry.
- **Technological Advancements-** The study explores the use of genetic engineering, recombinant DNA technologies, and nanotechnology to enhance biosurfactant production.
- It also calls for collaboration between researchers and industrialists to improve production techniques and expand the market for biosurfactants.
- They help emulsify fats, improve shelf life, act as dispersing agents, and retain moisture, used to remove heavy metals from vegetables, boost immunity in fish, and serve as natural antioxidants.
- **Health and Environmental Benefits-** Unlike synthetic surfactants, biosurfactants are ***eco-friendly, non-toxic***, and safe for human consumption.
- They do not cause adverse effects like imbalances in the gut microbiome or intestinal disorders.

6.2 RNA interference

Researchers found that the worm 'Caenorhabditis elegans' develops food habits which are inherited to their offspring spanning few generations.

- **RNA interference** – It is a simple and rapid method of *silencing gene expression* in a range of organisms *by RNA molecules* by neutralizing the targeted mRNA molecules.
- It is also called as *Post-Transcriptional Gene Silencing* (PTGS).
- It is a conserved biological response to double-stranded RNA that mediates resistance to both endogenous parasitic and exogenous pathogenic nucleic acids.
- **Mechanism** – An enzyme called 'Dicer' cut the long double-stranded RNA into small fragments that are known as ***siRNA*** or *small interfering RNA*.
- These siRNA *bind to other proteins and RNAs*, and either *enhance or reduce the expression* of other genes.
    - ***For instance:*** When the roundworm Caenorhabditis injects the bacterium Pseudomonas vranovensis, it also takes up a *siRNA from the bacterium*.

- This siRNA then *alters the worm's feeding behaviour* such that, from that point on, the worms 'know' to avoid feeding on this bacterium and save themselves from getting sick.

- **Applications** – They are used to target cancer-related genes, controlling neurodegerative disease and in antiviral treatments.
- In food industry, it can help to lower natural plants toxins by genetic engineering.

RNA - Ribonucleic acid

- It is a nucleic acid present in all living cells that has structural similarities to DNA (Deoxyribonucleic acid).
- **RNA molecule** – It can *either single or double stranded* but most often single-stranded, has a backbone made of *alternating phosphate groups and the sugar ribose*.
- Each sugar is attached to one of 4 bases: adenine (A), uracil (U), cytosine (C) or guanine (G).
- **Types** – Messenger RNA (mRNA), ribosomal RNA (rRNA) and transfer RNA (tRNA).
- **Relation with DNA** – A *gene* is a segment of a few thousand base-pairs of the DNA molecule and every gene is instructions that tell a cell how to make a protein.
- mRNA copies the sequence of As, Ts, Cs, and Gs in a gene in the DNA into the sequence of Us, As, Gs, and Cs in their RNA.
- It moves to structures called ribosomes, where the cell assembles the corresponding protein.

Caenorhabditis elegans

- It is a roundworm, often called as 'the worm' because of its widespread use in research to understand neuronal and molecular biology.
- It was the 1st multicellular organism to have its full genome sequenced and neural wiring mapped.
- In fact, discoveries based on studying C. elegans were recognised by Nobel Prizes in 2002, 2006, and 2008.

6.3 Trichoderma asperellum

Punjab Agricultural University has developed a biocontrol agent Trichoderma asperellum to manage 'foot rot' disease, in Basmati rice crops.

- **Biocontrol agent**- Ludhiana Punjab Agricultural University has developed Trichoderma asperellum and registered it with the Central Insecticides Board and Registration Committee (CIBRC).
- **Purpose**- To manage *foot rot disease* in Basmati rice crops.
- **Foot rot disease**- It is caused by *Fusarium verticillioides*, a soil-seed borne pathogen which spreads the infection through the root of the plant, and eventually leads to the colonisation of the stem base.
- **Occurrence**- It affects basmati rice at the seedling stage and can lead to crop rejection. The infected seedlings first turn pale yellow, then elongate and dry up, and eventually (usually) die.
- **Eco-friendly**- The new agent offers a *non-chemical alternative* to pesticides, reducing environmental harm and avoiding toxic residues.
- **Trichoderma asperellum**- It is a *species of fungus* that belongs to the genus Trichoderma, which is well-known for its biocontrol properties against plant pathogens.
- **ACCD enzyme-** *ACC deaminase enzyme* produced by Trichoderma asperellum influences plant defense mechanisms and development.

Central Insecticides Board and Registration Committee

- **About**-It is an Indian regulatory authority responsible for the registration and regulation of insecticides in the country.
- **Admintration-** Ministry of Agriculture and Farmers Welfare, Government of India.
- **Governance**- Insecticide Act, 1968
- **Objective-** To ensure the safety and efficacy of insecticides used in agriculture, public health, and other sectors, while also promoting the sustainable use of these chemicals.

6.4 SafeEXO-Cas

Recently, Columbia University Dental researchers unveiled "safeEXO-Cas," an exosome-based platform.

- **Objective-** The platform will boost **CRISPR/Cas9** delivery for *precise genome editing.*
- Researchers demonstrated that safeEXO-Cas effectively delivers CRISPR/Cas9 components, including *single guide RNA and single-stranded DNA templates.*
- This platform holds promise for on-demand in *vitro and in vivo gene editing.*

Currently, more than 27,000 tracked pieces of space debris orbit Earth at speeds of approximately 15,700 mph in low Earth orbit.

CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats)

- **About-** CRISPR/Cas9 (Clustered Regularly Interspaced Short Palindromic Repeats) is a unique technology to edit parts of the genome by removing, adding or altering sections of the DNA sequence.
- It is currently the simplest, most versatile and precise method of genetic manipulation.
- **Discovery-** CRISPRs were first discovered in archaea (and later in bacteria) by Francisco Mojica.
- **Working-** The CRISPR-Cas9 system includes:
- Cas9- An enzyme acting as molecular scissors, precisely cutting DNA strands at a specific location.
- Guide RNA (gRNA)- Comprising a short pre-designed RNA sequence within a longer RNA scaffold.
- **Applications-** It holds great potential for treating genetic medical conditions like cancer, hepatitis B, or high cholesterol.

6.5 Recombinant Proteins

Researchers have developed an innovative method for the mass production of recombinant proteins.

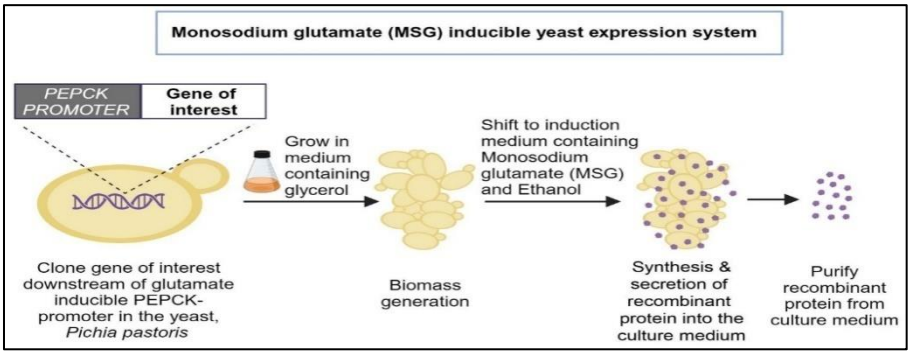
- **Recombinant proteins** – They are ***foreign proteins*** produced in expression hosts by introducing specific genes into host organisms.
    - **Examples** – Enzymes, hormones, cytokines, growth factors, blood clotting factors, monoclonal antibodies (mAbs), vaccines and antibody-related products.

***Proteins** are large, complex molecules made up of long chains of amino acids that perform many critical functions in organisms.*

- **Usage** – In *therapeutics, diagnostics, drug discovery* as well as vaccine development and production.
- **Production** – It is done by cultivating genetically modified *bacterial, viral, or mammalian cells* in large bioreactors.
    - **Example:** Yeast Pichia pastoris (Komagataella phaffii)
- **Methanol-induced process** – The gene coding for that recombinant protein is spliced into the yeast genome and the yeast cells are then *fed glycerol or glucose* as the carbon source.

***Alcohol oxidase (AOX)** is an enzyme that metabolises methanol.*

- Once enough cells have formed, *methanol is added*, which *activates the AOX promoter*, and the cells start *producing the recombinant protein*.
- **Challenges in using methanol** – It is highly flammable and hazardous, requiring stringent safety precautions.
- It is also metabolized to form hydrogen peroxide which can induce oxidative stress in the yeast cells or damage the recombinant proteins.
- **New process** – It relies on a



common *food additive called monosodium glutamate* (MSG).

- It can activate a different promoter in the yeast genome which led to protein production similar to methanol induced process.
- **Significance –** MSG induced process offers a novel expression system for mass-producing valuable proteins, including those found in milk, eggs, baby food supplements, nutraceuticals, and therapeutics.

6.6 Cross-species Transmission

Researchers find genetically altered Nidoviruses may trigger the next pandemic.

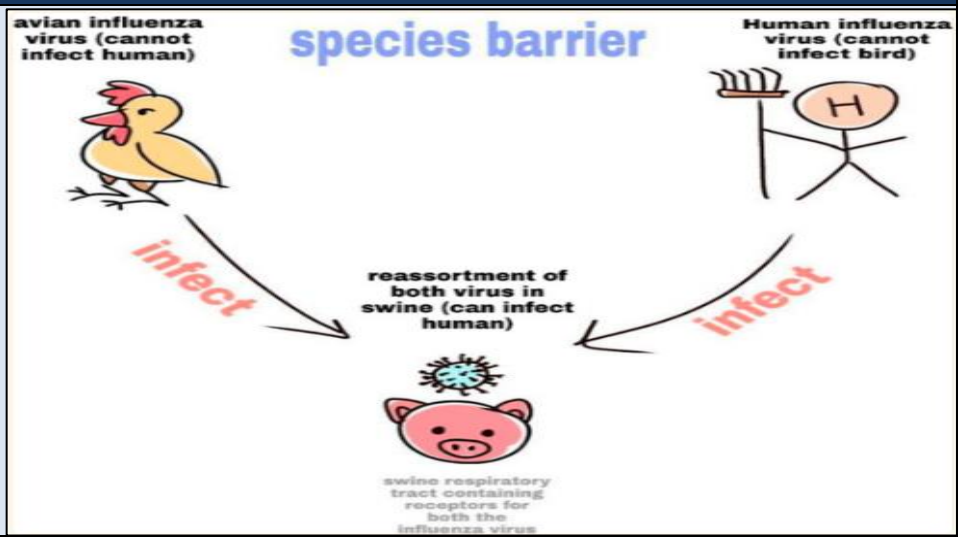
- **Cross-species Transmission** – Crossbreeding *between different viruses* may lead to the emergence of a ***completely new, altered virus*** with potentially more threatening characteristics.
- **Crossbreeding in Nidoviruses** – The discovered *nidoviruses in fish* frequently *exchanged genetic material* between different virus species, even across family boundaries.

> ***Nidoviruses*** *are RNA viruses that infect a broad range of animals including terrestrial and marine mammals, fish, birds, reptiles, insects, crustaceans, mollusks, and helminths.*

- **Susceptible populations** – Such natural crossbreeding processes among viruses may *easily take place in bats* that are known to carry a large number of viruses inside their bodies.
- **Concerns** – This natural evolution of viruses occurs as different virus species *create new pathogens inside vertebrates*.
- Such viruses may even *trigger another COVID-19-like pandemic*.

1918 Flu Pandemic - Cross-species transmission

- It is said to have originated in a farm where a bird with the flu virus and a human with another flu virus came in contact with a pig.
- The virus in the bird couldn't affect humans and vice versa however, they both could infect the pig.
- Inside the cells of the pig host, the *2 flu viruses through re-assortment*, form a *new strain of H1N1 (avian origin)* which was able to infect humans.



6.7 Polyatomic ion

Recently, researchers have discovered a new method to utilize carbon dioxide (CO_2) in ambient conditions, unlike the previously harsh thermal conditions.

- **Conversion of Amines to N-Formamides Using CO_2**- The transformation of amines to N-formamides is essential for synthesizing heterocycles, pharmaceuticals, and bio-active compounds.
- **Polyoxometalates (POMs)**- These are synthesized nanomaterials composed of three or more transition metals linked by shared oxygen atoms.
- These compounds are promising candidates for improving the photocatalytic conversion of CO_2 due to their unique properties:
    - POMs provide high-efficiency catalytic sites that enhance reaction rates.
    - They exhibit extraordinary thermal stability, making them suitable for various reactions.

- POMs have excellent redox abilities and properties like semiconductors, crucial for photocatalysis.
- The light absorption properties of POMs can be finely tuned by incorporating different transition metals, enhancing their photocatalytic efficiency.

- **Recent Advancements** - They have explored 2 novel Keggin POM-based solids.
- Among these, PS-97 was found to be highly efficient for the photocatalytic N-formylation of various substituted anilines and morpholine with CO_2 using phenyl silane as a reducing agent.
- Notably, this reaction operates under ambient conditions.

6.8 SRY Gene (sex-determining region Y)

Exceptional instances of females possessing the SRY gene have been reported three times in the medical literature, two in 2024 itself.

- **Role** – The SRY gene, *located on the Y chromosome*, is the primary determinant of maleness.
- Provides instructions for making a protein called the sex-determining region Y protein.
- Its presence typically *leads to the development of male characteristics*, while its absence leads to female development.
- **Typical Sex Determination** – Eggs carry an X chromosome, while sperm carry either an X or a Y.
- XX combinations result in females, and XY combinations result in males.
- **SRY Translocations** – Rarely, the SRY gene can move from the Y chromosome to an X chromosome (a translocation).
- **Sterile male** – If this X chromosome fertilizes an egg, the resulting XX individual usually develops as a sterile male, a man who is unable to reproduce due to a lack of sperm or other reproductive issues.
- **Exceptional Females with SRY** – Cases of fertile females with the SRY gene on an X chromosome are exceptional cases.
- **Key to Female Development in These Cases** – The key difference in these exceptional females lies in a specific *deletion on the X chromosome carrying the SRY gene*.
- This deletion results in the inactivation of the translocated X chromosome during female development.
- This "biased" inactivation silences the SRY gene, allowing female development to proceed.
- If the other X chromosome were inactivated, the individual wouldn't survive because the deleted genes are essential for life.
- **Significance** – These cases reinforce the SRY gene's importance in male development.
- Only when it is silenced (through biased X-inactivation due to the deletion) can female development occur even with the SRY gene present.
- **Further Research** – The article suggests the need for more research to understand the long-term effects of SRY translocations, even when they result in female development.
- It also highlights the potential value of screening for such translocations in the future.

6.9 Genome editing

The Kerala University of Fisheries and Ocean Studies (Kufos) is set to launch a genome editing mission.

- It is a method for making specific changes to the ***Deoxyribonucleic acid (DNA) of a cell or organism.***
- It can be used to ***add, remove or alter*** DNA in the genome.
- Human genome editing technologies can be used on ***somatic cells, germline cells and germline cells.***
- **Usage of Genome editing**
  - **Research-** Genome editing can be used to change the DNA in cells or organisms to *understand their biology* and how they work.
  - **Disease treatment-** Genome editing has been used to modify *human blood cells* that can be put back into the body to treat conditions including blood cancers and AIDS.

- **Biotechnology-** Genome editing has been used to *modify agricultural crops to improve their yields* and resistance to disease and drought.

Pearl spot production mission

- **Objective of the mission -** It will help enhance breeding and seed production of ***pearl spots.***
- **Significance-** Genome editing will target the genetic makeup of the fish ***to promote faster growth.***
- It will also enhance the breeding and seed production of pearl spots.

Pearl spot

- It is an indigenous fish extensively found along the east and south-west coasts of Peninsular India.
- **Scientific name-** Etroplus suratensis.
- **Common name-** "Karimeen" in Kerala.
- **Habitat-** It is an important candidate species for aquaculture in ponds in both brackish water and freshwater environments.
- **Distribution –** Kerala, Goa, Odisha in India and Srilanka.
- **Harvest-** Despite slow growth, high stocking density allows table-size pearl spot to be harvested within 9-12 months.
- **Conservation Status – IUCN –** Least Concern.

6.10 Mineral Nanoparticles

Recently, IIT-Madras team makes mineral nanoparticles with water.

- Water droplets are ***ubiquitous*** in our environment which exist in various sizes from large raindrops to minute aerosol particles.
- Among these, ***microdroplets***, which are a thousandth the size of typical raindrops, display unique properties and behaviors.
- Microdroplets, due to their ***confined space and close-packed molecules***, engage in chemical reactions more eagerly and up to a ***million times faster than bulk water***.
- Microdroplets at the beach can ***carry ions from seawater***, settling on skin.
- As larger droplets evaporate and shrink, remaining water molecules bond closer, potentially leading to the formation of *negatively charged hydroxyl ions (OH-) and free protons (H+)*.
- **Research Findings** - The team conducted an experiment using *quartz, ruby, and fused alumina crystals*.
- Applying a ***high voltage*** to mineral microparticles in water, they observed the particles breaking into nanoparticles within milliseconds.
- Free protons might infiltrate crystal layers and break them apart.
- Surface tension and electric fields could contribute to ***creating shockwaves*** that fragment the microdroplets.
- **Implications of the Study** -The study's findings could aid research on proto-cells, potential precursors to modern cells, providing insights into the origins of life.
- Silica nanoparticles, essential for plant growth, can be supplied to soil, improving agricultural productivity.
- This method could ***transform unproductive soils*** and desertified areas into fertile lands.

Nanoparticles

- **Nanoparticles** - They are tiny particles that measure between ***1 and 100 nanometers in size***.
- A nanometer is ***one-billionth of a meter***, making nanoparticles incredibly small, often comparable in size to atoms and molecules.

- **Property** - Due to their small size, nanoparticles have a ***large surface area relative to their volume***.
- This enhances their ***chemical reactivity and physical properties***.
- **Applications** - Medicine, Electronics, Energy, Environmental, Materials Science.

6.11 Bimetallic NiFe systems

A new study claims that a bimetallic Nickel-Iron layered double hydroxide system is the most efficient for oxygen production through water splitting.

- **Research by -** The Institute of Advanced Study in Science and Technology (IASST), under Department of Science and Technology (DST)
- **Finding-** A bimetallic Nickel-Iron layered double hydroxide system *efficiently produces O2 through water splitting*.
- It eliminates the need for trimetallic solutions to enhance productivity.
- To improve water splitting efficiency, scientists have focused on 2 key reactions i.e.
    - The hydrogen evolution reaction (HER) and
    - The oxygen evolution reaction (OER).

> ***Water splitting*** *is a sustainable and eco-friendly method to generate green and pure H2 and O2 on a large scale without harming flora and fauna.*

- **Composition -** NiFe systems combine nickel (Ni) and iron (Fe) at the molecular level.
- They are structured with ***positively charged*** metal hydroxide layers separated by anions and water molecules.
- This structure provides a high surface area and favorable catalytic sites.
- **Advantages-** The combination of Ni and Fe improves ***catalytic activity*** and stability.
- They are highly efficient catalysts for the OER, a crucial step in water splitting.
- They are made from abundant and inexpensive metals, making them a *cost-effective alternative* to precious metal catalysts like platinum and iridium.
- **Applications-** They are extensively used in electrochemical cells for splitting water into hydrogen and oxygen.
- They also explored applications in batteries, supercapacitors, and other energy storage and conversion devices due to their excellent electrochemical properties.

6.12 Kindlins

A recent study of Kindlins has uncovered significant and novel pathways to cancer treatment.

- They are a ***family of proteins*** that play crucial roles in cellular processes, particularly *cell adhesion, migration, and signaling.*
- There are 3 members in the Kindlin family - Kindlin-1, Kindlin-2, and Kindlin-3.

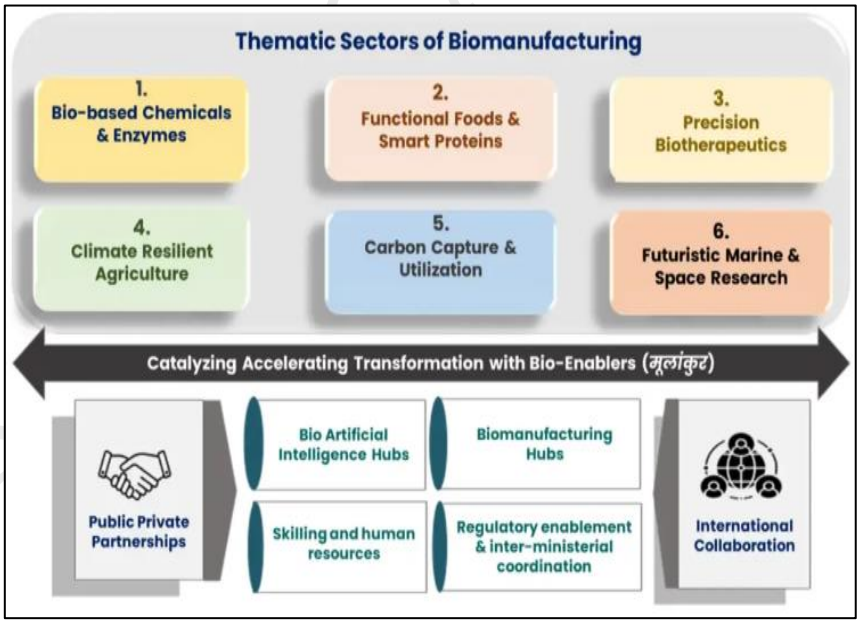
Kindlin family	
Kindlin-1	• It is primarily expressed in epithelial cells. • **Function-** It is involved in the regulation of integrin activation, which is essential for cell adhesion, migration, and wound healing. • **Clinical Relevance-** Mutations in the respective gene are associated with ***Kindler syndrome***, a rare genetic disorder characterized by skin fragility, blistering, and progressive skin atrophy.
Kindlin-2	• It is ubiquitously expressed, plays a role in integrin-mediated cell adhesion and signaling. • **Function**- It is involved in various cellular processes, including cell spreading, migration,

	and survival. • **Clinical Relevance-** Kindlin-2 is implicated in several diseases, including cancer, where it can influence ***tumor cell adhesion***, migration, and invasion.
Kindlin-3	• It is predominantly expressed in hematopoietic cells (blood cells). • **Function**- It is crucial for the activation of integrins in these cells, impacting processes like leukocyte adhesion and platelet aggregation. • **Clinical Relevance-** Mutations in the gene lead to a condition known as ***leukocyte adhesion deficiency type III (LAD-III)***, which results in severe immunodeficiency due to the inability of leukocytes to adhere and migrate properly.

- **Functions-** Kindlins interact with the cytoplasmic tails of integrins, helping to activate them and promote their binding to ECM proteins.
- It influences cell adhesion to the ECM and subsequent cell migration, which is critical in processes like wound healing and immune responses.
- It participates in ***signaling pathways*** that regulate cell survival, proliferation, and differentiation.

6.13 India's BioE3 Policy

- It focuses on driving ***innovation in biotechnology***, with a key area being precision therapeutics.
- **BioE3** - Biotechnology for Economy, Environment and Employment.
- **Ministry -** Ministry of Science & Technology.
- **Aim –** To foster High Performance Biomanufacturing, which is the ability to
  - Produce products from medicine to materials,
  - Address farming and food challenges, and
  - Promote manufacturing of bio-based products through integration of advanced biotechnological processes.



- **Significance** – It supports innovation-driven support to R&D and entrepreneurship across thematic sectors.
- It will accelerate technology development and commercialization by establishing Biomanufacturing & Bio-AI hubs and Biofoundry.

6.14 Bio-RIDE Scheme

The Union Cabinet approved the Biotechnology Research Innovation and Entrepreneurship Development (Bio-RIDE) scheme to support cutting-edge research and development in biotechnology.

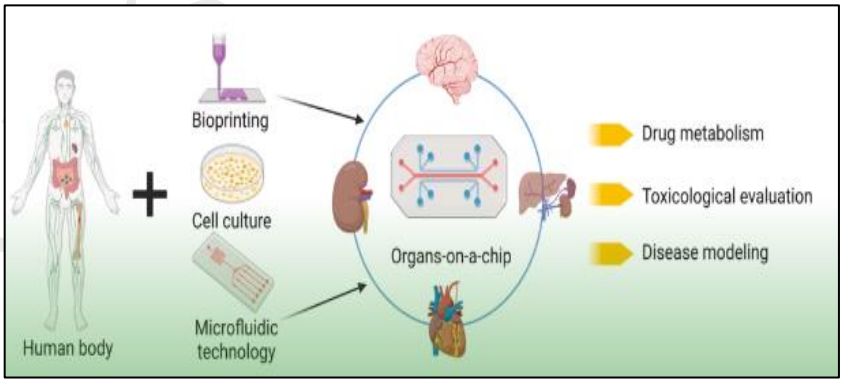
- The 2 umbrella schemes of Department of Biotechnology (DBT)
  - Biotechnology Research and Development (R&D) and
  - Industrial and Entrepreneurship Development (I&ED) merged as one scheme-'Biotechnology Research Innovation and Entrepreneurship Development (Bio- RIDE)'.
- **Aim -** To accelerate research, enhance product development, and bridge the gap between academic research and industrial applications.
- To foster innovation, promote bio-entrepreneurship, and strengthen India's position as a global leader in biomanufacturing and biotechnology.

- **Components**
  - Biotechnology Research and Development (R&D).
  - Industrial & Entrepreneurship Development (I&ED).
  - Biomanufacturing and Bio foundry (a new component).
- **Implementation –** During the 15th Finance Commission period (2021-2026).
- **Significance** - Promote Bio-Entrepreneurshipthrough Seed funding, incubation, and mentorship for startups.
- Grants and incentives for cutting-edge research in areas like synthetic biology, biopharmaceuticals, bioenergy, and bioplastics.
- Strengthen partnerships between academic institutions, research organizations, and industry to commercialize biotech products.
- Focus on environmentally sustainable practices aligned with India's green goals.
- Extramural funding for researchers in biotechnology fields like agriculture, healthcare, and environmental sustainability.
- Develop skilled manpower through holistic support and capacity building in biotechnology.

6.15 Organ-on-Chip Technology

Recent advancements in human-relevant 3D culture models have shown promising results in the field of precision therapeutics include organ-on-chips could boost BioE3 goal to personalise medicine.

- **Organ-on-chip-** A technology designed to ***mimic the dynamic functions of human organs*** in a controlled environment, offering a more accurate platform for drug testing.
- It works by integrating cells derived from a human body with a well-defined in-vitro biological environment (i.e. in the lab) that mimics the body's conditions.
- It offers a more reliable method for testing drugs, providing better insights into a drug's efficacy and toxicity in human-relevant models.
- It provides a solution to the limitations of animal testing in drug development.
- It offers potential for personalized medicine by enabling precise testing of drugs on human-derived cells.



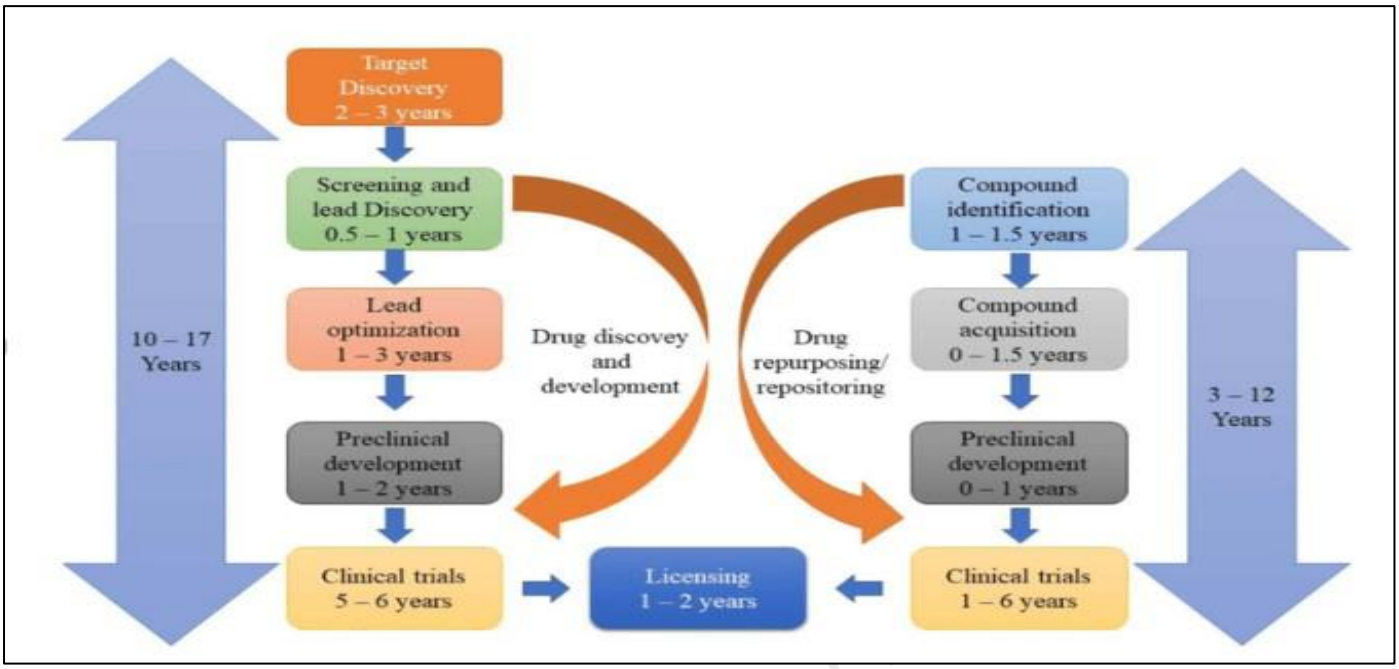
- **Usage -** The U.S. FDA Modernisation Act 2.0 allows the use of organ-on-chips as alternatives in preclinical drug testing.
- The EU is working on phasing out animal testing for cosmetics and developing regulations for NAMs, including organ-on-chips.
- **India -** India amends the New Drugs and Clinical Trials Rules, 2019 to permit the use of human organs-on-chips and other NAMs prior to and in conjunction with animal testing when evaluating new drugs.

6.16 Drug Repurposing

Researchers at the Institute of Advanced Study in Science and Technology (IASST) have found the repurpose potential of an antidepressant drug for cancer management.

- **Drug Repurposing** – It is the technique of using an ***existing drug or drug candidate for a new treatment*** or medical condition for which it was not indicated before.
- It is also known as ***drug repositioning or drug reprofiling***.
- It bypasses the pre-clinical work and *facilitate targeted treatment*.

- **Application** – Pharmaceutical companies are undertaking drug repurposing projects for rare diseases, oncology, infectious and autoimmune diseases and more.
- **Benefits** - *Fasten the drug discovery process* and find quicker solutions.
- Helps in quickly identify compounds with an established safety profile and known therapeutic advantages.
- It is particularly useful where traditional drug development is not cost-effective.



Selegiline Repurpose

- **Selegiline (L-deprenyl)** – It is an antidepressant drug from a class of drugs called monoamine oxidase (MAO) inhibitors.
- Researchers at IASST have found the repurposing potential of it for Cancer treatment.
- **IASST** -Institute of Advanced Study in Science and Technology (IASST) in Guwahati.
    - It is an autonomous institute under the Department of Science & Technology (DST), Govt. of India.
- **Function** - Selegiline interacts with genes intricately linked to various types of cancer.
- Particularly, it can induce cell death in breast cancer cells.

6.17 Global Guidance on Antibiotics Pollution from Manufacturing

Recently WHO released first ever global guidance to tackle antibiotic pollution from manufacturing processes.

- **Guideline** – Guidance on ***wastewater and solid waste management*** for manufacturing of antibiotics.
- **Released by** - World Health Organization (WHO)
- **Aim** - Foster a collective effort to mitigate the environmental impact of antibiotic manufacturing.
- **Framework** – It offers a scientific framework for regulators, industry players and other stakeholders to implement effective controls against antibiotic pollution.
- **Comprehensive Approach** - It covers all steps from the manufacturing of active pharmaceutical ingredients (APIs) and formulation into finished products, including primary packaging.
- **Antibiotic pollution control standards** – It provides scientific basis for regulators, procurers, inspectors and industries to include robust antibiotic pollution control in their standards.
- **3 Core elements** – It outlines three core elements and the parties responsible for implementing each one.
    - **Targets** - Defining targets for resistance selection and ecological effects, based on exposure and risk assessments.

- **Risk Management** - Establishing risk management processes to achieve these targets
- It is done by tools such as hazard analysis and critical control points, alongside internal audits and public communications.
- **Audits** - Conducting independent audits to verify that targets are being met.

- **Guiding Principles**
  - Precautionary approach for target setting
  - Progressive improvement towards meeting these targets.

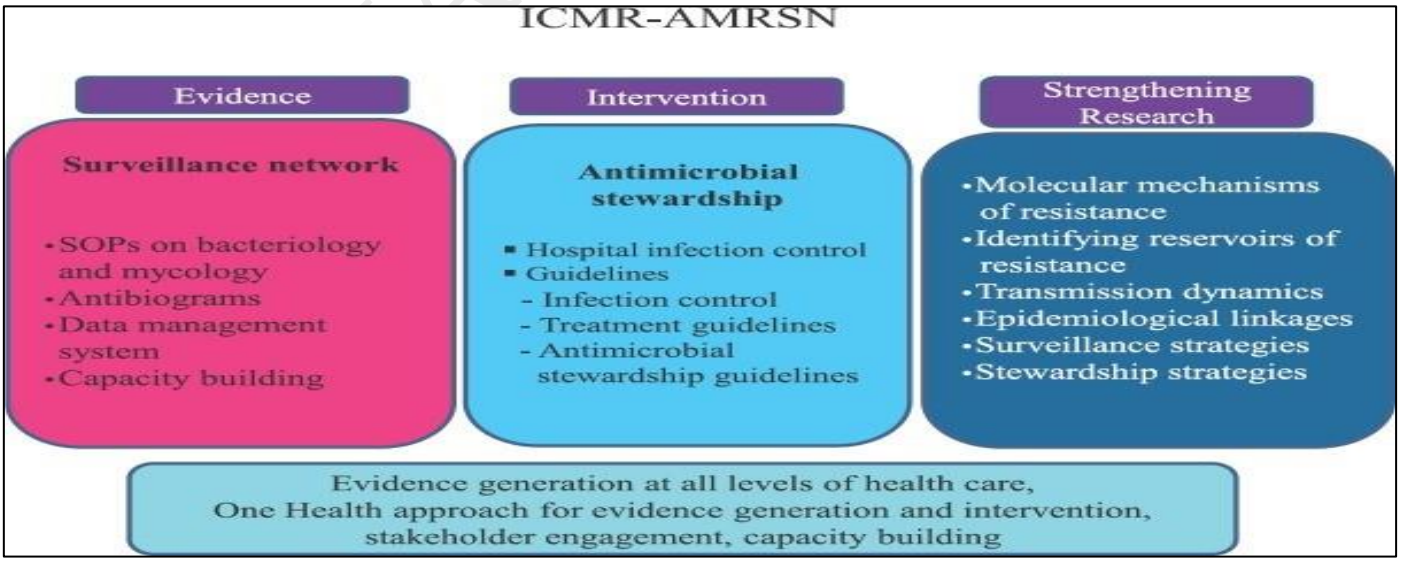
Anti-Microbial Resistance (AMR)

- AMR occurs when bacteria, viruses, fungi, and parasites no longer respond to medicines.
- It makes people sicker and increasing the risk of spread of infections that are difficult to treat, illness and deaths.
- **Causative factors** - AMR is driven largely by the misuse and overuse of antimicrobials.
- The emergence and spread of AMR caused by antibiotic pollution could undermine the effectiveness of antibiotics globally.
- **Antibiotic Pollution** - Pharmaceutical waste from antibiotic manufacturing can facilitate the emergence of new drug-resistant bacteria.
- It includes the medicines produced at the manufacturing sites and the unscientific disposal of them as waste after use.
- High levels of antibiotics in water bodies downstream of manufacturing sites have been widely documented.
- Currently, antibiotic pollution from manufacturing is largely unregulated and quality assurance criteria typically do not address environmental emissions.

6.18 Antimicrobial Resistance Surveillance Network (AMRSN)

The report published by the ICMR's Antimicrobial Resistance Surveillance Network (AMRSN) shows that UTIs, blood stream infections, typhoid and pneumonia show resistance to commonly used antibiotics.

- **Initiated by** – Indian Council of Medical Research (ICMR) in 2013 to collate nationally representative data.
- **Aim –** To understand the molecular mechanisms of bacterial resistance, how bacteria evolve, acquire and transmit antibiotic resistance is vital for forecasting and addressing the problem.



- **Goals –**Establish network of hospitals to monitor trends in the antimicrobial susceptibility profile of clinically important bacteria and fungi limited to human health.
- Include comprehensive molecular studies for identifying the clonality of drug-resistant pathogens and their transmission dynamics.

- Disseminate information on AMR in pathogenic organisms to stakeholders to promote interventions that reduce AMR
- Create data management system for data collection and analysis.
- **Recent findings - A**ntibiotic overuse and misuse are the biggest drivers of AMR.
- The experts brainstormed and identified the following 6 pathogens as focus areas for ICMR-AMRSN
    - Enterobacteriaceae causing sepsis,
    - Gram-negative non-fermenters,
    - Enteric fever pathogens,
    - Diarrhoeagenic bacterial organisms,
    - Gram-positives - staphylococci and Enterococci, and
    - Fungal pathogens (excluded in the WHO priority pathogens)-yeasts (Candida and Cryptococcus spp.) and mycelial fungi (Aspergillus spp. and Zygomycetes spp.).
- Data collected from the network is used to track resistance trends and to better understand mechanisms of resistance in the key priority pathogens using genomics and whole genome sequencing (WGS).
- **Diseases affected by AMR**- Urinary tract infections (UTIs), bloodstream infections, pneumonia, and typhoid are showing resistance to commonly used antibiotics.

6.19 Microalgae

Scientists at the CSIR-Indian Institute of Chemical Technology (IICT) have identified microalgae as a potential protein supplement.

- **About-** Microalgae are ***microscopic, single-celled*** organisms that belong to a diverse group of microorganisms called algae.
- **Size** - It can range from a few micrometers (μm) to a few hundreds of micrometers, they don't have roots or stems.
- **Diversity and Types-**
    - **Green Algae-** Such as Chlorella and Spirulina.
    - **Diatoms-** Have intricate silica shells.
    - **Blue-Green Algae (Cyanobacteria)** - Like Spirulina.
    - **Red Algae**- Used in agar production.
    - **Golden Algae**- Such as Chrysophytes.
- **Photosynthetic Nature -** Algae are mostly photosynthetic in nature. They are also important for carbon sequestration, as they can absorb carbon dioxide from the atmosphere through photosynthesis.
- **Habitat-** Microalgae are found in diverse habitats including freshwater, marine environments, soil, and even ***extreme environments like hot springs and polar regions.***

Chlorella Growth Factor (CGF)

- Scientists at CSIR-IICT have identified Chlorella Growth Factor (CGF), extracted from ***Chlorella sorokiniana microalgae***, as a valuable ingredient for food and feed.
- Chlorella's nucleus contains a unique substance produced during photosynthesis, packed with peptides, amino acids, nucleotides, polysaccharides, vitamins, and minerals.
- CGF, rich in *amino acids and high-quality protein*, shows great potential as an alternative protein source for both humans and animals.

- **Significance -** Microalgae play a crucial role in the ecosystem as they form the base of the food chain, providing nutrients for various organisms.
- They are rich source of proteins, vitamins, minerals, and omega-3 fatty acids.

- ***Spirulina and Chlorella*** are consumed as dietary supplements due to their high nutritional value.

6.20 Combination Therapeutic Implant

Scientists at Institute of Nano Science and Technology (INST) have developed & tested an indigenous intra-operative combination treatment consisting of drug and metal-based nanomedicine.

- **Need** – Surgery and chemotherapy are inevitable in managing solid tumours but *localised tumour reappears*.
- While Nano technological tools can reduce toxicity, there is an issue of the adsorption of host serum proteins over the surface of nanoparticles.
- **Combination therapeutic implant** – It consists of ***metal-based nanomedicine*** reinforced with patient derived blood clotting components.
- **Working principle** – The components are ***stabilized by patient derived serum protein corona*** termed as *Nano-Micro-Sera (NMS).*
- They are reinforced into autologous fibrin to aid in the post-surgical management of locally recurrent tumors.
- **Usage** – The autologous hybrid fibrin glue exhibited superior synergy and outcomes in *suppressing recurrent breast tumors*.
- Thus, it *reduces localised tumour* recurrence post-surgery.
- **Applications** – It can be used to *fabricate a therapeutic kit* that can generate this autologous hybrid implant which might be beneficial to marginalised cancer patients.

> ***Institute of Nano Science and Technology*** *(INST) is an autonomous institute of Department of Science and Technology.*

Protein Corona

- It is a dynamic *multilayer protein structure* on the surface of Nanoparticle, formed by the rapid adsorption and accumulation of various proteins (such as albumin, apolipoprotein, and fibrinogen) after entering the intercellular environment.
- **Importance** – It has been recently established as a *molecular fingerprint of a patient*.
- It can be integrated into the basic design of nanoparticles for a futuristic *personalized treatment strategy*.
- They can be channelized towards generation of *precision nanomedicines and diagnostic tools*.

- **Significance** – It is an affordable methodology for localized post-surgical management.

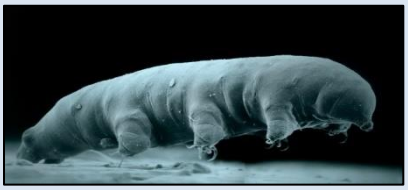
6.21 A Study on Hypsibius henanensis

A team of researchers has recently identified that the genetic mechanisms help a newly discovered species of tardigrades (Hypsibius henanensis) withstand high levels of radiation.

- The scientists discovered 2,*801 genes in Hypsibius henanensis that were involved in DNA repair*.
- They protect the microscopic animals' DNA from damage and repair breaks.
- **Experiment** – They exposed this species to radiation doses of gamma rays that were far beyond what would be survivable for humans.
- More specifically, they found 3 factors that help this species survive radiation.
    - **1st factor** – Its ability to quickly repair double-strand breaks in DNA due to radiation exposure, by using a protein called ***TRID1.***
    - **2nd factor** – It involved a gene that was switched on during exposure to radiation, resulting in the generation of 2 proteins that are known to be important for mitochondrial synthesis.
- The researchers also estimate that 0.5–3.1% of the tardigrade's genes were acquired from other organisms through a process known as ***horizontal gene transfer.***
- A gene that seems to have been acquired from bacteria, enables tardigrades to produce four types of *antioxidant pigments called betalains*.
- These pigments can mop up some of the harmful reactive chemicals that radiation causes to form inside cells, which account for 60–70% of radiation's damaging effects.

- **Applications**
  - Protect astronauts from radiation during space missions,
  - Clean up nuclear pollution or improve cancer treatment,
  - Tolerate other harsh conditions, such as extreme temperatures, air deprivation, dehydration and starvation.
  - Improve the shelf life of fragile substances such as vaccines.

Tardigrades



- **Presence** – They often found lurking in mosses and lichens.
- They live in liquid water, including oceans, freshwater lakes and rivers
- They don't live in or on humans, and they are not dangerous.
- They are also known as water bears or moss piglets.
- **Features** – They are short, plump, and covered in a tough cuticle (similar to that of grasshoppers and other insects) that they must shed to grow.
- They have 4 pairs of legs, with 4-6 claws on each foot.
- Their specialised mouthpart called a ***bucco pharyngeal apparatus*** allows them to suck the nutrients out of plants and other microorganisms.
- Their tiny bodies contain *no bones* and are instead supported by a hydrostatic skeleton a fluid-filled compartment known as a ***hemolymph.***
- They have *no spinal cord* but do have a similar system in place a ventral nervous system.

6.22 RNA editing

A biotechnology company in Massachusetts in the U.S. named Wave Life Sciences made for becoming the first company to treat a genetic condition by editing RNA at the clinical level.

- **Transcription –** It is the process of *making an RNA copy of a gene's DNA sequence*.
- This copy, called ***messenger RNA (mRNA)***, carries the gene's protein information encoded in DNA.
- **Faulty proteins -** During this process, the cell may make mistakes in the mRNA's sequence and based on it produce faulty proteins.
- Many of these proteins have been known to cause debilitating disorders.
- **RNA Editing -** It allows scientists *to fix mistakes in the mRNA* after the cell has synthesized it but before the cell reads it to make the proteins.
- One technique involves a group of enzymes called ***adenosine deaminase acting on RNA (ADAR).***
  - Adenosine is one of the building blocks of RNA.
- ADAR works by converting some of the adenosine blocks in mRNA to another molecule called ***inosine.***
- This is useful because inosine mimics the function of a different RNA building block called guanosine, thus the cell detects mistake and proceeds to correct it, in the process restoring the mRNA's original function.
- And then the cell makes normal proteins.
- Scientists took advantage of ADAR's effects to pair it with a guide RNA (or gRNA), the gRNA guides ADAR to a specific part of the mRNA, where the ADAR works its magic.
- They expect a variety of serious genetic conditions can be treated using such site-specific RNA editing.
- **Recent Finding -** RNA editing is used ***to treat α-1 antitrypsin deficiency (AATD),*** an inherited disorder, in which the levels of the protein α-1 antitrypsin build up and affect the liver and the lungs.
- People with AATD affecting the lungs currently go through weekly intravenous therapy for relief, among people where AATD has affected the liver, a liver transplant is the sole treatment option.

DNA editing	RNA editing

• DNA editing makes permanent changes to a person's genome and sometimes this can lead to irreversible errors.	• RNA editing makes temporary changes, allowing the effects of the edits to fade over time.
• CRISPR-Cas9 and other DNA editing tools require proteins acquired from certain bacteria to perform the cutting function, but these proteins can elicit undesirable immune reactions in some cases.	• RNA editing relies on ADAR enzymes, which already occur in the human body and thus present a lower risk of allergic reactions. • This is useful for people who require repeated treatment and/or who have immune sensitivities.

6.23 Bio-derived Foam

Researchers at the Indian Institute of Science (IISc) in Bengaluru have developed an innovative, eco-friendly bio-derived foam recently.

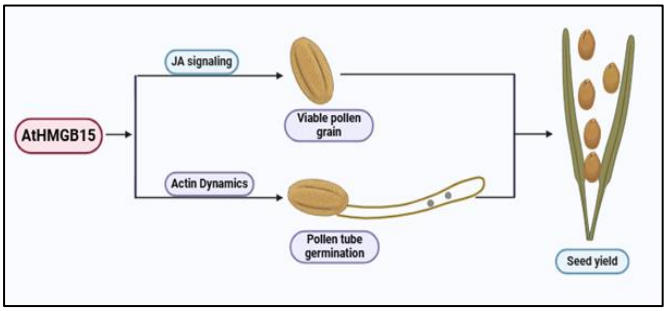
- Production – It is made from bio-based epoxy resins, made from non-edible oils approved by the US Food and Drug Administration (FDA) and hardeners derived from tea leaves.
- It contains chemical bonds that can be broken and reformed in response to external stimuli.
- This allows the material to be mechanically reprocessed or dissolved in eco-friendly solvents within hours.
- Advantages – It disintegrates in landfills ***without contaminating groundwater,*** offering a sustainable alternative to traditional plastic foams.
- It can ***disintegrate within 3 hours*** when exposed to eco-friendly solvents at 80°C.
- **Significance –** It is an alternative to conventional expanded polystyrene (EPS) and polyurethane (PU) foams.
- It offers a sustainable alternative to plastic materials used in traditional Fast-Moving Consumer Goods (FMCG) packaging.

Each year, around 2.3 million tonnes of plastic foam are produced worldwide, but less than 1% of it is recycled.

6.24 Gene HMGB15 – Architect of Pollen and Seed Development

Recently, a novel gene named HMGB15 identified by Bose Institute, Kolkata, an autonomous institution of Department of Science and Technology.

- **HMGB15 –** It is a *non-histone protein* that restructures chromatin.
- It plays a crucial role in the *development of stamens* (male reproductive structure) including *pollen grain and seed formation*, in *Arabidopsis* flowering plants related to cabbage and mustard.
- **Mutation in the gene** – It causes significant disruptions like
  - Partial male sterility in plants
  - Low pollen grain viability
  - Defective pollen wall patterning
  - Retarded pollen tube germination rate
  - Shorter filaments that are unable to reach the stigma
  - Reduced seed production



- The abnormalities in the mutants are due to the disruption in gene regulatory networks important for pollen development, maturation and pollen tube germination.
- **Significance** – Understanding the pollen development process opens up new possibilities for *improving crop fertility and seed production.*

Pollen and Seed Development in Flowering Plants
• It is a very important developmental stage in plant life cycle.

- **Pollen** – It represents the male gametophyte and its role is to deliver the genetic material to the embryo sac.
- **Seed development** – It involves the production & transfer of viable pollen grains to stigma, germination of the pollen grains, growth of the pollen tubes down the style and effective fertilization.
- **Factors determining a healthy pollen –** It depends on *Pollen germination speed and Pollen tube growth that* evolved with the evolution in flowering plants (Angiosperms).
- *Pollen development, Pollen hydration and Pollen germination* responsible for the formation of a mature viable pollen grains.

6.25 AroTrack

The scientists at the Indian Institute of Technology Bombay (IIT Bombay) have introduced a water-pollutant detecting device AroTrack.

- **AroTrack –** It is a portable device ***accurately detect harmful pollutants*** such as phenol, benzene and xylenols in water.
- It is a user-friendly, low-cost bio sensing device.
- **Developed by -** Indian Institute of Technology Bombay (IIT Bombay).
- **Working** - It uses a ***protein-based biosensor*** which typically found in bacteria living in heavily polluted environments to effectively identify multiple aromatic pollutants in water.
- The protein undergoes a highly selective ATP hydrolysis chemical reaction if an aromatic compound is present in the sample.
- This reaction is expressed with a change in the colour of the protein solution, which it can detect.
- **MopR** – It is a ***biosensing module and a sensitive sensor*** for detecting phenol.
- It is both selective and stable and it can *detect pollutants even in complex environments* with a high degree of precision.
- It detects by engineering mutations in the bacterial protein.
- The reaction is measured using a light-emitting diode (LED), phototransistor assembly within the device.
- **Significance -** It can detect several aromatic contaminants, even when these pollutants are present in low concentrations usually in the 10-200 parts per billion range.
- It can operate efficiently in water temperatures up to 50°C and it completes analyses within 30 minutes.
- It is highly reliable, offering a degree of accuracy and efficiency on par with modern spectrophotometers, which are currently used for detection.
- It promises to revolutionise water quality monitoring, particularly in rural and resource-limited areas.

6.26 Bioinspired Hydrogels

Recently, researchers have designed a new type of bioinspired hydrogel that can generate hydrogen and oxygen by splitting water molecules using sunlight.

- **Hydrogels** – They are *soft biomaterials* that can be engineered to mimic many aspects of a tissue structure.
- **Bioinspired hydrogels** – They are *3-dimensional networks* composed of *hydrophobic polymers* synthesized by crosslinking water-soluble polymers.

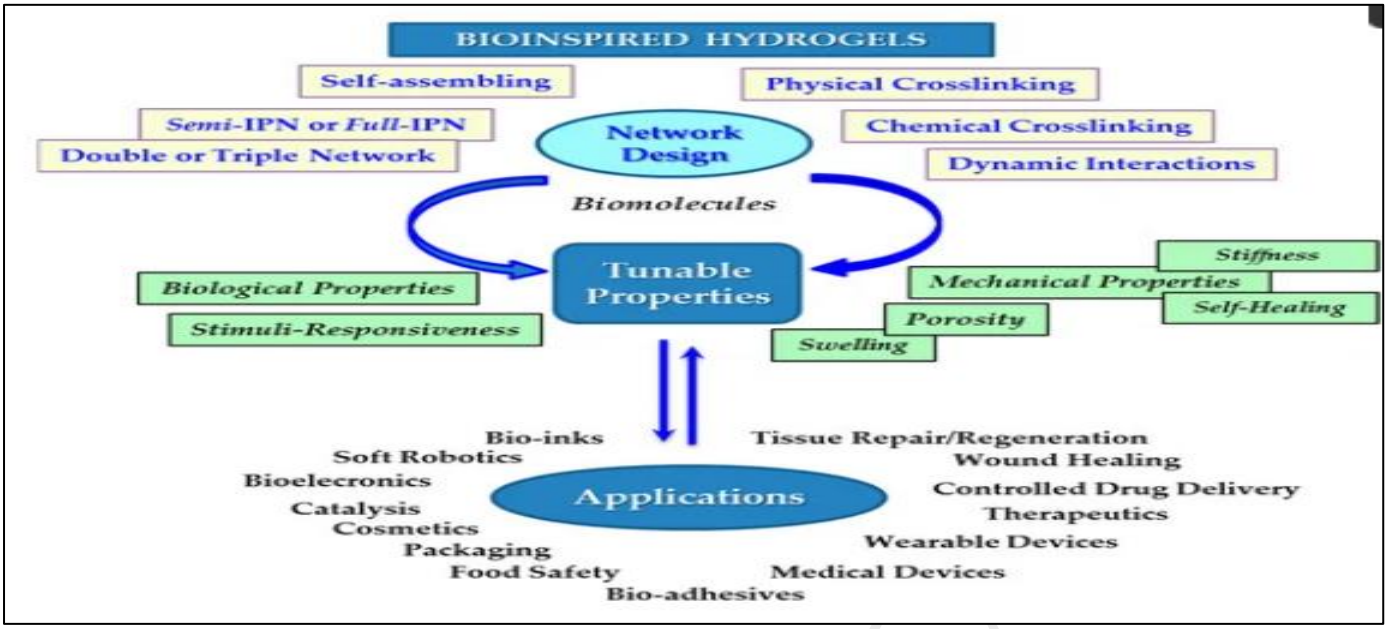
> ***Bioinspired materials*** *are synthetic materials whose structure, properties or function mimic those of natural materials or living matter.*

Bioinspired Hydrogels for Hydrogen Production

- **Working principle** – It mimics nature by using sunlight directly to split water.
- The polymer network prevents the molecules from clumping together and it helps *control the transfer of electrons*, which is crucial for splitting water into hydrogen and oxygen.

> ***Artificial photosynthesis*** *is a process that seeks to replicate nature's method, using sunlight to drive chemical reactions that generate clean energy.*

- **Working** – Functional molecules, such as *ruthenium complexes and platinum nanoparticles* work together to simulate the natural process of photosynthesis.
    - Photocatalytic splitting of water, $2\ H_2O \rightarrow 2\ H_2 + O_2$



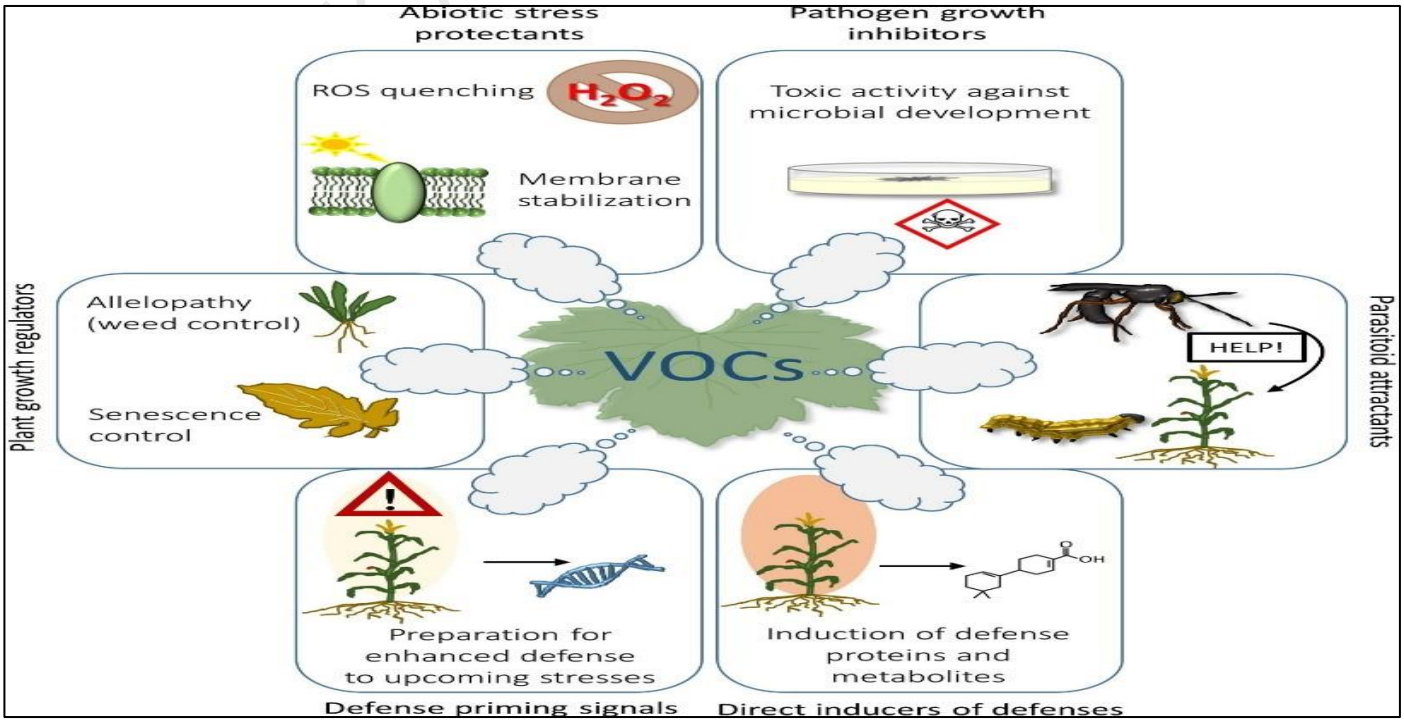
- **Advantages** – They boost the activity of the water-splitting process and *producing more hydrogen*.
- Molecules organized within the hydrogel made the energy conversion process much more efficient.
- **Significance** – It has major implications for clean energy and could help sustainably reshape energy technologies.

6.27 Science of Plant Communication

The Biologists and scientists discovered that plants understand the significance of communication which is better than any other organisms.

- **Plant's communication –** It appear to be the quiet, silent and solitary type of organisms but they have a complex way of communicating.
- They communicate using volatile organic compounds (VOCs), electrical signaling, and common mycorrhizal networks between plants and a host of other organisms.

Volatile organic compounds (VOCs) *are a group of chemicals that can vaporize into air.*



- **Communication via chemical signals -** It release VOCs into the air when in danger, alerting the neighbouring plants to start producing defensive compounds or toxic substances to keep the herbivores away.
- It releases the signals through soil also by when it experience stress by pest attacks or droughts immediately sends out signals to others through their roots.
- **Underground networking** –Extending the plant's root system with fungi's web of filament and this wide network helps the plants to share the nutrients received from fungi to other plants in time of distress.

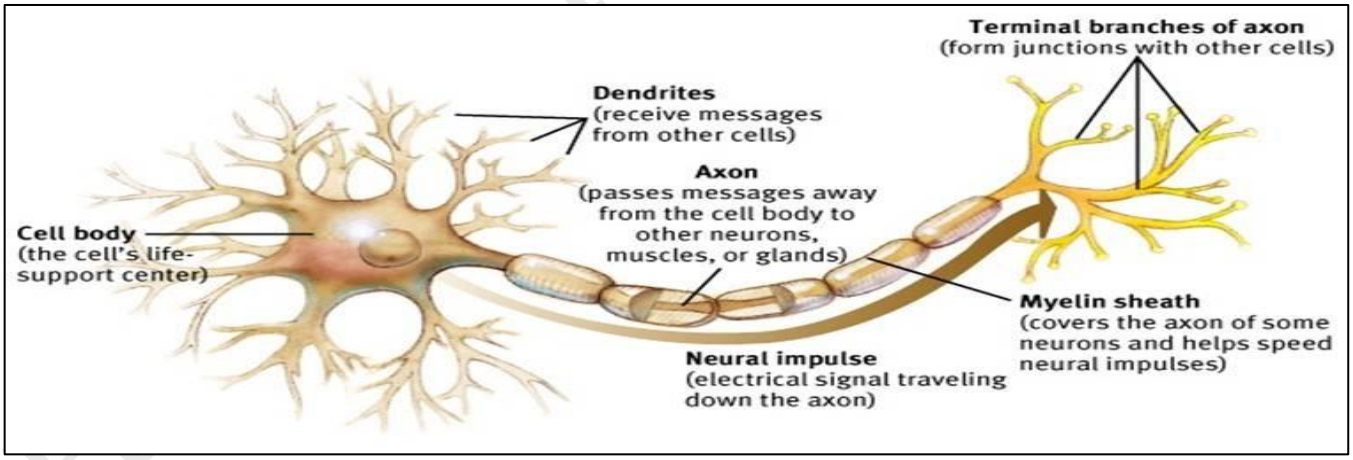
*Biologists and scientists discovered that plants form a symbiotic bond with mycorrhizal fungi that connects roots of different plants and thus named this fungal network '**wood wide web**'.*

- **Cooperative behaviour** – When a growing plant know about their struggling neighbour, they share nutrients to support their neighbour's growth which is widely noticeable in densely populated forests where there is an intense need for light, water and nutrients.
- **Significance –** It shows their understanding of the surrounding and their prompt response to potential threat or dangers.
- It prioritise their resources to support close and far plants in distress which helps in the overall forest health.
- It shows the resilient and reliable ecosystem by working together.

6.28 Dendrites

Recently, the Scientists have first time uncovered a unique type of electrical signal from dendrites in the human brain.

- **Dendrites –** It is ***branch like extensions at the beginning of a neuron*** that help increase the surface area of the cell body.
- **Characteristics –** They are short, narrow and highly branched.
- The length of dendrites is about 2 µm, and they are usually 5 to 7 in numbers.
- Dendrites comprise various cytoskeletal structures, the Golgi apparatus, ribosomes, and smooth endoplasmic reticulum.



- **Functions –** Its primary job is to *collect signals from other neurons and pass them* to the neuron's main body, called the Soma.
- Dendrites also accumulate all incoming information from axon terminals.
- Dendrites collect messages from other neurons, which are then forwarded to the brain.
- The brain, then, sends back the instructions to various parts of the body so that a reaction can happen.
- Dendrites also have a significant role to play in psychological processes such as ***memory formation.***

Recent Findings

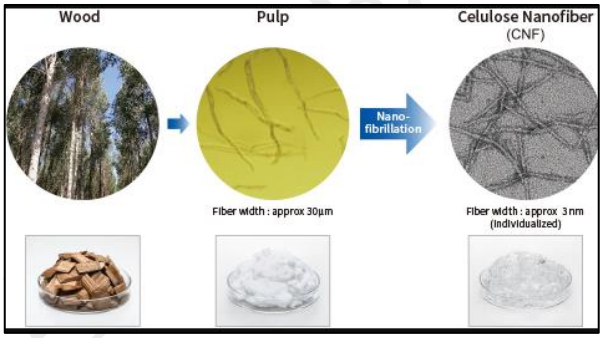
- Researchers examined layer 2/3 (L2/3) pyramidal neurons from human brain tissue, specifically from the ***cerebral cortex***, which plays a key role in advanced thinking and problem-solving.

- **Calcium-Mediated Dendritic Action Potentials (dCaAPs) -** They have uncovered for the 1st time a unique type of electrical signal in the human brain called dCaAPs.
- It showed a "graded" response which means their strength varied depending on the level of stimulation, they *reached their peak at just the right level of input* but became weaker with stronger inputs.
- These dendritic signals *allow individual neurons to solve problems* that scientists previously thought required entire networks of brain cells.
- Essentially, a single neuron can classify inputs that are traditionally seen as too complex for one cell to handle, redefining our understanding of brain computation.

6.29 Cellulose Nanofibers

A recent study has aimed to create hydrophobic paper by exploiting the mechanical properties and water resistance of cellulose nanofibers.

- They are tiny elements of cellulosic material with diameters of the order of 15–20 nm.
- They are extracted from agricultural resources such as soy, wheat, corn, beet and biomass.
- It exist in the form of bundles of cellulose microfibrils, a main component of plant and wood pulp fibers.



- **Properties**
  - Large surface area-to-volume ratio
  - High strength and versatility
  - Good mechanical properties
  - Very low coefficient of thermal expansion
  - Not soluble in aqueous solutions
  - High level of crystallinity

> ***Cellulose*** *is the most abundant renewable organic compound that is structural component of the cell walls of natural plant bodies.*

- **Applications** - Uses in tissue engineering, wound healing, medical implants and delivery of bioactive molecules.
- Freeze-dried nanocellulose as aerogels are employed in napkins with sanitation purposes, diapers and wound dressing.
- Composite coating agent in cosmetics
- Tablets for treating intestinal disorders
- Used as low-calorie replacements for carbohydrate additives
- Reinforcing elements in plastics and polymer nanocomposites.

> ***Crystallinity*** *refers to the degree to which a material or substance is composed of ordered, i.e. repeating arrangements of atoms or molecules in a crystalline lattice structure.*

6.30 Super-Absorbent Polymer

Super-absorbent polymers (SAPs) play a crucial role in modern diapers, enhancing their absorbency and effectiveness.

- It is a *water-absorbing hydrophilic homopolymers* or copolymers that can absorb and retain extremely large amounts of a liquid relative to its own mass
- Water's ability to be absorbed or repelled by materials is influenced by ***microscopic forces*** and the material's nature.
- A water molecule, composed of ***two hydrogen atoms and one oxygen atom***, exhibits unique properties.
- Although each atom is charge neutral, the hydrogen electrons shift slightly toward the larger oxygen atom due to its pull.
- **Cotton vs Super-Absorbent Polymers (SAPs) -** ***Cotton*** is effective for absorbing small amounts of water.
- However, for absorbing large volumes of fluids, such as those produced by a baby overnight, a more advanced material is needed super-absorbent polymer (SAP).

Feature	Polymer	Super-absorbent polymer
Definition	Large molecules composed of repeating units	Polymers that can absorb and retain large amounts of liquid
Water Absorption Capacity	Low to moderate	Extremely high
Chemical Structure	Linear, branched, or cross-linked chains	Cross-linked network structure
Physical State	Solid at room temperature	Gel-like when swollen with water
Degradability	Varies, many are non-biodegradable	Often non-biodegradable, but some are designed to be environmentally friendly

- **Sodium and Water Interact in Super-Absorbent Polymers (SAPs) -** Sodium and water have a strong affinity for each other, much like how salt (sodium chloride) dissolves in water as ***sodium ions separate from chlorine ions and bond*** with water molecules.
- In super-absorbent polymers (SAPs), water molecules attach to sodium ions within the polymer structure.
- Water molecules then link together, forming a rigid network that traps the water and swells, creating a gel.
- This gel formation is what allows SAPs to absorb and retain large amounts of liquid.

6.31 Extrachromosomal DNA (ecDNA)

A research team called eDyNAmiC recently revealed a study showing how ecDNA is formed and contributes to cancer and drug resistance progression.

- **ecDNA -** In normal human cells, the nucleus contains 23 pairs of chromosomes that enclose the DNA but there are some natural processes that can damage DNA.
    - **For example**, in *chromothripsis*, which occurs in some cancers, the chromosomes are broken and rearranged.
- Cells can also make mistakes in the DNA when making copies of it to imbue in new cells.
- Such processes could cause a small part of the DNA to break away from the main chromosome and form a ***circular structure that floats freely inside the nucleus*** which are called as ecDNA.
- It is present in nearly 40% of cancer cell lines and in up to 90% of patient-derived brain tumour samples.
- **Recent Findings –** The mutation patterns in tumours before and after the formation of ecDNA is studied.
- They identified various environmental factors, including smoking, exposure to certain substances, and genetic mutations, to be triggers of DNA damage that could lead to the formation of ecDNA.
- They validated their findings using a method called ***fluorescence in-situ hybridisation (or FISH)***, which specifically looks for certain cancer-related genes in tissue samples.
- They found that ecDNA was present in about 17% of tumour samples but more so in liposarcomas, brain tumours, and breast cancers.
- They also reported that the ***prevalence of ecDNA rose after treatments like chemotherapy***, and correlated with metastasis and worse patient outcomes.
- **Association with cancer growth** - ecDNA present in tumours often contain multiple copies of oncogenes, mutated genes capable of causing cancer, required to activate tumour growth.
- But these oncogenes are not present in chromosomes.
- While chromosomal DNA is fixed within specific regions in the cell, ecDNA *moves freely and can interact with other ecDNA to form hubs*, concentrated zones where oncogenes are expressed more.
- Cells transcribe DNA to mRNA to use the latter to manufacture proteins.
- It has been found that when cells transcribe ecDNA to mRNA, the process causes specific oncogenes to become 4-times more common in the cell than if the DNA came from the chromosomes.
- This anomaly has the potential to accelerate the evolution of tumours and help the cancer resist drugs.

- **Violation of Mendel's third law -** ecDNA is passed on in clusters to the daughter cells during cell division is a violation
- This clustering gives some cancer cells an advantage because it allows them to enhance gene interactions, support cancer growth, and preserve favorable genetic combinations over multiple life-cycles.

Mendel's third law of independent assortment

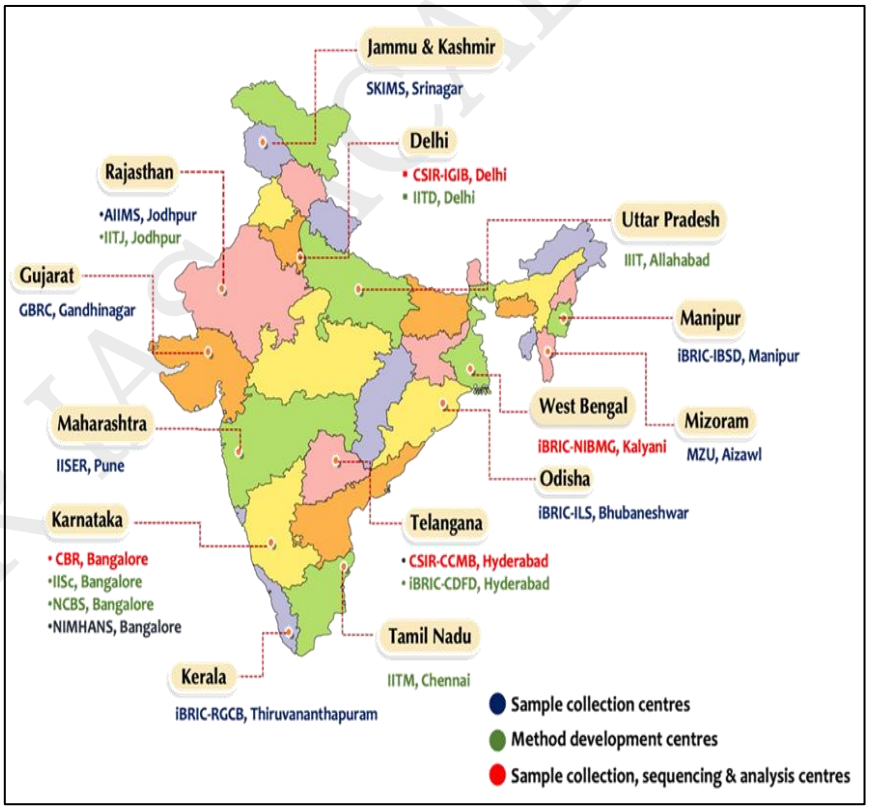
- When cells divide, they duplicate the chromosomes and distribute it equally among their daughter cells.
- The genes on the same chromosome are inherited together while those on different chromosomes are distributed independently of one another.

6.32 Genome India Database

Recently, India has completed the 'Genome India' database'.

*A **genome** is the complete set of genetic information in living organisms, which is stored in long molecules of DNA called Chromosomes.*

- **Aim** – To create a robust and comprehensive database of India's genetic diversity.
- **Housed at** – Indian Biological Data Centre (IBDC), Haryana.
- **Indian Genomic Data Set** – It is the entire collection of ***10,000 Whole Genome Sequencing (WGS) samples*** accessible to researchers within India and globally.
- It represents *83 population groups or about 2%* of the country's 4,600 population groups as a database.
- **Analysis** – The genomes estimate around *27 million low-frequency* (or relatively rare) *variants*, 7 million of them not found in similar reference databases around the world.
- Certain population groups show higher frequencies or different versions of the same gene.
- **Data privacy** – The database is *numerically coded*.
- Researchers must send a proposal to access the data.
- **Significance** – It holds the potential *targeted clinical interventions* and advancing precision medicine.



7. NUCLEAR AND OTHER ADVANCED TECHNOLOGIES

7.1 History of India's Nuclear Program

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

- **Dual intent strategy -** It was followed by then Prime Minister of India Jawaharlal Nehru.
- **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.
- In 1960's almost all the permanent members in United Nations Security Council had tested nuclear weapons.

- **Smiling Buddha (Pokran 1)-** India's *1st 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.

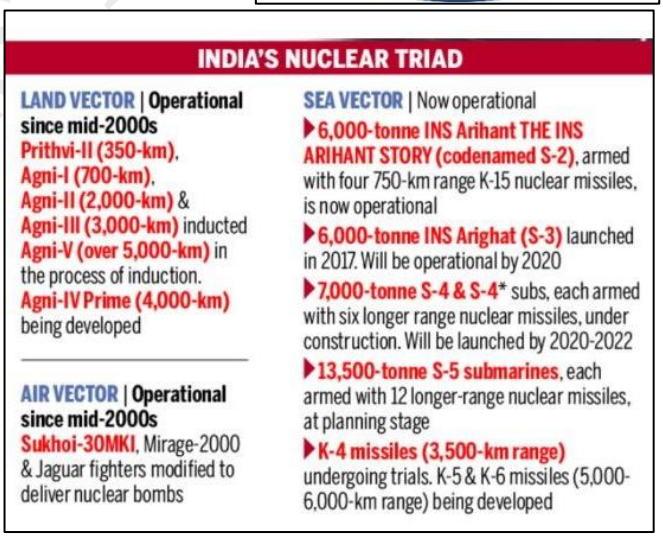
Nuclear Command Authority		
Council	**Head**	**Function**
Political council	Prime Minister	Authorize the use of nuclear weapons
Executive council	National Security Advisor	Provides inputs for decision making and executes the directives given to it by the Political Council

- **Operation Shakthi (Pokran 2)-** It is India's *2nd nuclear test in 1998*.
- **India's Nuclear Doctrine –** It was codified in a 2003 document, from the 1999 draft doctrine.
- Since 2003, it has had 3 primary components
  - No First Use
  - Massive Retaliation
  - Credible Minimum Deterrence

*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.*

- **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 it 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.

"Under the Glenn Amendment, if the U.S. President determines that a non-nuclear weapon state detonates a nuclear explosive device, certain sanctions apply"



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: 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.
- It aims to promote the peaceful use of nuclear energy and to inhibit its use for any military purpose, including nuclear weapons.
- 177 member states including India.
- It was awarded in 2005 for their work for a safer and more peaceful world.

India is a member of the all 3 Multilateral Export Control Regime ***except the Nuclear Suppliers Group.***

7.2 Type of Reactors

During the 2024 Budget speech, the finance minister highlighted small modular reactors (SMRs) as a promising technology.

- Bharat Small Reactors are compact nuclear ***reactors designed to generate electricity*** on a smaller scale than traditional large nuclear power plants.
- The BSRs will be based on India's tried and tested *220-megawatt pressurized Heavy Water Reactor (PHWR) technology*, of which 16 units are already operational in the country.

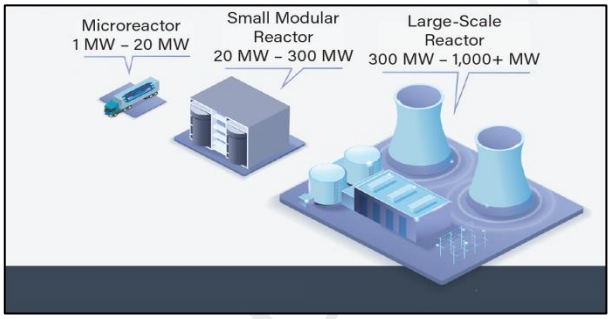
A ***pressurized heavy-water reactor (PHWR)*** *is a nuclear reactor that uses heavy water (deuterium oxide D2O) as its coolant and neutron moderator.*

Feature	Large Conventional Reactors	Small Modular Reactors (SMRs)	Micro Reactors
Power Output	1000 - 1700+ MW	10 - 300 MW	< 10 MW
Size	Very large, requires significant space	Modular, smaller footprint	Minimal, compact design
Construction Time	5-10 years	3-5 years	1-3 years
Scalability	Limited, typically single unit	High, can be added incrementally	Very high, suitable for remote or small-scale applications
Fuel Cycle	Typically uses enriched uranium	Can use enriched uranium, thorium, or other fuels	Often uses advanced fuels like TRISO fuel
Economic Model	Economies of scale, centralized power generation	Cost-effective through factory assembly and modular construction	Cost-effective for niche markets and remote locations
Environmental Impact	High impact due to large footprint and water usage	Lower impact, more efficient land and water use	Minimal impact, designed for minimal environmental footprint
Grid Compatibility	Requires robust, stable grid	Can support both large and small grids	Ideal for microgrids and isolated applications
Use Cases	Base load power generation for large urban centers	Flexible use for urban, industrial, and rural areas	Remote areas, military bases, disaster recovery, small communities

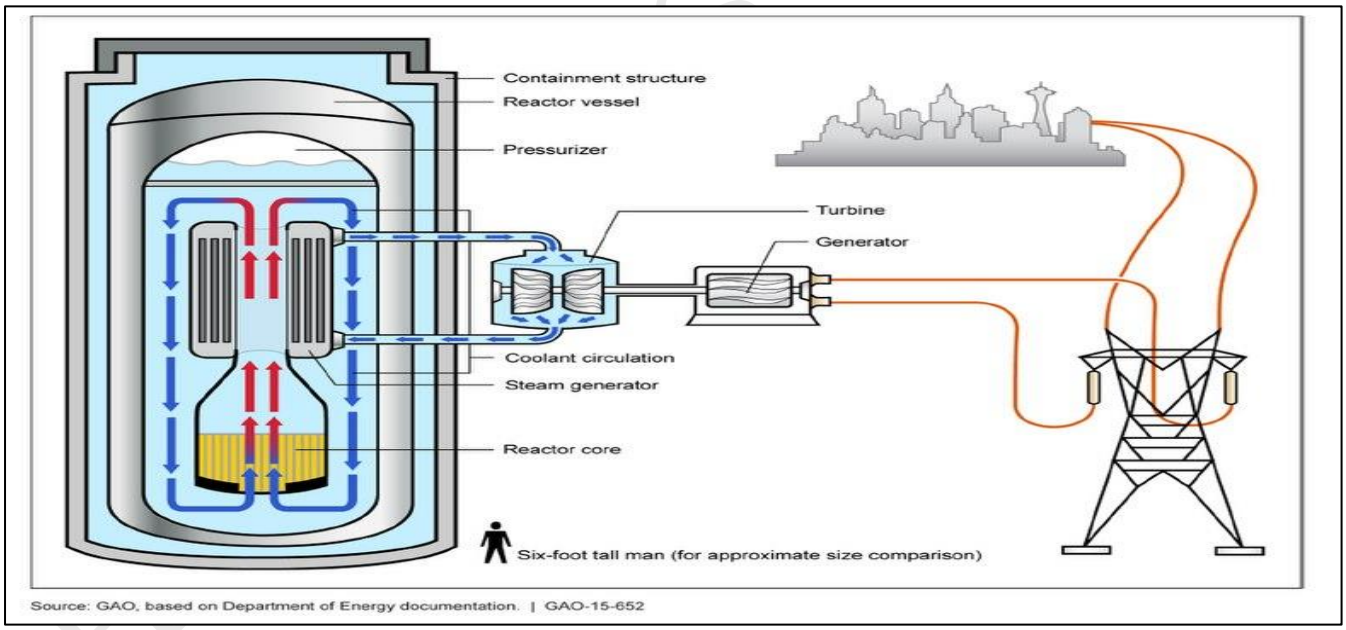
- **Objective-** SMR reactors represent a significant shift in India's nuclear energy strategy, aiming to make nuclear power more accessible and versatile.
- **PPP model-** The government plans to partner with the private sector to set up Bharat Small Reactors and ***conduct R&D on small modular reactors*** and new nuclear technologies.

7.3 Small Modular Reactors

In the Budget 2024-25, 'Bharat Small Reactors' (BSR) has been emphasized to achieve clean energy and energy security.



- **Small Modular Reactors** – They are a class of small nuclear fission reactors, designed to be built in a factory, shipped to operational sites for installation and then used to power buildings or other commercial operations.
    - **Small** – Physically a fraction of the size of a conventional nuclear power reactor.
    - **Modular** – Making it possible for systems and components to be factory-assembled and transported as a unit to a location for installation.
    - **Reactors** – Harnessing nuclear fission to generate heat to produce energy.
- **Types** - Reactor type and the nuclear processes may vary based on SMR designs. Of them pressurized water reactor (PWR) is the most common.
- **Capacity** – They have a power capacity of up to ***300 MW(e)*** per unit.
- It is about one-third of the generating capacity of traditional nuclear power reactors and can produce large amount of low-carbon electricity.



- **Refuelling** - Power plants based on SMRs may require less frequent refuelling, ***every 3 to 7 years***, in comparison to between 1 and 2 years for conventional plants.
- Some SMRs are designed to operate for up to 30 years without refuelling.
- **Benefits** – Many of the benefits of SMRs are inherently linked to the nature of their design, small and modular.
- **Locational Accommodation** - SMRs can be sited on locations not suitable for larger nuclear power plants.
- **Affordability** - Prefabricated units of SMRs can be manufactured and then shipped and installed on site, making them more affordable to build.
- **Easy Construction** - SMRs offer savings in cost and construction time, and they can be deployed incrementally to match increasing energy demand.

- **SMR in India** - There are 15 pressurised heavy water reactors (PHWR) of 220 MW each being operated in India, accounts for half of India's 6780 MW nuclear power capacity.
- Government is considering modifying the PHWRs pressurised heavy water reactors into BSRs.

7.4 1GeV Particle Accelerator

The Department of Atomic Energy plans to build a 1 giga-electron volt (GeV) particle accelerator.

- **Particle Accelerator** – It is a machine that uses electromagnetic fields to propel charged particles like electrons, protons and neutrons to very high speeds and energies to contain them in well-defined beams.
- **Function** - Subatomic particles are shoot on to target or made to collide with each other.
- **Applications**
  - Fundamental research in particle physics
  - Used as synchrotron light sources for the study of condensed matter physics.
  - Particle therapy for oncological purposes.
  - Radioisotope production for medical diagnostics.
  - Ion implanters for the manufacture of semiconductors.
  - Accelerator mass spectrometers for measurements of rare isotopes such as radiocarbon.
- India has many particle accelerators (cyclotrons and synchrotrons) in the ***range of upto 30 MeV*** but *none are in the GeV range.*

Accelerators in India		
Accelerators	**Location**	**Applications**
10 MeV electron RF LINAC	Bhabha Atomic Research Centre, Mumbai	Photo-fission Nuclear data
3 MeV electron DC Accelerator	Bhabha Atomic Research Centre, Mumbai	Food processing Industrial applications
6 MeV electron RF LINAC	Bhabha Atomic Research Centre, Mumbai	Cargo Scanning
16.5 Medical cyclotron	Bhabha Atomic Research Centre, Mumbai	Isotope Production and PET
Variable energy cyclotron	Variable Energy Cyclotron Centre, Kolakata	Research in basic and applied nuclear sciences
Synchrotron Radiation Source INDUS-I & II	Raja Ramanna Centre for Advanced Technology, Indore	Research Studies
Microtron Accelerator (8MeV)	Mangalore University	Photo-fission Neutron source
Low energy cyclotron (2-3MeV proton)	Panjab University, Chandigarh	Research Studies

- **1 GeV particle accelerator** — It is a continuous wave, high-intensity proton accelerator that will help convert thorium, abundantly available in India, into uranium-233 nuclear fuel.
- **Other Methods of Leveraging Thorium**
  - **Fast-breeder Reactor** - Breeding uranium-233 by irradiating thorium in a nuclear reactor.

*In a **fast-breeder reactor**, one can produce more fissile material than what is consumed.*

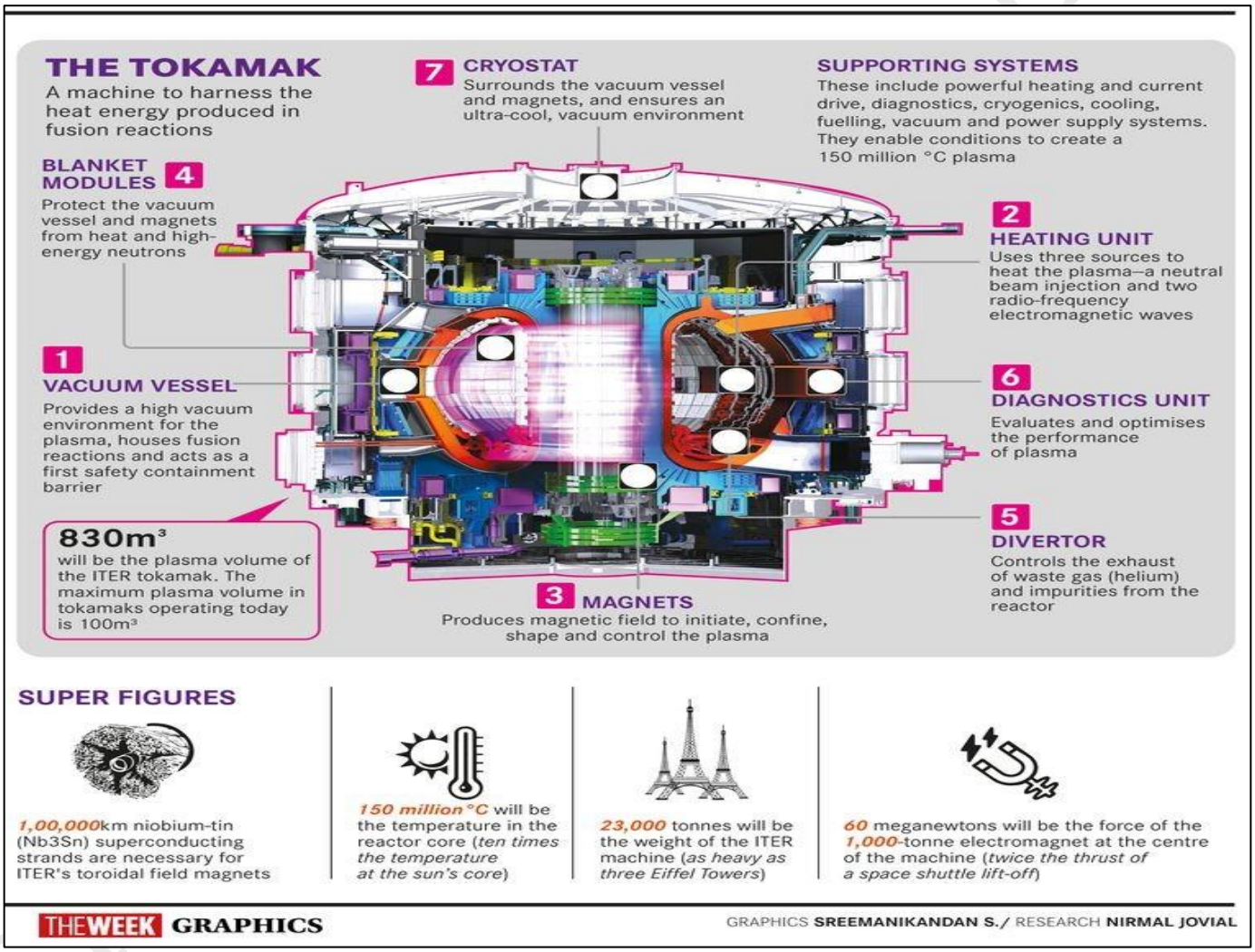
- **Burn up Configuration** - Using thorium along with uranium in in a reactor to derive surplus energy from thorium **through in situ fission of generated uranium-233.**

7.5 International Thermonuclear Experimental Reactor (ITER)

Prime Minister Shri Narendra Modi and the President of France, H.E. Mr. Emmanuel Macron, jointly visited the International Thermonuclear Experimental Reactor (ITER) in France recently.

- **ITER** – Is a large-scale scientific experiment to prove the viability of fusion as an energy source by building the world's largest tokamak.
- **Tokamak** – A magnetic fusion device that has been designed to prove the feasibility of fusion as a large-scale and carbon-free source of energy based on the same principle that powers our Sun and stars.
- **Location** – Under construction in the *south of France*.
- **ITER Council** – Is the governing body that supervises the work of the ITER Organization.

> ***Fusion*** *is the nuclear reaction that powers the Sun and the stars, is a promising long-term option for sustainable, non-carbon-emitting energy.*



- Is an intergovernmental organization that was ***created by an international agreement signed in 2006***, and formally established on 24 October 2007 after its ratification by all Parties.
- **Members** – China, European Atomic Energy Community (Euratom), ***India***, Japan, Korea, the Russian Federation and the United States of America.
- India is among the 7 ITER members contributing to the project over the last two decades.

7.6 Cubic Kilometre Neutrino Telescope (KM3NeT)

Recently, the scientists have deployed 2 telescopes under the Mediterranean Sea to detect high-energy neutrinos.

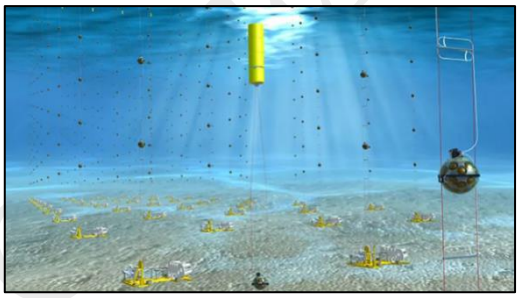
- It is an ***underwater Neutrino telescope***.

- **Aim** – To *study high-energy neutrinos* also known as ghost particles that could reveal secrets of the cosmos.
- **Need**– While both frozen ice and deep-sea waters are used for detecting neutrinos, *underwater neutrino telescopes could be more efficient* than IceCube.
- That is because ***water scatters light less***, which gives a more accurate idea about where the detected neutrinos came from.
- **Features** – It consists of *2 telescopes* made up of glass baubles arranged on vertical cables.
- Each strand dangles in the water like a pearl necklace that's up to 700 meters long.

> ***Neutrinos*** *are weakly interacting subatomic particles that can travel astronomical distances undisturbed. They are the 2nd most abundant subatomic particles after photons.*

> *Neutrino detectors needs to be in dark because it looks for flashes of* ***Cherenkov radiation****, a light that neutrinos produce when they interact with a water or ice molecule. These flashes trace the path of that neutrino, giving details of its source, the amount of energy it contains, and its origins.*

- Each bauble, a pressure-resistant sphere 44 centimeters wide, contains *31 photomultiplier tubes* that sense light generated when neutrinos crash into the seawater.
- **Deployment** – Detectors are *deployed in 1 month-long campaign every year* and at the end of 2024, the telescopes boasted 57 strands.
    - Eventually, 100's of such cables will sway in the currents, a few kilometers below the surface off the *coasts of Sicily and the South of France*.



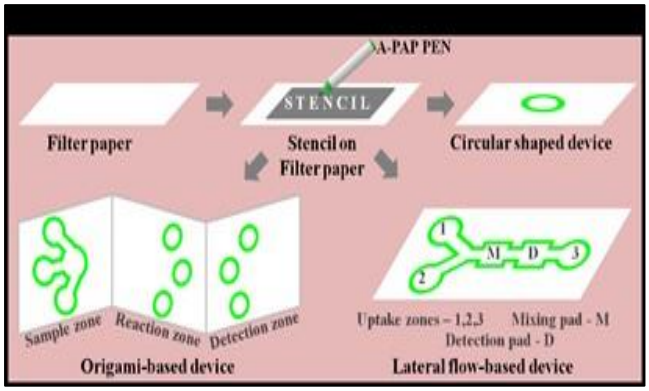
- **Sicilian telescope** – Study high-energy *neutrinos from space*.
- **French telescope** – Study *neutrinos from the atmosphere* to understand how they oscillate, or change from 1 type of neutrino to another.
- **Disadvantage** – Water absorbs light more and as a result, there will be less light to examine.

8. INNOVATIONS, EXPLORATIONS AND DISCOVERIES

8.1 Advanced PAP (A-PAP) Pen

Scientists have recently developed fabricating paper-based devices using an Advanced PAP (A-PAP) pen.

- **A-PAP pen** – It is a ***hydrophobic barrier pen*** used in laboratory applications to draw barriers on glass slides to confine the flow of reagents.
- *It does not require any machinery or heating/drying* steps and adopts a DIY approach.
- **Recent analysis** - Using the A-PAP pen, the fabrication of 2-dimensional (2D) paper-based devices for chemical detection of heavy metal and nitrite can be done.
- *Biological sensing* using 2D lateral flow paper-based devices for the detection of dopamine can be done.
- The technique is also validated for fabricating complex 2-dimensional (3D) paper-based devices using a *paper origami technique for heavy metals sensing*.



Paper-based devices

- Also known as paper-based analytical devices (PADs) or microfluidic paper-based analytical devices (µPADs).
- **Made by** - Patterning paper to create channels & barriers.
- **Usage** – It can be used with a variety of detection methods.
- **Detection -** It can detect biological analytes associated with disease, such as glucose, or foodborne pathogens.
- **Monitoring -** It can monitor environmental, health, and food issues.

- **Diagnosis -** It can be used for clinical diagnosis.

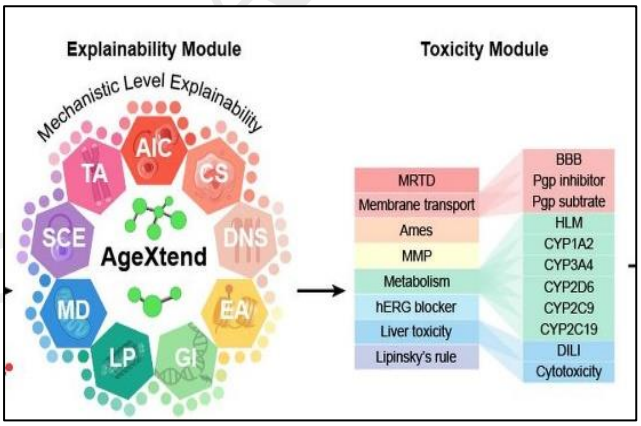
Drug development - It can be used in drug development.

- **Benefits -** This technique provides a valuable tool for creating affordable, efficient, and accessible chemical and biological testing solutions.
- Its versatility extends to fabricating simple & complex devices like lateral-flow-based and 3D origami devices.

8.2 AgeXtend

Researchers at IIIT-Delhi develop AI-based platform to identify age-defying molecules rapidly.

- It is a unique platform that ***uses data from existing anti-ageing molecules to predict new ones***.
- It harnesses Artificial Intelligence to *discover substances that support healthy aging*.
- **Developed by** - Indraprastha Institute of Information Technology in Delhi.
- **Methodology** - Over two years, they evaluated more than 1.1 billion compounds.
- The findings have been corroborated through experiments conducted on yeast, C. elegans (a type of worm), and human cellular models.
- From this extensive search, less than 1% of compounds were recognized for their anti-aging effects.
- It employs AI to forecast and pinpoint components with age-reversing properties, evaluate their safety profiles, and analyze their biological impacts.
- It examines the structural attributes of novel molecules and can accurately predict their gero-protective qualities.
- It has effectively revealed the advantages of established compounds like metformin and taurine, even without any previous information about them.
- It also explores natural metabolites sourced from the human microbiome and their potential in reducing cellular senescence.



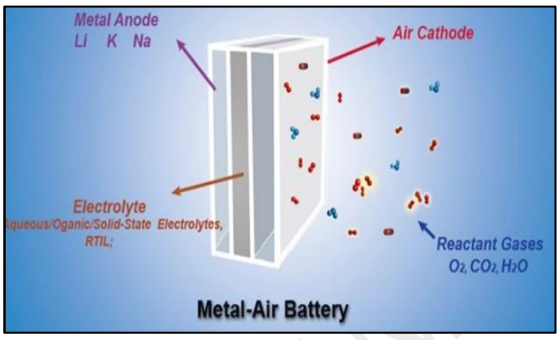
8.3 Polyatomic ion

Recently, researchers have discovered a new method to utilize carbon dioxide (CO_2) in ambient conditions, unlike the previously harsh thermal conditions.

- **Conversion of Amines to N-Formamides Using CO_2**- The transformation of amines to N-formamides is essential for synthesizing heterocycles, pharmaceuticals, and bio-active compounds.
- **Polyoxometalates (POMs)**- These are synthesized nanomaterials composed of three or more transition metals linked by shared oxygen atoms.
- They are promising for improving the photocatalytic conversion of CO_2 due to their unique properties:
    - POMs provide high-efficiency catalytic sites that enhance reaction rates.
    - They exhibit extraordinary thermal stability, making them suitable for various reactions.
    - POMs have excellent redox abilities and properties like semiconductors, crucial for photocatalysis.
    - The light absorption properties of POMs can be finely tuned by incorporating different transition metals, enhancing their photocatalytic efficiency.
- **Recent Advancements** - They have explored 2 novel Keggin POM-based solids.
- Among these, PS-97 was found to be highly efficient for the photocatalytic N-formylation of various substituted anilines and morpholine with CO_2 using phenyl silane as a reducing agent.
- Notably, this reaction operates under ambient conditions.

8.4 Metal - Air Batteries

Scientist from CSIR-CMERI, Durgapur have synthesised a cathode material to be used as a catalyst in Metal Air batteries to enable them function in sub-zero climatic condition.



- They ***utilize atmospheric oxygen*** to generate electricity when in contact with metals like aluminum.
- It *replaces the need for heavy cathode materials* in Li-Ion batteries with metals such as Li, Na, K, Mg, Al, Zn, and Fe, utilizing O_2 at the air electrode.
- They have *higher energy density* than lithium-ion batteries.
- Metals like aluminum are lightweight materials that produce energy equivalent or more than lithium-ion batteries.
- **The Catalyst** – It combines an efficient durable cathode catalyst and anti-freezing electrolyte fabricated for Zn-air batteries.
- It is formed by integrating CoFe alloy and Fe_3C nanoparticles using an in-situ growth technique.
- The CoFe/Fe3C alloy/carbide hybrid structure enhances the durability and shows catalytic performance as a cathode.
- These are multifunctional catalysts capable of accelerating the ORR (Oxygen Reduction Reaction), OER (Oxygen Evolution Reaction), and HER (Hydrogen Evolution Reaction) simultaneously.
- **Benefits**
    - Remarkable efficacy in both liquid and solid-state zinc-air batteries.
    - Ability to function even under sub-zero temperatures.
    - Long-range, lightweight, and recyclable source of energy.

8.5 Twisted bilayer tungsten diselenide ($tWSe_2$)

The researchers recently explored superconductivity in twisted bilayer tungsten diselenide ($tWSe_2$).

- **Moire Pattern -** Even though the 2 layers of a moire material have the same arrangement of atoms, the *misalignment caused by small twist produces a completely different pattern* when seen from the top.
- It gives rise to new behaviours that are not present in the individual 2D materials alone.
- This is because the ***twist leads to the formation of flat bands*** in the electronic structure of the material.
- In moire materials, because the ***energy bands are flat***, the electrons experience very little variation in energy. As a result, the electrons move slowly and are said to be heavy.

> ***The energy bands*** *are a way to visualize the energy the electrons possess and how fast they move within the material.*

Recent Findings

- The superconductivity is explored in a moire material created by stacking 2 layers of tungsten diselenide, a semiconductor, and rotating one layer by a small angle.

> *The **transition temperature** is the critical value below which a material enters the superconducting state, exhibits zero electrical resistance. Conventional superconductors transition around –250° C*

- **Features -** tWSe2 was a robust conductor with a ***transition temperature*** of around –272.93° C.
- The superconductivity in tWSe2 occurs precisely when the electronic states are half-filled.
- It could *transition to an insulating (non-conducting) state* by altering the electronic properties of the material.
- It had a coherence length ***about 10-times longer than other moire materials***, meaning that its superconducting state is not fragile.
- For tWSe2, superconductivity is driven by electron-electron interactions and half-band filling, while graphene-based systems depend on flat bands and electron-lattice interactions.

- While graphene-based systems become superconducting at higher temperatures, tWSe2 is more stable.

8.6 Diamond Battery

Scientists and engineers from UK Atomic Energy Authority (UKAEA) have created a Diamond Battery with the potential to power devices for thousands of years.

- It is the ***world's first carbon-14 diamond battery***.
- It is safely held within a diamond, , *no short-range radiation can escape.*
- It functions similarly to solar panels but instead of using light particles, it captures fast-moving electrons from within the diamond structure.
- **Uses** - It is used in extreme environments, both in space and on earth where it isn't practical to replace conventional batteries.
- It can support a whole range of important applications from space technologies and security devices to medical devices like ocular implants, hearing aids, and pacemakers.
- It also used in the future, in everyday electronic devices or watches.
- The battery also provides a safe way of dealing with nuclear waste.

> ***Carbon-14*** *is a radioactive isotope of carbon, which has a half-life of 5,700 years meaning the battery will still retain half of its power even after thousands of years. It emits a short-range radiation, which is quickly absorbed by any solid material.*

8.7 Hyperloop track

Union minister recently announced that the construction of India's 1st Hyperloop test track at the Discovery Campus of IIT Madras in Chennai has been completed.

- It is the ***1st Hyperloop test facility*** (ultra-high-speed public transportation system) in Asia.
- **Led by -** IIT Madras's Avishkar Hyperloop team in partnership with TuTr, a startup incubated at the institute.
- **Partnered with -** Ministry of Railways.
- It is expected to be operational by the end of 2024.
- **Implementation in 2 phases**
  - First phase will feature an 11.5-kilometre test track to validate and certify the technology.
  - The second phase will expand the track to nearly 100 kilometres after successful trials.
- **Speed –** Up to 1,100 km/h, with an operational speed of around 360 km/h.
- **Efficiency –** Operating within a vacuum-sealed, frictionless environment, it offers higher energy efficiency.
- The first full-scale Hyperloop project in India is planned for the ***Mumbai-Pune corridor.***

Hyperloop technology

- Hyperloop is a high-speed transportation system in which pods, functioning as pressurized vehicles, and travel at incredible speeds through low-pressure tubes.
- Each pod, capable of carrying 24-28 passengers, will travel directly between destinations *without stops*, making it a highly efficient and promising solution for point-to-point travel.
- The idea of using low-pressure tubes for transportation has been around since the late 17th century. Elon Musk first proposed the Hyperloop in 2012.

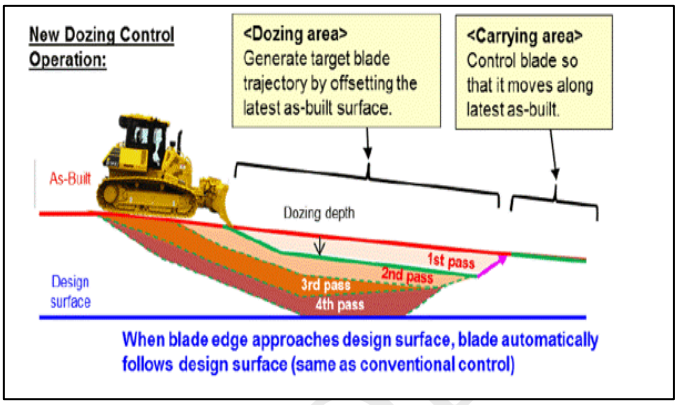
8.8 Dozer Push Mining Trial

Recently, India has successfully conducted the 1st trial blast of the Dozer Push Mining Method.

- **Dozer Push Mining** – It is a cutting-edge *technological solution that integrates advanced digital technologies* to revolutionise coal extraction processes.
- It is a viable *alternative to the conventional truck-shovel mining technique* or shovel-dumper and *dragline methods*.

> ***Truck-Shovel (TS) systems*** *are the most common mining system used to remove the upper and thinner overburdens found within a deposit.* ***Dragline methods*** *remove the much deeper overburdens.*

- **Developed by** – Dhanbad based CSIR-Central Institute of Mining and Fuel Research (CSIR-CIMFR).
- **Objective** – To ensure the vibration and fly rock which are controlled within safe limits.
- **Key technical innovation** - *Automated drilling process* with unmanned operations.
- Precise *cast/throw blasting techniques* for optimal material displacement.
- *Automated dozer* for efficient material movement.
- Integration of advanced digital technology for operational oversight.
- **Trial** – It involved drilling of 108 holes using automated drill machine, followed bycast/throw blasting using 60 tons of bulk emulsion explosives.
- The blasted material will be pushed in decoaled area using specially designed, large-sized automated dozer machine.
- **Benefits** – *Faster coal recovery rates*, accelerating project timelines.



- *Reduced weather-related production delays*, ensuring consistent output.
- Enhanced dragline machine utilisation, maximising equipment efficiency.
- *7-10% reduction in operational costs* and lower unit production costs.

9. IT & COMPUTER

9.1 Diffusion transformer (DiT)

The new AI model 'Sora' is powered by Diffusion transformer (DiT)

- **Sora** – An AI model developed by OpenAI that process the prompts in natural language and generate minute-long videos in high definition *using diffusion transformer model.*

AI models

- They are essential architecture that have redefined the landscape of machine learning (ML), a subset of AI, applications.
- **Transformer-based models** – It is used to change a simple picture bit by bit into something you want.
- **Diffusion models** – It is essentially the *spreading of particles* from a dense space to a lesser dense area.
- It have become the most preferred for AI that generates images.

- **DiT** – Diffusion transformer, is essentially *a class of diffusion models* that are based *on the transformer architecture*.
- **Developed by** – William Peebles at UC Berkeley.
- **Aim** – To improve the performance of diffusion models by switching the commonly used U-Net backbone with a transformer.

***U-Net** is an architecture employed in diffusion models for iterative image denoising but it may not provide the best solution all the time.*

- **Principle**
  - Use concept of diffusion – For predicting videos
  - Use the strength of transformers – For next-level scaling
- **Working** – It make videos by breaking them down into smaller parts, adding a bit of randomness (noises), and then cleaning things up based on the text.
- **Latent diffusion process** – *Noise* is gradually transformed *into the target image* by reversing the diffusion process guided by a transformer network.
- **Diffusion timesteps** – It act like checkpoints and at

*Runway's Gen-2 and **Google's Lumiere** had previously showcased some breathtaking capabilities of video generation that could potentially replace filmmaking in the future.*

each checkpoint, DiT looks at the picture and decides to make it better.

9.2 Phi-3-mini

The latest version of a lightweight AI model, the Phi-3-Mini was launched.

- It is a small language model, available on AI development platforms such as Microsoft Azure AI Studio, HuggingFace, and Ollama.
- **Launched by** – Microsoft
- It expands the selection of high-quality language models available to customers, offering more practical choices as they build generative AI applications.
- **In India** – India's ITC also leveraged the new Phi-3-mini.
- **A language model** – It is a *machine learning model* that aims to predict and generate plausible language.
    - *Autocomplete* is a language model, for example.
- These models are *trained on existing data* to solve common language problems such as text classification, answering questions, text generation, document summarisation, etc.

> ***Language models** are the backbone of AI applications like ChatGPT, Claude, Gemini, etc.*

> *The amount of conversation that an AI can read and write at any given time is called the context window, and is measured in something called **tokens**.*

	Small Language Models	Large Language Models
Size	Less parameter count	Higher parameters
Processing speed	Quicker	Relatively slower
Computational Requirement	Can use mobile device processor	Require hundreds of GPU processors
Handling capacity	Simple tasks	Complex tasks
Deployment	Easier	Require substantial infrastructure
Training Time	In a week time	Can take months
Training Data	Specialisation	On general data
Efficiency	More efficient	Less efficient
Training and Inference Cost	Expensive	Less expensive

9.3 Deadbots

A new study urges caution in the development of Artificial Intelligence (AI) chatbots designed to mimic deceased loved ones, known as 'deadbots'.

- They are *AI-enabled digital representations* of departed loved ones, also known as ***griefbots***.
- **Working principle** – They *simulate* the person's language patterns and personality traits using their digital footprint like emails and even voice recordings, to create a *conversational AI* that reflects their personality.
- **Challenges** – Limited understanding of *psychological impact* of digital immortalisation on adults and their grieving processes.
- **Economic and emotional issues** – *Profit-focused exploitation* of personal data, emotional manipulation, or privacy violation.

> *Conversational AI works by using a combination of natural language processing (NLP), foundation models, and machine learning (ML).*

- **Cultural issues** - The topics of death, grief and immortality are very delicate and are culturally sensitive.
- Solutions that might be enthusiastically adopted in one cultural context could be completely dismissed in another.
- There is a *need to understand these cross-cultural differences* in the approach to digital immortality in 3 different Eastern locations, including Poland and India.
- **Future design recommendations** – Developing sensitive procedures for 'retiring' deadbots
    - Ensuring meaningful *transparency* through disclaimers on risks and capabilities of deadbots
    - *Restricting access* to adult users only
    - Following the *principle of mutual consent* of both data donors and recipients to partake in the re-creation project.

9.4 GPT-4o

The new flagship model GPT-4O was launched.

- **Released by** – ***OpenAI***
- **Aim** – To *accept audio and visual inputs* in addition text and to generate output almost flawlessly.
- **Mechanism** – It works by *clubbing 3 models*: turning the user's voice into text, carrying out operations, and returning an audio-based result.

The 'o' in GPT-4o stands for "omni", which means it can receive multimodal inputs through text, audio, and image. ChatGPT still receives text input to provide output.

- **Response time** – 232 milliseconds for audio input, while its average response time is *320 milliseconds*.
- It uses the usual fillers, or sometimes repeats part of the question to cover for this latency.
- **Response voice** – In most of the demo clips shared, the voice *sounded female*.
- Unlike more basic iterations they were expressive, friendly, and even affectionate, *sounding more like a friend or someone closer* rather than a machine-generated voice.
- **Activities** – It can do a range of activities like
    - Turning a picture of a man into a caricature.
    - Creating and manipulating a 3D logo
    - Generating meeting notes based on an audio recording
    - Designing a cartoon character, and even make a stylised movie poster with real people's photos.
    - Assisting a child in solving a math problem by setting a game
    - Assessing the readiness of user for interview

OpenAI claims it to beat existing rivals such as Claude 3 Opus and Gemini Ultra 1.0, as well as its own GPT-4 offering, in several areas across text evaluation and vision understanding evaluations.

- **Advantages** – *2 times faster*, *half the price*, and has 5 times higher rate limits compared to GPT-4 Turbo.
- **Safety** – It has safety built-in by design across modalities, through techniques such as filtering training data and refining the model's behaviour through post-training.
- It has new safety systems to provide *guardrails on voice outputs*.
- **Challenges** – It has *omitted the capacity of generating a video* like trailer and had also *made some slip-ups and errors* when demonstrating its abilities.
    - **Example**: While converting 2 portraits into a crime movie-style poster, it initially produced gibberish instead of text.

9.5 AI agents

The recently launched GPT-4O by OpenAI and Project Astra by Google were powered by AI agents.

- **AI agents** – They are sophisticated AI systems that can engage in real-time, multi-modal interactions with humans.

- Both GPT-4O and Project Astra are capable of processing the real world through audio and visual inputs and provide intelligent responses and assistance.
- They can have instant real-time conversations with a user.
- **Processing** - It can process and respond to a wide variety of inputs including voice, images, and even input from their surroundings.
- **Working**
    - Perceive their environment via sensors
    - Process the information using algorithms or AI models
    - Take subsequent actions.
- **Applications** – In fields such as gaming, robotics, virtual assistants, autonomous vehicles, etc.
- **Advantages** – They are *superior over conventional language models*, which solely work on text-based inputs and outputs.
- They are versatile & capable of handling a wide range of situations.

	Large Language Models (LLMs)	AI Agents
Examples	GPT-3 & GPT-4	GPT-4O & Project Astra
Interaction	Generate only human-like text	Natural and immersive interactions with the help of voice, vision, and environmental sensors.
Input range	Text	Text, Audio, Vision
Response Time	Relatively time consuming	Instantaneous, real-time conversations with responses much similar to humans.
Contextual Awareness	Lacks	Understands & provides personalised responses.
Autonomy	No since they only generate text output.	It can perform complex tasks autonomously such as coding, data analysis, etc.
Physical actions	No	When integrated with robotic systems, it can even perform.

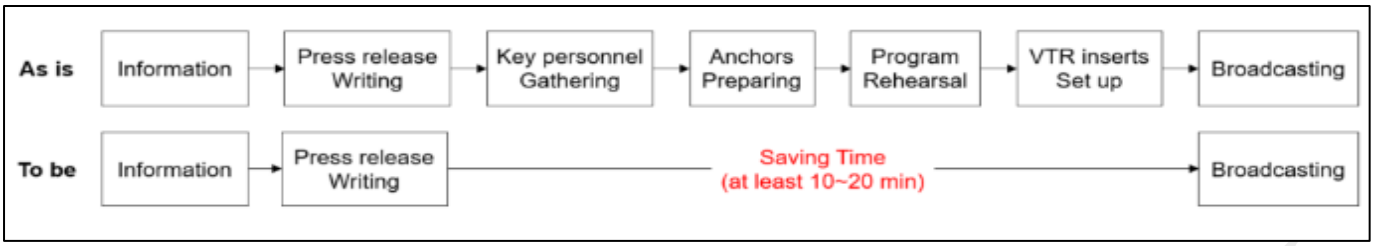
- **Challenges** – *Privacy and security issues* and can *carry forward biases* from their training data or algorithms, leading to harmful outcomes.

9.6 AI Anchors - AI Krish & AI Bhoomi

DD Kisan deploys 2 Artificial Intelligence (AI) anchors.

- **AI anchors** – Also known as a virtual news anchor.
- **Not a physical robot** – It is a computer-generated representation of a human news anchor existing solely in the digital realm.
- **AI technologies** – It uses *natural language processing*, *speech synthesis*, and *computer vision* to generate realistic and human-like speech and movements.
- **Working** – It involves several stages like
    - **Text Generation** – For the AI anchor to deliver.
    - **Speech Synthesis** – The text is then transformed into lifelike speech.
    - **Facial Animation** – It synchronize expressions with the spoken words.
    - **Video Generation** – The synthesized speech and facial expressions, is compiled into a video format.
- **Advantages** – In the event of an emergency, an AI Anchor can *quickly deliver new video.*

- The script immediately becomes a news video, *saving at least 10 to 20 minutes* in breaking news time.



- **2 AI anchors of DD Kisan** – ***AI Krish and AI Bhoomi***, and both can speak in *50 Indian and foreign languages*.
- **Availability** – In all the states of India.
- **Role** – It will provide information about agricultural research in India and globally, trends in agriculture mandis, changes in the weather, or any other information of government schemes.

DD Kisan

- It is also known as *Doordarshan Kisan*.
- **Launched in** – 2015.
- **Launched by** – Union *Ministry of Information and Broadcasting*
- **Aim** – To cater to the *farming and rural community* with necessary information related to agriculture.
- **Significance** – It is also working to bring forward the efforts of progressive farmers to all the people and works towards creating an environment of holistic development by educating them.

***DD Kisan** is strengthening the 3-dimensional concept of agriculture which includes balanced farming, animal husbandry and plantation.*

9.7 Snowblind Malware

A new Android-targeting banking malware named 'Snowblind' is stealing banking credentials.

- It is a new Android malware that uses a built-in Android security feature to ***bypass anti-tamper mechanisms and steal banking credentials.***
- It is a type of ***Trojan malware*** that cover-ups as legitimate software to infiltrate Android devices.
- **Discovered by-** Promon (Cybersecurity firm).
- **Operating procedure-** People usually get this virus by downloading a malicious app that looks legitimate. The malware repackages an app to avoid detection and misuses accessibility features to steal sensitive information and control the app remotely.
- Once installed, it remains dormant until triggered by specific actions or commands.
- **Working -** Snowblind bypasses Android's built-in security by exploiting a feature called ***"seccomp"*** in the Linux kernel, which is supposed to check for tampering.
- Snowblind injects code before seccomp activates, allowing it to bypass security checks and use accessibility services to monitor your screen.
- It can also ***disable biometric and two-factor authentication (2FA)***, the security features commonly used by banking apps to thwart unauthorised access.
- The malware works quietly in the background, so users might not even realise it is on the device.

*A **Trojan Horse Virus** is a type of malware that downloads onto a computer disguised as a legitimate program.*

*The **Linux kernel** is the kernel used by Linux-based operating systems and the interface between the hardware and the computer processes.*

Other Trojan horse virus attacks	
Rakhni Trojan	• It delivers ransomware or a cryptojacker tool, enables an attacker to use a device to mine cryptocurrency to infect devices.

Tiny Banker	• Tiny Banker enables hackers to steal users' financial details. • It was discovered when it infected at least 20 U.S. banks.
Zeus or Zbot	• It is a toolkit that targets financial services and enables hackers to build their own Trojan malware. • The source code uses techniques like form grabbing and keystroke logging to steal user credentials and financial details.

9.8 Internet Archive

The Internet Archive is facing a legal battle with traditional publishers over alleged copyright violations.

- It is an American non-profit digital library which offers free access to digitized collections like websites, software, music, videos, and books.
- **Foundation in-** 1996, by Brewster Kahle
- **Headquarters-** San Francisco, California, U.S.
- **Open Access-** It operates under ***principles of open access*** and aims to provide digital materials for educational and research purposes.
- Much of the content on the Internet Archive is *freely accessible to the public.*
- **Projects-** In addition to archiving web pages, the Internet Archive runs various projects such as *digitizing books, partnering with cultural institutions* for preservation efforts, and providing resources for people with disabilities.
- **Legal dispute-** In 2020, traditional publishers sued the Internet Archive.
- **Wayback Machine-** The Wayback Machine is easy and free of cost digital archive of the *World Wide Web* and other information on the Internet.
- It allows users to browse through over 650 billion web pages archived from *1996 to the present.*
- Users can use it to see how websites looked at different points in *time and to access content* that has been deleted or changed.
- The archive is maintained by the Internet Archive.

> ***Copyright infringement*** *occurs when the violating party exercises any of the creator's exclusive rights to the work without permission.*

> *The* ***World Wide Web (WWW),*** *often called the Web, is a system of interconnected webpages and information that you can access using the Internet.*

9.9 Machine learning in Tibetan Plateau crustal movement

Recently, scientists have used Machine learning technology to predict crustal movements in Tibetan Plateau.

- **Study conducted by** - Wadia Institute of Himalayan Geology, Dehradun.
- Global Positioning System (GPS) and Machine Learning technologies were used to model the crustal deformations over the Tibetan Plateau and forecast velocity vectors of such movements.
- **CORS** - A dense network of Continuously Operating Reference Station (CORS) is employed to monitor crustal deformation continuously.
- Campaign-mode GPS surveys are often used to densify the existing CORS network.
- The scientists analysed data from 1,271 permanent continuous and campaign-mode GPS stations located on the Tibetan plateau and its surrounding areas.
- Machine learning techniques such as support vector machines, decision trees, and Gaussian process regression were used to accurately model crustal

> ***Wadia Institute of Himalayan Geology*** *is an autonomous Natural Resources research institute for the study of Geology of the Himalaya under the Department of Science and Technology, Ministry of Science and Technology, Government of India.*

> ***CORS*** *(National Survey Network) is a repositioning infrastructure operated by the Survey of India which was launched in 2023. It can provide Precise Location based service with centimetre level accuracy in real-time.*

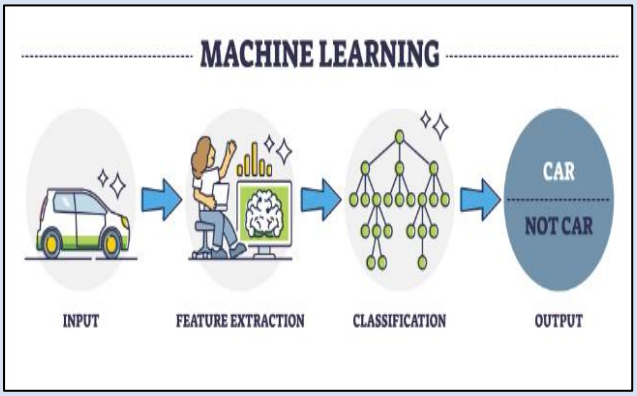
movement.

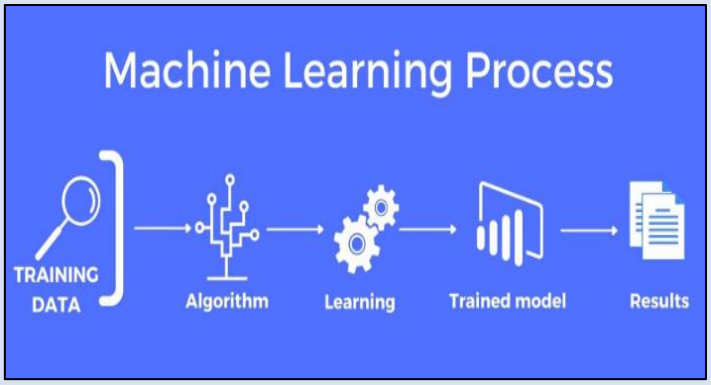
- The ML algorithm demonstrates a remarkable achievement in the field of geodetic studies in a cost-effective manner.
- Geodetic velocities predicted using machine learning are extremely precise.

> ***Geodesy*** *is the science of accurately measuring and understanding the Earth's geometric shape, orientation in space, and gravity field.*

Machine learning (ML)

- It is a branch of artificial intelligence (AI) and computer science that focuses on the using data and algorithms to enable AI to imitate the way that humans learn, gradually improving its accuracy.
- **Working of ML** – A Machine Learning model consists of three major functions.
- **A Decision Process -** These algorithms are used to make a prediction or classification.
- Based on some input data, which can be labelled or unlabelled, your algorithm will produce an estimate about a pattern in the data.
- **An Error Function -** An error function evaluates the prediction of the model.
- If there are known examples, an error function can make a comparison to assess the accuracy of the model.
- **A Model Optimization Process -** If the model can fit better to the data points in the training set, then weights are adjusted to reduce the discrepancy between the known example and the model estimate.
- The algorithm will repeat this iterative "evaluate and optimize" process, updating weights autonomously until a threshold of accuracy has been met.



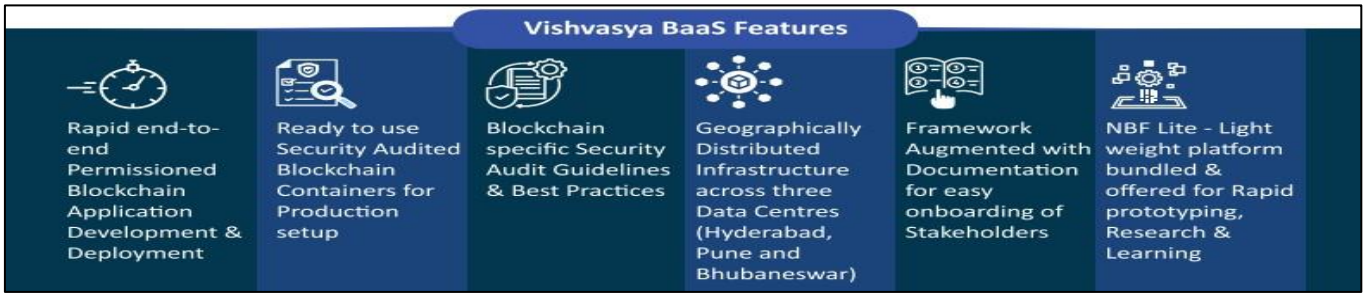


9.10 Vishvasya Blockchain Technology Stack

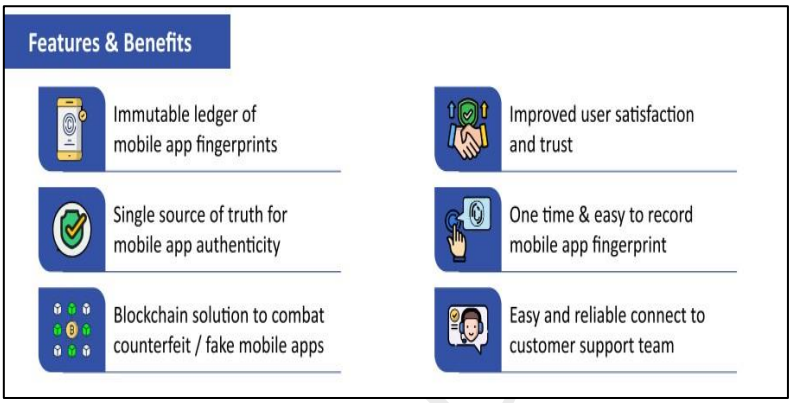
Recently Government has launched Vishvasya-Blockchain Technology Stack and other block chain related Initiatives.

- **Vishvasya** – It is a Blockchain Technology Stack, consists of blockchain related platforms and frameworks.
- It facilitates in enabling trust by developing new types of distributed software architectures and providing a single source of truth.
- It contains BaaS, NBF, NBFLite, Praamaanik, and National Blockchain Portal.

> ***Blockchain*** *is a technology suitable for developing applications with transactional data stored across network of nodes. It provides tamper resistant storage with audit trail for future verification.*



- **Nodal Ministry** – Ministry of Electronics & IT.
- **Vishvasya BaaS** – Blockchain as a Service (BaaS) model that provides security assurance of various Blockchain components across the stack.
- It enables technological support to organizations in developing and deploying Blockchain applications.
- It provides geographically distributed infrastructure designed to support various permissioned Blockchain based applications.
- **National Blockchain Framework** – It aims to create trusted digital platforms for promoting research and application development.
- It facilitates state of the art, transparent, secure and trusted digital service delivery to citizens.
- NBF currently supports two permissioned Blockchain platforms and is extensible.

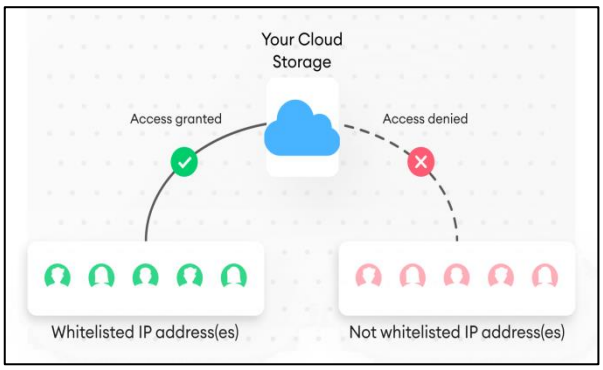


- **NBFLite** – It is a *Blockchain sandbox* platform developed especially for startups/academia for rapid prototyping of applications, carrying out research and capacity building.
- **Developed by** - Collaborating efforts of C-DAC, NIC, IDRBT Hyderabad, IIT Hyderabad, IIIT Hyderabad and SETS Chennai.
- **Praamaanik**- It is a solution that harnesses Blockchain technology to verify mobile app origins.
- It is powered by the National Blockchain Framework.
- **National Blockchain Portal** - It is developed to manage the contents related to the National Blockchain Framework initiatives.

9.11 Whitelisting URLs

Over 3,000 registered senders complied with the new requirement by whitelisting as per TRAI.

- **Website Whitelist** – A whitelist (*allowlist*) is a cybersecurity strategy that ***approves a list*** *of email addresses, IP addresses, domain names or applications*, while denying all others.
- It refers to the process of *explicitly allowing certain trusted websites to access* specific resources or perform actions on a computer or network.
- **Importance** – It is a quick and easy way to help safeguard computers and networks from potentially harmful threats or inappropriate material on local networks or across the internet.
- It also blocks external tracking and advertising websites.



TRAI's directive on whitelisting

- **Directive** – It instructing all access providers to block any traffic containing URLs, Android Package Kits (APKs) or over-the-top (OTT) links that have not been whitelisted.
- It is all set to come into effect from October 1st 2024.
- **Aim** – To curb the misuse of Uniform Resource Locators (URLs) in messages.
- To safeguard consumers from unsolicited messages containing malicious links while fostering a transparent and secure communication system.
- **Features** - To ensure smooth flow of SMS traffic containing URLs, TRAI advises registered senders to promptly upload their whitelisted URL/APK/OTT links to the portal of the respective access providers.
- Senders who fail to whitelist their links by the due date will not be able to transmit any messages containing URL/APK/OTT links, the regulator

Recently, Bharti Airtel launched an artificial intelligence (AI) powered spam detection solution that will significantly solve the issue of spam calls and messages for its customers.

added.

9.12 Digital Arrest Scam

A recent scam has emerged, resulting in significant financial losses for individuals and businesses, amounting to crores of rupees, under the guise of digital arrest.

National Crime Records Bureau (NCRB) data shows a significant rise in cybercrimes have been reported in the last few years.

- It is an online scam that defrauds victims of their hard-earned money.
- **Process -** In digital arrest scam, fraudsters impersonate law enforcement officials to deceive their victims.
- They initiate contact with victims via phone calls andrequest that the victims switch to video communication through platforms like WhatsApp and Skype.
- The scammers then threaten the victims with a digital arrest warrant, citing various reasons such as financial misconduct, tax evasion, or other legal violations.
- They also create a police station-like set-up to further convince victims that the call is legitimate.
- Under the guise of "clearing their name", "assisting with the investigation", or "refundable security deposit/escrow account", individuals are coerced into transferring large sums of money to specified bank accounts or UPI IDs.
- Once the victims comply and make the payment, the scammers vanish, leaving the victims to face financial loss and potential identity theft.

9.13 AI Data Bank

The Minister of Science & Technology launched an Artificial Intelligence (AI) Data Bank, at the 7th edition of the ASSOCHAM AI Leadership Meet 2024.

7th ASSOCHAM AI Leadership Meet 2024

- ASSOCHAM is Associated Chambers of Commerce & Industry of India () is the country's oldest apex chamber.
- **Vision -** Creating a New India.
- **4strategic priorities -** Sustainability, Empowerment, Entrepreneurship and Digitisation.
- **Theme -** AI for India: Advancing India's AI Development - Innovation, Ethics, and Governance.

- It is ***India's first practical AI Data Bank.***
- **Aim -** To accelerate *technological growth and innovation* by providing researchers, startups, and developers access to high-quality, diverse datasets.
- It is essential for creating scalable and inclusive AI solutions.
- It *enhances national security* through real-time analytics of satellite, drone, and IoT data.
- This step aligns with India's goal to utilize AI for predictive analytics in disaster management and cyber security.
- **India's AI -** It is guided by a comprehensive approach focused on innovation, ethical governance, and global collaboration.
- It is fostering partnerships between academia, private enterprises, and startups to propel AI applications in critical sectors such as healthcare, agriculture, smart cities, and space exploration.
- It focuses to *empower citizens and ensure equitable access* to the benefits of this transformative technology.
- **Significance -** It aligns with India's goal to utilize AI for predictive analytics in disaster management and cyber security.
- It shows India's strategic roadmap for harnessing the transformative potential of AI.
- It addresses pressing challenges such as climate change, public service delivery, and national security.

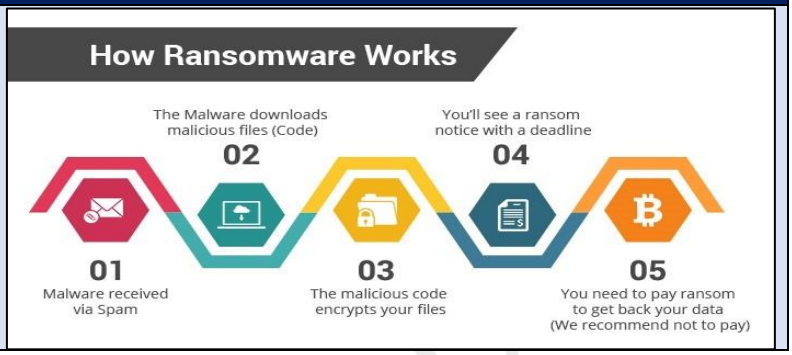
9.14 Ransomware Trends in 2024

Recently, the CyberPeace released a report of Ransomware Trends 2024: Insights for Global Cybersecurity Readiness.

- CyberPeace used advanced *Open-Source Intelligence Techniques (OSINT)*, for continuous monitoring of Ransomware Group activities.

Ransomware

- It is a type of malware that *holds data and devices hostage* until a ransom is paid.
- **Encrypting ransomware** – Holds the victim's data hostage by encrypting it.
- **Non-encrypting ransomware** – Locks the victim's entire device, usually by blocking access to the operating system.



- **Threat** – Ransomware groups orchestrated 5,233 claims across 153 countries using these underground resources.
- **Most targeted nations** – United States, followed by Canada, the UK, Germany, and others.
- It revealed that *killsec was the most frequent threat*, followed by lockbit3 as the second most prominent threat.
- **Vulnerable targets** – It poses significant risks to industries, governments, and individuals alike.
- **In India** – It witnessed a *55% rise in ransomware attacks with 98 recorded cases.*

Impacted Sectors in India	Incidents
Industrial sector	75%
Health Care center	12%
Finance sector	10%
Government sector	3%

- The *industrial sector was frequently targeted*, accounting for 75% of the total incidents.
- The *government sector experienced the least impact*, with only 3% of the incidents, indicating minimal targeting compared to the other sectors.
- **Proactive Measures** – Implement Data Backup and Recovery Plans
  - Enhance Employee Awareness and Training
  - Adopt Multi-Factor Authentication (MFA)
  - Utilize Advanced Threat Detection Tools
  - Conduct Regular Vulnerability Assessments.

9.15 Quishing

A new report by a cybersecurity firm reveals that hackers are constantly finding new ways to deploy QR codes in phishing campaigns.

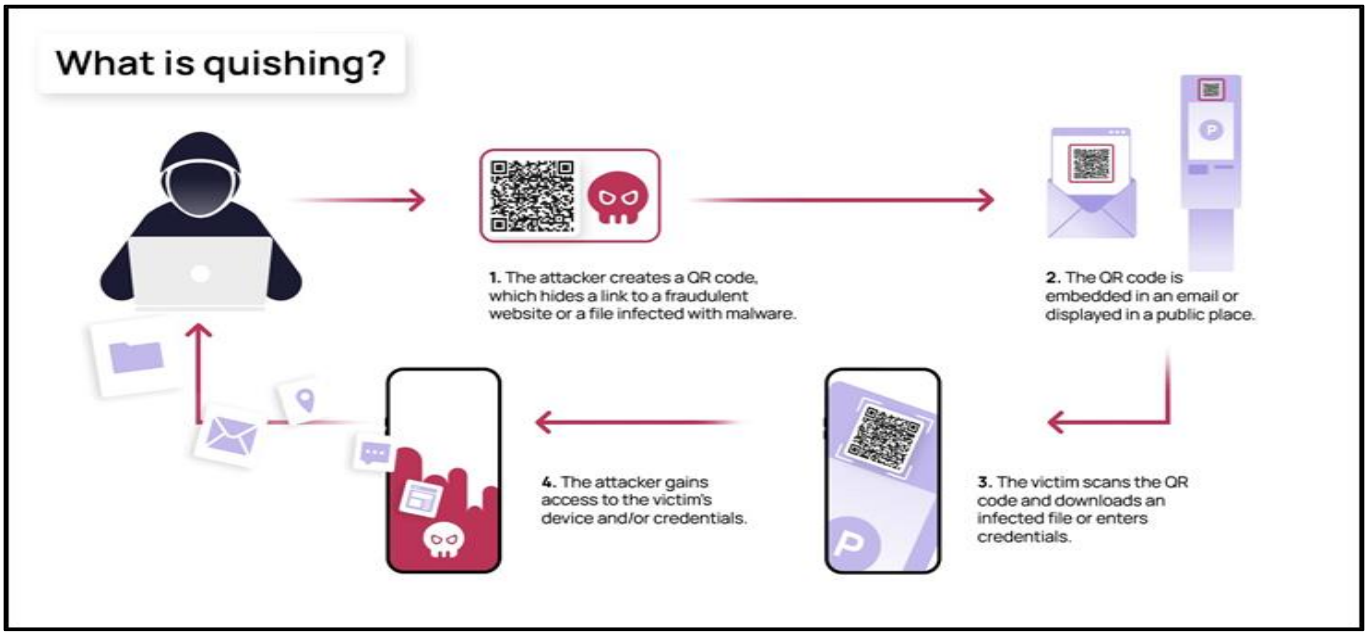
- **Quishing** – It is a ***QR code phishing***, a cybersecurity threat in which attackers use QR codes to redirect victims to malicious websites or prompt them to download harmful content.

Quick Response codes (QR codes)

- They are 2-dimensional barcodes that can be scanned easily with a camera or a code reader application.
- It have the capability to store information including URLs, product details, or contact information.
- Scanning technology allows smartphone cameras or code readers to easily and quickly access the website to which the URL points.

- **Technique used –** *Conditional QR Code Routing Attacks*.

- **Working** – The targeted person is tricked into *scanning a QR code* embedded with a uniform resource locator (URL).



- It redirects to the *credential harvesting page*, which results in the *installation of a malware* that steals sensitive information such as bank account details.
- **Threat** – The number of UPI frauds doubled from *15,000 cases in 2022 to 30,000 in 2023.*
- **Causes** – Due to the widespread use of mobile phones and *digital payment systems*, coupled with poor cybersecurity practices.

> ***Phishing*** *is a common type of cyber-attack that targets individuals through email, text messages, phone calls, and other forms of communication.*

- **Challenges** – The attack is incredibly *personalised and targeted,* by providing the legitimate company logo and using the correct name and user name.
- By changing dynamically depending on the target, this *attack is scalable*, as well.

10. AWARDS

10.1 Nelson Mandela Award for Health Promotion

NIMHANS bags the Nelson Mandela Award for Health Promotion for 2024.

- **Instituted by** – World Health Organisation (WHO).
- **Established in** – ***2019***, upon the initiative of the Ministers of Health of Member States of the African Region.
- **Aim** – To reward work that has extended *far beyond the call of normal duties*.

> *The* ***World Health Assembly*** *is the main decision-making body of WHO and is comprised of 194 Member States.*

- In *recognition of the humility of Nelson Mandela*, the Award given to each laureate consists of a plaque.
- **Presented by** – Group of members including
  - The President of the World Health Assembly
  - The Director-General of the WHO
  - A representative of the Nelson Mandela foundation
- **Beneficiary** – *Individuals, institutions* and/or governmental or nongovernmental organizations
- **Eligibility** – A significant *contribution to health promotion,* as per the Statutes for the award.
- **Ineligible** – Current and former staff members of the WHO and current members of the Executive Board.

- **Nomination by** – Any national health administration of a Member State of the WHO, or any former recipient of the award.
- **2024 award** – National Institute of Mental Health & Neuro Sciences (NIMHANS), Bengaluru.
- It is a testament to NIMHANS' dedication and outstanding contributions to promoting mental health and well-being.
- NIMHANS has been at the forefront of mental health and neurosciences, championing innovative approaches to research, education, and patient care.

NIMHANS, established in 1974, whose precursor is the All India Institute of Mental Health (AIIMH). It is an Institute of National Importance under the Ministry of Health and Family Welfare, Government of India.

***Mental Health Units** are supported in almost all districts of India today through the National Health Mission. India's national tele mental health helpline, Tele MANAS, which was launched in 2022 also recently achieved the landmark of having handled 10 lakh calls.*

10.2 National Metallurgist Awards, 2024

Union Ministry of Steel invites applications for the National Metallurgist Awards, 2024.

- **Objective -** To recognize the outstanding contributions in the metallurgical field, covering Operations, Research & Development, Waste Management, and Energy Conservation.
- The awards are given on an ***annual*** basis.
- The 1st award was given in the year ***1963***.
- **Categories –** The Awards are given in the following ***5 categories.***
- **Eligibility -** This scheme is *only for Indian nationals*, who have contributed to the field of metallurgy in India through their work in Industry, R&D or Academia.
- **Mode of Nominations -** Nominations will be through companies/organizations or from the public through self-nomination.
- **Assessment Criteria & Weightage -** It shall be considered only on a minimum score of 75 out of 100.

10.3 International Earth Sciences Olympiad (IESO)

The Indian student team has bagged multiple prestigious medals at the 17th edition of the International Earth Sciences Olympiad (IESO).

- **IESO** – It is established in 2003 at the ***International Geoscience Education Organization Council Meeting in Calgary, Canada.***
- It is an ***annual***competition for secondary school students from across the globe.
- **Aim** - To generate awareness of earth sciences through teamwork, collaboration, exchanging ideas, and competition.
- **Vision** - To generate interest among the young in earth system sciences, with a focus on promoting awareness & solution-centric discussions around climate change, environmental challenges and natural disasters.
- **Competition Categories**
  - Theory and Practical, Earth Science Project, International Team Field Investigation and Data Mining.
- **17th Edition of IESO** - It held in Beijing, China, from August 08-16, 2024.
- **India & IESO** - India has participated in the IESO since 2007 and hosted its 10th edition in Mysore.
- The four-membered Indian team comprising students from Gujarat, Kerala, Chhattisgarh, and Rajasthan have won three gold and bronze each and two silver medals across three competition categories.
- **INESO** - To encourage the participation of Indian students (of grades 9 to 12) in IESO, the MoES supports the *Indian National Earth Science Olympiad (INESO)* held in various schools across India.
- INESO is a national-level prelude to the IESO and is facilitated annually by the Geological Society of India in collaboration with MoES.
- **Assessment topics** - Geology, Meteorology, Oceanography, and Environmental sciences.

- The MoES supports the INESO and IESO as part of the REACHOUT scheme under the PRITHVI (PRITHvi Vigyan) scheme.

REACHOUT

• Research, Education, Training and Outreach scheme.
• It aims to support research, education, and training in Earth System Science in India.
• It is an umbrella scheme of the following 6 sub-schemes.
  ○ Research and Development in Earth System Science (RDESS).
  ○ Outreach and awareness.
  ○ Knowledge Resources Center Network (KRCNet).
  ○ BIMSTEC Centre for Weather and Climate (BCWC).
  ○ International Training Centre for Operational Oceanography (ITCOocean).
  ○ Program for development of skilled workforce in Earth system sciences (DESK).

10.4 Nobel Prize, 2024

The Nobel Prize, 2024 has been announced recently.

- A Nobel Prize is a prestigious ***international award*** given to individuals or organizations annually.
- **Founder -** Alfred Nobel.
- **Fields awarded -** Physics, Chemistry, Physiology or Medicine, Literature, Peace, and Economic Sciences.
- **Rationale -** To honor individuals who have made significant contributions that benefit humanity.
- The first set of awards were handed out in 1901, 5 years after Nobel's death.
- A Nobel Prize ***cannot be awarded posthumously.***
- **Award ceremony -** Takes place annually on December 10, the anniversary of Alfred Nobel's death.
- The award winners are also given a sum of $1.1 million per prize.

Chemistry, 2024	David Baker	For computational design
	Demis Hassabis and John M.Jumper	For protein structure prediction
Physics, 2024	John J. Hopfield and Geoffrey E. Hinton	Use of statistical physics concepts in the development of artificial neural networks
Physiology/Medicine, 2024	Victor Ambros and Gary Ruvkun	Discovery of microRNAs

11. OTHERS

11.1 GOLDENE

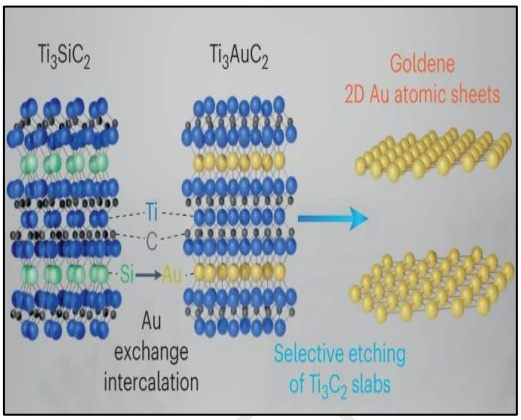
Sweden's Linköping University involves in development of goldene.

- **GOLDENE** – A ***sheet of gold that is only one atom thick.***
- **Technical difficulties** – Due to metals' tendency to cluster together to make nanoparticles.
- **Manufacturing** – The following steps were done to create goldene
- An atomic monolayer of *silicon was sandwiched* between layers of *titanium carbide*.
- Gold were deposited on top of this sandwich structure, thus gold atoms

Since the 2004 development of graphene, the atom-thin material made of carbon, scientists have identified hundreds of 2D materials.

diffused into the material and replaced the silicon atoms, forming a *trapped monolayer of gold atoms*.

- Then, the titanium carbide layers were etched away to create a free-standing, one atom thick layer of gold.
- **Technique used** – A *Japanese technique* used to forge katanas (Knives), using a chemical popularly known as Murakami's reagent.
- **Properties** – These sheets are roughly 100 nanometres (nm) thick (nm – A billionth of a metre), approximately 400 times thinner than the thinnest commercially available gold leaf.
- Each gold atom in 2-Dimensional form has only 6 neighbouring atoms, compared to 12 in a 3-dimensional crystal.
- **Potential applications** – This *super thin, super light* material can revolutionise the electronics industry, which use gold for its *electrical conductivity*.
- It can potentially use lesser amounts for the same purpose.
- **Future applications** – In carbon dioxide conversion, hydrogen-generating catalysis, selective production of value-added chemicals, hydrogen production, water purification, etc.
- **Significance** – While gold sheets sandwiched between other materials have been previously produced, goldene is the 1st free-standing 2D metal that is only one atom thick
- It's much more economically viable than thicker 3D gold.



Gold the 1st metal to be formulated into (freestanding) 2D sheets. Scientist are also working to make 2D sheets of iridium and platinum.

11.2 Browning of Food

Some foods, like meat, cakes, breads etc. turn brown when heated.

- A chemical process called the Maillard reaction is responsible for it.
- **Maillard Reaction** –It is a chemical process that occurs *when amino acids*, which are the building blocks of proteins, *and sugars are heated*.
- **Changes** – It changes the *colour* and also affects the *flavours, aromas, and textures* of foods.
- It is called as non-enzymatic browning as the colour change occurs without the activity of enzymes.
- **Mechanism** –When food is heated, the sugars and proteins present in the food undergo a *condensation reaction* to form a protein-sugar compound called *unstable Schiff base*.
- When the Schiff base is rearranged and dehydrated, various *intermediate compounds form* which react further to produce new flavour and aromas in the food.
- It also results in the reorganisation of the atoms in the Schiff base, creating a *more stable product*.
- These compounds undergo further changes like condensation and polymerisation, leading to the *formation of melanoidins*.
- **Dependent factors** – *Temperature, acidity, moisture* content, and the *types and concentrations of proteins and sugars* in the food.
    - Acceleration – Higher temperatures.
    - Inhibition – Acidic conditions and the presence of water.
- **Ideal temperatures** – In the range of 110 degrees C and 170 degrees C, and higher than that can burn the food and render bitter flavours.
    - Foods *brown more quickly at higher temperatures* and dry foods, such as bread crusts, can develop a deep brown colour during baking.

***Melanoidins** is nitrogen containing compound which are responsible for the brown coloration of the food.*

11.3 Anendophasia

A new study found that some people with anendophasia perform worse in tasks remembering words and rhymes.

- **Anendophasia** – It is a ***condition of having no inner voice***.

An Inner Voice

- **Meaning** – It is the *sound you imagine inside your head* when you are consciously thinking.
  - Like, for instance, framing a sentence in your mind before typing it out.
- It is also called as *internal monologue*.
- **Grades** – Some *think in pictures* and then translate the pictures into words when they need to say something.
- Some have a *verbal, as words* without sound.
- **Universality** – It is not human universal as some lack it.

- **Impact** – Experiments suggested that participants without an inner voice were significantly *worse*, than those without the condition, at *remembering the words and determining whether a set of words, rhyme*.
- However, it did *not seem to affect cognitive reasoning abilities*.

11.4 Helium in Rockets

Boeing's Starliner spacecraft landed uncrewed in a New Mexico desert recently, due to Helium leakage in the rocket system.

Helium

- It is the 2nd most abundant element in the universe after hydrogen.
- It is a *colorless & odorless inert* gas.
- It does not react with other substances or combust.
- It is the 2ndlightest element after hydrogen.

Helium Properties	
Atomic Number	2
Atomic Weight	4.002602
Melting Point	none
Boiling Point	−268.9 °C (−452 °F)
Density (1 atm, 0 °C)	0.1785 gram/litre
Oxidation State	0
Electron Configuration	$1s^2$

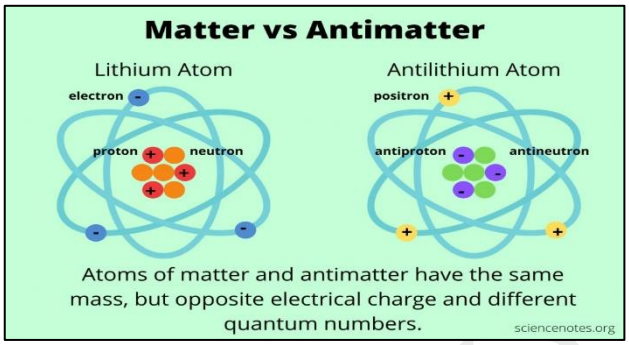
- **Use of Helium in Rocket** – As Helium has a ***very low boiling point (-268.9° C),*** it to remain a gas even in super-cold environments.
- Many rocket fuels are stored in that temperature range.
- Helium is used to ***pressurize fuel tanks***, ensuring fuel flows to the rocket's engines without interruption and for ***cooling systems***.
- As fuel and oxidizer are burned in the rocket's engines, helium fills the resulting empty space in the tanks, maintaining the overall pressure inside.
- Because it is non-reactive, it can safely mingle with the tanks' residual contents.
- **Leakage Prone** – As Helium is small in atomic size and low in molecular weight, its atoms can escape through small gaps or seals in storage tanks and fuel systems.
- **Easy to Detect** - Because there is very little helium in the Earth's atmosphere, leaks can be easily detected
- **Alternatives** - Argon and nitrogen, which are also inert and can sometimes be cheaper.

11.5 Antimatter

- **Antimatter** – It is the ***twin of almost all the subatomic particles*** that make up the universe.
- **Subatomic particles** – It includes*protons and neutrons* (also known as baryons), *electrons and neutrinos* (also known as leptons), and a variety of other particles in the Standard Model of Particle Physics.
- Protons and neutrons are themselves made up of particles known as quarks and gluons.
- All the subatomic particles in matter either ***have their own anti-twins*** (antiquarks, antiprotons, antineutrons, and antileptons such as antielectrons).

*The matter in universe comes in many forms like **solids, liquids, gasses, and plasmas**. These forms of matter all consist of subatomic particles that give matter its mass and volume.*

- **Property** – Anti-particles can combine to form anti-atoms and, in principle, could even form anti-matter regions of the universe.
- They might have an opposite electrical charges like ***positrons*** (positively charged electrons).
- When they meet their matching matter particles, they cancel each other out, *releasing a lot of energy*.
- **Occurrences** – They are rare in the observable universe, but scientists find it in places with lots of energy, like cosmic rays and certain experiments in labs.



- **Artificial creation** - Humans have created antimatter particles using ultra-high-speed collisions at huge particle accelerators such as the Large Hadron Collider, located outside Geneva and operated by CERN, European Organization for Nuclear Research.
- Several experiments at CERN create antihydrogen, the antimatter twin of the element hydrogen.

Positrons were discovered by American California Institute of Technology physicist ***Carl Anderson.***

- The most complex antimatter element produced to date is ***antihelium***, the counterpart to helium.

11.6 Supramolecular self-assembly

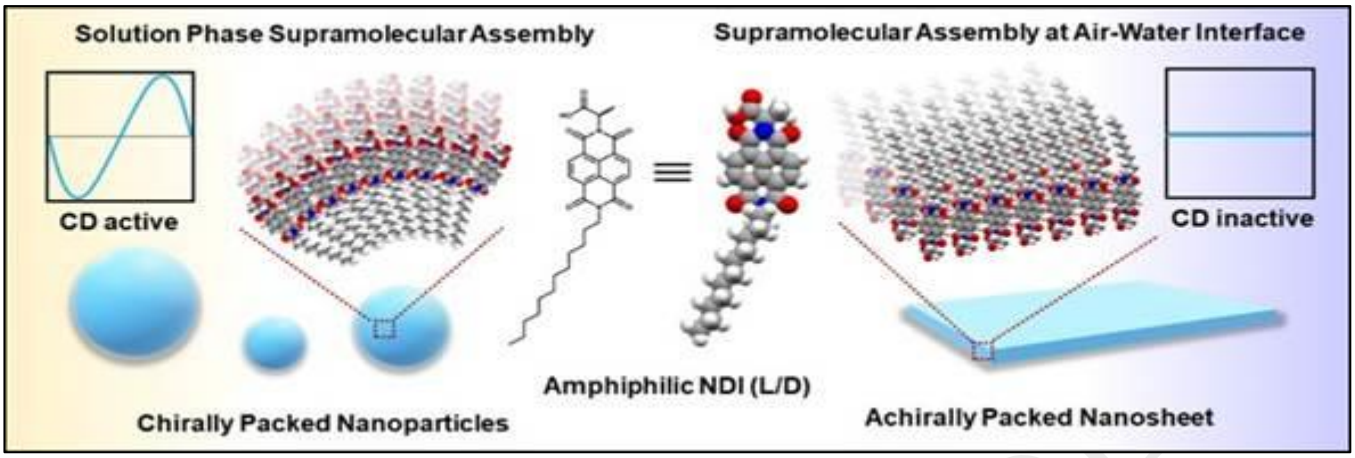
A new breakthrough in understanding the process of controlling the assembly of tiny molecular units into complex structures.

- **Supramolecular self-assembly** – It is a process where small molecules spontaneously organize into larger, well-defined structures without external direction.
- **Research findings by** – It is done by *2 autonomous institutes* in Bengaluru under Department of Science and Technology (DST)
    - Centre for Nano and Soft Matter Sciences (CeNS)
    - Jawaharlal Nehru Centre for Advanced Scientific Research
- **Key findings** – They explored the *self-assembly behaviour* of specific molecules called ***chiral amphiphilic naphthalene diimide*** derivatives (NDI-L and NDI-D).
- They experimented with 2 different methods of assembling.

	Solution Phase Assembly	Air-Water Interface Assembly
Assembly Environment	In a liquid solution	At the boundary between air and water
End product	Forms spherical nanoparticles.	Forms into a flat, two-dimensional layers with irregular edges
Properties	Unique optical properties, such as strong mirror-imaged circular dichroism (CD) signals, which are important for materials that interact with light in precise ways.	not exhibit the same optical properties as the solution-assembled nanoparticles

- It indicates that the environment in which molecules assemble plays a critical role in determining their final structure and properties.
- **Significance** – Understanding this process is crucial *for creating new organic materials* that can be used to develop nanodevices.
- It not only advance the *field of material science* but also provide a foundation *for future innovations* in various industries.
- For example,

- **In biomedicine**, it could be used to develop *more effective drug delivery* systems that target specific areas of the body.
- **In electronics**, these materials could lead to the development of *faster, more efficient devices*.



11.7 Black Plastic

A study found that black plastic contains toxic chemicals that may pose health risks.

- **Source** – It is often made *from recycled electronic waste* such as computers, TVs, and appliances.
- **Manufacturing process** – The casings of products like computers, TVs and coffee machines are typically *treated with flame retardants* to prevent electrical fires.
- **Usage** – They are used to make cooking spatulas, takeout boxes and kitchen peelers.
- **Health impacts** – The flame retardants and heavy metals associated with black plastic are known to be toxic to humans at high levels of exposure and are now banned in many countries.
  - **Flame retardant** – Bromine, antimony and decabromodiphenyl ether.
  - **Heavy metals** – Lead, cadmium, and mercury.

***Legacy Plastic** is a high-grade 100% post-consumer processed plastic recovered from used marine gear, coastal shorelines and our oceans for use in the manufacturing of new value-added, durable products.*

Toxic chemicals in Black Plastic	Health Risks
Decabromodiphenyl ether	Hormone imbalances, nervous system damage and cancer.
Bromine	Thyroid hormone imbalances and reproductive problems.
Antimony	Skin irritation, respiratory problems and an increased risk of cancer.
Lead	Impaired brain development, high blood pressure and kidney problems.
Cadmium	Weaken bones and damage kidneys and lungs.
Mercury	Damage the brain and nervous system, especially dangerous for children and pregnant women.

11.8 World Patient Safety Day, 2024

On the eve of World Patient Safety Day, the World Health Organization (WHO) urged all stakeholders to commit to reducing diagnostic errors and improving patient safety.

- World Patient Safety Day, observed ***annually*** on September 17.
- **Established by -** World Health Organization (WHO) in 2019 following the adoption of resolution WHA72.6 by the World Health Assembly.

- The resolution was a response to the high global rate of avoidable medical errors and patient harm, highlighting the urgent need for action to minimize harm in healthcare.

- **Aim -** To raise awareness about the critical importance of patient safety in healthcare systems worldwide.
- **2024 Theme -** Get it right, make it safe!
- **Objectives** - To increase public awareness & commitment to patient safety.
- To promote global solidarity and action and to address specific patient safety issues.

Global Patient Safety Action Plan 2021-2030 *indicated that only 47% of countries are addressing diagnostic safety.*

- **Raise awareness -** It educates healthcare professionals, policymakers, and the general public on the importance of safety in medical care.
- **Prevent harm** - The day advocates for the prevention of errors, the reduction of avoidable harm, and the improvement of healthcare outcomes.
- **Patient-centred care** - It promotes a culture where patients are empowered and actively involved in their care decisions, fostering transparency and communication between healthcare providers and patients.

11.9 World Polio Day

World polio day was organized recently by Rotary International in collaboration with global health organisations like the World Health Organization (WHO) and UNICEF.

- World Polio Day is observed annually on ***October 24.***
- The Day was established by Rotary International to commemorate the birth of ***Jonas Salk,*** who led the first team to develop the vaccine against the disease in the 1950s.
- **Aim -** To raise awareness about the importance of polio vaccination and to recognize progress made toward a polio-free world.
- **Theme, 2024 -** A Global Mission to Reach Every Child.

Polio

- Polio (Poliomyelitis) is a ***highly viral infectious disease***, mainly affecting children ***under 5.***
- **Transmission** - The virus is spread from person to person, mainly through the faecal-oral pathway or, less frequently, by a shared object (such as contaminated food or water).
- It multiplies in the intestine, from where it can enter the nervous system and cause paralysis.
- **Severity** - There are cases of paralytic poliomyelitis due to a loss of viral attenuation in the oral polio vaccine (OPV), known as vaccine-associated paralytic poliovirus (VAPP).
- Vaccine-associated paralytic poliovirus (VAPP) is very rare, occurring approximately 3.8 times per lakhs of cases in countries using the oral poliovirus vaccine. It can cause sometimes death.
- **Prevention -** Along with vaccination, it is required to wash hands, boil drinking water, and give only breastmilk to babies under 6 months of age.
- There is ***no cure*** but can be prevented through a vaccine.

Over the past 35 years, cases of wild poliovirus have decreased by more than 99%.

- **Inactivated Polio Vaccine (IPV)**
  - **Developed by -** Jonas Salk in 1955.
  - **Administration** - Given via injection.
  - **Characteristics** - IPV contains a killed virus, making it safe but less effective at inducing immunity in the intestines compared to oral vaccines.
- **Oral Polio Vaccine (OPV)**
  - **Developed by** - Albert Sabin in the early 1960s.
  - **Administration** - Administered orally, often in a sugar cube form.
  - **Characteristics** - OPV contains a weakened live virus, which not only protects the vaccinated individual but can also help immunise others in the community through "herd immunity.
- **In India -** In 2009, India had reported 741 polio cases, the highest in the world. In January 2011, India reported its last polio case.

- India was declared polio-free in 2014 by the World Health Organization (WHO).

Global Polio Eradication Initiative

- The Global Polio Eradication Initiative (GPEI) is a public-private partnership that aims to eradicate polio worldwide.
- **Goal -** To ensure that no child will ever be paralyzed by polio.
- **Partners**
  - World Health Organization (WHO), Rotary International, US Centers for Disease Control and Prevention (CDC), United Nations Children's Fund (UNICEF), Bill & Melinda Gates Foundation and Gavi, the Vaccine Alliance
- The GPEI uses a monitoring and evaluation (M&E) matrix to track progress and adjust to risks. The matrix includes milestones, outcomes, and key performance indicators (KPIs).

11.10 World AIDS Day

According to the Tamil Nadu State AIDS Control Society (TANSACS), the State had declined in the HIV prevalence from 1.18% in 1997 to 0.16% during 2023-2024.

- **World AIDS Day -** It has observed every year on ***1st December*** since 1988 after a recommendation by the World Health Organization (WHO) and the United Nations (UN).
- It serves as a global movement to unite people in raising awareness about HIV and AIDS.
- The ***first known cases of aids*** were reported in 1981.
- It is an opportunity for every community and individual to honor the more than 32 million people who have died worldwide from AIDS-related illness.
- **World AIDS Day, 2024 - Theme** - Take the Rights Path, My Health, My Right.
- It seeks to foster inclusivity, reduce stigma, and encourage global cooperation to eradicate AIDS as a public health threat.

Human Immunodeficiency Virus (HIV)

- **HIV** – It is a retrovirus that targets the body's white blood cells, and weaken the immune system.
- **AIDS** - acquired immunodeficiency syndrome (AIDS) is occurred at the late stage of HIV Infection.
- It occurs when the body's immune system is badly damaged because of the virus.
- **Transmission**– It is transmitted by the exchange of body fluids from people, including blood, breast milk, semen, and vaginal secretions.
  - It is not spread by kissing, hugging, shaking hands, or sharing personal objects, food or water.
- **Treatment**– There is no cure for this infection.
- **Prevention**– It is a preventable disease which is treated with antiretroviral drugs, which currently does not cure HIV infection but allows a person's immune system to get stronger.
- **Global response** - The Joint United Nations Programme on HIV/AIDS (UNAIDS) is leading the global effort to end AIDS as a public health threat ***by 2030*** as part of Sustainable Development Goals.
- **India's Response –** ***National AIDS and STD Control Programme (NACP)*** launched on 1992 for prevention and control of HIV/ AIDS.
- Over 35 years, it has become one of the largest HIV/AIDS control programs in the world.
- HIV Estimation in 2012, has demonstrated an overall reduction of 57% through this programme.
- The adult HIV prevalence has decreased from 0.41% in 2001 to 0.27% in 2011.
- ***Wider access to Anti-Retroviral Therapy (ART)*** has resulted in 29% reduction in estimated annual deaths due to AIDS.
- It is committed to achieving ***Millennium Development Goals (MDG)*** in reducing HIV mortality.

- Efforts are being made to reduce the number of HIV cases to zero and there is a long way to go for an "AIDS Free India".

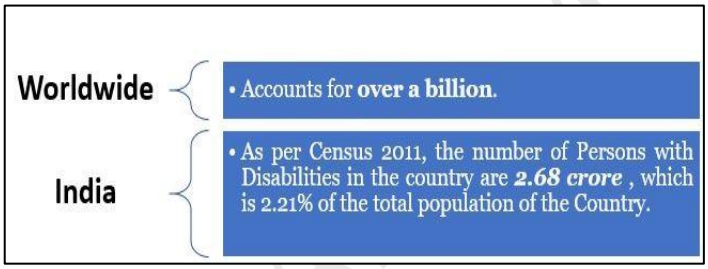
11.11 World Braille Day

Recently, the World Braille Day was observed on January 4th, to commemorate the birthday of Louis Braille.

- **Braille** – It is a tactile representation of ***alphabetic and numerical symbols using 6 dots*** to represent each letter, number and even musical, mathematical and scientific symbols.
- **Significance** – It is used by *blind and partially sighted people* to read the books and periodicals as those printed in a visual font.

*Braille, named after its inventor, **Louis Braille** i n 19th century in France.*

- **Demographic Status**:
- According to the Rights of Persons with Disabilities (RPWD) Act, 2016, there are **21 types of Disabilities** which includes Locomotor Disability, Visual Impairment, Hearing Impairment, Speech & Language Disability, Intellectual Disability, Multiple Disabilities, Cerebral Palsy, Dwarfism etc.



Initiatives for Visually Impaired Person

- **National Association for the Blind** – It aims to make approximately 10,000 pages of *documents of government schemes and legal reliefs*, accessible to persons with visual disabilities.
- **National Institute for the Empowerment of Persons with Visual Disabilities (NIEPVD) (Divyangjan)** – It works in the field of visual disability for the education, training, rehabilitation & empowerment of persons since 1943.
- **Model School for the Visually Handicapped (MSVH)** – It imparts *education to children* from the Bal Vatika to senior secondary level.
- **Braille Development Unit** – Contribution to the development of *Braille Codes* in different Indian languages.
- **National Accessible Library** – To provide *learning materials* in various accessible formats Braille, large print, audio and E-pub.
- **Braille Production** – NIEPVD infrastructure for printing Braille textbooks and magazines.
- It infrastructure comprises the *Central Braille Press established in 1951*, the Regional Braille Press established in 2008 at Chennai and 25 other Braille Presses established by the Government.
- The Braille literature in the following *14 languages*, that include Assamese, Bangla, English, Garo, Hindi, Khasi, Kannada, Lusai, Nagamese, Punjabi, Sanskrit, Telugu, Tamil and Urdu.

11.12 World Leprosy Day

Why in News?

The World Health Organization (WHO) has requested governments to prioritize leprosy elimination and ensure sustained funding for surveillance, treatment, care and support.

World Leprosy Day

- It is observed annually on the ***last Sunday*** of January since 1954.
- It was established by Raoul Follereau in honor of ***Mahatma Gandhi's*** compassion for leprosy patients.
- **Aim -** To raise public awareness about leprosy.
- **World Leprosy Day, 2025 – Theme** - 'Unite, Act, and Eliminate Leprosy'.

Leprosy

- It is a neglected tropical disease that primarily affects the nervous system.
- It is also known as Hansen's disease.
- **Caused by** – *Bacterium*, *Mycobacterium lapre*
- **Symptoms -** Most prominent in cooler parts of the body such as the hands, feet, and face.
- In some cases, body parts may lose their sense of touch and pain, increasing the likelihood of injuries such as cuts and burn.
- **Transmission** - It is not so contagious, repeated contact with nose and mouth droplets from someone with untreated leprosy can spread.
- **Treatment** - Leprosy is curable with antibiotics, Treatment usually lasts one to two years, and early treatment can prevent disability.
- **Global scenario** - In 2023, 1,82,815 new cases were reported from more than 100 countries, with 95% of those concentrated in 23 global-priority countries.
- 5.6% of the new cases were among children, with some countries reporting child rates exceeding 30%, indicating ongoing transmission.
- Elimination **-** *Jordan became the 1st country* to be verified and acknowledged by the WHO for elimination of leprosy, demonstrating what is possible with focused and concerted efforts
- Additionally, in 2023, 56 countries reported zero new case of leprosy.
- **Global Leprosy Strategy -** The Global Leprosy Strategy 2021-2030 has a vision of zero disease, zero disability and zero stigma and discrimination.
- **India -** It accounts for 53% of the global leprosy cases.
- As of recent statistics, India has successfully achieved the goal of eliminating leprosy as a public health problem, defined as having less than 1 case per 10,000 people.

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SHANKAR IAS