VISIONIAS
INSPIRING INNOVATION

PT 365

SCIENCE & TECHNOLOGY

Classroom Study Material (April 2024 to October 2024)

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SCIENCE AND TECHNOLOGY

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QUIZ

SMART QUIZ

You can scan this QR code to practice the smart quiz at our open test online platform for testing your understanding and recalling of the concepts.

Note to Students

Dear Students,

PT 365 document comprehensively covers the important current affairs of the last 1 year (365 days) in a consolidated manner to aid Prelims preparation.

In our endeavour to further enhance the document in the interest of the aspirants, the following additions have been incorporated:

Summarised infographics: Includes sphere such as

- **Key Applications:** With the help of the infographics applications of different technologies/ methods have been provided crisply.
- **Working of Technologies:** Various techniques are presented through interactive infographics.
- **Comparison/Differences:** Comparison between different **techniques/methods/ concepts** has been provided for holistic understanding.

Concept Corner: Key Concepts/Technologies have been covered holistically, followed by related developments

- It will enhance the readability and comprehension of the subsequent articles.

Tables: Interactive tables are included to present key **news updates** on topics such as space missions, missiles, and more.

Quiz: QR-based Smart Quiz will test your knowledge and ensure a more engaging and effective learning process.

Remember, success is the sum of small efforts repeated day in and day out. Stay consistent, stay motivated, and give your best!

Best Wishes
Team VisionIAS

Building Mental Resilience for UPSC CSE with VisionIAS Student Wellness Cell

The UPSC Civil Services Examination is one of the most prestigious exams in the country, bringing immense professional and personal satisfaction. However, the journey often involves overcoming loneliness, intense competition pressure, anxiety, and other psychological challenges. These issues can impact both your preparation and overall well-being.

At **VisionIAS**, we recognize the multifaceted nature of this journey. To support our students comprehensively, we have established a dedicated Student Wellness Cell. Since April 2024, our highly professional psychologists and experienced professionals have provided confidential and mindful support as per student needs.

From Stress Management to Academic Excellence

Enhancing Academic Performance: Effective stress management contributes to better academic outcomes.

Professional Mental Health Support: Seeking professional help is crucial for success in UPSC preparation.

Well-Supported Mind for Excellence: Mental well-being is essential for achieving success in UPSC exams.

Comprehensive Wellness Cell: Addressing various issues impacting mental health and academic performance.

Safe and Non-Judgmental Environment: A space for students to discuss issues and receive personalized support.

Confidential and Structured Support: Multiple, structured sessions based on the severity of the issues.

Common Issues and Our Approach

Our counseling services have addressed a variety of issues, including:

Anxiety and Hopelessness: Using Cognitive Behavioural Therapy (CBT) to promote positive thinking.

Lack of Motivation and Focus: Introducing time management strategies and SMART goal-setting.

Emotional Struggles: Providing a safe space for expression and techniques such as journaling and progressive muscle relaxation.

Social Isolation and Loneliness: Encouraging healthy social interactions and setting personal boundaries.

Family and Personal Issues: Offering advice on coping with family dynamics, personal loss, and significant life stressors.

Scan the QR code for more details

To support the larger student community, **VisionIAS** is now extending our counseling and wellness support to all students preparing for UPSC CSE, regardless of their coaching institute affiliation. Schedule a session by visiting our office at Apsara Arcade near Karol Bagh Metro Station or emailing ***student.wellness@visionias.in.***

Remember, seeking help is a sign of strength, not weakness.

1. BIOTECHNOLOGY

1.1. GENES AND RELATED CONCEPTS

Genes and Related Concepts

CONCEPT CORNER

Genes

» **Genes** are segments **of Deoxyribonucleic acid (DNA).**
- DNA is an important nucleic acid found in human cells along with **Ribonucleic acid (RNA).**
- **Chromosomes** are **thread like structures made of protein** and a **single molecule** of **DNA.**

» **Genome** is the entire set of DNA instructions found in a cell.

Comparison Between DNA and RNA

Parameters	DNA	RNA
Structure	Double-stranded helix	Single-stranded
Nitrogenous Bases	Adenine (A), Thymine (T), Cytosine (C), Guanine (G)	Has Uracil in the place of Thymine (T)
Function	**Stores genetic information** for inheritance	Regulates gene expression and plays key role in **protein synthesis**

Genome Editing (also known as Gene Editing)

» Enable scientists to change an organism's **DNA** sequence, leading to changes in physical traits, like eye color, and disease risk.
- Uses **Site Directed Nucleases (SDNs)** to make changes that may either be a small deletion, a substitution, or the addition of several nucleotides.
- SDN refers to the practice of cleaving DNA strands to affect the subsequent genome editing.

» **Key Gene Editing Technologies:**
- CRISPR/Cas9 (Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR)/Cas9),
- Zinc-finger nucleases (ZFNs),
- Transcription activator-like effector nucleases (TALENs) etc.

» **Genome editing** is **different** from **Genetic engineering (Genetic Modification)** in the sense that genome editing does not involve the introduction of **foreign genetic material** (called **transgene**), the latter does.

CRISPR/Cas9

» It changes genetic code or edits **DNA** at **particular locations.**

» **Working:**
- Works as **cut and paste mechanism on DNA Strands.** Genetic codes that need to be changed are identified.
- **Cas9 protein** is used as a **pair of molecular scissors to cut off a part from strand,** allowing modifications to the genome.

Genome sequencing

» Determines the exact order of base pairs in an individual's DNA strand.

Applications of Genome Sequencing

Predictive diagnostics and personalized healthcare Enable treatments for genetic diseases	**Paternity Testing** Confirms biological relationships	**Agricultural** Identifying **traits for higher yield,** disease resistance, and climate resilience.

1.1.1. NOBEL PRIZE IN MEDICINE 2024 (GENE REGULATION)

Why in the News?

Nobel Prize in Physiology or Medicine has been awarded to Victor Ambros and Gary Ruvkun for the discovery of **microRNA** and its role in **post-transcriptional Gene Regulation.**

Discovery of Victor Ambros and Gary Ruvkun

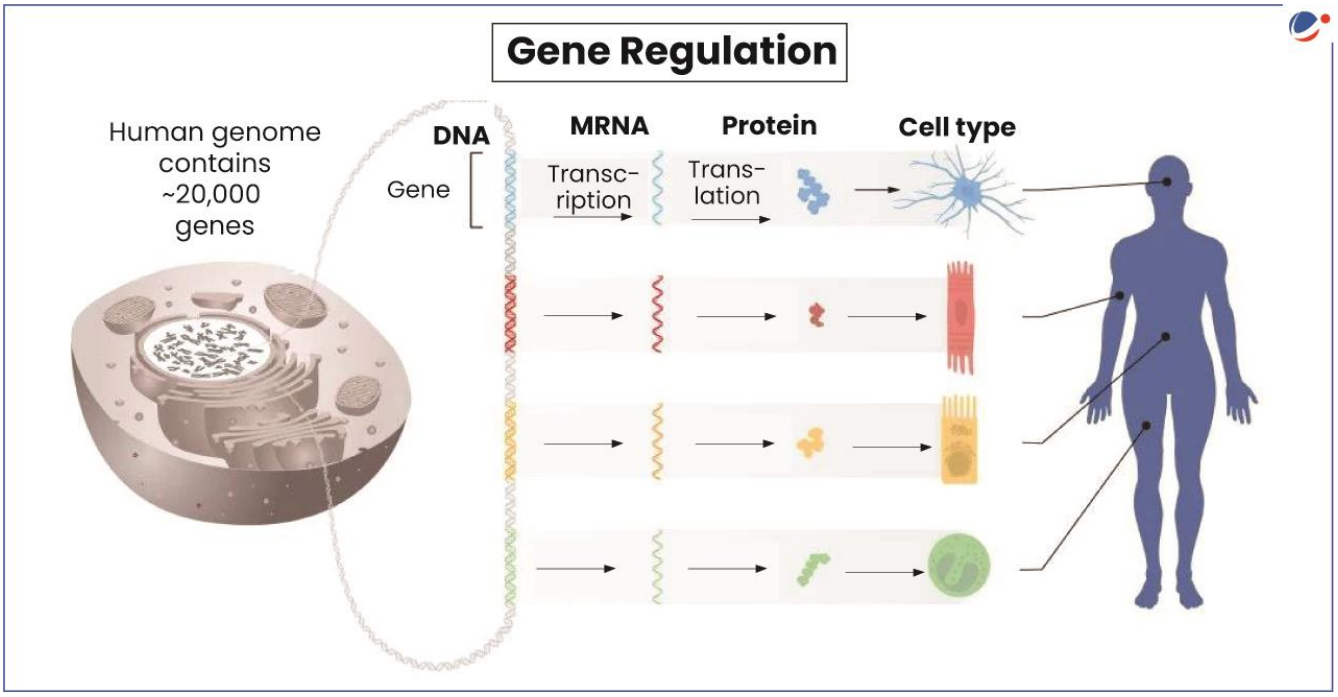
- In 1993, they discovered **microRNA and** its role in gene regulation after **transcription**.
  - Till 1993, it was believed that **gene regulation** is limited to **specialized proteins** called **transcription factors**, which bind to specific regions in **DNA** and determine which **messenger Ribonucleic acid (RNA)** (mRNA) is produced.
- They discovered the role of microRNA by investigating mutant **Caenorhabditis Elegans nematodes**.

About microRNA (miRNA)

- A small **non-coding RNA** that helps cells regulate gene expression.
- Controls gene expression by binding with **mRNA** and preventing them from being translated into proteins or by degrading or destroying mRNA altogether.
  - Proteins in the nucleus **regulate RNA transcription** and splicing while microRNAs control the translation and degradation of mRNA in the cytoplasm.

About Gene Regulation

- Refers to the process that controls the timing, location, and amount in which **genes (**out of many genes in a genome) are **expressed**.
- **Gene Expression:**
  - Human organs and tissues consist of **different cell types**, the chromosomes in the cell contain the same set of genes with the same set of instructions.
  - However, due to gene regulation, these **different cells** (like muscle cells, nerve cells, etc.) express unique sets of proteins, enabling them to perform their specialized function.



Significance/Application of the Discovery

- **Understanding Cellular Development:** E.g. Self-renewal and differentiation of stem cells

- **Immune Response:** Regulate innate and adaptive immune responses.
- **Oncogenesis:** To avoid healthy cells conversion to cancer cells.
- **Disease diagnostics:** E.g. Cancer

Related Concept
Reverse Transcriptase (RTs)

- Researchers found that when infected by viruses, bacteria (Klebsiella pneumoniae) use RNA to bind Reverse transcriptase.
- **About RT**
  - They are RNA-dependent DNA polymerases, a group of enzymes that play a unique role in the flow of genetic information.
  - These enzymes enable the reverse transcription reaction.
    - Reverse transcription is the **synthesis of DNA** from **an RNA template**.

1.1.2. GENETICALLY MODIFIED (GM) CROPS

Why in the News?

The Supreme Court pronounced a split verdict on the validity of the Union government's decision to grant approval for the environmental release of **Genetically Modified (GM) mustard crops** in 2022.

About GM Mustard Crop (DMH-11)

- **Developed by:** Centre for Genetic Manipulation of Crop Plants (Delhi University)
  - GM mustard **has not been released** for commercial cultivation yet.
  - It is India's first indigenously developed GM food crop.
- DMH-11 is a result of a crossing between two **mustard varieties** ('Varuna' and East European 'Early Heera-2').
- This cross has been done after introducing the **barnase** and **barstar gene** from the soil bacterium **Bacillus amyloliquefaciense**.

Other Genetically Modified (GM) Crops in India

- **Bt-Cotton: First** non-food and **only approved GM crop in 2002** for commercial cultivation.
  - It was introduced to protect against the **widespread infestation of bollworms** such as **Pink Bollworm (PBW).**
- **Bt-Brinjal:** In 2009, Bt-brinjal was cleared by GEAC for commercial cultivation, but it was put on a **moratorium**

Regulatory Framework of GM Crops in India

- **Food Safety and Standards Act, 2006:** Prohibits import, manufacture, use, or sale of GM food without FSSAI's approval.
- **Review Committee on Genetic Manipulation (RCGM):** Under the **Department of Biotechnology (DBT)**, this committee monitors various aspects of R & D projects involving GM organisms.
- **State Biotechnology Coordination Committee (SBCC):** Reviews the safety and control measures in various institutions handling Genetically Modified Organisms (GMOs).

- **District Level Committee (DLC):** Inspects, investigates, and reports to the SBCC or the **GEAC** about compliance.

Genetic Engineering Appraisal Committee (GEAC)

Genesis: Statutory committee constituted under the **"Rules for Manufacture, Use, Import, Export and the Storage of Hazardous Micro-organisations, Genetically Engineered Organisms or Cells, 1989 ".**
- The rules are framed under the **Environment (Protection) Act, 1986.**

Ministry: Ministry of Environment, Forest and Climate Change (MoEF&CC)

Responsibilities:
- Appraisal of proposals relating to the release of Genetically engineered (GE) organisms and products.
- Appraisal of activities involving large-scale use of hazardous microorganisms and recombinants in research and industrial production.

1.1.3. HERITABLE HUMAN GENOME EDITING (HHGE)

Why is the News?

South Africa becomes the first country to allow Heritable Human Genome Editing (HHGE).

About HHGE

- Unlike somatic cell editing, which affects only individuals, HHGE introduces **changes in germline cells (sperm, eggs, or embryos),** enabling these alterations to be inherited by offspring.
- **Potential Applications:**
  - **Disease Prevention:** These include Heritable diseases, Huntington's disease, and sickle cell anemia.
  - **Assisted reproductive technology:** Can improve technologies, such as in vitro fertilization (IVF).
- **Concerns:**
  - **Unforeseen consequences:** Germline genome edits would be heritable, and their effects could be multigenerational.
  - **Societal Impact:** Creation of "designer babies," where traits like intelligence, etc. might be engineered.

1.1.4. RNA EDITING

Why in the News?

The first successful clinical demonstration of RNA editing in humans was conducted.

More on the News

- Wave Life Sciences has successfully performed **RNA editing to treat alpha-1 antitrypsin deficiency** (AATD, an inherited disorder).
- In AATD, levels of **protein α-1 antitrypsin build up** and **affect the liver and lungs**.

About RNA (Ribonucleic acid) Editing

- A process that **modifies genetic information on RNA sequences** through insertion, deletion or substitution.
- Scientists used a technique called '**Adenosine Deaminase Acting on RNA (ADAR)'** with guide RNA (gRNA). (refer image)
  - **gRNA** are **small RNA molecules** that **direct editing machinery by base-pairing with mRNA** in specific regions for modification.

Comparison between RNA and DNA editing

- **Form of change: DNA editing** makes **permanent changes** while **RNA editing** makes **temporary changes.**
  - Thus, RNA editing is **safer and flexible** compared to DNA editing which may result in **irreversible errors.**
- **Allergic and immune reactions**: **DNA editing** has a **higher risk** of undesirable reactions compared to RNA editing.
  - DNA editing tools use **proteins** from **certain bacteria** to perform **cutting functions** while RNA editing relies on **ADAR enzymes**, already occurring in the **human body**.

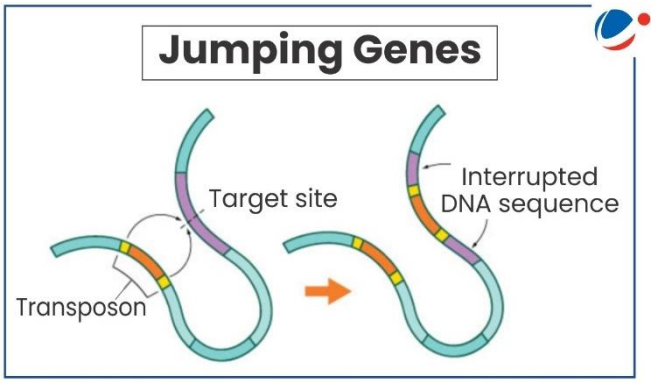
1.1.5. BRIDGE RECOMBINASE MECHANISM (BRM)

Why in the News?

Scientists discovered a naturally existing DNA editing tool - Bridge Recombinase Mechanism (BRM) which utilizes **mobile genetic elements or "jumping genes"**.

About BRM

- **Extra DNA** at the ends of jumping genes **gets joined together** and converts the DNA double helix structure into a **single-stranded RNA molecule**.
- This **bridge RNA molecule** can **bind to two DNA segments (donor and target)**, allowing for **flexible DNA modifications**.



About Jumping Genes

- Jumping genes are **DNA sequences that move from one location** on the **genome to another.**
- These are also known as **transposable** elements.
- These small DNA segments contain **recombinase enzyme** along with **extra DNA segments at the ends of the genes** that bind and manipulate DNA.
  - They can **replicate themselves** and **insert copies at new locations.**
  - Their movement can **cause genetic mutations and contribute to genome evolution.**

1.1.6. ONE DAY ONE GENOME

Why in the News?

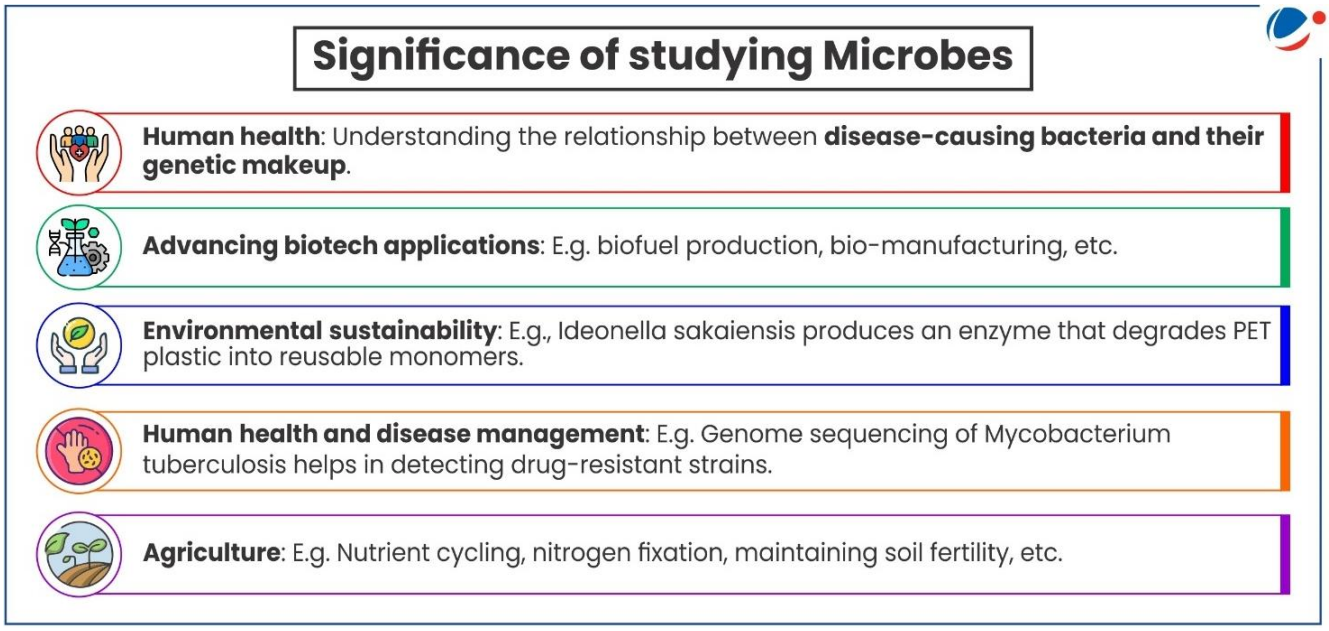
The Department of Biotechnology (DBT) and **Biotechnology Research and Innovation Council (BRIC)** launched the **'One Day One Genome'** initiative on 1st foundation day of **BRIC**.

About One Day One Genome

- **Aim**: An **annotated microbial genome will be publicly released every day** to make microbial genomics data more accessible to researchers.
- It will highlight the **unique bacterial species** found in our country.

About Microbial Genomics

- It is the scientific field that studies the complete genetic material of microorganisms to understand their **structure, function, evolution,** and interactions with other organisms.
- Microbes (or microorganisms) are too **small to see with the naked eye**. E.g., bacteria, algae, etc.



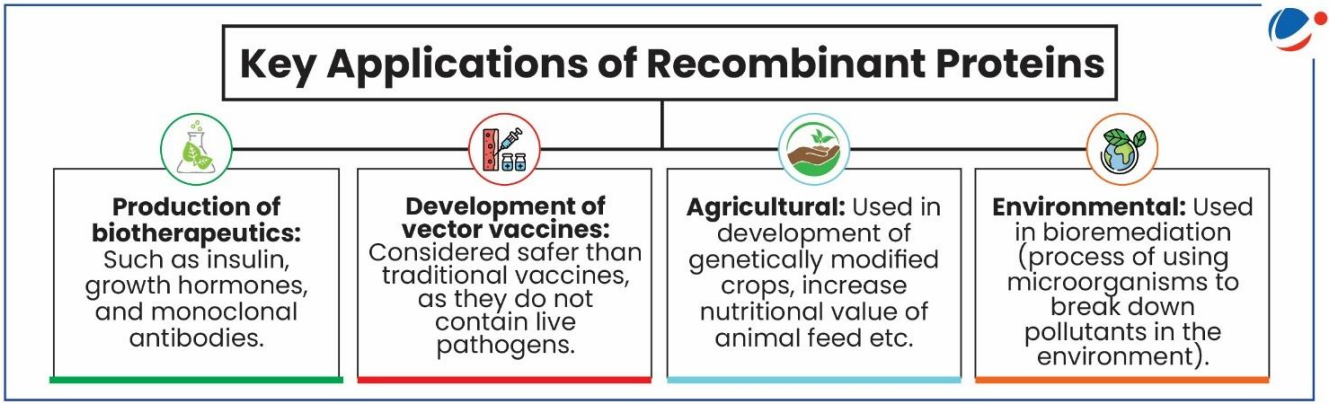
1.1.7. OTHER DEVELOPMENTS

1.1.7.1. RECOMBINANT PROTEINS

Researchers at the Indian Institute of Science (IISc) have developed a **new process for production of recombinant proteins**.

What are Recombinant Proteins (RPs)?

- Recombinant proteins are proteins that are artificially produced using genetic engineering techniques.
- These are modified or manipulated proteins encoded by recombinant DNA (rDNA).
  - **rDNA** is an **artificially made DNA strand** that is **formed by the combination** of two or more DNA molecules.
  - rDNA technology can be used to **combine (or splice) or transfer DNA from different species or to create genes** with new functions.
- **Production:**
  - RPs such as **monoclonal antibodies** (**moAbs or mAbs)**, are **mass-produced by growing modified bacterial, viral, or mammalian cells** in large bioreactors.
    - > **mAbs** are **lab-made proteins mimicking natural antibodies.**



1.1.7.2. TMESIPTERIS OBLANCEOLATE (FERN WITH LARGEST GENOME)

New research shows that Tmesipteris oblanceolata, a species of fork fern, has the **largest genome**.

About Tmesipteris Oblanceolata

- Contains **160 billion base pairs** (the units that make up a strand of DNA) outstripping the human genome by more than 50 times.
- Belongs to a **primordial group of plants** that evolved long before dinosaurs set foot on the earth.

1.1.7.3. DNA REPAIR

Recently, scientists have discovered a new target for cancer treatment which is used by cancer cells to regulate DNA repair during Cell division.

- Cancer cells **use the enzyme TDP1** (**Tyrosyl-DNA phosphodiesterase 1)** to **repair DNA damage** caused by chemotherapy drugs like camptothecin, leading to treatment resistance.
    - **TDP1** is an important **enzyme in humans** that plays a **crucial role in DNA repair by removing damaged DNA bases.**

About DNA Repair

- DNA repair is a **mechanism** of a cell to **maintain the integrity of its genetic code**.
- Exists in both **prokaryotic and eukaryotic organisms.**

1.1.7.4. PLANT GENOME EDITING TOOL ISDRA2TNPB'

ICAR recently developed a miniature plant genome editing tool **ISDra2TnpB.**

- **TnpB** proteins are considered the **evolutionary ancestors of Cas12 nucleases.**

About Genome editing tool ISDra2TnpB

- Derived from bacteria called **Deinococcus radiodurans** (it can survive extreme environmental conditions).
- Belongs to a family of **jumping genes**.
- **Significance**
    - TnpB **can target unique regions in the genome** that **Cas9** and **Cas12 cannot**.
    - **Facilitates the creation of fusion proteins** (chimeric protein), created by joining two or more genes that originally coded for separate proteins.

1.1.7.5. EXOSOMES

An exosome-based gene editing platform **SafeEXO-Cas,** has been developed by Scientists at Columbia University.

About Exosomes

- **Exosomes** are naturally occurring vesicles that have the potential to be manipulated to become **promising drug delivery vehicles**.
- Exosomes are membrane-enclosed vesicles actively released into the extracellular space.

1.2. GENE THERAPY

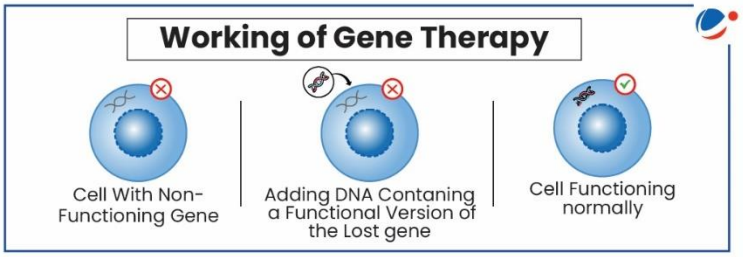
Gene therapy

CONCEPT CORNER

Gene therapy

» A technique that uses a gene(s) to treat, prevent, or cure a disease or medical disorder.

- In most gene therapy, a **normal gene** is inserted into the **genome** to supplement an **abnormal disease-causing gene** and **restore the target cell** to a normal state.
- It uses products/methods such as **Plasmid DNA** (Genetically engineered Circular DNA molecules), etc.



Types of Gene Therapy

- **Germline gene therapy:** In it, the Germline cells (egg or sperm) are modified by the introduction of functional genes.
- **Somatic cell gene therapy:** In this, therapeutic genes are transferred to a patient's somatic cells (cells other than germline cells).

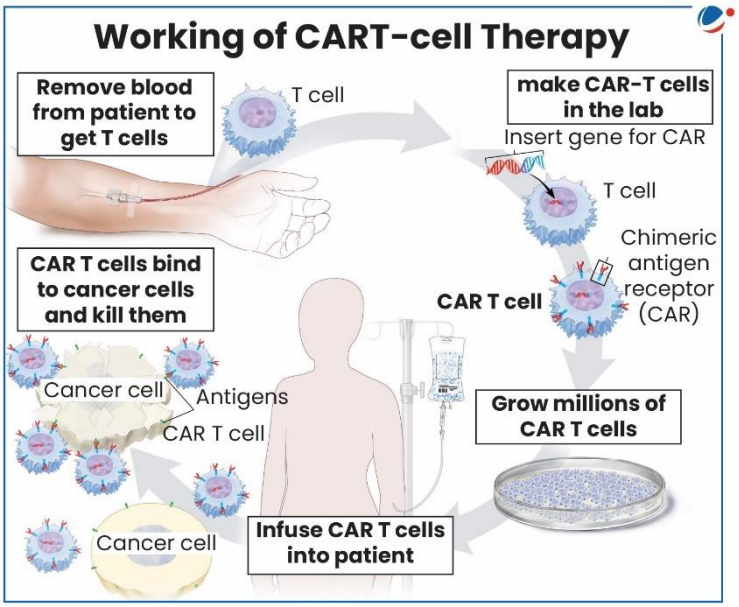
Application:

- Both inherited genetic diseases (e.g., sickle cell disease, Haemophilia A) and acquired disorders (e.g., leukemia) could be treated.

1.2.1. CHIMERIC ANTIGEN RECEPTOR (CAR) T-CELL THERAPY

Why in the News?

India's first homegrown gene therapy **NexCAR19 CAR-T cell Therapy** for cancer has been launched by the President of India.



More on the News

- NexCAR19 CAR-T cell Therapy has been developed by the **Indian Institute of Technology (Bombay),** and others.

About Chimeric Antigen Receptor (CAR) T-cell therapy

- **Modifies immune cells, specifically T-cells,** by turning them into potent cancer fighters known as **CAR-T cells**.
  - **T-cells** are special cells (types of white blood cells) whose primary function is cytotoxic, meaning killing other cells.
- T-cells are taken from patient blood and are changed in the lab by **adding a gene for a man-made receptor (called CAR).**
  - CARs are proteins that assist the T-cells to **recognise and attach to a specific protein present in cancer cells.**

- This therapy is considered as a "**living drug**".
- **Benefits of the CAR T Cell therapy:**
  - Can treat cancer for an extended period, with the potential to cure specific cancers completely.
  - Short treatment time is needed and more rapid recovery.
- **Challenges:** CAR-T cell Therapy for one cancer won't work for another type of cancer, and can have negative effects on the nervous system, risk of infection, etc.

1.3. STEM CELL

Why in the News?

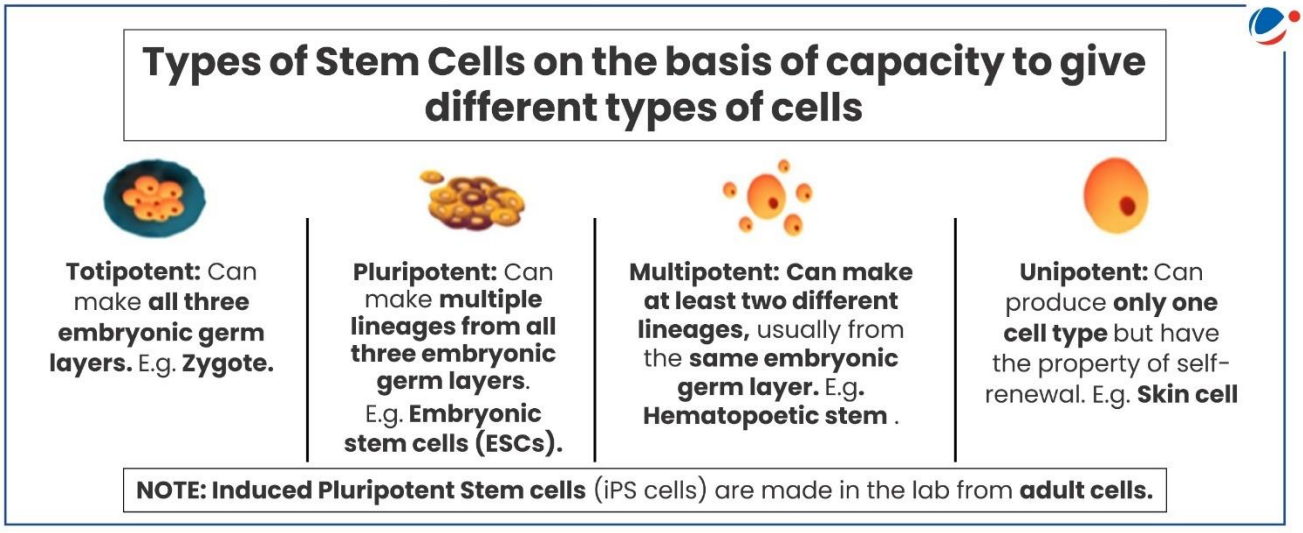
For the **first** time**, a Type 1 diabetic** woman was treated by using cells derived from her own body after a reprogrammed stem cell transplant.

More on the News

- **Allogeneic stem cell transplantation** was performed, it uses stem cells from someone other than the patient.
  - Allogeneic stem cell transplantation is a kind of **Stem cell therapy (SCT)**.
- In **type 1 diabetes**, the pancreas does not make insulin, because the body's immune system attacks the islet cells in the pancreas that make insulin.
  - In **diabetes type 2**, the pancreas makes less insulin than used to.

About Stem Cells

- A cell with the **unique ability** to develop into specialised cell types in the body.
- **Two unique properties**:
  - Can divide over and over again to produce new cells andand replace specialised cells that are damaged or lost.
  - As they divide, they can change into the other types of cells that make up the body.
- **Major sources**: **Embryos** and **adult tissues** (adult stem cells).



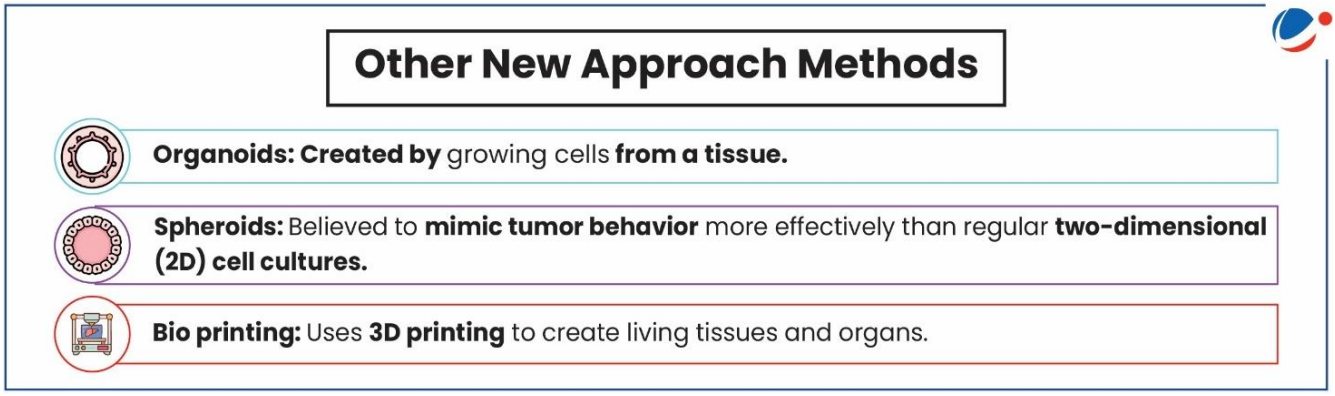
1.4. ORGAN-ON-CHIP (OOC) TECHNOLOGY

Why in the News?

Organ-on-chip technology could boost BioE3 (Biotechnology for Economy, Environment, and Employment) Policy goal to personalize medicine.

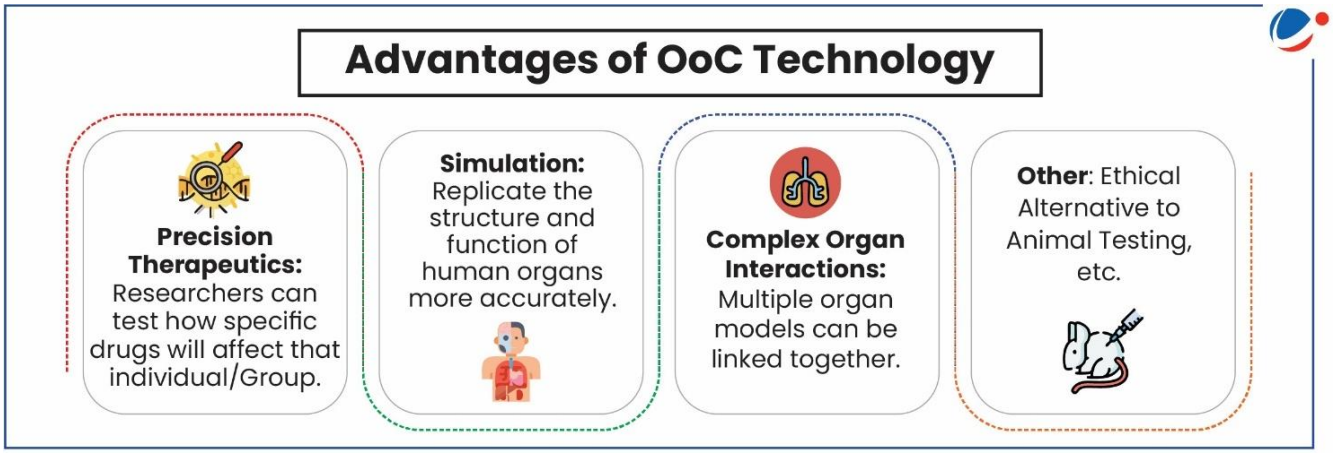
About Organ-on-Chip (OoC) Technology

- Refers to **micro-scale system** used for **mimicking the human body environment.**
  - One of the **human-relevant 3D culture models,** also known as **'New Approach Methods' (NAMs).**
    - 3D culture system allows researchers to recreate human organs and diseases in one dish.
- **Control the movement and behaviour of materials and cells** by using channels, chambers, membranes, etc.



How does organ-on-a-chip technology work?

- **Cells** are placed on a chip and allowed to grow into **3D structures with the help of a polymer** that resembles real tissue in the human body.
- Uses tiny fluid channels that **simulate blood flow,** oxygen delivery, nutrient transport, etc. to create **miniature models of biological organs (lung, heart, etc.)** on a chip-sized device.



Steps Facilitating the development Organ on chip technology in India

- **Amendment of New Drugs and Clinical Trials Rules 2019:** Permits the use of human organs-on-chips.
- **Genome India Project (GIP):** 10,000-genome Database will be available to researchers across the globe under it.
  - Launched in **2020** by **the Department of Biotechnology.**
  - **Indian Biological Data Centre (IBDC),** the **first national repository for life science data,** will facilitate a database to researchers.
- **Phenome India Project:** By CSIR, for generating a comprehensive phenome database
  - The **phenome** is the entire set of **phenotypes** (set of observable characteristics or traits) in a cell, tissue, organ, organism, or species.

Related News

Chimeroids

- For the first time, scientists have successfully grown 3D brain models, known as "chimeroids,"
- They are grown using stem cells from **multiple individuals**.
- **Benefits**: Accurately replicate human brain biology compared to traditional 2D cellular models or animal models like lab mice.

1.5. MITOCHONDRIA

Why in the News?

Researchers studied Mitochondrial dynamics to treat **Parkinson's Disease**.

More on the News

- **Parkinson's disease** is a **neurodegenerative disease caused by the death of brain cells**.
- Researchers have found that **inhibiting Dynamin-related protein (Drp1) activity could restore mitochondrial function** and serve as a potential treatment.
    - **Drp1 protein travels to mitochondria** when they divide into smaller sizes **for higher mobility and quality control.**

About Mitochondria

- Mitochondria are **membrane-bound cell organelles** that generate most of the cell's energy in the form of **ATP (Adenosine Triphosphate).**
- **Functions**
    - **Energy Production:** Sites of **aerobic respiration**, producing ATP, hence termed the **powerhouses of the cell.**
    - **Genetic Material**: Contains **its own circular DNA (Mitochondrial DNA or mtDNA)**, RNA, ribosomes, and components for protein synthesis.
        - mtDNA is useful for **tracing genetic lines.**
        - **mtDNA is inherited exclusively from the mother**, making these **diseases maternally inherited.**

Related Concept
Mitogenome

- The latest study on the South African Leopard's mitogenome revealed their possible origin.
- **About Mitogenome**
    - A **small circular chromosome** found inside the **mitochondria**.
    - **Built of double-stranded DNA** similar to the nuclear genome and entirely maternal.
    - **Nuclear genomes are inherited equally from both parents.**

1.6. UNIFIED GENOMIC CHIP

Why in the News?

Prime Minister launched **Unified Genomic Chip** and **indigenous sex-sorted semen technology for the benefit of livestock in India**.

About Unified Genomic Chip

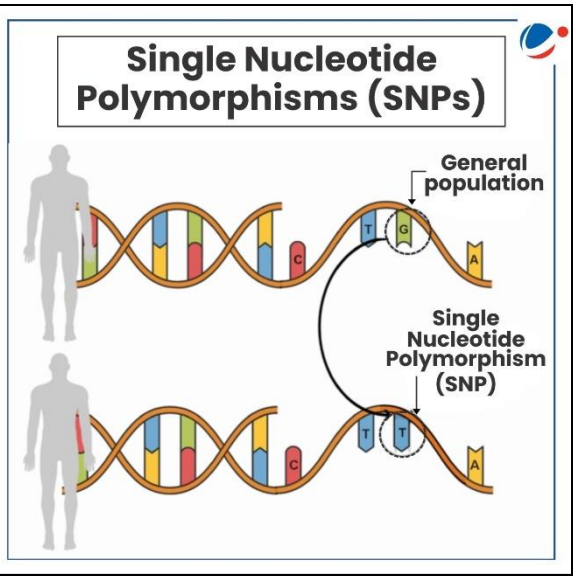
- A **Single Nucleotide Polymorphism (SNP)** chip.
- **Objective**: Designed for **genomic profiling** and **evaluation** of **Indian cattle breeds.**
    - Enables the direct application of **DNA technologies** to enhance the **genetic potential** (genetic improvement) of diverse dairy animal.
- **Variants of the chip**:
    - **Gau** chip for cattle

- **Mahish** chip for buffaloes

- **Developed by**: Consortium led by the **Department of Animal Husbandry and Dairying (DAHD),** Ministry of Animal Husbandry, Dairying and Fisheries.

About Single Nucleotide Polymorphisms (SNPs)

- Refers to a variation in a DNA sequence where a single nucleotide is different from the reference sequence.
  - An **SNP** may replace the nucleotide **Guanine** (G) with the nucleotide **thymine (T)** in a certain stretch of DNA.
- These are the most common type of **genetic variation among people**.
- They can act as **biological markers (or biomarkers)**, helping scientists locate genes that are associated with disease.



About Sex-sorted Semen Technology

- Sex Sorted Semen is the **'gender selected' semen used in Artificial Insemination (AI)** for cattle and buffaloes.
- Ensures the birth of only female calves with more than 90% accuracy whereas conventional semen produces equal proportion of male and female (50:50) calves.
- **National Dairy Development Board (NDDB)** has developed the indigenous technology of sex sorted semen.

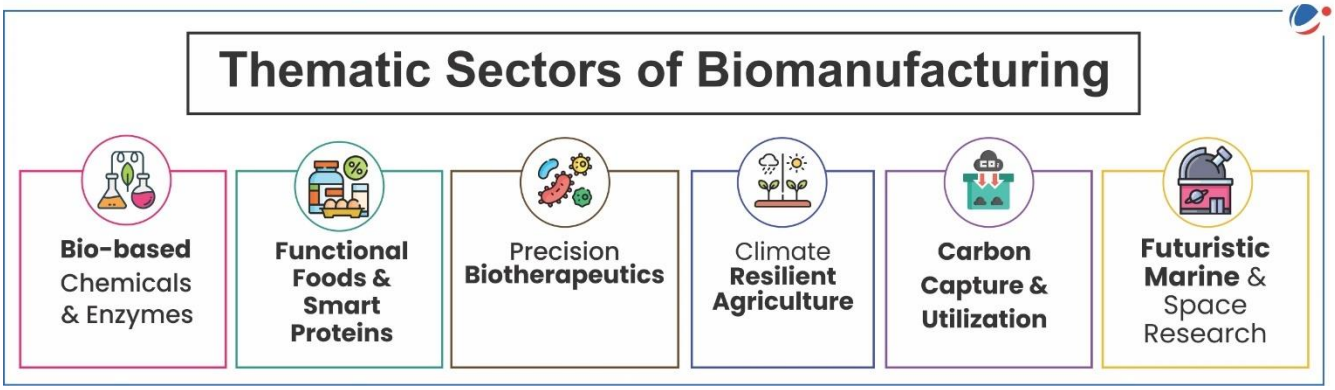
1.7. BIOE3 POLICY (BIOTECHNOLOGY FOR ECONOMY, ENVIRONMENT AND EMPLOYMENT)

Why in the News?

The Union Cabinet has approved the BioE3 (Biotechnology for Economy, Environment and Employment) Policy for "Fostering High-Performance Biomanufacturing."

About BioE3 Policy

- **Aim:** Establish a framework to adopt advanced technologies and align research to revolutionize biomanufacturing processes.
  - **Biomanufacturing** refers to using engineered microbial, plant, and animal (including human) cells with increasing precision and control to produce commercially important products on scale.
- **Implementation Agency**: Department of Biotechnology (DBT)
- **Key Target**: Policy aims to achieve a **US $300 billion** bioeconomy by 2030.
  - **Bioeconomy** is "the production, use and conservation of biological resources, including related knowledge, science, technology, and innovation to provide information, products, processes and services to all economic sectors.
- **Salient Features:**
  - It includes innovation-driven support to **R&D** and entrepreneurship across **six thematic sectors.**
  - The research and translational activities under **thematic sectors** will be catalyzed by **Bio-Artificial Intelligence (AI) Hubs: Integrating AI**, and **Biomanufacturing Hubs**.



Related News

Biotechnology Research Innovation and Entrepreneurship Development (Bio-RIDE) Scheme

- Union Cabinet recently approved the Bio-RIDE Scheme.
- **About Bio-RIDE Scheme**
  - **Nodal Department:** DBT, Ministry of Science & Technology
  - **Three Components:** It combines two existing schemes with a new third component:
    - **Biotechnology Research and Development (R&D)**
    - **Industrial and Entrepreneurship Development (I&ED)**
    - **Biomanufacturing and Biofoundry (B&B),** this new component aims at furthering India's goal of **creating a Circular Bioeconomy** in **alignment with the Lifestyle for the Environment (LiFE) mission.**

1.8. OTHER IMPORTANT NEWS

1.8.1. ENDOSYMBIOTIC THEORY

Researchers have discovered **a type of organelle**, called **nitroplast**, in a marine algae ***Braarudosphaera bigelowii***, that can fix nitrogen.

Key Findings

- It is generally believed that nitrogen fixation **only occurs in bacteria** and **archaea** but **Braarudosphaera bigelowii** marks the **first known nitrogen-fixing eukaryote**.
  - **Nitrogen fixation** is a biological process in which **nitrogen gas is converted into a usable form** for cell growth.
- This generated interest in **Endosymbiotic theory**

About Endosymbiotic theory

- Posits that some eukaryotic cell organelles, such as mitochondria and plastids, evolved from free-living prokaryotes.
  - **Eukaryotic cells** have a membrane-bound nucleus which stores the genetic information.
  - In **prokaryotes**, DNA is bundled together in the nucleoid region, but it is not stored within a membrane-bound nucleus.
- Some of these organisms ingested prokaryotic cells that then survived within the organism and developed a symbiotic relationship.

1.8.2. WOLBACHIA BACTERIA

Recently, a study has highlighted that **Wolbachia bacteria** had manipulated the wasp Encarsia Formosa to get rid of its males entirely.

About Wolbachia Bacteria

- Commonly found in nematodes and arthropods, especially insects.
- In insects, these are **present in eggs** but **absent in the sperm**. Due to this, females can transmit them to their offspring whereas males can't.
  - As a result, Wolbachia have evolved ways to manipulate their insect hosts to produce more female than male progeny.
  - **Tra gene** of Wolbachia plays a key role in showing this feature.
- **Potential Application**: Mosquitoes with Wolbachia can be used to reduce the numbers of target mosquito species, such as Aegypti mosquitoes.
  - Also, the population of mosquitoes can be controlled by genetically modifying them with the help of Laboratory Methods (introduces **self-limiting genes**) and Gene Drive Technology (GDT).
    - > **GDT** is a type of **genetic engineering technique** that **modifies genes** so that they don't follow the typical rules of heredity.

1.8.3. HAYFLICK LIMIT

Leonard Hayflick passed away recently, who introduced the 'Hayflick limit' that changed the understanding of aging.

About Hayflick limit

- Refers to the number of times a **cell population** can **divide** until it attains a cell cycle arrest.
- Depends on the length of **chromosomal telomeres**, which decreases in standard cells with every cell division.
  - **The telomere** is the **region of repetitive DNA sequences** at the end of a chromosome.
- The "Hayflick limit" is around 125 years for humans.

2. NANOTECHNOLOGY

Nanotechnology

CONCEPT CORNER

Nanotechnology

- Involves working with materials and devices at the nanoscale, typically ranging from **1 to 100 nm in size** (nanoparticle).
- On the **nanometer scale,** materials may exhibit unusual properties. Their properties depend on shape, size, surface characteristics, and inner structure.
- **Types:**
  - **Natural nanomaterials:** E.g. Volcanic ash
  - **Artificial nanomaterials:** E.g. Carbon Nanotube
- **Concern/Challenge:** Potential toxicity of nanoparticles to humans and the environment.

Key Applications of Nanotechnology

	**Agriculture: Nanofertilizers** (nutrient uptake with **90-100% utilization efficiency**), **Nanobiosensors** (Monitor soil conditions), etc.
	**Health:** Better imaging and diagnostics, Targeted Drug Delivery, etc.
	**Energy: Nanostructured solar cells** could be **cheaper** to **manufacture and easier** to **install,** etc.
	**Environment:** Nanomaterials can be employed in **water purification and desalination technologies** etc.
	**Electronics and IT:** Quantum dots and other nanostructures can be used to develop **advanced displays, lighting,** etc.
	**Other: Cosmetics** (uses nanoparticles of some metallic oxides), etc.

2.1. NANO FERTILISERS

Why in the News?

Indian Farmers Fertiliser Cooperative Limited (IFFCO) got the Fertiliser (Control) Order, 1985 (FCO) approval for Nano Zinc and Nano Copper liquids.

Nano Fertilisers

- Nano fertilizers are nutrients encapsulated within a nanomaterial to enable **controlled release** and subsequent **slow diffusion into the soil**.
- Nano Zinc and Nano Copper liquids would help effectively address the deficiency of micronutrients.
  - **Zinc**: Enzyme functioning in plants, plant growth and development, etc.
  - **Copper**: Enzymatic activities in plants and chlorophyll and seed production
- Earlier, IFFCO's **nano-liquid urea** and **nano-liquid Di-Ammonia Phosphate (DAP)** were also approved.

Other Government Initiatives on Nanotechnology in Agriculture

- **Mission on Nano Science and Technology (Nano Mission),** 2007, under the Department of Science & Technology (DST).

- **Others**:
  - **Skill development training programme on nanotechnology** by ICAR
  - **Nano Fertilizer Plant (NFP),** established by IFFCO at Phulpur, Prayagraj.

2.2. OTHER DEVELOPMENTS

2.2.1. GOLDENE

Scientists have developed a sheet of Gold, called Goldene, which is just one atom thick.

About Goldene

- Created by **sandwiching silicon between titanium carbide layers**, depositing gold, allowing gold atoms to replace silicon, forming a monolayer.
- 400 times thinner than the thinnest commercially available gold leaf.
- **Potential applications**: Catalyst in the electronics industry, carbon dioxide conversion, hydrogen generation, etc.

2.2.2. FLUORESCENT NANODIAMOND (FND)

Recently, Scientists, levitated and spun fluorescent nanodiamonds at incredibly high speeds to observe how the rotation affected the **spin qubits** in a unique way known as the **Berry phase**.

About Fluorescent Nanodiamond (FND)

- FNDs are nanometre-sized diamonds made of carbon nanoparticles.
  - **Fluorescence** is the property of some materials to emit light of lower frequency when irradiated with light of a higher frequency.
- They are produced in a high-temperature and high-pressure process
- **Key Property**: Remains stable under light and isn't toxic to living things
- **Key Applications:** High-resolution imaging, microscale temperature sensing, and correlative microscopy, and to track cells and their progeny over long periods.

2.2.3. PIEZOELECTRIC POLYMER

Researchers from the **Centre for Nano and Soft Matter Sciences** (CeNS) have developed a security alert system based on **Piezoelectric Polymer nanocomposite**.

About Piezoelectric Polymer

- Piezoelectric polymers can **generate electric charges** on the surface under **pressure** or **strain**, thus converting mechanical energy into electrical energy.
- **Advantages:** They are widely used due to their **flexibility, lightweight, and processability.**
- **Applications**: Sensors, wearables, medical implants, consumer electronics, etc.

3. IT AND COMPUTER

3.1. ARTIFICIAL INTELLIGENCE

Artificial Intelligence & Related Terms

CONCEPT CORNER

Artificial Intelligence (AI)

» AI is a technology that **enables computers** and machines to simulate human learning, comprehension, problem-solving, decision-making, creativity, and autonomy.

Stages of AI

Artificial Narrow Intelligence (ANI)	Artificial General Intelligence (AGI)	Artificial Super Intelligence (ASI)
Stage One: Machines imitate human behavior, specializing in one area to solve a problem. i.e. Siri, ChatGPT, Alexa	**Stage Two:** Machines can continuously learn and are as smart as humans.	**Stage Three:** Machines that are smarter than humans across the board.

Generative AI

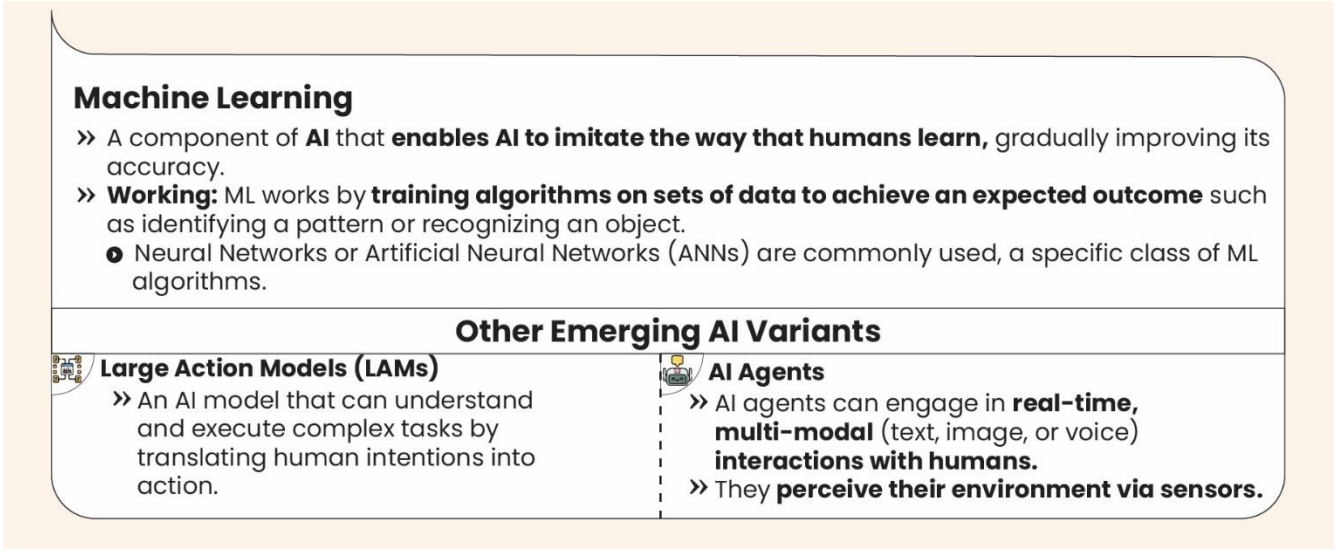
» AI that can create original content—such as text, images, video, audio, or software code.
» Its tools are built on underlying AI models, such as **LLM,** which is the foundation for text-based generative AI tools like ChatGPT.
» It **relies on deep learning models -** algorithms that simulate the learning and decision-making processes of the human brain.

Comparison Between Traditional AI and Generative AI

Parameters	Traditional AI	Generative AI
Key Focus	Analyzes data, performs specific tasks and automate decision making.	Creates new data (text, images, music etc.)
Learning Approach	Explicit rules and algorithms	Data-driven learning (Neural Networks)
Output	Structured outputs such as predictions, solutions or classifications	Entirely new content or creative outputs
Adaptability	Require manual intervention and reprogramming	Automatically adjust and improve its performance over time

Large Language Models (LLMs)

» A category of foundation models (large AI models) **capable of understanding and generating natural language** and other types of content to perform a wide range of tasks.
» These work by **learning patterns from vast amounts of data** and interpreting human language.
» These are typically based on a type of **neural network** called **transformer architecture** and consist of **multiple layers of neural networks and self-attention mechanisms** that enable them to learn patterns.



3.1.1. NOBEL PRIZE IN PHYSICS 2024 (ARTIFICIAL NEURAL NETWORKS (ANNS))

Why in the News?

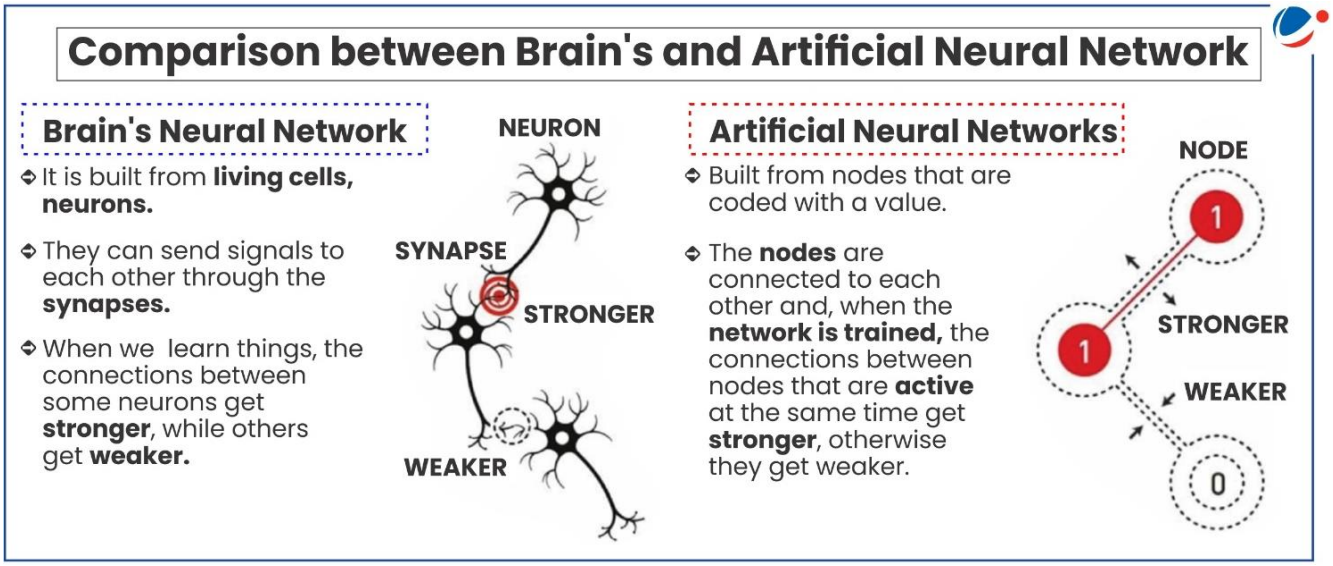
John J. Hopfield and **Geoffrey Hinton** have been awarded the Nobel Prize in Physics 2024 for their foundational discoveries and inventions, which **enable Machine Learning (ML)** with **Artificial Neural Networks (ANNs)**.

Discoveries that were awarded Nobel Prize

- **John Hopfield invented** the **Hopfield network**, a type of **recurrent neural network** that can **store and reconstruct information**.
  - This network works like a memory system, where they can **store patterns (like images) and retrieve them.**
  - The network relies on Donald Hebb's hypothesis—when neurons act together, they can **enhance the network's capability** to process and store information.
- **Geoffrey Hinton** invented a method (**Boltzmann machine**) that can **independently discover properties in data**.

Artificial Neural Networks (ANNs)

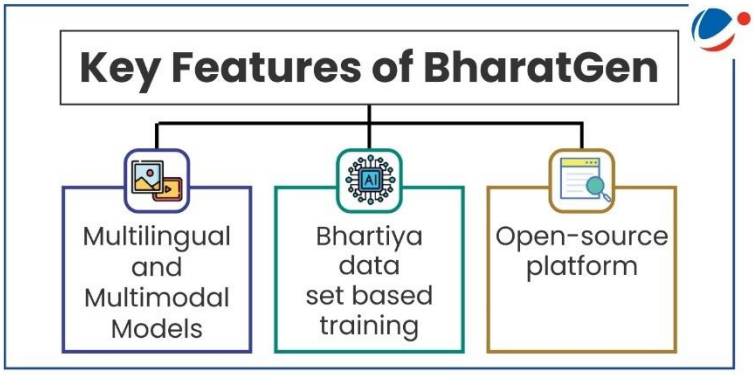
- **Definition: ML program or model** that makes decisions like **the human brain**, by using processes that mimic the way **biological neurons work together** to identify phenomena, weigh options, and arrive at conclusions.
- **Working: Human brain is the inspiration** behind neural network architecture.
- ANN that closely mimic natural neural networks are known as **Spiking Neural Networks (SNNs)**.
- **Major types of ANN:**
  - **Deep Neural Networks:** Network with many layers, each building on the previous layer.
  - **Convolutional Neural Networks (CNNs):** Detect features and patterns in images and videos
  - **Generative Adversarial Networks (GANs):** Used to create new data resembling the original training data.



3.1.2. BHARATGEN PROGRAMME

Why in the News?

Ministry of Science and Technology launched **BharatGen**, a pioneering initiative in **Generative Artificial Intelligence (AI)**.



About BharatGen Programme

- A **Multimodal LLM** project focused on creating **Generative AI systems** that can generate **high-quality text and multimodal content (audio** and **imagery)** in various Indian languages.
- **Aim and Purpose**:
  - To revolutionize **public service delivery and boost citizen engagement.**
  - Crafting a **path tailored to India's diverse linguistic, cultural,** & **societal fabric**.
- **Implementing Agency: TIH Foundation for IoT & IoE (TIH-IoT)** under the **National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS)**.
- **Timeline:** Project is expected to be completed in **two years (July 2026)**.
- **Bharat Data Sagar:** Aims at establishing a vast repository of India-centric data that ensures the AI models are deeply rooted in the country's unique context.

National Mission on Interdisciplinary Cyber Physical Systems (NM-ICPS)

- **About:** A comprehensive mission approved in 2018.
- **Aim:** To promote **translational research in Cyber-Physical Systems (CPS)** and associated technologies
- **Implementing Agency:** Department of Science & Technology (DST)

Other initiatives taken to promote AI Ecosystem in India

- **IndiaAI Mission:** implemented by **'IndiaAI' Independent Business Division (IBD) under Digital India Corporation (DIC)** under **the ministry of Ministry of Electronics and Information Technology.**
- **National AI Portal (INDIAai):** Joint venture by MeitY, National e-Governance Division (NeGD) and NASSCOM.
- **AI Research Analytics and Knowledge Dissemination Platform (AIRAWAT):** For providing a common compute platform for AI research and knowledge assimilation.

- **Global Partnership on Artificial Intelligence (GPAI):** To guide the responsible development and use of AI.
  - **India** is a **founding member**.
- **Other**: **National AI Skilling Program,** YuvaAI initiative for Skilling and Capacity Building, Srijan (GenAI Centre of Excellence), etc.

3.1.3. FACIAL RECOGNITION TECHNOLOGY

Why in the News?

NITI Aayog released '**White Paper: Responsible AI for All (RAI) on Facial Recognition Technology (FRT)**'.

About Facial Recognition Technology (FRT)

- An AI system that allows the **identification or verification of a person based on certain images or video data** using complex algorithms.
- FRT can be used for **two purposes:**
  - **1: 1 verification of identity:** Facial map is obtained for matching it against the person's photograph on a database. **E.g. 1.1 is used to unlock phones**.
  - **1: n identification of identity**: Verification **against the entire database** to identify the person in the photograph or video. **E.g. 1: n is used for mass monitoring and surveillance.**

Key applications of FRT

- **Security Related Uses**
  - **Law and order enforcement**: E.g. **Identification of Persons of Interest** or **Missing Persons.**
  - Crowd Control (E.g. Divya Drishti)
- **Non-Security Related Uses**
  - **Verification and authentication of individual identity** for access to products, services, etc**. E.g., Using Aadhar Card for Authentication based on Facial Recognition.**
  - **Airports:** E.g., contactless onboarding **at airports through Digi Yatra**.
  - **Banking**: Facial recognition is safer as there are no passwords for hackers to compromise.

3.1.4. OTHER DEVELOPMENTS

3.1.4.1. DEEPFAKES

The Election Commission of India has warned parties against using AI-based tools to create deep fakes that distort information or propagate misinformation**.**

About Deepfakes

- Refer to **synthetic media**, usually images and videos created using AI and **deep learning techniques**.
  - It differs from Shallowfake which uses conventional technologies to create altered media (videos etc.)
- **Working:** Uses **Generative Adversarial Networks (GANs)** to analyze and synthesize audio and visual content.
- **Applications of Deepfakes:** Natural and accurate dubbing in movies and TV shows, training simulations in fields, such as medicine, aviation, etc., etc.

Measures to counter Deepfakes

- **Section 66D of the Information Technology (IT) Act, 2000** provides for punishment for cheating by impersonation using any communication device.
- **Rules 3(1)(b) and Rule 3(2)(b) of Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Rules, 2021** mandate social media intermediaries to observe due diligence to not host obscene content, deceives or misleads the addresses, etc.

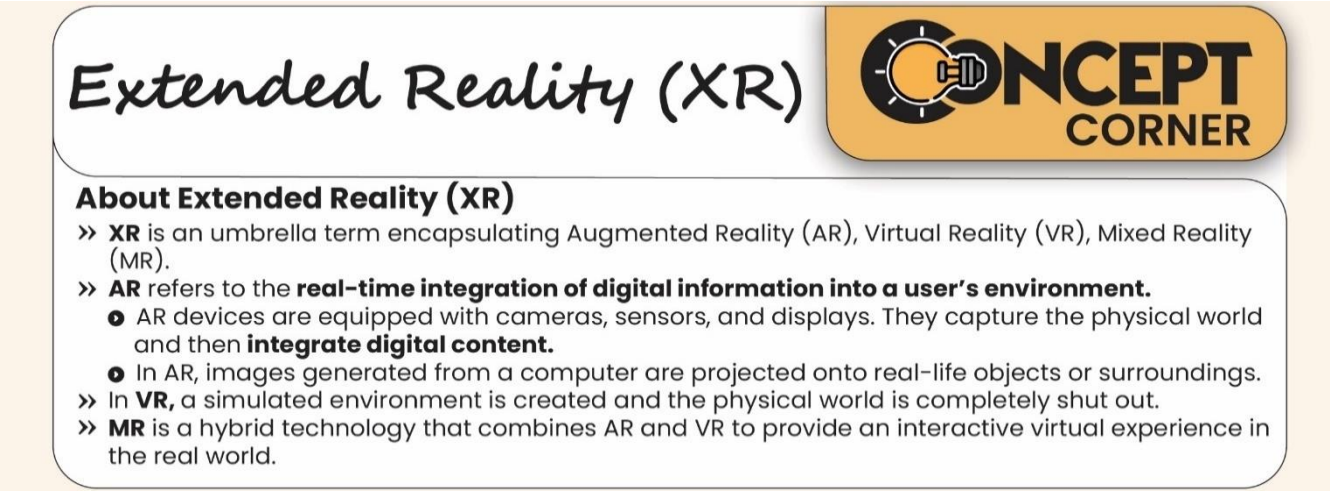
3.1.4.2. S.A.R.A.H.

WHO unveiled a **digital health promoter prototype** S.A.R.A.H **harnessing Generative AI** for public health.

About S.A.R.A.H.

- Provides **information across major health topics**, including healthy habits and mental health.
- Supports **developing better understanding of risk factors** for some leading causes of death. **E.g., cancer, heart disease, lung disease, and diabetes.**

3.2. EXTENDED REALITY (XR)



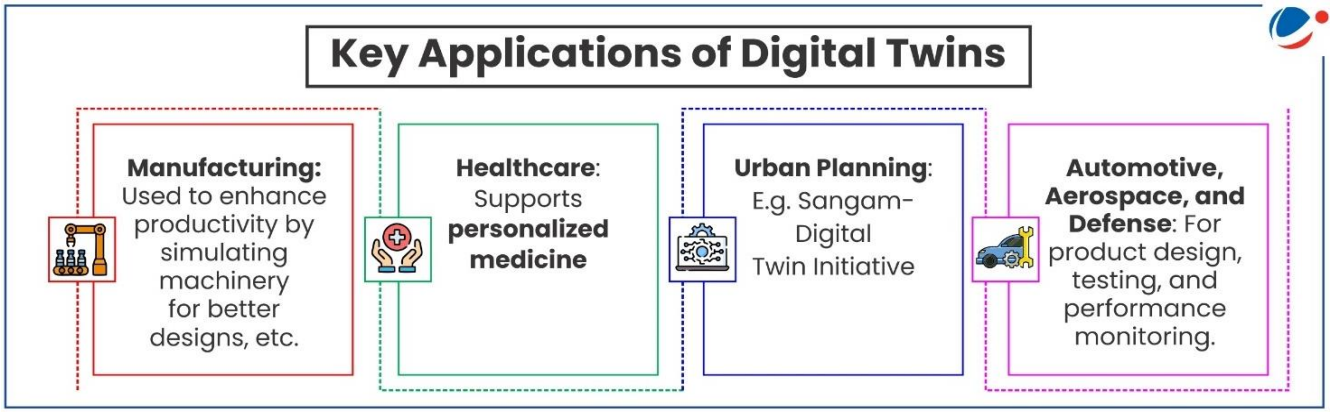
3.2.1. DIGITAL TWINS

Why in the News?

The use of digital twins is growing across the industry.

What are Digital Twins?

- Digital twins are **virtual replicas of physical objects, systems, or processes** that simulate their real-world counterparts in real-time.
- By integrating data from various sources, digital twins enable **real-time monitoring, analysis, and optimization of physical entities.**
- It uses **four key technologies** to create a **digital representation, collect real-time data, and provide valuable insights**: the Internet of Things (IoT), Extended Reality (XR), Cloud computing, and Artificial Intelligence.



Related Concept
Internet of Things (IoT)

- Refers to a network of **physical devices**, vehicles, appliances, and other physical objects that are **embedded with sensors**, software, and network connectivity, allowing them to **collect** and **share data**.

- IoT devices are also known as **smart objects**.
- **An IoT system has three components**: Smart devices (e.g. television), IoT application and A graphical user interface.
- **Key Applications**: **Agriculture** (monitor soil conditions, weather patterns and crop growth), Healthcare (monitor patients remotely), etc.

3.3. BLOCKCHAIN TECHNOLOGY

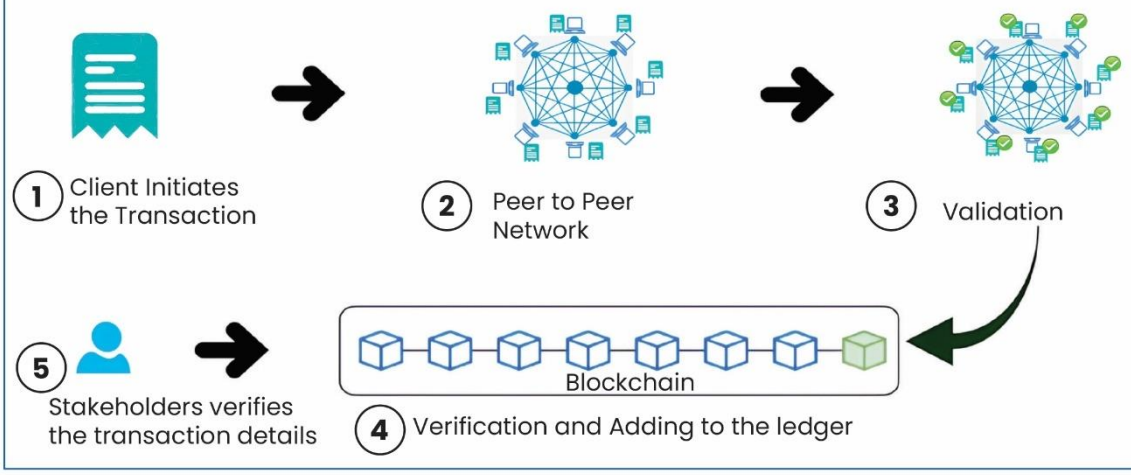
Blockchain Technology

CONCEPT CORNER

Blockchain Technology

- An innovative **distributed ledger technology,** first introduced in the design and development of cryptocurrency, Bitcoin, in 2009, by Satoshi Nakamoto.
- An **exchange process,** which works on data blocks. In this, one block is connected to another block.

Working of Blockchain Technology



Properties of Block Chain

- **Smart Contracts:** Auto execution of digital contracts.
- **Immutable:** Any validated records are irreversible and cannot be changed.
- **Time-stamped:** A transaction timestamp is recorded on a block.
- **Consensus**: All network participants agree to the validity of each of the records.
- **Secured:** All records are individually encrypted

Potential applications of Blockchain Technology

Cryptocurrencies: E.g. Bitcoin, Ethereum, Litecoin, Ripple, etc.	**Voting Systems:** Facilitates features such as voter identification, eligibility checks, etc.	**Intellectual Property Protection:** E.g., **companies** can use blockchain technology to manage their trademarks and patents.	**Others: Supply Chain Management** (enables more efficient communication between stakeholders), Law Enforcement, banking, etc.

3.3.1. VISHVASYA: NATIONAL BLOCKCHAIN TECHNOLOGY STACK

Why in the News?

Union **Ministry of Electronics and Information Technology** (MeitY) has launched the '**Vishvasya: National Blockchain Technology Stack**'.

More on the News

- **MeitY also unveiled**
  - **NBFLite-Lightweight Blockchain Platform**: A Blockchain **sandbox platform for startups/academia** .
  - **Praamaanik**: A blockchain-enabled solution for **verifying the origin of mobile apps.**

About Vishvasya: National Blockchain Technology Stack

- Offers **Blockchain-as-a-Service (BaaS)** with a geographically distributed infrastructure designed to support various permissioned Blockchain-based applications.
  - **BaaS** is a third-party **cloud-based infrastructure** and management that organizations and businesses use for developing and managing blockchain applications.
- Part of the **National Blockchain Framework (NBF)** provided under the **National Strategy on Blockchain.**
- **Key Features:**
  - Rapid end-to-end Permissioned Blockchain Application Development & Deployment.
  - Ready to use Security Audited Blockchain Containers for Production setup.

3.3.2. OTHER DEVELOPMENTS

3.3.2.1. WEB3

India's share of a global pool of Web3 developers has increased from 3% in 2018 to 12% in 2023.

About Web 3

- **Third generation** of **the World Wide Web.**
- Enables peer-to-peer transactions and interactions without intermediaries.
- Provides a version of the web where **users have a financial stake** and more **control over web**.
- Enables **people to control** their **own data**.
- Includes cryptocurrencies, Non-Fungible Tokens etc.
- In the web3 world, there can be **blockchain-based social networks.**
- **Operated by users collectively** rather than a corporation.

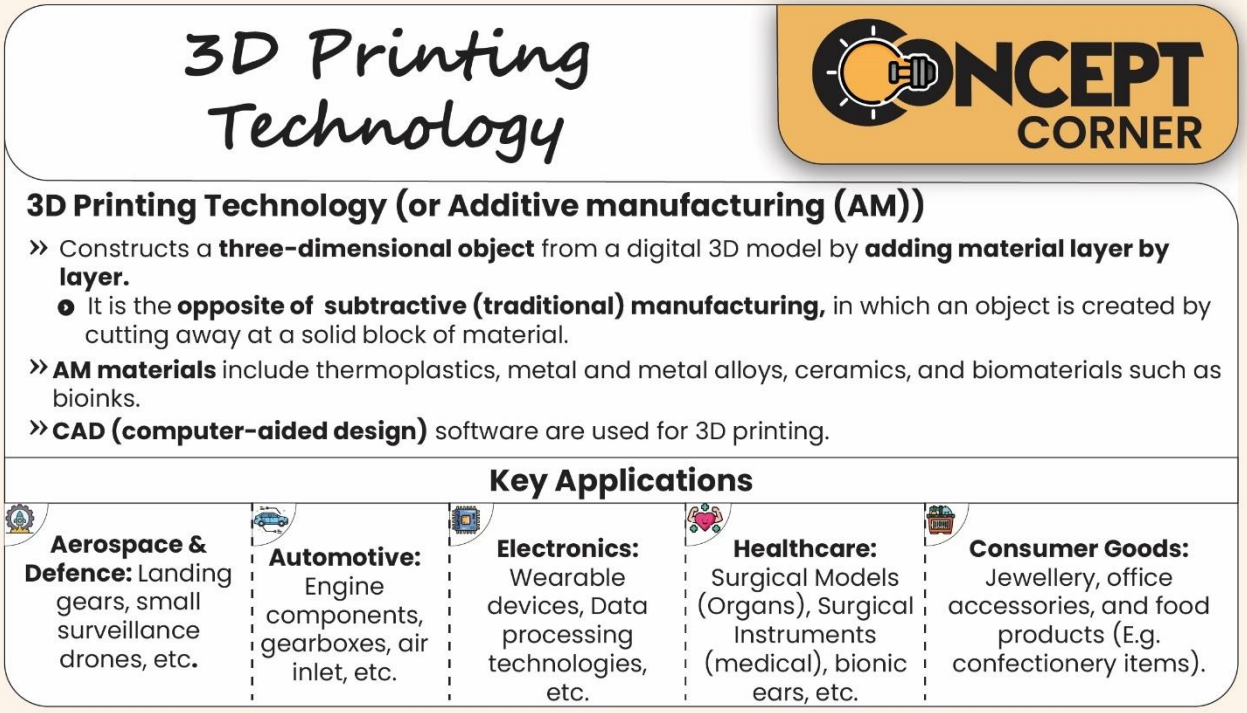
3.3.2.2. BITCOIN HALVING

Bitcoin, the world's largest cryptocurrency, has recently undergone **halving**.

About Bitcoin Halving

- Refers to the 50% reduction in the reward paid to **Bitcoin miners.**
  - **Bitcoin miners** successfully process other **people's cryptocurrency transactions** so that they can be added to the **public digital ledger** known as the **blockchain**.
- Takes place every four years.
- The halving policy was written into Bitcoin's mining algorithm to counteract inflation by maintaining scarcity.
- In theory, the reduction in the pace of Bitcoin issuance means that the price will increase if demand remains the same.

3.4. 3D PRINTING TECHNOLOGY



3.4.1. 4D PRINTING

Why in the News?

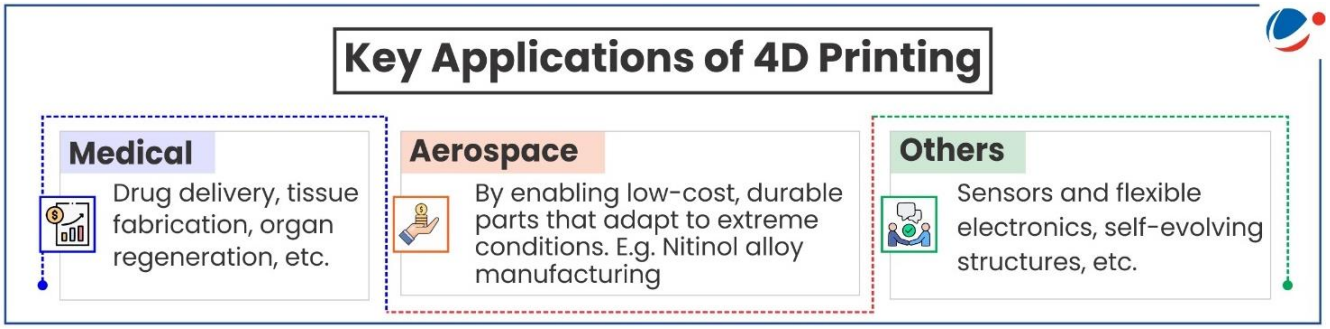
Indian Researchers developed 4d-printed artificial blood vessels for Advanced Medical Grafts.

About 4D Printing

- Evolved from **3D printing by adding** the **dimension of time.**
- In it, objects **can change shape or function over time in response to environmental stimuli** such as heat, light, or moisture, etc.

Advantages

- **Dynamic Functionality:** By creating adaptive structures beyond the capabilities of traditional 3D printing.
- **Material Efficiency:** By reducing wastages.
- **Complex Design fabrication:** Stereo lithography 4D technique fabricates complex designs efficiently.



Related News

Agnibaan SOrTeD

- IIT Madras-incubated space startup **Agnikul Cosmos** has successfully launched the world's first rocket (**Agnibaan SOrTeD)** with a single piece 3D printed engine.
- **About Agnibaan SOrTeD**
  - **Rocket Agnibaan SOrTeD (SubOrbital Technological Demonstrator) is** India's first **semi-cryogenic engine-powered rocket launch flight**.
  - **Launched from: India's first privately developed launchpad** called **'Dhanush'** established by Agnikul at Sriharikota in Andhra Pradesh.

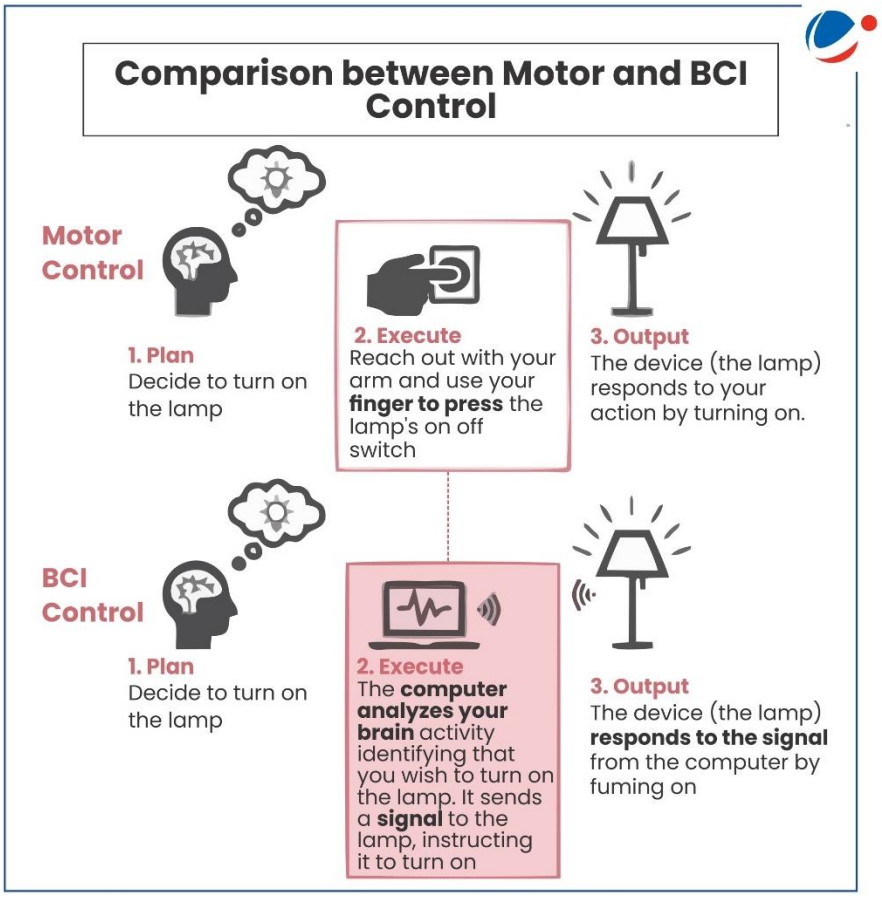
3.5. BRAIN COMPUTER INTERFACES (BCIS)

Why in the News?

Neuralink's 'BLINDSIGHT'**,** a Brain-Computer Interface (BCI) implant, **received "breakthrough device" status** by the US Food and Drug Administration (FDA).

More on the News

- BLINDSIGHT Chip aimed at **helping blind patients** (who have lost their both eyes and optic nerves) or those who have been **blind from birth** to regain their sight.



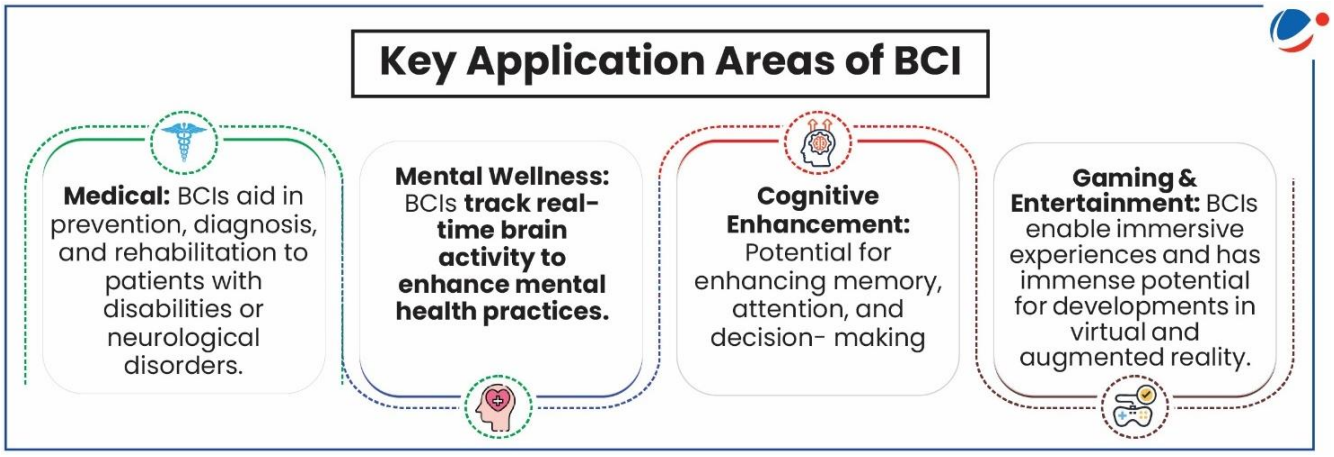
About Brain-Computer Interface (BCI)

- A **computer-based system that** acquires, analyzes, and translates brain signals into commands for an output device to **carry out a desired action** (refer to the infographic).
- **BCI has three main parts:**
  - **A headset device** with specialized sensors.
  - **A computer to process and analyze** the recorded **brain activity.**
  - **Application/device to** carry out command.
- **Another important** part of **BCI is feedback.**
- **BCI do not read minds** to extract information from unsuspecting or unwilling users **but enables users to act** on the world by **using brain signals rather than muscles.**

Types of BCIs

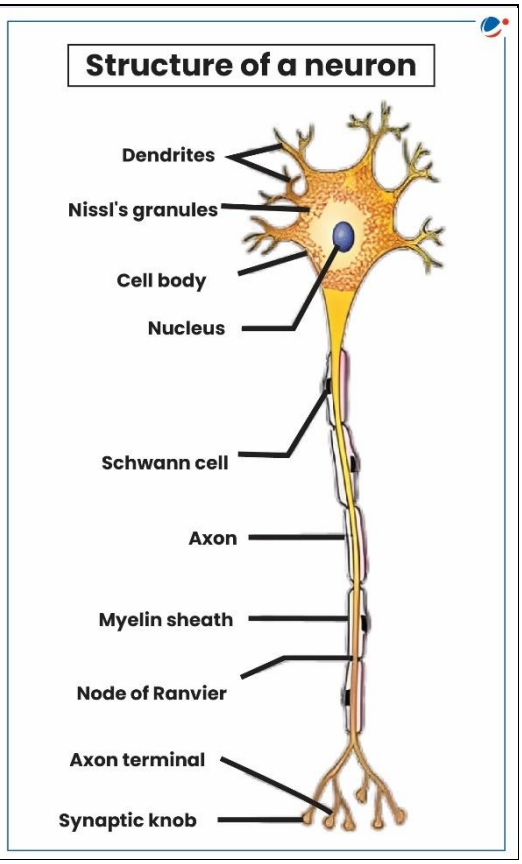
- **Invasive BCI (Brain Implants)**: **Implanted** directly into **grey matter of brain.** E.g., Neuralink's Implant.
- **Non-invasive BCI (**Surface Detectors): E.g. Electroencephalograph (EEG), Functional Magnetic Resonance Imaging (fMRI) etc.

- **Partially Invasive BCIs (Dura Mater Implant): Implanted inside the skull but rest outside the brain** rather than within the grey matter. E.g.**, Electrocorticography (ECoG)**



Key Concepts

- **Neuron, Control and co-ordination:**
  - Brain is made up of millions of cells called **neurons**.
    - > These neurons work together in large **networks** to coordinate processes in body **(Hearing, taste, heart rate etc.)** and execute movements.
  - **Neurons communicate** via electrochemical signals.
- **Brain Activity and Its Measurement:**
  - Brain activity **refers to the electrical signals** and chemical processes **that occur in the brain**, which are responsible for various cognitive functions, emotions, sensations, and behaviors.
  - This electrical brain activity can be **measured by placing special sensors onto/into the head.**



3.6. SUPERCOMPUTERS

Why in the News?

Prime Minister virtually launched three Param Rudra Super Computing Systems and a High-Performance Computing (HPC) system for weather and climate research.

More on the News

- These supercomputers have been developed indigenously under the **National Supercomputing Mission (NSM).**

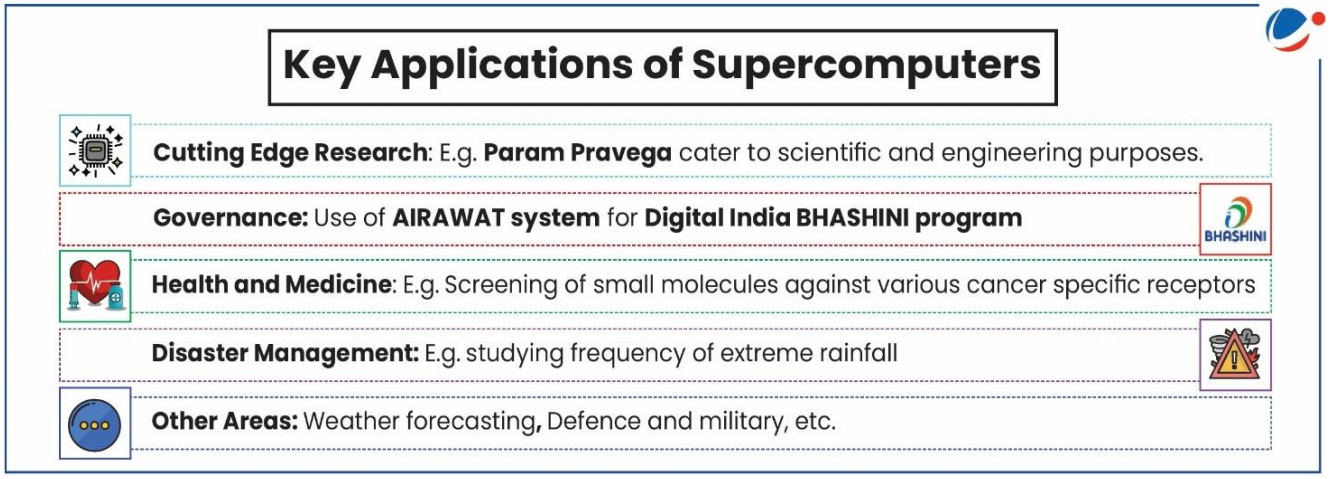
- New HPC systems named **'Arka'** and **'Arunika'** will enhance accuracy and predictions related to tropical cyclones, heavy precipitation, thunderstorms, etc.

What is a Supercomputer?

- A **high-performance computing system** that delivers **exceptional processing power** and computational capacity compared to a general-purpose computer.
  - Performance is measured in **floating-point operations per second (FLOPS)**.
- **India's supercomputers:**
  - India's **first supercomputer** was **PARAM 8000**.
  - India's **largest and fastest AI** supercomputer **AIRAWAT** was ranked 75th in the Top 500 Global Supercomputing List of 2023.
- **World's fastest Supercomputer** is **Frontier** (USA), capable of more than a quintillion operation per second (Exaflop)

About National Supercomputing Mission (NSM), 2015

- **Objective**: To make India one of the world leaders in Supercomputing
- **Jointly steered by:** Department of Science and Technology (DST) and MeitY.
- **Implemented by:** Centre for Development of Advanced Computing (C-DAC) and Indian Institute of Science (IISc), Bengaluru.
- **NSM envisages:**
  - **Installing** a network **of supercomputers** with a **cumulative capacity of 45 PetaFlops**
  - Connecting these supercomputers on the National Supercomputing grid over the **National Knowledge Network**.



3.7. LI-FI TECHNOLOGY

Why in the News?

The Ministry of Defence funded a start-up under the **Innovations for Defence Excellence (iDEX)** will secure Li-Fi technology for the Indian Defence sector, particularly focusing on the Navy.

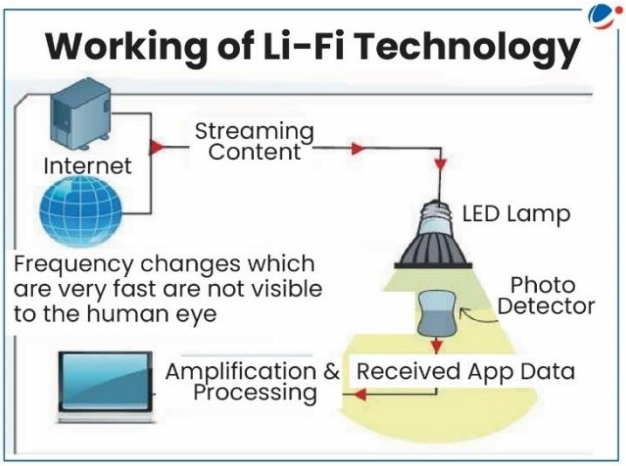
More on the News

- **iDEX** fosters innovation and technology development in the Defence and Aerospace sector.
  - **iDEX is** managed by **the Defence Innovation Organization** under **MoD.**

About Li-Fi (Light Fidelity) Technology

- A **bidirectional** wireless system that uses visible light communication or infra-red and near ultraviolet (instead of radio frequency waves) spectrum
  - It transmits data with the help of a **Light light-emitting diode (LED)**.

- **Working:** On/off activity of **the LED transmitter** enables data transmission by the **incoming binary codes**.
- **Applications:** Aircrafts, hospitals (operation theatres), power plants, etc. where **electromagnetic (Radio) interference** creates security issues.
- **Advantage of Li-Fi over Wi-Fi**
  - **Faster:** Combination of low interference, and high bandwidths provides a high data rate.
  - **Cheaper and sustainable:** It is up to 10 times cheaper than Wi-Fi, requires fewer components, and uses less energy.
  - **Secure:** Since light does not pass through walls like radio waves do, it prevents interception.



- **Disadvantages**: **Much shorter range** than Wi-Fi, **can't be accessed** beyond the **illumination range** of light, etc.

Comparison Between Li-Fi and VLC Technology

Features	Li-Fi	VLC
Light Source	Infrared/Invisible/Visible	Visible Light (375 to 780 nm)
Transmission Style	Bi-directional	Point-to-point
Data Rates	High	Low
Interference Level	Low	Low

3.8. OTHER IMPORTANT NEWS

3.8.1. SEMICONDUCTOR

Recently, the Union Cabinet approved the **fifth semiconductor unit in India**, to be set up in **Sanand, Gujarat** under the **India Semiconductor Mission (ISM).**

- **India Semiconductor Mission (ISM)** is a specialized **Business Division** within **Digital India Corporation** under MeitY.
  - It has been working as the **nodal agency** for the Schemes approved under the **Semicon India Programme.**

About Semiconductor

- **Semiconductors, also referred to as integrated circuits (IC),** are materials with characteristics intermediate between a "conductor" and "insulator".
  - It can be made of a **single element** or a **combination of elements** in the form of a compound.
    - E.g., **Silicon** is an elemental semiconductor and **Gallium nitride** is a compound semiconductor.
- **Applications**: Essential in electronics, including diodes, transistors, integrated circuits, and telecommunications.
  - Semiconductors are found in **almost all electronic devices** and play a pivotal role in emerging technologies like AI, 5G, IoT, etc.

3.8.2. NETWORK-AS-A-SERVICE (NAAS)

The **market for NaaS in India** is expected to expand from $1.18 billion in 2024 to $7.32 billion by 2029.

About NaasS

- A cloud service model in which **customers rent networking services** from cloud providers.
  - It provides the **flexibility to pay** for services based on usage and to scale as business needs change.
- Allows customers to operate the networks **without maintaining their** networking infrastructure.

3.8.3. NEUROMORPHIC COMPUTING

Indian Institute of Science scientists reported a breakthrough in **neuromorphic computing**.

What is Neuromorphic Computing or Neuromorphic Engineering?

- Mimics the **human brain's structure and function.**
- Involves designing hardware and software that **simulate neural networks and synapses** to process information.
- **Working:**
  - Mimics biological brains using **hardware** like **Spiking Neural Networks (SNNs).**
  - **SNNs consist of nodes (spiking neurons)** connected by **artificial synapses**, which use **analog circuitry to transfer signals.**

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4. DEVELOPMENTS RELATED TO PHYSICS

Elementary Particles & Related Terms

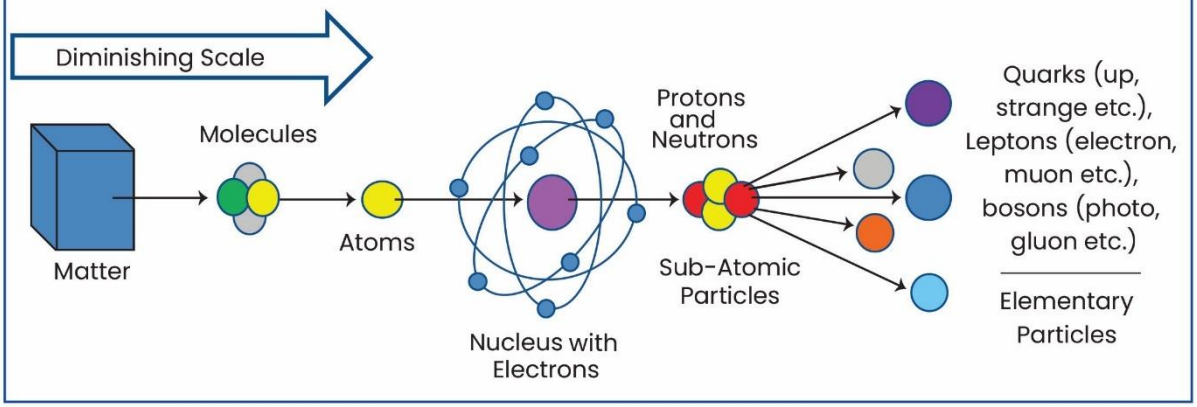
CONCEPT CORNER

Elementary Particles (Fundamental Particles)

» **Elementary particles** are the smallest known building blocks of the universe.

» These particles **join together to create the more well-known particles,** such as the neutron and the proton.

Particle Hierarchy

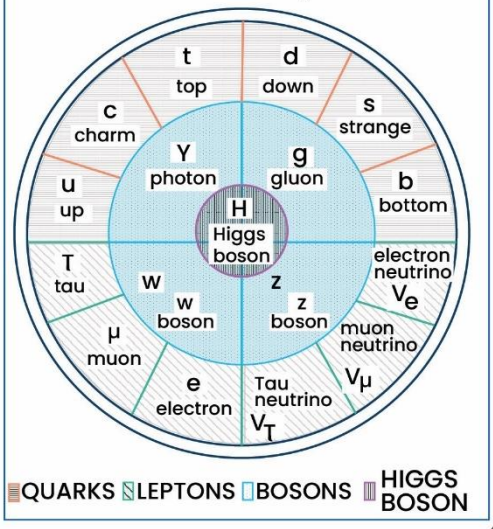


Standard Model of Particle Physics

» **Describe the most basic building blocks of the universe.**
- Explains how particles called **quarks** (which make up protons and neutrons) and **leptons** (which include electrons) make up all known matter.
- Also explains how **force-carrying particles (bosons)** influence the quarks and leptons.

» Also, **explains three of the four fundamental forces** that govern the universe:
- **Electromagnetism is carried by photons** and involves the interaction of electric fields and magnetic fields.
- The **strong force, which is carried by gluons,** binds together atomic nuclei to make them stable.
- The **weak force, carried by W and Z bosons,** causes nuclear reactions that have powered our Sun and other stars for billions of years.
- The **fourth fundamental force is gravity,** which is **not adequately explained** by the Standard Model.

Standard Model of Particle Physics



4.1. HIGGS BOSON

Why in the News?

Nobel Laureate Physicist Peter Higgs passed away recently.

About Peter Higgs

- Peter Higgs **proposed the Higgs field in 1964** as a **new field** that **fills the entire Universe** and gives **mass** to all elementary particles.
  - Also, he **proposed a new fundamental particle 'Higgs Boson'.**
- His idea was validated in 2012 through experiments at the **European Organization for Nuclear Research (CERN)'s Large Hadron Collider**.

Relationship between Higgs Field and Mass of Elementary Particles

- **Mass from interaction:** Elementary Particles do not have a mass of their own, they get their mass by interacting with the Higgs field.
  - This **mass-giving interaction** with the **Higgs field** is known as the **Brout-Englert-Higgs mechanism**, proposed by theorists Robert Brout, François Englert, and Peter Higgs.
- **Quantity of mass**: **Intensity** of **interaction** between the field and the particle decides the quantity of mass of the particle.
  - It means that the stronger the interaction of the particle with the Higgs field, the heavier the particle ends up being.

About Higgs Boson

- An **elementary particle**, it is popularly known as the **God particle**.
- A type of **boson**, a force-carrying subatomic particle.
- **Gets its mass** just like other particles—from its interactions with the Higgs field.
- **Properties of Higgs Boson:**
  - **Mass:** 125.35 GeV
  - **Spin:** A **scalar particle that has a '0' spin**.
    - It is the only elementary particle with no spin.
  - **Lifetime: Very short** and it **rapidly decays into other particles** after it is produced in high-energy collisions.
  - **Detection: Detected indirectly** by observing the particles it decays into.

HQ: Geneva, Switzerland

European Organization for Nuclear Research (CERN)

Genesis: Established in 1954 as an International Scientific Organization

Objective: Collaborative research into high-energy particle physics.

Members: 23 Member States (10 Associate Member States)
- **India** is an Associate Member.

Key Achievements:
- Discovery of the Z Boson and W Boson Particles
- **The World Wide Web** was invented at CERN by British scientist Tim Berners-Lee.
- CERN's LHC is the world's largest particle accelerator.
- Launched the **White Rabbit Collaboration (WRC)** to foster the **uptake of White Rabbit technology.**
  - **WR technology** provides **sub-nanosecond accuracy and picosecond precision of synchronisation** for the LHC accelerator chain.

4.2. NEUTRINOS

Why in the News?

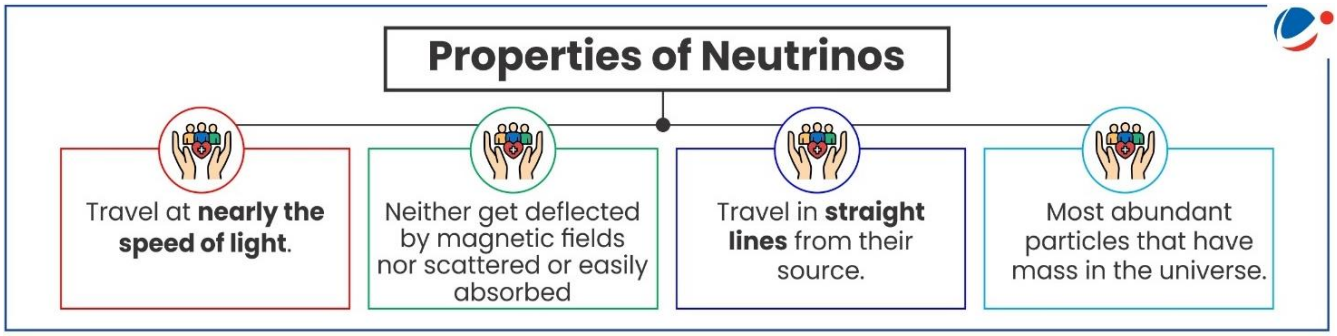
International NOvA collaboration reveals new findings on Neutrinos.

More on the News

- **NovA (NuMI Off-axis *ν*e Appearance)** is in the United States.
- **Key Finding**
  - New NOvA results suggest there are **two lighter neutrinos** and a **heavier one** (Normal Order Theoretical Model).
    - **Neutrinos come in three varieties**: muon, electron, and tau.

What are neutrinos/Ghost Particles?

- **About: Subatomic particles** with **no electrical charge and negligible mass.**
  - High-energy neutrinos which are released from **cosmic sources at the Milky Way's edge** are known as "**astrophysical neutrinos".**
  - Referred as **Ghost Particles** because nearly 100 trillion neutrinos pass through the human body every second without us noticing.
- **Possible sources of high-energy neutrinos**: Events like supernovas and objects like active galactic nuclei and black holes.
  - **Sun's nuclear reactions, particle decay in Earth, Beta decay, particle accelerators, and nuclear power plants** all release neutrinos.
- Due to their properties, they are **excellent information messengers** about the objects or events in which they originate.
- **Note:** It is **different from the 'God Particle' or Higgs boson**.



Key Neutrino Observatories

- **Indian Neutrino Observatory (INO)**
  - Jointly funded **by the Department of Atomic Energy** and the **Department of Science and Technology.**
  - **Location:** Bodi West Hills of **Theni District of Tamil Nadu.**
- **China's TRIDENT** (Tropical Deep-sea Neutrino Telescope) and **Jiangmen Underground Neutrino Observatory (JUNO)**
- **Ice Cube Observatory** (World's largest neutrino Observatory)

Other Messengers of Celestial Events

- **Cosmic rays**: They are charged particles and are deflected by magnetic fields.
- **Gamma-ray bursts (GRBs)**: Short-lived bursts of gamma-ray light.
  - Gamma rays have the **smallest wavelengths a**nd the most energy of any wave in the electromagnetic spectrum.

- **Sources:**
  - > **In the universe,** such as neutron stars and pulsars, supernova explosions, and regions around black holes.
  - > **On Earth**, generated by nuclear explosions, lightning, and the activity of radioactive decay.
- It is an **extragalactic transient** (phenomena that change their brightness over a relatively short time).

- **Other**: Gravitational waves, **supernova remnant (SNR)**, Active Galactic Nuclei (AGN) (E.g. Quasar) etc.

Related Concept
Quasar
- The word quasar is short for "**Quasi-stellar Radio Source**".
- Quasars are powered by supermassive black holes.
- They are among the **most luminous objects** in the known Universe.
- Despite their brightness, due to their great distance from Earth, no quasars can be seen with an unaided eye.
- They **emit** radio waves, visible light, UV rays, infrared waves, X-rays, and gamma-rays.

4.3. GRAVITATIONAL WAVES (GW)

Why in the News?

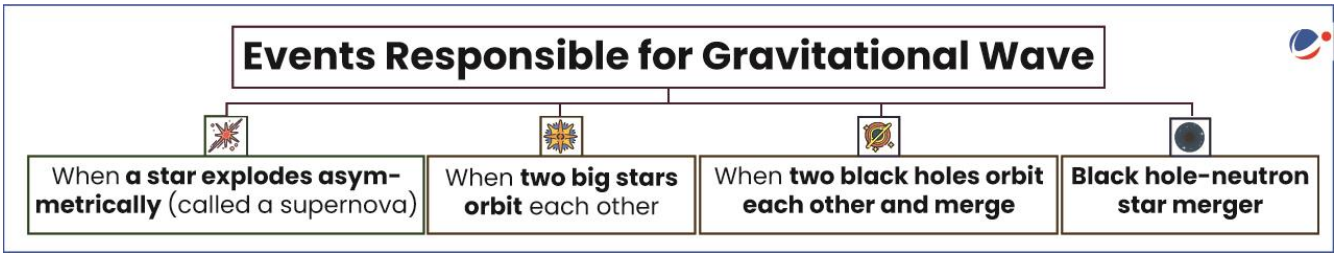
Gravitational waves (GW) reveal a 1st-of-its-kind merger between a neutron star and a mystery object.

More on the News

- **Merger** is officially known as **GW230529**, detected by t**he LIGO-Virgo-Kagra collaboration in 2023.**
- The GW came from **a merger of two objects:**
  - **Neutron Star (**formed when a massive star runs out of fuel and collapses)
  - **Mystery object** whose mass lies in the **'mass gap**'.
    - > **Mass gap** is the **range of mass** between the **heaviest known neutron sta**r and the **lightest known black hole.**

About Gravitational waves (GW)

- **GWs are 'ripples'** in **space-time** caused by some of the **most violent** and **energetic processes in the Universe** that propagate in all directions away from the source.
- Predicted in **Einstein's General Theory of Relativity (1916).**
- Travel at the speed of light.
- **GWs' first detection:** Detected at the Laser Interferometer Gravitational-Wave Observatory (LIGO) in 2015.
  - 2017 Nobel Prize in Physics was awarded"for decisive contributions to the **LIGO detector** and the observation of gravitational waves".
- **Importance of Studying GW**:
  - Helps scientists expand their knowledge about the nature and evolution of the universe.
  - To answer mysteries about the nature of merging supermassive black holes, etc.



About LIGO

- Consists of **two interferometers,** each with two **4 km long arms** arranged in the **shape of an "L"**. These instruments act as '**antennae**' to detect GWs.
- Comprises **stable high-power lasers**, **precisely figured mirrors**, **ultraquiet vibration** isolation systems, and **sophisticated hierarchical feedback systems.**
- **LIGO-India:** It will be built by the **Department of Atomic Energy (DAE)** and the **Department of Science and Technology (DST),** in Maharashtra.

4.4. OTHER IMPORTANT DEVELOPMENTS

4.4.1. ANTIMATTER

Recently Scientists spotted the heaviest **antimatter nucleus** in a particle accelerator Relativistic Heavy Ion Collider.

- It is called **anti-hyperhydrogen-4 (**Made up of an **antiproton,** two **antineutrons,** and **antihyperon)**

About Antimatter

- Antimatter particles **share the same mass** as their matter counterparts, but qualities such as electric charge are **opposite.**
  - E.g. A positively charged **positron** is an antiparticle to a **negatively charged electron.**
- **Antimatter particles** corresponding to **electrons, protons, and neutrons** are called **positrons, antiprotons, and antineutrons.**
- **Matter and antimatter particles** are always produced as a pair and if come in contact annihilate **one another** (leaving **pure energy).**

4.4.2. HIGH ENERGY PHOTON SOURCE (HEPS)

China is planning to construct a High Energy Photon Source (HEPS).

About HEPS

- **First Brightest Synchrotron X-Rays** in Asia.
  - **Synchrotrons** (a type of circular particle accelerator) use electricity to produce **intense beams of light** more than a million times brighter than the sun.
- **Benefits:** understand matter in the dimensions of space, time, and energy, as well as at the level of molecules, atoms, electrons, and spin.
- **Indus-1** was India's first synchrotron.

4.4.3. GIANT RADIO SOURCES

Indian astronomers discovered **34 new Giant Radio Sources using the Giant Metrewave Radio Telescope (GMRT).**

- Located near Pune, **GMRT** is operated by the National Centre for Radio Astrophysics (NCRA).

Giant Radio Sources (GRSs)

- GRSs are **among the largest objects** in the universe and at the heart of GRSs lies a **supermassive black hole**.
- Serving as a central engine, a black hole **pulls in surrounding matter**, creating jets of hot plasma, and **producing massive lobes of radio emissions**.

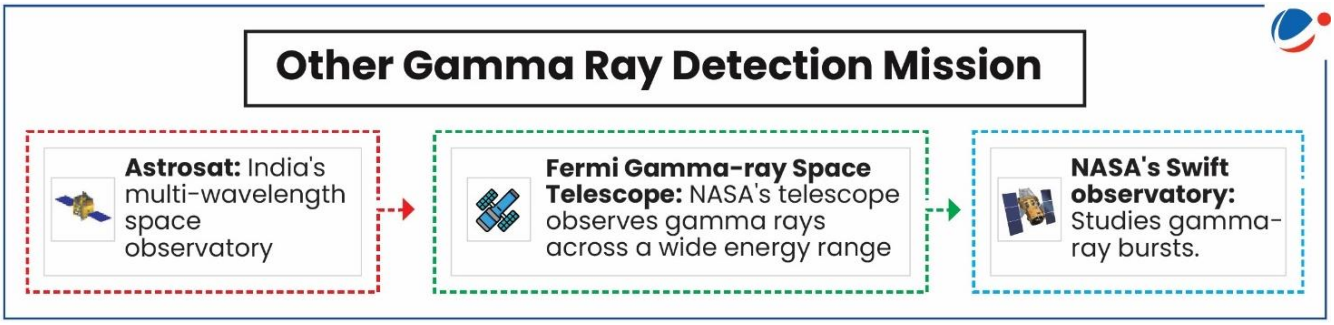
4.4.4. DAKSHA PROJECT

IIT Bombay is leading the Daksha project.

- It is leading in close collaboration with the **Physical Research Laboratory (PRL), Tata Institute of Fundamental Research (TIFR), Raman Research Institute (RRI)**, etc.

About the Daksha project

- An ambitious proposal to build **two high-energy space telescopes** to study **explosive astrophysical sources.**
- **Objectives**
  - Detect, localize, and characterize **high-energy counterparts to gravitational wave sources.**
  - High sensitivity detection and **studies of Gamma-Ray Bursts (GRB)**



4.4.5. HYDROGEN LINE (21 CM LINE)

Recently, the hydrogen line was in the news.

About the Hydrogen Line or 21 cm Line

- A spectral line emitted by **atomic hydrogen**.
- This phenomenon occurs when an electron in a hydrogen atom jumps from a **higher energy level to a lower one.**
  - This jump **releases energy in the form of light**, specifically with a **wavelength of about 21 centimeters.**
- **Applications in Radio Astrophysics: Studying composition** and **evolution of the solar system & Universe,** etc.

5. SPACE TECHNOLOGY

5.1. ISRO AND RELATED DEVELOPMENTS

HQ: Bengaluru

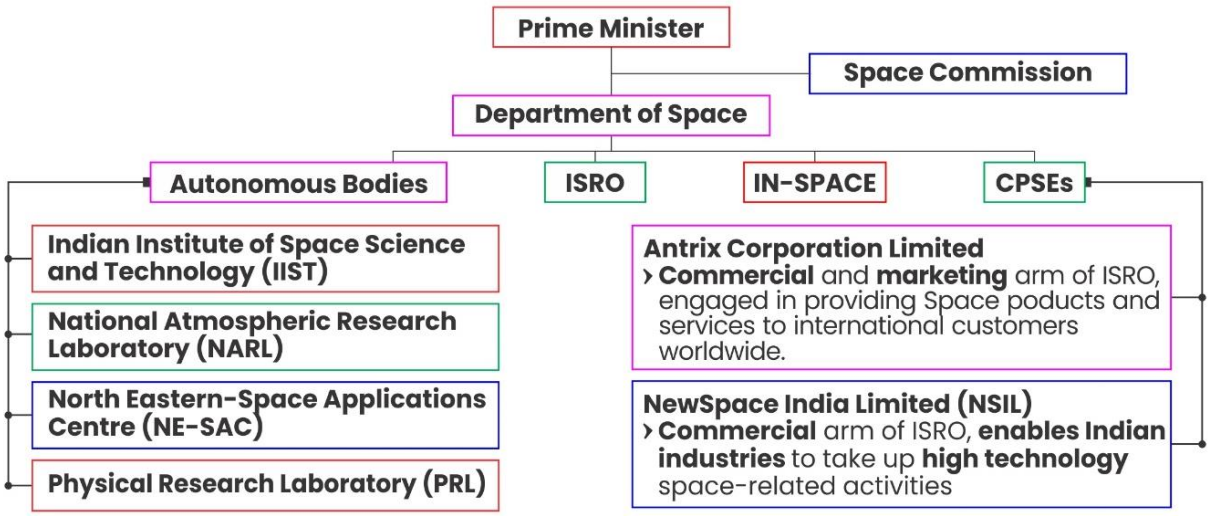
Indian Space Research Organisation (ISRO)

Genesis: Indian National Committee for Space Research (INCOSPAR) was set up by in 1962.
- ISRO was formed in 1969 superseding INCOSPAR.
- Brought under **Department of Space (DOS)** in 1972.

Mandate: As **National Space Agency,** development and application of space technology for various national needs.

Chairman: Headed by Chairman, who is secretary of DOS and Chairman of Space commission.

Overview of Organisation Structure



5.1.1. SPACE DOCKING EXPERIMENT (SPADEX)

Why in the News?

India becomes 4th country to successfully conduct space docking after the US, Russia, and China.

More on the News

- ISRO launched the **Space Docking Experiment (SpaDeX) satellites** by PSLV-C60.

About Space Docking

- Involves **precise connection of two spacecraft**, whether manned or unmanned, allowing those **to operate as a single unit for critical tasks** such as refueling, repair, and crew exchange.
  - Enables the construction of cutting-edge facilities (like the International Space Station (ISS)) in orbit and advancing space exploration.
- Some spacecraft dock with the ISS and others berths with the station.
  - **In Docking,** the spacecraft can manoeuvre and attach to the station by itself.

- **In Berthing,** an astronaut uses the station's robotic arm to capture the spacecraft. Then Mission Control takes control from the ground and directs the arm to manoeuvre the spacecraft to the attachment site.

About Space Docking experiment (SPADEX)

- ISRO's SPADEX is **a technology demonstration experiment** aimed at mastering autonomous docking, a critical capability that only a select few countries (the US, Russia, and China) have.
- Consists of two satellites named '**Chaser'** and '**Target'** which will dock at an **altitude of about 700 km.**
- This technology is essential for space ambitions such as sample return from the Moon, the building and operation of BAS, etc.
- These satellites will perform **complex maneuvers**, including:
  - **Autonomous Rendezvous and Docking**
  - **Formation Flying** (Demonstrating precise orbital control to maintain relative positions)
  - **Remote Operations**: The mission will experiment with controlling one spacecraft using the Attitude Control System of the other.
    - > Additionally, it will explore the **use of robotic arm** technologies for in-space manipulation and servicing.

Related News

PSLV Orbital Experimental Module (POEM)

- POEM-4 has been also launched with the PSLV-C60.
- **About POEM**
  - **Purpose:** To provide a **cost-effective platform** for on-orbit experiments. So far. **Launching proprietary systems** into space has traditionally been **prohibitively expensive** for smaller entities.
  - **Strategic importance:** Reduces entry barriers for startups, and promotes space technology innovation in India.

5.1.2. BHARATIYA ANTARIKSH STATION (BAS)

Why in the News?

The union cabinet has approved the **building of the first unit of the Bharatiya Antariksh Station (BAS)** by extending the scope of the Gaganyaan programme.

More on the News

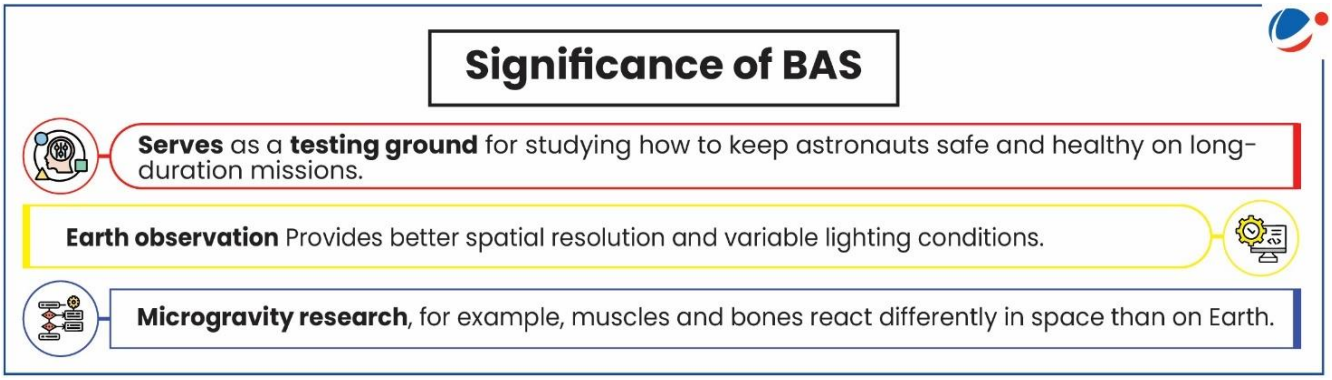
- **Revised Gaganyaan Programme include:**
  - Development of the **first module of BAS** and four missions for **demonstration & validation of various technologies for BAS** by December **2028.**
  - **Four missions** under the **ongoing** Gaganyaan Programme by **2026**.
- Union Cabinet also approved the development of **Next Generation Launch Vehicle (NGLV),** a significant step towards **establishing & operating** BAS.
  - It will **have 3 times** the payload **capability of Launch Vehicle Mark-3 (LVM3**), with ability to carry up to **30 tonnes to Low Earth Orbit (LEO).**

About Gaganyaan Programme

- **India's first Human Space Flight** mission
- **Objective: Transport a team of astronauts to an orbit 400 km** above Earth for **a three-day expedition** before safely returning them in the short term.
  - It will also carry the female **half-humanoid Vyomitra** (space friend).
- **Technological development under it:**
  - **Human-rated LVM3 (HLVM3)** for carrying crew safely to space.
    - > HLVM3 is a re-configured version of LVM3 (consists of **solid stage, liquid stage, and cryogenic stage**) to meet human rating requirements.
- The successful launch of Gaganyaan will make India only the **4th country** (after the **US**, **Russia**, and **China**) that has launched crewed spacecraft.

About Bharatiya Antariksh Station

- India's **planned space station for scientific research** which will orbit around **400 – 450km above the Earth's surface**
  - It will have **five modules** and will be built in phases.
- **Targets: The first module** (the Base Module) **will be launched in 2028** and it will be operationalized by **2035.**



Other Space stations

- **Inoperative**
  - **Salyut 1: World's first space station** launched by the **Soviet Union**
  - **Skylab:** USA's first space station, launched by NASA
- **Operative**
  - **International Space Station (ISS):** Assembled in 1998 and operational since 2000.
    - It is maintained in **low Earth orbit (LEO)** by a collaboration of **five space agencies** and their contractors: **NASA (United States), Roscosmos (Russia), European Space Agency (ESA) , Japan Aerospace Exploration Agency (JAXA) , and CSA (Canada).**
  - **China:** Tiangong space station was launched in 2021 (fully operational since late 2022).
- **Upcoming:**
  - **Gateway Space Station:** NASA-led Gateway Program to establish **humanity's first space station around the Moon** as a vital **component of the Artemis campaign.**
  - **Axiom Station**: Commercial space station being developed by Axiom Space to operate in LEO.
    - It will be the **first commercial space station** in the world.

5.1.3. VENUS ORBITER MISSION (VOM)

Why in the News?

Union Cabinet has approved the **Venus Orbiter Mission (VOM)** as **India's maiden mission to Venus.**

About VOM

- **Objectives of VOM: Examine dust** in the Venusian atmosphere **and its airglow, map its surface topography**, study **solar X-ray spectrum,** and investigate **sub-surface characteristics**.
  - **VOM** will also **demonstrate technologies:** e.g., **testing aerobraking** and **thermal management techniques**.
- **Target date for launch:** March 2028
- **Launch Vehicle:** Launch Vehicle Mark-3 (LVM-3).
- **Key Payloads:** Venus Advanced Radar for Topside Ionosphere and Subsurface Sounding (VARTISS), Venus Orbit Dust Experiment (VODEX), etc.

About Venus

- **Earth's nearest** planetary neighbour and is **considered as 'Earth's-twin'** due to similar size and shape.
  - It has an **orbital period of 224.7 Earth days** and is located 108.2 million km (0.72 AU) from the Sun.

- Thick atmosphere of this planet traps heat creating a **runaway greenhouse effect** – making it the **hottest planet** in our solar system.
- Permanently shrouded in **thick, toxic clouds of sulfuric acid.**
  - **Phosphine**, a possible indicator of microbial life, has been observed in the clouds.
- **Venus, along with Uranus,** rotates from east to west, while all other planets rotate west to east**.**

Missions to Venus	
Past Missions	**Mariner 2 (1962, USA):** First spacecraft at Venus. Detected no magnetic field. **Venera 7 (1970, Soviet Union): First successful soft landing** on another planet (Venus). **Magellan (1990, USA):** First near-global **radar mapping** of Venus' surface. **Other:** Akatsuki (Japan), etc.
Future Missions	NASA's **DAVINCI** - Venus Flyby and Probe and **VERITAS** - Orbiter, **EnVision** - ESA's Venus Orbiter.

5.1.4. ADITYA-L1

Why in the News?

Aditya-L1 was inserted in its **halo orbit** in early 2024 and takes 178 days to complete a revolution around the **Lagrange L1** point.

About Aditya-L1 Mission (2023)

- **First Indian space mission** to study the Sun.
- **Objectives**
  - **Study** of **Solar upper atmospheric (chromosphere and corona) dynamics.**
  - Study of chromospheric and coronal heating, initiation of the **coronal mass ejections (CMEs)**, and solar flares.
  - **Observe the in-situ particle and plasma environment.**
  - **Study drivers** for **space weather**
- **Payload:** Carries 7 payloads (Visible Emission Line Coronagraph (VELC), Solar Ultraviolet Imaging Telescope (SUIT), etc.)

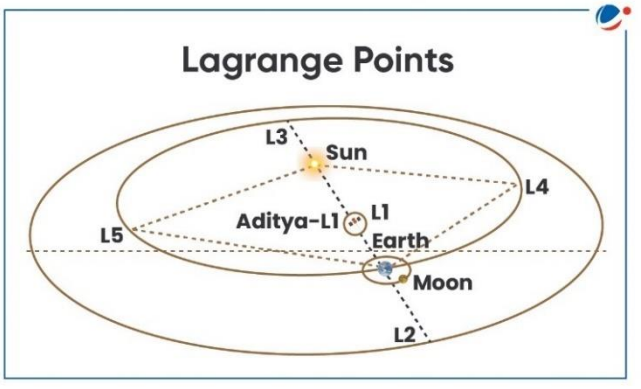
What are Halo orbits?

- These are **periodic** and **three-dimensional orbits** resulting from an interaction between the **gravitational pull** of the two planetary bodies and **the centrifugal force** on a spacecraft.
  - Halo orbits exist in any **3-body system.** E.g., **Earth-Moon orbiting satellite system**.
  - Mainly linked to L1, L2 or L3.

About Lagrange point

At the **Lagrange point**, the **gravitational pull** of the **two large bodies** equals the necessary **centripetal force** required for a small object to move with them.

- For two-body gravitational systems, there are a total of five **Lagrange points** denoted as L1, L2, L3, L4, and L5.
  - Out of five L4 and L5 are stable.
- **Significance**: Spacecraft remain at these positions with reduced fuel consumption.
  - L1 has the advantage of continuously viewing the Sun without any occultation/ eclipses.



- **Other key information:**
  - NASA-ESA's joint **Solar and Heliospheric Observatory Satellite (SOHO) mission** is placed near L1 point
  - NASA's **James Webb Space Telescope** is placed around L2 point.

Other key Missions launched to study Solar Activity

- **Parker Solar Probe (NASA):** First human-made object to fly close to the Sun.
  - Also, it travelled at a speed of approximately 700,000 kilometers per hour, making it the fastest human-made object in history.
- **Interface Region Imaging Spectrograph (NASA):** Aims to understand how the Sun's atmosphere is energized, leading to solar eruptions.

5.1.5. CHANDRAYAAN-3

Why in the News?

India celebrated its maiden **National Space Day (NSD)** on 23rd August 2024 to commemorate the historic landing of Chandrayaan-3 on the Moon.

About National Space Day

- Chandrayaan-3 mission accomplished the safe and soft landing of **Vikram Lander** on the lunar surface on August 23, 2023.

About Chandrayaan-3

- A follow-on mission to Chandrayaan-2 (2019).
- Became the world's **first mission** to soft-land near the lunar South Pole.
  - The landing site was named as **'Shiv Shakti' point** (Statio Shiv Shakti).
  - Soft-landing was followed by the successful deployment of **Pragyan Rover**.
- India became the **fourth country** to soft land on the moon, after the US, Russia, and China.
  - Recently, Japan became the fifth country to land its **Smart Lander for Investigating Moon (SLIM)** on the Moon.
- **Launch vehicle**: Geosynchronous Satellite Launch Vehicle Mk III
- **Key Payload**: Chandra's Surface Thermophysical Experiment (ChaSTE), Alpha Particle X-ray Spectrometer (APXS), etc.

Related Concept

Far Side of Moon

- Chang'e-6 probe from China has successfully brought back the **first samples ever collected from the Moon's far side.**
  - In 2019, China became the **first country to land a probe (Yutu-2) on the far side** of the moon.
- **About the far side of the Moon**
  - Refers to the **hemisphere of the Moon that always faces away from Earth (hence** also referred to as the dark side of the Moon).
    - > This happens because the **Moon is tidally locked with Earth** due to gravitational pull.
  - It has a **thicker crust, more craters, and fewer lava plains** than near side**.**
  - **Reaching the Moon's far side is challenging** due to its remoteness and rugged landscape, featuring massive craters and limited flat areas.

5.1.5.1. OTHER LUNAR MISSION IN NEWS

Mission	Key Detail/Features
Chandrayaan 4 	⊛ Union Cabinet approved the Chandrayaan-4 Mission, a successor to Chandrayaan-3. ⊛ **Aim:** To develop and demonstrate key technologies for landing on the Moon, **collecting lunar samples**, and returning to Earth safely. ➔ It will achieve the **foundational technologies** capabilities eventually for an Indian landing on the moon (planned by year 2040) and return safely back to Earth.
LUPEX Mission 	⊛ **Purpose: Investigate the quantity and quality of water on the Moon** and is envisaged to **explore the dark side of the moon.** ➔ It is a **project between ISRO** and **JAXA.** ⊛ **Landing Location:** Landing point will be the **south pole of the moon** as this area is believed to **have a high-water potential.** ➔ However, landing on the South Pole is challenging as there are **very few flat, easy landing sites with good illumination and communication conditions.**

5.1.6. REUSABLE LAUNCH VEHICLE (RLV) TECHNOLOGY

Why in the News?

ISRO completes its Reusable Launch Vehicle (RLV) technology demonstrations.

More on the News

- ISRO has achieved a **third consecutive success** in the final test of the **RLV Landing Experiment (LEX)**, following the success of RLV LEX-01 and LEX-02 missions**.**
- RLV LEX is part of the **RLV-Technology Demonstration Programme,** which aims to develop essential technologies for a **fully reusable launch vehicle** to enable **low-cost access to space**.

About RLV LEX-03

- This mission **simulated high-speed landing conditions for a vehicle returning from space**.
- Test was conducted with a **winged vehicle,** named **'Pushpak'**.
  - **Unlike SpaceX's Falcon 9** which lands back **vertically**, Pushpak has **wings** to help it **glide horizontally.**

ISRO's RLV-Technology Demonstrator (RLV-TD) Vehicle

- 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.
- Consists of **a fuselage (body), a nose cap, double delta wings,** and **twin vertical tails** and looks similar to an **aircraft.**
- RLV-TD will be scaled up to become the **first stage of India's reusable two-stage orbital launch vehicle**.

5.1.7. OTHER DEVELOPMENTS

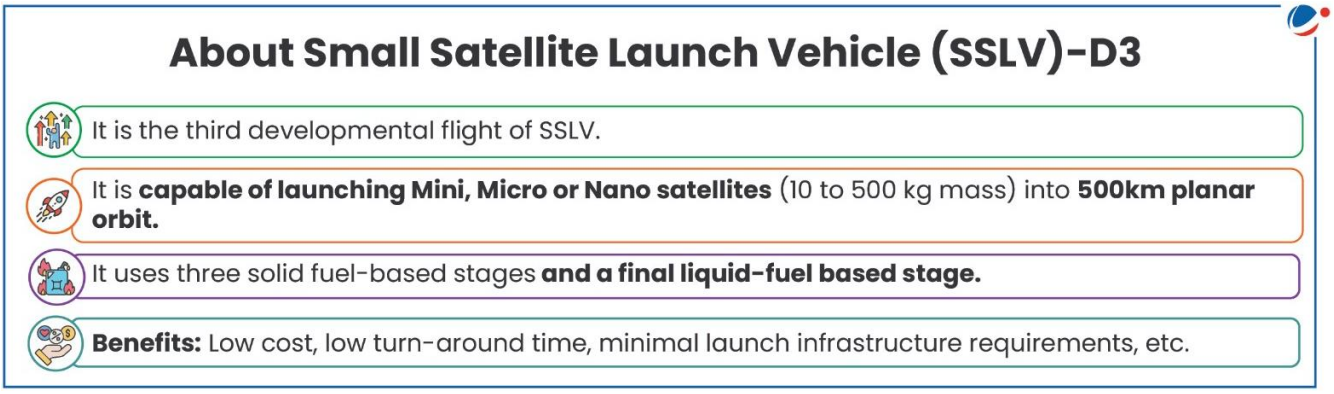
5.1.7.1. EARTH OBSERVATION SATELLITE EOS-08

ISRO launched Earth Observation Satellite EOS-08.

- Satellite has been launched under **SSLV-D3/EOS-08 mission** by the **Small Satellite Launch Vehicle (SSLV)-D3** from Satish Dhawan Space Centre, Sriharikota.
- Mission configuration is set to operate in circular **Low Earth Orbit.**

About Earth Observatory Satellites (EOS)

- EOS or Earth remote sensing satellites are designed for Earth observation (EO) from orbit.
  - EO refers to **collecting information** about activities on Earth, both natural and artificial, including **physical, chemical, biological,** and **human systems.** EO includes:
- **Applications:** Used in Early warning systems, environmental impact monitoring, etc.



5.1.7.2. AIR BREATHING PROPULSION SYSTEM

ISRO successfully carried out the **second experimental flight** for the **demonstration of Air Breathing Propulsion Technology**.

- The Propulsion systems were symmetrically mounted on either side of a **RH-560 Sounding rocket**.
  - RH-560 is a two-stage, **solid motor-based sub-orbital rocket**.
  - It is the **heaviest** sounding rocket in the **ISRO's family of sounding rockets**.

About Air Breathing Propulsion Technology

- **Utilizes atmospheric oxygen for combustion**, **eliminating the need to carry oxidizer**.
- Provides a technological key for **low-cost space transportation systems** and improves the **payload fraction**.
- **3-main types**:
  - **Ramjet:** Work most efficiently at **supersonic speeds around Mach 3.**
  - **Scramjet:** Efficiently operates at **hypersonic speeds.**
  - **Dual mode Ramjet (DMRJ):** Can be operated in both subsonic and supersonic combustion modes.

5.1.7.3. ARYABHATA

ISRO celebrated Satellite Technology Day (STD) commemorating the **50th year of the Aryabhata launch** in 1975.

About Aryabhata

- **India's first satellite**, named after the famous Indian astronomer in the 5th century.
- **Built by: ISRO** and launched by a **Soviet Kosmos-3M rocket from Kapustin Yar (Russia).**
- Aimed to conduct **experiments in X-ray astronomy, aeronomics,** and **solar physics.**

5.1.7.4. ASTROSAT

AstroSat observations have helped discover irregular emission of high energy X-ray photons from a Black Hole X-ray binary system (BH-XRB).

About AstroSat

- Launched by **ISRO in 2015** using PSLV-C30 in Low Earth Orbit.
- **Objectives:** Understand high energy processes in binary star systems, detect new transient X-ray sources, study star birth regions, etc.

- **India's first** dedicated **multi-wavelength space observatory**.
  - It aims to study celestial sources in **X-ray, optical, and UV spectral bands** simultaneously.
- It has **five payloads** for multi-wavelength observations.

5.1.7.5. TRISHNA: INDO-FRENCH THERMAL IMAGING MISSION

TRISHNA (Thermal Infra-Red Imaging Satellite for High-resolution Natural Resource Assessment) mission is a collaborative endeavour between ISRO and CNES (French Space Agency).

About TRISHNA Mission

- **Objective:** Detailed **monitoring of energy** and **water budgets** of the **continental biosphere** for quantifying terrestrial water stress and water use and high-resolution observation of water quality and dynamics.
- It will operate in a **Sun-synchronous (SSO) orbit**.
  - SSO is a **particular kind of polar orbit** in which satellites are synchronized to always be in the same position relative to the Sun.

5.1.7.6. NATIONAL INFORMATION SYSTEM FOR CLIMATE AND ENVIRONMENT STUDIES (NICES) PROGRAMME

The NICES programme has invited Indian researchers to join in combating climate change.

About NICES Programme (2012)

- Operated by the **ISRO** and **Department of Space** along with **other ministries** under the **National Action Plan on Climate Change**.
- **Objective: Generating and disseminating long-term Essential Climate Variables,** derived from Indian and other Earth Observation satellites

5.2. SPACE-RELATED PHENOMENON

5.2.1. EXPANSION OF UNIVERSE

Why in the News?

Research revealed the most precise measurement of the universe's expansion with the help of data collected by the **Dark Energy Spectroscopic Instrument (DESI)**.

More on the News

- Researchers found that the universe is expanding at a rate of 68.5 (±0.6) kilometers per second per megaparsec.
- They have created the **largest 3D map** of the universe.
- DESI, located in the USA, measures the effect of dark energy on the expansion of the universe.

Key Theories Related to the Expansion of the Universe

- **Big Bang Model**
  - The universe originated from an extremely **hot** and **dense singularity** approximately 13.8 billion years ago and has been expanding ever since.
  - It is the **only model** that can explain the existence of the **Cosmic Microwave Background (CMB).**
    - The CMB is the cooled remnant of the first light that could ever travel freely throughout the Universe.
- **Lambda CDM (Cold Dark Matter) Model**
  - Both **matter and dark energy shape how the universe expands** – but in opposing ways.
  - **Matter and dark matter slow** the expansion down, while **dark energy speeds it up.**
- Expansion of the Universe is measured by the **Hubble Constant**.

The Universe's Building Blocks

- **Dark Energy**: It makes up about 68% of the universe.
- **Dark Matter:** It is a hypothetical form of matter that **cannot be directly observed**, but its existence is inferred from its gravitational effects on visible matter and background radiation in the universe.
  - It makes up about **27% of the universe**.
- **Normal Matter:** The rest of 5% of the Universe is made up of **normal matter**. It includes Earth, the sun, other stars, and galaxies.

About Hubble Constant

- In 1929, Edwin Hubble provided the first mathematical description of the universe's expansion.
- **Hubble constant** is calculated by:
  - Analysing changes to **Cosmic Microwave Background (CMB)**.
  - **Cosmic Distance Ladder** uses techniques to measure distance to objects that are close, further away, and very far away from the Earth. E.g. **Redshift and blueshift**
    - When an object is moving away from us, the light from the object is known as **redshift**, and when an object is moving towards us, the light from the object is known as **blueshift**.
- **Hubble Tension** refers to the discrepancy that **two equally valid methods** to measure "**how fast the universe is expanding**" have yielded different estimates.

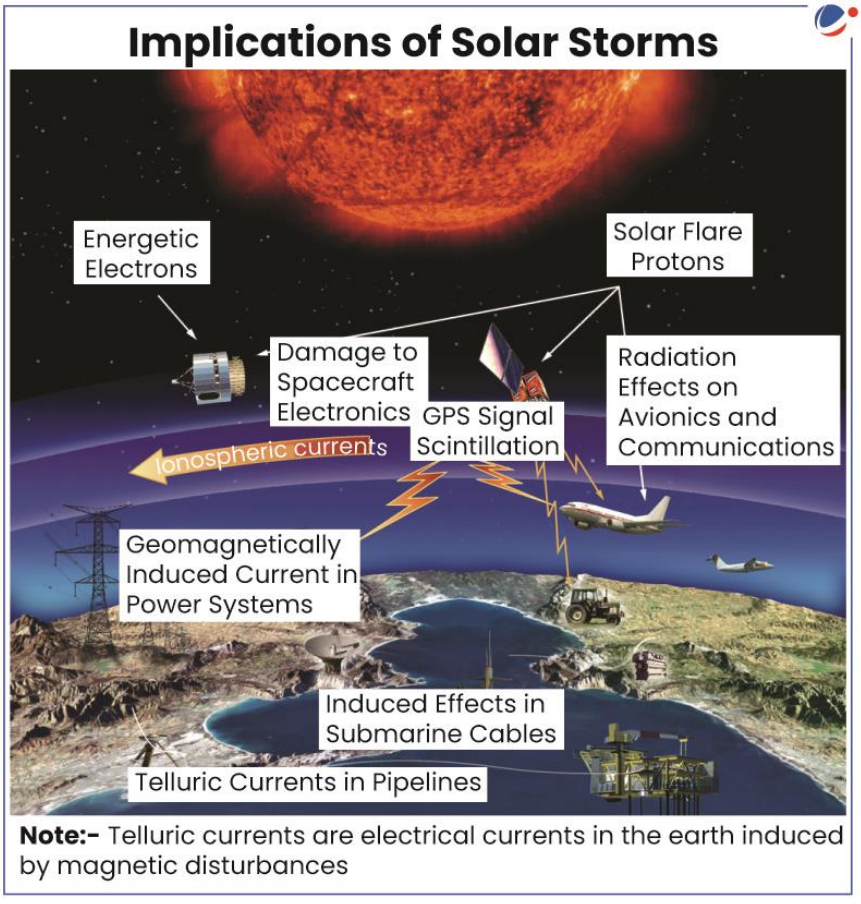
5.2.2. SOLAR STORM (GEOMAGNETIC STORM)

Why in the News?

Earth witnessed a **G5-level solar storm**, the strongest in two decades and possibly one of the strongest displays of auroras in the past 500 years.

What are Solar Storms?

- **Solar storms** are like massive bursts of energy from the Sun.
  - They happen when a large eruption on the Sun's surface, often accompanied by **solar flares** and **coronal mass ejections (CMEs),** accelerates charged particles to incredibly high speeds.
- Depending on the intensity, they are classified from **G1 (Minor) to G5 (extreme).**
- **High-speed solar winds** bring **geomagnetic storms.**
- These are a result of the Sun entering a **period of peak activity** called **Solar Maximum**.



Note:- Telluric currents are electrical currents in the earth induced by magnetic disturbances

About Solar Flare and CME

- **Solar Flare** is an intense burst of radiation, while **CMEs** are huge clouds of plasma (hot, ionized gas) and magnetic fields ejected from the Sun near Sunspots.

- These ejected particles can travel over a **million miles per hour**, and they interact with our planet's magnetic field, causing disturbances.
- **Sympathetic Solar Flares** are caused by multiple eruptions across the Sun's magnetic field.

The Sun's Activity Cycle

- The Sun goes through cycles of activity, **with periods of high and low activity**.
- **These cycles last about 11 years**, and during the peak of the cycle, called the **solar maximum**, there are frequent **solar storms** and increased instances of **sunspots** (cooler regions on the Sun's surface)
  - This is because the **Sun's magnetic fields are** more complex and twisted during this phase, leading to more eruptions and ejections of charged particles.

Related Concepts

Granules and Super Granules

- Energy generated in the Sun's core is **transported by convective fluid flows through the convection zone** (Sun's outermost 30%).
- These convection motions are visible at the surface as **granules** (about 1000 km across) and **supergranules** (about 35,000 km across) **cellular features**.
  - These features are the **tops of convection cells** where hot fluid rises up from the interior, spreads out across the surface, cools, and then sinks inward.

Aurora

- **Multi-coloured lights appear** in the **upper atmosphere** (ionosphere) **over the Polar Regions** and are visible from locations in the middle and high latitudes.
- Aurora in the **Northern Hemisphere** is called **aurora borealis** and **aurora australis** in **Southern Hemisphere.**
- **Caused by** the interaction of **solar wind with oxygen and nitrogen gas** in the atmosphere.

5.2.3. SPACE DEBRIS

Why in the News?

ISRO released the **Indian Space Situational Assessment Report (ISSAR) for 2023** compiled by **ISRO System for Safe and Sustainable Space Operations Management (IS4OM).**

More on the News

- **Report** highlighted five major on-orbit break-up events in 2023, resulting in a net addition of fragmented objects to the space debris population.
- **IS4OM (**2022) safeguards ISRO's space assets and improves compliance with internationally recognized guidelines on the Long-Term Sustainability (LTS) of outer space activities.

About Space Debris

- **Definition:** Includes all **non-functional, artificial objects**, including fragments and elements thereof, **in Earth orbit** or re-entering into Earth's atmosphere.
- **Debris concentration: Maximum debris concentrations** can be noted **at altitudes of 800-1000 km**, and near 1400 km (mainly in LEO).
- **Origins:** Majority of debris objects originate from **on-orbit break-ups** as well as on-orbit collisions.
  - Space debris also originates from **defunct satellites, missing equipment, spent rocket stages**, and the use of space-based weapons.
- **Kessler Syndrome:** A phenomenon in which the density of objects in the Low Earth Orbit grows and leads to collision, triggering a chain reaction that generates more space debris and further collisions.

Initiatives for mitigating Space Debris

- **Global initiatives and international partnerships**
  - **Inter-Agency Debris Coordination Committee (IADC),** an international governmental forum for the worldwide coordination of activities related to man-made and natural debris in space.

- **UN Space Debris Mitigation Guidelines**
- **Zero Debris Charter:** Signed by **12 countries** such as Austria, Belgium, Cyprus, etc.

- **India's initiatives**
  - Debris Free Space Missions (DFSM) 2030
  - Space Situational Awareness Control Centre (SSACC)
  - Project Network for Space Object Tracking and Analysis (NETRA)

5.2.4. PLANETARY DEFENSE

Why in the News?

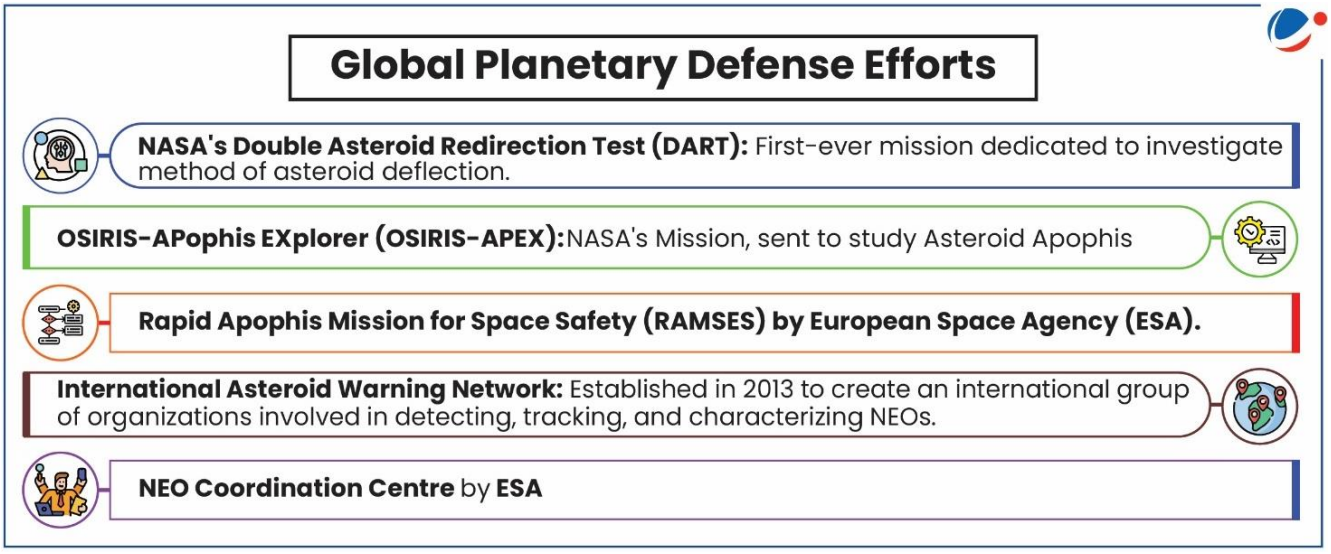
At an international workshop on Asteroid Day 2024, ISRO Chairperson said that ISRO is looking to study **asteroid Apophis** when it is **32,000 km away from Earth in 2029** to prepare for planetary defense efforts.

About Asteroid Apophis

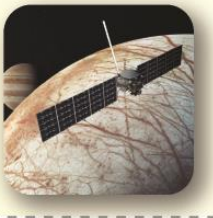
- **Discovered in 2004**, it is a **near-Earth object (NEO)** and was identified as one of the most hazardous asteroids that could impact Earth.
  - There are billions of comets and asteroids in our solar system. The vast majority never approach Earth. When a **comet or asteroid's orbit brings it close to Earth, it is classified as NEO**.
- However, a radar observation campaign in March 2021, combined with precise orbit analysis, allowed astronomers to conclude that there is **no risk of Apophis impacting our planet for at least a century**.

Planetary Defense

- Refers to **efforts and strategies aimed at protecting Earth from potential impacts by NEOs** such as asteroids and comets.
  - It involves **multiple strategies** including detection, tracking, impact assessment, deflection, etc.
- **Need for Planetary Defense:** If the **NEO path intersects with that of Earth's orbit,** then depending on their size, speed, angle, and impact region, could threaten billions of lives on impact and in the ensuing tsunamis, earthquakes and fires.



5.3. KEY SPACE MISSIONS IN NEWS

Mission	Agency	Objective/Key Detail
Juno mission 	**NASA**	⊛ To understand the origin and evolution of **Jupiter.** ⊛ It will investigate the existence of a possible **solid planetary core**, map Jupiter's intense magnetic field, etc.
PACE Mission 	**NASA**	⊛ Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) Mission aims at understanding **how the ocean** and **atmosphere exchange carbon dioxide.** ⊛ Also, revealing how aerosols might fuel phytoplankton growth in the surface ocean.
MAVEN Mission 	**NASA**	⊛ **Mars Atmosphere and Volatile Evolution (MAVEN) Mission** is the **first mission** devoted to **understanding** the **Martian upper atmosphere.**
Dragonfly Mission 	**NASA**	⊛ Aims to explore the chemistry and habitability of multiple surface sites covering a large area of Titan **(Saturn's moon)**. It will help in investigating Titan's habitability. ➝ It is the fourth mission of **NASA's New Frontiers Program.** The other three are **New Horizons, Juno, and OSIRIS-Rex (also OSIRIS-APEX).**
Europa Clipper 	**NASA**	⊛ Determine whether Europa (Jupiter's moon) has conditions that could support life. ⊛ **Largest spacecraft NASA** has ever **developed for a planetary mission.** ⊛ First dedicated Mission of NASA to **study an ocean world beyond Earth.**

EarthCARE Mission 	**ESA** and the **JAXA**	⊛ Earth Cloud Aerosol and Radiation Explorer (EarthCARE) Mission aims to provide a holistic view of the complex interplay between **clouds, aerosols,** and **radiation.**
RISE Mission 	**ESA**	⊛ **RISE (Remove Debris In-Orbit Servicing) Mission is the first in-orbit servicing mission of ESA** which is a significant step towards **refueling, refurbishment, and assembling in orbit.** ⊛ It will have the ability t**o dock and control orbit of geostationary satellites.**

5.4. TELESCOPE IN NEWS

5.4.1. MAJOR ATMOSPHERIC CHERENKOV EXPERIMENT (MACE)

Department of Atomic Energy (DAE) inaugurated the **Major Atmospheric Cherenkov Experiment (MACE) Observatory at Hanle, Ladakh.**

About MACE Observatory

- Largest imaging **Cherenkov telescope in Asia** and **2nd largest in the world.**
  - **Cherenkov Telescope Array (CTA),** consisting of two arrays located in Spain and Chile, respectively, will be the **largest Cherenkov telescope** in the world. It is currently under construction.
- **Location:** Altitude of ~4,300 m, the highest of its kind in the world.
- **Objective:** Observe **high-energy gamma rays** to understand the most energetic phenomena in the universe (such as supernovae).
  - Named after scientist **Pavel Alekseyevich Cherenkov,** who discovered that charged particles glow when they pass through a non-conducting medium under certain conditions (referred to as **Cherenkov radiation**).
- Indigenously built by **Bhabha Atomic Research Centre (BARC)** with support from other partners.

5.4.2. SQUARE KILOMETER ARRAY

Square Kilometer Array (SKA) has carried out its **first observations** and became partially functional.

About SKA

- Aims at building the world's **largest radio telescope**, with eventually over a square kilometer of collecting area.
- Consists of one global observatory, operating two large telescopes (South Africa and Australia).
- **Objectives of SKA Telescopes:**
  - Understand the birth of the Universe.
  - Detect Gravitational Waves.
  - Understand the evolution of Galaxies, Dark matter, and Cosmic Magnetism.
- India **joined the SKA Organization in 2012** as **an Associate Member** and has actively participated in the pre-construction phase of the SKA telescopes.

5.4.3. UNIVERSITY OF TOKYO ATACAMA OBSERVATORY (TAO) PROJECT

TAO telescope site completion ceremony held in Santiago, Chile.

About TAO Project

- The project aims to construct the **optical-infrared telescope** at the summit of **Cerro Chajnantor**, in the **Atacama Desert** of Chile.
  - It is the **world's highest astronomical site**
  - Region's **high altitude, thin atmosphere, and perennially arid climate** make it possible to observe almost **entire range of near-infrared wavelengths**.

5.5. KEY CONCEPTS/TERMS IN NEWS

5.5.1. BROWN DWARF

James Webb Space Telescope (JWST) observations were used to **map the weather on a pair of brown dwarf stars.**

- JWST is a **large infrared telescope**, the result of an international collaboration among **NASA, the European Space Agency, and the Canadian Space Agency**.

About Brown Dwarf

- Objects that have a **size between that of a giant planet like Jupiter and that of a small star.**
- They do **not have enough mass** to fuse normal hydrogen like a regular star and thus are **not able to sustain nuclear fusion**. So, they are often called 'Failed Stars'.

5.5.2. WHITE DWARF STAR

The **first rocky planet** has been spotted orbiting a burned-out star **called a white dwarf.**

About White Dwarf Star

- It is a **stellar core left behind** after a **dying star has exhausted its nuclear fuel** and expelled its outer layers **to form a planetary nebula.**
  - Compared to dwarf stars, giant stars have a greater rate of nuclear reactions.
  - Therefore, the latter have shorter lifespans compared to dwarf stars.
- **Chandrasekhar limit (1.44 times the mass of the Sun)** is the maximum mass theoretically possible for a stable white dwarf star.
  - A star that ends its nuclear-burning lifetime with a mass **greater than Chandrasekhar's limit** must become **either a neutron star** or **a black hole.**

5.5.3. PLUNGING REGION

A study at Oxford University Physics provided the **first observational proof of 'plunging regions'** as per Einstein's theory.

About Plunging region

- An **area around the Black Hole** where **matter stops circling the black hole** and instead **falls straight in**.
  - It was predicted by **Albert Einstein's theory of general relativity** which states that it is impossible for particles to safely follow circular orbits sufficiently close to a black hole.
- Plunging regions **exert some of the strongest gravitational forces** in the galaxy.

5.5.4. TROJAN ASTEROID

Discovery of a **Trojan asteroid (2019 UO14)** for Saturn establishes the presence of celestial bodies alongside all **giant planets (Jupiter, Neptune & Uranus).**

About Trojan asteroids

- They occupy a stable Lagrange Point (**Usually L4 and L5**) in a planet's orbit around the sun.
- **Significance:** As they remain gravitationally stable for a long period, studying them can provide useful insights into the evolution of the solar system.
- **Mission Lucy (2021)** was the first mission to explore the Jupiter Trojan asteroids.

5.5.5. SUPER BLUE MOON

Recently, a super blue moon, an occurrence that happens on average every 10 years, was observed.

About Super Blue Moons

- A Super Blue Moon is the convergence of a Supermoon and a Blue Moon.
- When the Moon is **at or near its closest point to Earth (perigee)** at the same time as it is full, it is called a **Supermoon.**
- There are **two types of Blue Moon**.
  - A **monthly blue moon** occurs when a full moon is seen twice in a single month.
  - A **seasonal blue moon** occurs when there are four full moons in a single season instead of the usual three.

5.6. OTHER IMPORTANT NEWS

5.6.1. RHUMI-1

India's first Reusable Hybrid Rocket named RHUMI-1 launched.

About RHUMI-1

- Developed by **Tamil Nadu-based startup Space Zone India** in collaboration with Martin Group.
- Carried **3 Cube Satellites and 50 PICO Satellites**, which will collect data on climate change.
  - **Cube satellites** are a class of **nanosatellites**, weighing between 1-10 kg.
  - **Pico satellites** typically weigh between 0.1 and 1 kg.
- **Features:**
  - **Hybrid Rocket Engine:** Uses a **combination of solid and liquid propellants** to improve efficiency and reduce operational costs.
  - **Environment Friendly:** RHUMI is **100% pyrotechnic-free** and 0% TNT.

Reusable Rockets

- Reusable rockets release the payload, **land back on Earth,** and can again be launched with a new payload.
- **Benefits: Cost Savings** (Up to **65% cheaper** than building a new rocket)**, reduces Space Debris**, and **increased launch frequency.**

5.6.2. SPACE-BASED SURVEILLANCE

Cabinet Committee on Security (CCS) has approved the third phase of the Space-based Surveillance (SBS-3) project for better land and maritime domain awareness for civilian and military applications.

About SBS-3 Project

- Successor of **SBS-1 (2001) and SBS-2 (2013).**
  - Cartosat-2A, RISAT-2, Eros-B, RISAT-2A etc. satellites were launched during SBS-1 and SBS-2.
- SBS-3 includes **52 satellites** in **Low Earth Orbit (LEO)** and **Geostationary Orbit (GEO)** for surveillance.

- The new fleet of satellites will be at different orbits **based on artificial intelligence (AI)** and will be able to **"interact with each other in space to gather geo-intelligence"** on the Earth.
    - When a satellite in GEO (36,000 km) detects something, it can request a closer look from a satellite in **LEO (400–600 km),** providing more detailed information.
- Three services will have dedicated satellites for their land, sea, and air-based missions.

About Space-based Surveillance (SBS)

- Involves the **use of satellites and other space assets to monitor and collect data on objects and activities in space and on Earth.**
- SBS systems are used **primarily for national security, space situational awareness,** etc.
- The U.S. has the most extensive network, including systems like the **Space-Based Infrared System (SBIRS)** and the **upcoming Next-Generation Overhead Persistent Infrared (Next-Gen OPIR) satellites**.

5.6.3. VAN ALLEN RADIATION BELT

Polaris Dawn Mission completed the **World's First Private Spacewalk.**

- Polaris Dawn Spacecraft has **traveled through Earth's regions of high radiation**, i.e., the **South Atlantic Anomaly** and **Van Allen Radiation Belt**, to **study space radiation's impact on human health.**

About Van Allen Radiation Belt (Discovered in 1958 by astrophysicist James Van Allen)

- Earth's **magnetosphere traps the high energy radiation particles and shields the Earth** from solar storms and solar winds that can damage technology as well as people living on Earth.
    - These **trapped particles form two belts of radiation (inner and outer), known as Van Allen Belts**, that surround the Earth.
        - **Inner belt** results from **interactions of cosmic rays with Earth's atmosphere** and **Outer belt** is made up of billions of **high-energy particles** that originate from Sun.
- Astronauts and **spacecraft must fly through Van Allen Belts to reach outer space,** so it is important to fly through this region quickly to **limit their radiation exposure**.

South Atlantic Anomaly

- A geographical region over the **South Atlantic Ocean** where the **inner Van Allen radiation belt** extends down particularly close to Earth.
- This leads to highly increased levels of **ionizing radiation** and related impacts on spacecraft in LEO.

5.6.4. SPY OR RECONNAISSANCE SATELLITE

South Korea puts a second military spy (reconnaissance) satellite successfully into orbit.

About Spy or Reconnaissance satellite

- Provides **intelligence information** on the military activities of foreign countries.
- Can be either a **communications satellite** or an **Earth observation** satellite.
- **Major Types**:
    - **Optical-imaging satellites**: They have light sensors that detect missile launches and see enemy weapons on the ground.
    - **Radar-imaging satellites**: They can observe the Earth using radar technologies even during cloud cover.
    - **Signals-intelligence or ferret satellites**: They capture the radio and microwave transmissions.

5.6.5. SPACE TOURISM

Space startup Blue Origin has announced that Gopi Thotakura will be part of its New Shepard's 25th Mission (NS-25 mission).

What is Space Tourism?

- Space tourism is the commercial practice of sending **private individuals to space for recreational, adventure, or leisure purposes**.
- **Types**:
  - **Suborbital**: In it, passengers are taken between **50 and 70 miles** above Earth (crossing the **Kármán line**).
    - > **The Karman line is** a boundary **100 kilometers** above mean sea level that borders Earth's atmosphere and the beginning of space.
  - **Orbital**: In it, passengers are taken significantly above the **Karman line**.

6. HEALTH

6.1. DISEASES AND RELATED DEVELOPMENT

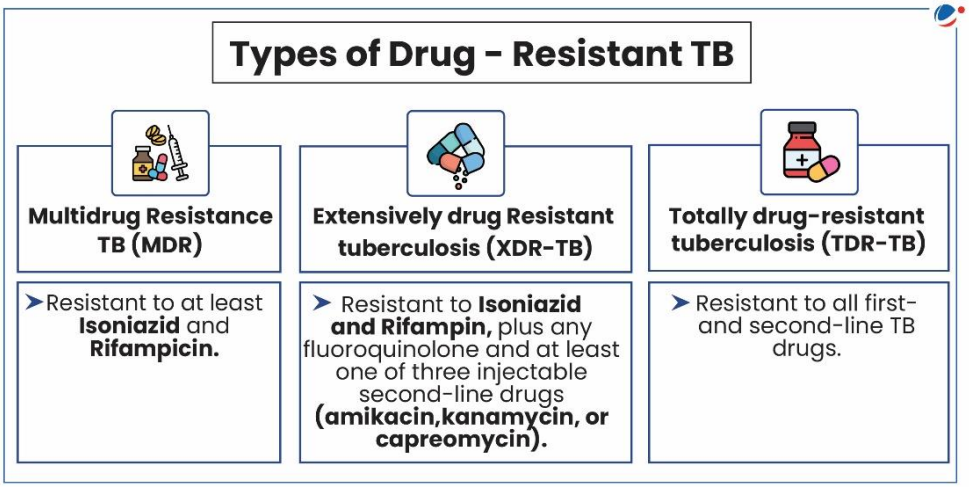
6.1.1. TUBERCULOSIS

Why in the News?

Global Tuberculosis (TB) Report 2024 has been released by the **World Health Organisation**.

Key findings

- India accounted for **26% of the global TB burden** in 2023.
- India **ranks 1st globally in the burden of multidrug-resistant/Rifampicin-resistant TB.**



About Tuberculosis

- An infectious disease caused by bacillus **Mycobacterium tuberculosis bacteria** which most often **affects lungs** and is known as **pulmonary TB.**
  - **Extrapulmonary TB** is the TB that affects **other areas of the body. (e.g.** gastrointestinal TB, liver TB)
- **Transmission:** By air when an infected person coughs, speaks, laughs, sings, or sneezes.
- **Common symptoms**: Prolonged cough (sometimes with blood), chest pain, weakness, etc.
- **Tests for Identification:** Xpert MTB, RIF Ultra, and Truenat assays.
- **Drug-resistant TB** that doesn't respond to standard drugs.

Key Initiatives

India's Initiatives

- **National Tuberculosis Elimination Programme (NTEP)**
- **The Ministry of Health and Family Welfare approved a new BPaLM** regimen consisting of **four drugs- Bedaquiline, Pretomanid, Linezolid,** and **Moxifloxacin.**
  - It brings down treatment time to 6 months (earlier 20 months).
- **Pradhan Mantri TB Mukt Bharat Abhiyan,** provides additional patient support, **augments community involvement,** etc.
- **Other:** Nikshay Poshan Yojana, National TB Call Centre – Ni-kshay SAMPARK, TB Mukt Panchayat Initiative, etc.

WHO Initiative

- **End TB Strategy,** aims **to reduce TB incidence by 80%, TB deaths by 90%, and to eliminate catastrophic costs for TB-affected households by 2030.**
- TB Vaccine Accelerator Council, facilitates the development, testing, authorization, and use of new TB vaccines

6.1.2. MONKEYPOX (MPOX)

Why in the News?

World Health Organization (WHO) declared the Monkeypox outbreak a **Public Health Emergency of International Concern (PHEIC).**

More on the News

- WHO also **announced the inclusion** of the **Monkeypox (mpox) In Vitro Diagnostic (IVD) kid** under **its Emergency Use Listing (EUL)** procedure**.**
  - EUL **is a Risk-based procedure** for assessing and listing unlicensed medical products.
  - **Includes three product streams:** Vaccines, Therapeutics, and In Vitro Diagnostics.

About Mpox

- **A Viral illness** caused by the **monkeypox virus,** a species of the **genus Orthopoxvirus.**
  - It is a **zoonotic disease**, meaning it can be spread between animals and people.
- Occurs mostly in central and western Africa.
- **Two distinct clades:** Clade I and Clade II
- **Vaccines and therapeutics** developed **for smallpox** and approved for use in some countries **can be used for mpox** in some circumstances.
  - Recently, WHO prequalified the MVA-BN Vaccine.
- A recent study shows that the mpox virus uses a '**genomic accordion**' to evolve and infect humans.
  - **Genomic Accordions are** used to describe **the evolution of Poxviruses**, which is a **multi-step process of gene amplification, mutation,** and **reduction.**
- The **Indian Council of Medical Research (ICMR)** has conducted **a Serosurvey** for it.
  - **Serosurvey** is the collection and testing of blood from a specimen of a defined population over a specified period.

About PHEIC

- As per **IHR (2005), an outbreak qualifies** as a **PHEIC if** it is **unusual or unexpected;** it has **the potential for international spread;** and may **require immediate international action.**
- PHEIC represents the **highest level of alert issued by WHO** under IHR.

Related News
Vishanu Yuddh Abhyas

- **Vishanu Yuddh Abhyas,** a mock drill on Pandemic Preparedness conducted under **the National One Health Mission (NOHM).**
- **NOHM emphasizes the "One Health" approach** to achieve integrated disease control and pandemic preparedness.

6.1.3. NEGLECTED TROPICAL DISEASES (NTDS)

Why in the News?

India has become the **third country in the Southeast Asia Region** after Nepal and Myanmar that eliminated Trachoma, **Neglected Tropical Diseases (NTDs)**.

About Trachoma

- **Eye infecting disease** caused by infection with the bacterium **Chlamydia trachomatis.**
  - It is a contagious (spreading through contact with **eyes, nose, etc.**) disease and if left untreated can cause **irreversible blindness**.
- **Status in India:** In 1971, blindness due to Trachoma was **5%** and now it has come down to less than **1%.**

About Neglected Tropical Diseases (NTDs)

- NTDs are a diverse group of **conditions** mainly prevalent in tropical areas.
- They are caused by a variety of pathogens including **viruses, bacteria, parasites, fungi, and toxins**.
- Referred **Neglected** because they are almost absent from the global health agenda, Low global funding, and associated with stigma and social exclusion.
- **India** has the world's largest **absolute burden of at least 10 major NTDs** such as hookworm, dengue, lymphatic filariasis, etc.
  - WHO certified India as free of **Guinea Worm disease** (2000) and **Yaws** (2016).

6.1.4. ANTI-MICROBIAL RESISTANCE (AMR)

Why in the News?

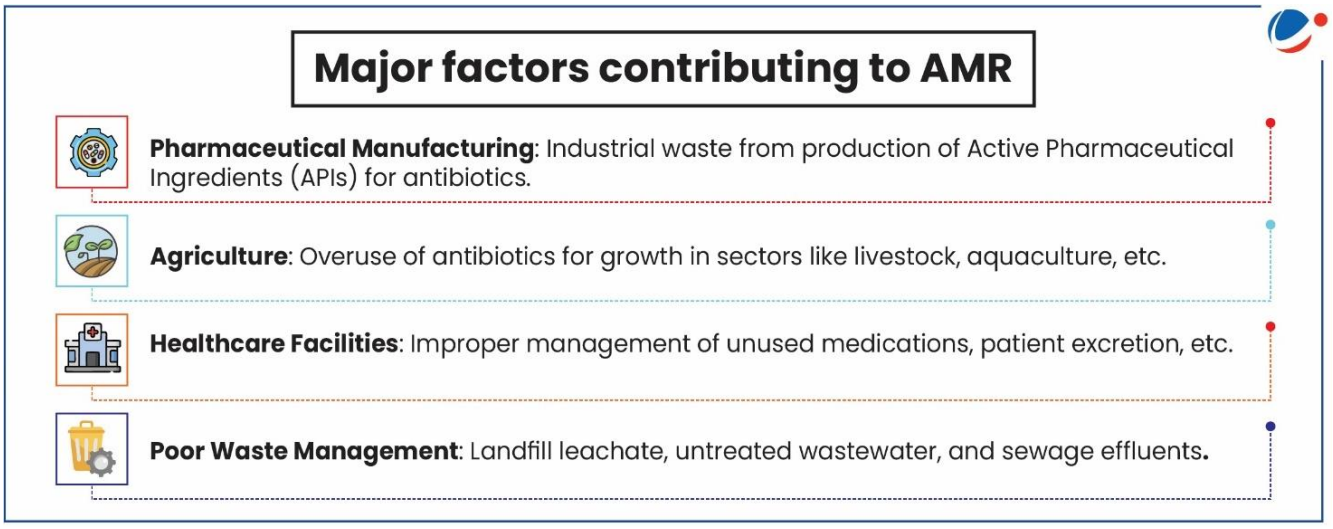
Jeddah Commitments adopted at Fourth **Global High-Level Ministerial Conference on Antimicrobial Resistance (AMR).**

More on the News

- It is a **comprehensive framework** for global action **to combat AMR** through a **One Health approach.**
- Commitments aim to **translate the Political Declarations of the United Nations General Assembly's (UNGA's) High-Level Meeting on AMR into practical commitments** for urgent actions.

What is Anti-Microbial Resistance (AMR)?

- AMR is a **condition when microorganisms** such as bacteria, viruses, fungi, and parasites change in ways that render the **medications used to cure the infections they cause ineffective.**
  - **Superbugs** are strains of bacteria, viruses, parasites, and fungi that are resistant to most of antibiotics and other medications.



Key Initiatives Taken

- **Global**
  - **Global Action Plan on Antimicrobial Resistance (GAP)** and Global **Antimicrobial Resistance Surveillance System (GLASS)** by WHO.
  - **National Centre for Disease Control (NCDC) Collaborations**
  - **One Health Global Leaders Group on Antimicrobial Resistance** - Tripartite collaboration of WHO, FAO, and World Organisation for Animal Health (OIE).
- **India**
  - **National Action Plan on AMR (NAP-AMR)**, 2017
  - National AMR surveillance network of state medical college labs (NARS-Net)

- **Regulation of Antibiotics under Schedule H and H1:** Antibiotics are listed under Schedule H and H1 of the Drugs Rules, 1945
- **Other:**
  - **Operation AMRITH** (AMR Intervention for Total Health) by Kerala
  - India launched the first indigenous **antibiotic "Nafithromycin"** for resistant infections.

Related News
Dysbiosis
- Irrational use **of antibiotics is associated with** dysbiosis.
- **About Dysbiosis**
  - Refers to an **imbalance of microbial species and a reduction in microbial diversity** within certain bodily microbiomes.
  - As a result, **beneficial bacteria are usually minimized**, whereas other bacteria that may be **harmful increase** in number.

6.1.5. OTHER DISEASES IN NEWS

6.1.5.1. AVIAN INFLUENZA

Avian influenza has caused the **deaths** of more **than 300 million birds** worldwide**.**

About Avian Influenza

- Refers to the disease caused by infection with **avian (bird) influenza (flu) Type A viruses.**
- **Influenza A viruses** are divided into subtypes based on **two proteins** on the surface of the virus: **hemagglutinin (H) and neuraminidase (N).**
  - H and N of the influenza A virus **possess antagonistic activities on interaction with sialic acid (SA), which is the receptor for virus attachment**.
  - There are 18 different H subtypes and 11 different N subtypes Avian case.
    - In **birds**, **16 H and 9 N subtypes have been identified**. (Two additional subtypes, H17N10 and H18N11, have been identified in bats.)
- **Classification**:
  - **Low pathogenicity avian influenza (LPAI) A viruses:** H4N6
  - **Highly pathogenic avian influenza (HPAI) A viruses:** E.g. H5N1

6.1.5.2. ZIKA VIRUS

Union Health Ministry has issued an advisory to state governments to stop the spread of the Zika Virus.

About Zika Virus

- **Transmitted:** Primarily transmitted by the bite of an infected mosquito **Aedes aegypti**.
- **Health Concerns: Non-fatal but** associated with **microcephaly** (reduced head size) of babies born to affected pregnant women.
- It can also trigger **Guillain-Barré syndrome, neuropathy myelitis, etc.**
- **Reverse Transcription Polymerase Chain Reaction (RT–PCR)** is used for its detection.
  - RT-PCR is an inexpensive technique to determine the expression level of target genes.
- **Vaccine:** No vaccine available to prevent or medicine for it.

6.1.5.3. CHANDIPURA VIRUS

WHO has warned that the current Chandipura virus infection in India is the largest in 20 years.

About Chandipura Virus

- Also known as **Chandipura vesiculovirus (CHPV),** it is an **RNA** virus belonging to the **Rhabdoviridae** family.
  - It is known to outbreaks of acute **encephalitis syndrome (AES) in western, central, and southern parts of India**.

- **Transmission by:** vectors such as **sandflies, mosquitoes,** and **ticks.**
- **Symptoms:** Fever, vomiting, loose motion and headache.
- **Vaccine**: **No antiretroviral treatment or vaccine** accessible for treatment.

6.2. FIXED DOSE COMBINATION DRUGS

Why in the News?

The **Ministry of Health and Family Welfare** prohibited the manufacture, sale, or distribution of 156 **fixed-dose combination (FDC)** medicines**.**

What are Fixed Dose Combinations (FDCs) Drugs?

- **Definition**: Refer to **products containing two or more active ingredients** also referred to as cocktail drugs used for a particular indication(s) (as per **Drugs & Cosmetics Rule 1945).**
  - **Active Ingredient** is the biologically active component of a drug product (tablet, capsule, cream, injectable) that produces the intended effects.
- **As per the Drugs and Cosmetics Act** of **1940,** the FDCs are considered New Drugs, and the **CDSCO issues** approval.
- Mostly FDCs are in **combinations** of **cough, cold, and fever preparations**; **antimicrobials; vitamins and minerals,** etc.

Rationale for Usage of FDCs	Issues associated with FDCs
➤ **Enhanced efficacy** and reduces pill burden ➤ **More affordable** than purchasing individual medications separately. ➤ They have a **pharmacokinetic** (absorption, distribution, metabolism, and excretion of drugs by the body) advantage.	➤ Lack of **individual dose flexibility** ➤ Easy access to such **Unapproved and Banned FDCs** creates a potentially hazardous situation for public health. ➤ Increased risk of **Anti-microbial Resistance (AMR)**

About Regulation of Drugs in India

- **Central Drugs Standard Control Organisation (CDSCO)**, under the Ministry of Health and Family Welfare, is the **primary regulatory body for the pharmaceutical sector**.
  - Regulates the **quality, safety, and efficacy of Drugs, Medical Device, and Cosmetics** in the country under the provisions of the **Drugs & Cosmetics Act, 1940** and Drugs and Cosmetics Rules, 1945.
- **State Drug Regulatory Authorities (SDRAs):** Responsible for licensing of manufacturing establishments, surveillance over sale of spurious drugs, etc.
- **Statutory Bodies:** DCA 1940 provides for the establishment of the **Drugs Technical Advisory Board (DTAB)**, **Drugs Consultative Committee (DCC)**, etc.

National Pharmaceutical Pricing Authority (NPPA)

- **Genesis**: It was constituted in 1997, as an independent Regulator for the pricing of drugs.
- **Ministry**: Attached office of Department of Pharmaceuticals, Ministry of Chemicals & Fertilizers.
- **Role**: It fixes/ revises prices of controlled bulk drugs and formulations.
  - Enforces the Drugs (Prices Control) Order, 2013, etc.

6.3. XENOTRANSPLANTATION

Why in the News?

First Human recipient of a Genetically Modified Pig Kidney Transplant has died.

About Xenotransplantation

- **Involves transplantation**, implantation, or infusion of **live non-human animal cells**, tissues, or organs into a human recipient.
- **Process of Xenotransplantation**
  - Gene Editing Technology **CRISPR-Cas9 was utilized** to **eliminate specific pig genes** responsible for producing sugars triggering immune responses.
  - It **introduces specific human genes to enhance organ (kidney, heart) compatibility** with humans.
- **Benefits of Xenotransplantation**
  - **Alternative supply of organs** to those with life-threatening diseases.
  - Reduce the **shortage of transplantable** organs.
- **Concerns**: High **Organ rejection** rate; **Risk of infection** from an animal organ; Animal welfare, etc.

Why are Pigs often used for Xenotransplantation?

- Pig's **organ size, physiological metabolism,** and **immune system are similar** to those of human beings.
- Varieties of pig breeds are farmed, providing an **opportunity for harvested organs to be matched with specific needs** of human recipients.

About Framework for Organ Transplant in India

- **Transplantation of Human Organs and Tissues Act (THOTA), 1994** (amended in 2011) is the primary law governing transplants in the country.
  - Provides for a **Three-tier regulatory structure:** NOTTO at the National level and similar organizations at regional and state levels.
- **Eligibility for organ donation**
  - Most organ donation is determined by the **donor's physical condition, not age.**
  - **Both living** (must be at least 18 years of age) and **deceased** can donate organs.
  - **Consent from the family is required for organ donation** from the dead.

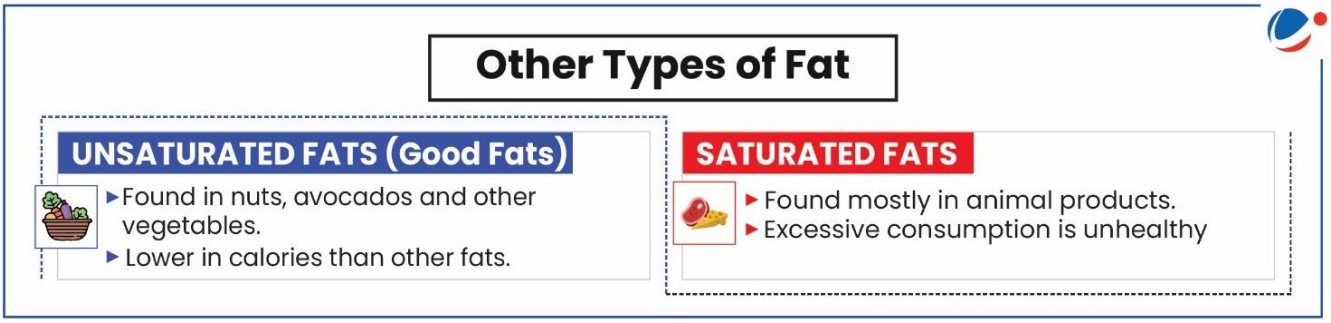
6.4. TRANS-FAT ELIMINATION

Why in the News?

World Health Organisation (WHO) has published the **fifth milestone report** on **progress** towards **global trans-fat** elimination, covering the period from 2018–2023.

About Trans-fat (or Trans-fatty acids (TFA))

- Trans fats are **unsaturated fatty acids** that have been partially saturated with hydrogen**.**
  - They are considered the worst type of fats (bad fat).
- **Types**: Based on sources, they can be Natural or Artificial.
  - **Natural:** Also called **ruminant trans fats**, as they are present in small quantities in meat and dairy products. These are not generally considered harmful.
  - **Artificial:** Also called **industrial-produced trans-fat** as they are formed in an industrial process that adds **hydrogen** to **vegetable oil**, converting the liquid into a solid and resulting in partially hydrogenated oil (PHO).
    - > On average, **trans fat concentrations in PHO are 25–45%.**
    - > Mainly **used in processed foods and has no nutritional benefits.**



Steps taken to regulate Trans fat

India

- Initiative taken by the **Food Safety and Standards Authority of India (FSSAI)**
  - Trans-fat-free logo – **Voluntary labelling to promote TFA-free products**
  - In 2021, the amount of TFA in oils and fats was capped at 3% for 2021 and 2% by 2022
  - **Other**: Eat Right India Movement, Heart Attack Rewind (Mass media campaign) etc.
- **Revised Dietary guidelines** by the Indian Council of Medical Research (National Institute of Nutrition)

Global

- **REPLACE action framework** by **WHO (2018)**
- **WHO Validation Programme** for Trans Fat Elimination to further drive policy progress.

Related News
Omega-3 Fatty Acids

- In a study, it has been found that regular use of **fish oil supplements** might be a risk factor for atrial fibrillation (an irregular and often very rapid heart rhythm) and stroke among the general population.
  - Fish oil is rich in two important omega-3 fatty acids called **eicosapentaenoic acid (EPA)** and **docosahexaenoic acid (DHA)**.
- **About Omega-3 Fatty Acids**
  - These are **polyunsaturated fats**.
    - > Polyunsaturated fats are fat molecules that have more than one unsaturated carbon bond in the molecule.
  - Apart from **EPA and DHA,** ALA (alpha-linolenic acid), another **Omega-3 Fatty Acid** is obtained from plants.
    - > These are **essential fats** (the human body is **unable to make on its own).**
  - **Key Sources**: Nuts and seeds (such as flaxseed) Plant oils (such as flaxseed oil,), seafood etc.
  - **Benefits**: **Reduces inflammation** in the body, **lowers blood triglyceride (a type of fat (lipid)) levels,** etc.

6.5. GLYCEMIC INDEX

Why in the News?

A recent study has revealed the relationship between the Glycemic Index in food to the risk of Type II diabetes and cardiovascular diseases.

About Glycemic Index (GI)

- **Definition: Measures how quickly a carbohydrate-containing food raises blood sugar levels** after it is consumed.
  - The index **ranks the carbohydrate-rich foods on a scale of 0 to 100** based on their ability to raise blood sugar levels as compared to pure glucose (which has a GI of 100).

- **Factors that determine GI:**
  - **Internal factors** like amylose, lipids, protein, etc.
  - **External factors** like cooking, processing, retro-gradation, soaking, and germination
- **Glycemic Load (GL): Uses GI and the amount of total Carbohydrates in a serving of a specific food** to estimate how quickly and how much blood sugar will rise after its consumption.

GI Index	Examples
High (>70)	Wheat, White rice, potatoes, white bread etc.
Medium (56-69)	Orange juice, honey, and wholemeal bread etc.
Low (<55)	Fruits, Non Starchy vegetables (Carrots, Spinach, Tomatoes etc.), Whole Grains, Legumes etc.

6.6. A1 AND A2 MILK

Why in the News?

Recently, the **FSSAI** withdrew its direction to **Food Business Operators (FBOs)** to not market their milk and milk products in the name of **A1** and **A2**.

Basis of the Classification

- **A1 and A2** are genetic variants of **Beta (β)-casein protein**.
  - **Casein** (make 80 % of milk protein) is one of the two types of protein found in milk. The other one is **Whey protein**.
- Differentiation in both is linked to the difference in the structure of the **amino acid** sequence.
  - Also, A1 evolved from A2 through **natural mutation**.
    - **Mutation** is a change in the DNA sequence of an organism.
- **Regular milk** contains both A1 and A2 beta-casein, while **A2 milk** is unique in that it contains only the A2 variant.
  - Studies by the **National Bureau of Animal Genetic Resources (NBAGR)** have confirmed that **indigenous cows** and **buffaloes** produce **A2 milk.**

Comparison between A1 and A2 Milk		
Parameters	**A1 Milk**	**A2 Milk**
Nutrition	• Higher **fat** content and **calorie** count.	• Higher **protein** content.

Health benefits	• Contains **histidine** (essential amino acids).
	  ○ **Histidine** is used by the body to produce **histamine**.
	• As per studies, A1 milk **cannot be digested** well by some people and A2 is a better alternative for them.
		• Contains **proline** (a non-essential amino acid).
		  ○ It is an essential component of **collagen** and important for proper functioning of joints and tendons.

Source	• Found predominantly in **cow breeds that originated in northern Europe** e.g. Holstein, Friesian, Ayrshire, and British Shorthorn.	• Present in milk from breeds n**ative to Channel Islands and southern France,** including Guernsey, Jersey, Charolais, and Limousin cows.

Related Concept
Histamine

- Plays a **key role in the inflammatory response of the body** and is also responsible for autoimmune conditions, gastric acid secretion, and hematopoiesis.

- They can be **released in our body due to different factors**, including:
  - Factors **related to the immune system** (for example contact with allergens, snake venom, etc.)
  - **other factors** that are not related to the immune system (for example physical injury).
- **Antihistamines** are **drugs that act to treat histamine-mediated conditions**.

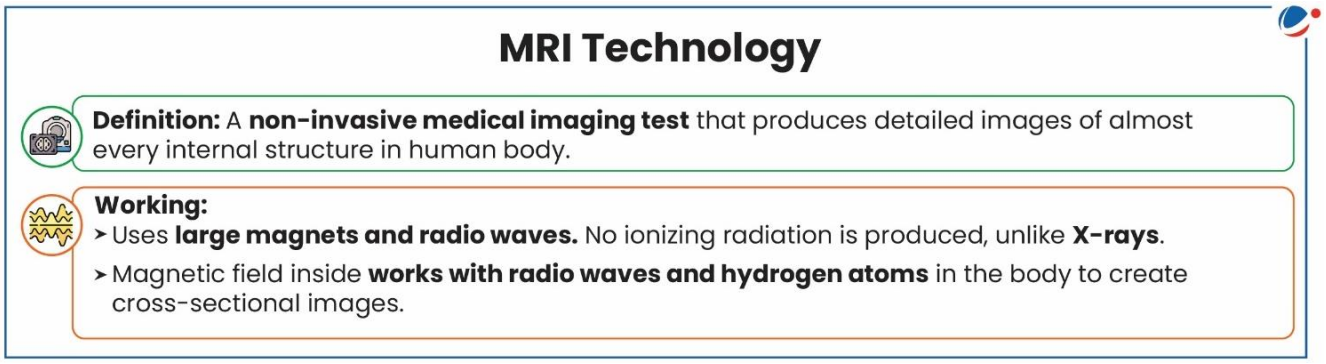
6.7. MAGNETIC RESONANCE IMAGING (MRI) TECHNOLOGY

Why in the News?

'Iseult' the World's most powerful **Magnetic Resonance Imaging (MRI)** scans the first images of the human brain.

More on the News

- Iseult' can help refine our understanding of **the anatomy of the brain.**
  - It could also shed light on diseases like **Alzheimer's** or psychological conditions like **depression or schizophrenia**.



Applications

- Images produced by an MRI scan can show **organs, bones, muscles, and blood vessels**.
- MRI is widely used in **medical diagnosis and treatment planning** for brain disorders, cardiovascular diseases, cancer, etc.

6.8. RADIATION THERAPY FACILITY

Why in the News?

Delhi's Lady Hardinge Medical College opens a **Radiation Therapy facility**.

About Radiation therapy

- Radiation therapy, or radiotherapy, is a **type of cancer treatment** in which cancerous cells are killed by exposing them to **ionizing radiation**s, such as **X-rays, gamma rays, high-energy electrons, or heavy particles**.
- **Significance: Highly effective and well-established treatment** for brain, breast, head and neck, cervical cancers, etc., while minimizing damage to healthy tissues from high doses of radiation.
- **Potential side-effects of Radiotherapy:** Fatigue, Nausea, Hair loss, Loss of appetite, etc.

About Proton therapy

- **Proton therapy** is an advanced and highly precise radiation treatment for cancerous cells.

Comparison between Traditional Radiotherapy and Proton Therapy

Parameters	Traditional Radiation Therapy	Proton therapy
Risk of damaging the nearby healthy cells	Low	Very low
Applicability	Not suitable for treatment near sensitive organs like eyes, brain, spine, etc.	Suitable for treatment near sensitive organs like eyes, brain, etc.
Cost	Less expensive	More expensive
Side effects	Mostly severe, affecting day-to-day activities	Less severe and do not interfere with normal functioning.

6.9. VACCINES IN NEWS

Vaccines

CONCEPT CORNER

Major Types of Vaccines

» **Live attenuated vaccines**
- Contain weakened live pathogens from bacteria or viruses. E.g., the measles, mumps, and rubella (MMR) Vaccine.

» **Inactivated or Dead vaccines**
- Uses **deactivated live pathogens,** creating immunity without causing disease. **E.g.** Polio vaccines, Influenza vaccine and COVAXIN.

» **Acellular or Subunit vaccines**
- Contain polysaccharides or proteins from the surface of the bacteria or virus.

Types of Subunit Vaccines

Toxoid Vaccine	Conjugate Vaccine	Recombinant Vaccine	DNA/RNA Vaccine
Uses **inactivated toxins** to target the toxic activity created by the bacteria, rather than targeting the bacteria itself. E.g. Diphtheria vaccine	Uses **two specific parts** of a pathogen, to enhance the immune response. E.g. ZyVac TCV, an indigenously developed Typhoid vaccine.	Small piece of the DNA from the disease-causing **bacterium or virus** is used. E.g. Hepatitis B vaccine, Human papillomavirus (HPV) vaccine, and Covishield	**Genetic material**, either **DNA or RNA**, from the pathogenic bacteria or virus is introduced into the human cells. E.g HIV vaccine

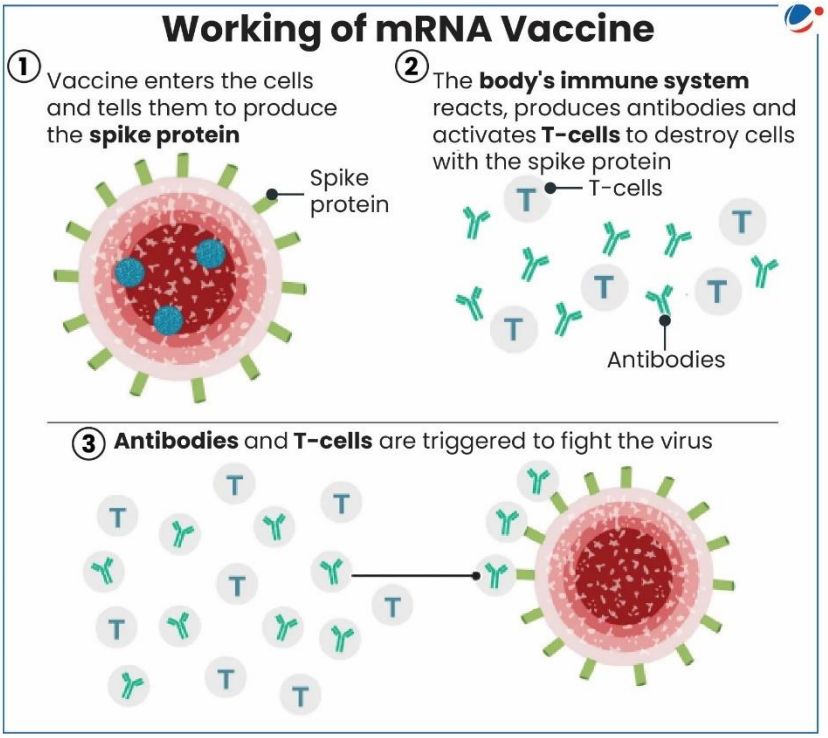
6.9.1. MRNA VACCINE

Why in the News?

World's first **mRNA (messenger Ribonucleic Acid)** lung cancer vaccine trials begin in Europe.

More on the News

- **Vaccine BNT116** is designed to treat **non-small cell lung cancer**.



About mRNA Vaccine Technology

- **Working Mechanism:**
  - Works by introducing a piece of **mRNA** that corresponds to a **viral protein**, usually a small piece of a protein found on the virus's outer membrane.
  - This mRNA prompts cells to **create viral proteins**, triggering the immune system to produce antibodies and **boost the immune system**.
    - > **E.g.,** the mRNA vaccine for COVID-19 directed cells to produce copies of a protein on the outside of the coronavirus known as the **spike protein**.
- **Benefits**
  - **Safer** as it **does not contain** any **live** or **weakened viruses**.
  - Also, can be **developed quickly**, unlike other traditional vaccines.

6.9.2. RELATED DEVELOPMENTS

6.9.2.1. NEW DENGUE VACCINE TAK-003

WHO Prequalifies New Dengue Vaccine **TAK-003**, a **live-attenuated vaccine**.

- It is **the second dengue vaccine** to receive **WHO prequalification**, following the **CYD-TDV vaccine.**

About WHO Vaccine prequalification

- Assure the quality of vaccines distributed by UN purchasing agencies.
- However, inclusion in the list does not imply approval of vaccines and manufacturing sites by the WHO.
  - Such approval is a prerogative of the National Regulatory Authorities.
- Other vector-borne diseases for which vaccines are included in this list include malaria, yellow fever, Japanese encephalitis, Rabies, etc.

About Dengue (Break-Bone Fever)

- **Viral infection** that transmits with a bite of an **infected female Aedes mosquito** (also responsible for chikungunya and Zika).
- Escalate to **severe conditions like dengue hemorrhagic fever** and **dengue shock syndrome** in adults.
- Transmitted from a pregnant mother to her baby, organ donation and transfusions.
- Currently, there is no **antiviral treatment or licensed vaccine** against dengue in India.
  - **Indigenous tetravalent** dengue vaccine**, DengiAll** has proceeded toward its **phase-3 clinical trials.**

6.9.2.2. R21/MATRIX-M

Serum Institute of India (SII) has started exporting **R21/Matrix-M malaria vaccine to Africa**.

- Malaria is caused by a **single-cell parasite (Plasmodium Falciparum** and **P. VIVAX) of the genus Plasmodium**.
  - It is transmitted through Mosquito Anopheles Stephensi.
  - Only female mosquitoes bite and transmit malaria.

About R21/Matrix-M

- Developed by the University of Oxford and the SII, leveraging Novavax's **adjuvant technology** (used with vaccines to augment the immune response.)
- It acts against **P. falciparum**.

6.9.2.3. HEPATITIS A VACCINE

Indian Immunologicals Limited launched a pediatric (for children) dose of **India's first indigenous Hepatitis A vaccine, Havisure.**

About Hepatitis

- An **inflammation of the liver**.
- Caused by **infectious viruses** as well as **non-infectious agents**.
- **Five main strains**: Types A, B, C, D, and E.
  - Types B and C together are the most common cause of liver cirrhosis, liver cancer, and viral hepatitis-related deaths.
  - Vaccine is not available for type C.
- **National Viral Hepatitis Control Program 2019** seeks to **eliminate Hepatitis C in India by 2030**.
- **Mission Indradhanush** provides vaccination against Hepatitis B along with 7 other infections

6.9.2.4. CODON DE-OPTIMISATION TECHNOLOGY (CDT)

Indian Immunologicals Limited in collaboration with Griffith University has developed a needle-free intra-nasal booster vaccine against SARS-CoV-2 using CDT.

About CDT

- A technology that involves **decreasing the frequency of underrepresented codon pairs (genetic determinants for amino acids)** without **changing the amino acid sequences**.
- **Benefits**:
  - Efficient virus attenuation strategy, where the degree of attenuation can be regulated as required.
  - Extremely Safe and takes less time

6.10. KEY ORGANIZATIONS/BODIES IN NEWS

6.10.1. WORLD HEALTH ORGANIZATION (WHO)

HQ: Geneva

World Health Organisation (WHO)

Genesis: Founded in 1948 as a specialized agency of the UN.

Objective: Leads and champions global efforts to give everyone, everywhere an equal chance to live a healthy life.

Membership: 194 Member States (including India)

Governance: The **World Health Assembly** is the Supreme decision-making body

Key Initiatives

- **MeDevIS** (Medical Devices Information System)
- **Global Benchmarking Tool (GBT),** evaluates national regulatory systems for various products like medicines, vaccines, blood products, and medical devices.
- **Global Strategic Preparedness, Readiness and Response Plan (SPRP),** aims to tackle dengue and other Aedes-borne arboviruses (Zika and chikungunya) by fostering a global coordinated response.
- **Coronavirus Network** (CoViNet)
- **Global Initiative on Digital Health** (GIDH)

6.10.2. CODEX ALIMENTARIUS COMMISSION (CAC)

India participated in the 86th session of the Executive Committee (CCEXEC) of the Codex Alimentarius Commission (CAC).

- **FSSAI** represented India (as a member elected on a geographic basis (Asia)), in the **session.**

HQ: Rome

Codex Alimentarius Commission (CAC)

Genesis: An international food standards body established jointly by the **Food and Agriculture Organization (FAO)** and **WHO** in 1963.

Objective: Protecting consumer's health and ensuring fair practices in food trade. Develops food standards called **Codex Alimentarius (CA)**.

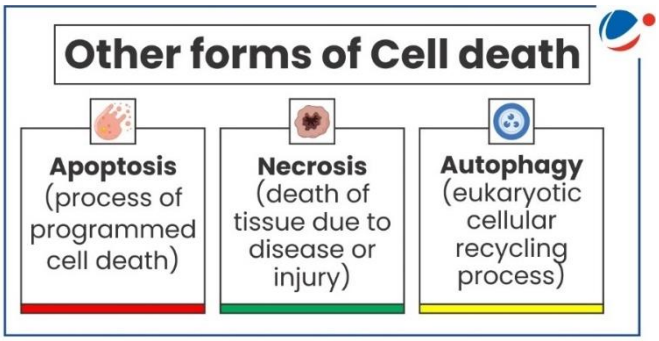
- CA is a collection of **international standards, guidelines, and codes of practice** to protect the health of consumers and ensure fair practices in the food trade.
  - These standards are **voluntary.**
- **WTO Agreements on Sanitary and Phytosanitary Measures (SPS Agreement)** encourages members to harmonize national regulations with CA.

Members: 189 (188 Member Countries and 1 Member Organization (EU))

6.11. OTHER IMPORTANT NEWS

6.11.1. FERROPTOSIS

A new study by researchers at Columbia found that **Ferroptosis** is a major cell death mechanism that underlies COVID-19 lung disease.



About Ferroptosis

- An **intracellular iron-dependent** form of cell death which is usually **accompanied by a large amount of iron accumulation** and **lipid peroxidation** during the cell death process.
- Studies have shown that ferroptosis is **closely related to pathophysiological processes of many diseases**, such as tumors, nervous system diseases, kidney injury, etc.

6.11.2. PROBIOTIC

Scientists have uncovered a new strain of lactic acid bacterium that could be a promising probiotic for the food and pharmaceutical industry.

About Probiotic

- Probiotics are **live microorganisms (bacteria and yeasts)** that are intended to have health benefits when consumed or applied to the body.
  - **Lactobacillus acidophilus** (**probiotic bacteria) naturally occurs in the human gut** and other parts of the body.
  - It **helps the digestive system to break down sugars** like lactose into lactic acid.
- They can be **found in yogurt and other fermented foods, dietary supplements,** etc.
- On the other hand, **prebiotics** are foods (typically high-fiber foods) that act as food for human gut microorganisms.

6.11.3. XYLITOL

Recent studies have found that the Artificial sweetener xylitol may pose health risks.

About Xylitol

- A **sugar alcohol** that is commonly used as a **sweetener.**
  - Sugar alcohols combine traits of **sugar molecules and alcohol molecules.**
- Common ingredient in sugar-free chewing gums, diabetes-friendly foods, and oral-care products.

6.11.4. THROMBOCYTOPENIA SYNDROME (TTS)

AstraZeneca for the first time admitted that its COVID-19 vaccine (Covishield) had rare side effects including TTS.

About TTS

- Also referred to as **Vaccine-induced Immune Thrombotic Thrombocytopenia** (VITT).
- Occurs when a person has **blood clots (thrombosis)** together with a **low platelet count (thrombocytopenia)**.
  - It is a **rare condition** in which blood clots form in unusual places in the body.
  - It can affect a person's brain, abdomen, lungs, arteries, etc.

6.11.5. WEIGHT LOSS DRUGS

Research reveals that medications designed to combat obesity can also be beneficial in treating a variety of other diseases.

How do Weight loss drugs work?

- Weight loss drugs mimic the action of a gut hormone called **glucagon-like peptide 1 (GLP-1).**
- **Glucagon-like peptide (GLP-1)** is secreted from three major tissues in humans' i.e**. enteroendocrine L-cells in the distal intestine, α cells in the pancreas, and the central nervous system.**
  - GLP-1 increases the **production of insulin** (a hormone that lowers blood sugar levels) and reduces the production of glucagon (which increases blood sugar levels).
  - They **suppress appetite and slow digestion**, making people feel full faster and longer, which reduces food intake.
  - GLP-1 is broken down by enzymes in the body very quickly, so it sticks around for **only a few minutes**.

6.11.6. ULTRASOUND TECHNOLOGY

Scientists have successfully mapped brain activity using Functional Ultrasound Imaging (fUSI).

- fUSI is an emerging technique that offers **sensitive, large-scale, high-resolution neural imaging**.

About Ultrasound technology

- Uses **high-frequency (above 20 kHz)** sound waves to view the body's **internal organs**.
- Does not use any radiation, making it a safe and effective tool.
- **Working**: Based on Piezoelectric effect
- **Applications:** Ultrasound imaging in diagnostic medicine, Ultrasound in underwater acoustics (Sonar), Non-destructive testing of various materials, Welding and Cleaning.

6.11.7. METHANOL

Deaths have been attributed to **methanol (methyl alcohol)** poisoning from illicitly produced **Hooch** /Spurious liquor (poor quality alcohol).

About Methanol (CH3OH)

- Also known as **wood Alcohol or spirit**.
- **Characteristic**:
  - A colourless and fairly volatile liquid with a faintly sweet pungent odor.
  - Completely mixable with water and it is an **antifreeze** agent.
- **Applications:** Used as solvent in paints, varnishes and chiefly for making formaldehyde, can be used as a **biodegradable energy resource,** etc.
- **Impacts:** Ingestion of even small quantities of methanol can cause **blindness** and large quantities causes' even death.

6.11.8. ETHYLENE OXIDE

Singapore Food Agency (SFA) has ordered a recall of India's Spice product due to the presence of ethylene oxide.

About Ethylene Oxide (C2H 4O)

- A colourless, flammable gas with a sweet odour.
- Used to make other chemicals, including antifreeze, textiles, plastics, detergents, and adhesives.
  - It is also used as a pesticide and sterilizing agent for medical equipment.
- **Health Impact**: Long-term exposure can result in **irritation of the eyes, skin, and respiratory passages** and **affects the nervous system.** Also, it is **carcinogenic** to humans.
- **FSSAI directions to use Ethylene**
  - Permits **Ethylene for artificial ripening** provided concentration does not **exceed 100 ppm** (parts per million).
  - Any source of **ethylene gas coming in direct contact with fruits is not permitted**.

6.11.9. CALCIUM CARBIDE

FSSAI alerts fruit traders to ensure compliance with the prohibition of Calcium Carbide in fruit ripening.

About Calcium Carbide

- **Prepared by heating quick lime with coke** and releases **acetylene gas** which contains harmful traces of arsenic and phosphorus.
- Use of calcium carbide for ripening fruits has been **banned** under **Food Safety and Standards (Prohibition and Restrictions on Sales) Regulations, 2011.**

6.11.10. COALITION OF EPIDEMIC PREPAREDNESS INNOVATIONS (CEPI)

Asia's first health research-related **Pre-clinical Network Facility** has been inaugurated in Faridabad (Haryana) under the **CEPI.**

About CEPI

- **Genesis**: Launched in **2017** by Norway and India, the Bill & Melinda Gates Foundation, the **World Economic Forum (WEF)**, etc.
- **Aim:** To accelerate the development of vaccines against emerging infectious diseases and enable equitable access to these vaccines.

6.11.11. GLOBAL ALLIANCE FOR VACCINES AND IMMUNIZATION (GAVI)

Recently, the role of GAVI was highlighted in a study, led by the WHO

About GAVI

- **Genesis**: Launched in 2000
- **Objective**: Expand the impact of the **Expanded Programme on Immunization (EPI)**, launched by WHO, and help the poorest countries in the world increase coverage.
- **Members**: Alliance includes WHO, UNICEF, and the Bill & Melinda Gates Foundation (BMGF) as core founding members.

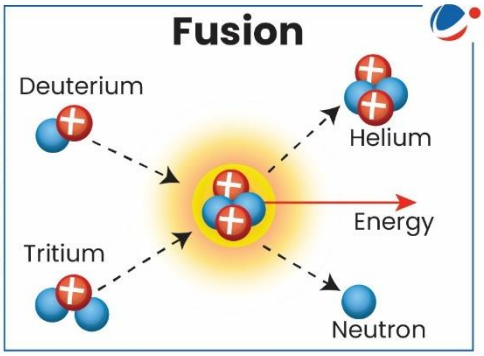
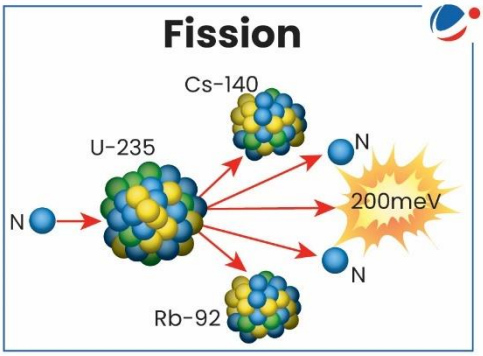
7. ALTERNATIVE ENERGY

7.1. NUCLEAR ENERGY

Nuclear Energy

CONCEPT CORNER

Comparison between Nuclear Fusion and Fission

Parameter	Nuclear Fusion	Nuclear Fission
Definition	**Combining** two light atomic nuclei to form a heavier nucleus. 	**Splitting** a heavy atomic nucleus into two smaller nuclei. 
Energy Release	Releases significantly **more energy** than fission.	Releases **less energy** compared to fusion.
Fuel	Light isotopes like **hydrogen** (e.g., **deuterium, tritium**)	Heavy isotopes like **Uranium-235** or **Plutonium-239**
By-products	**Helium** and some **neutrons**	Produces radioactive waste requiring long-term storage
Chain Reaction	**Does not** require a chain reaction	**Requires** a controlled chain reaction for sustained energy.
Conditions	**Requires extremely high temperatures** (millions of degrees) and pressure	Operates at relatively lower temperatures and pressures.
Occurrence	Happens naturally in stars (e.g., the sun).	Does not occur naturally on Earth; needs reactors.

Note: Net Energy Gain (NEG) is critical for commercial fusion power, which implies nuclear fusion process generates more energy than the nuclear fusion process consumes.

7.1.1. FAST BREEDER REACTOR

Why in the News?

Atomic Energy Regulatory Board (AERB) granted Permission for the **First Approach to the Criticality** of a 500 MWe sodium-cooled **Prototype Fast Breeder Reactor (PFBR)**.

About PFBR

- India's first **indigenous** PFBR, located at Kalpakkam, Tamil Nadu.
- Commissioned by **Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI)**, a Government Company under the administrative control of the **Department of Atomic Energy (DAE)**.

Atomic Energy Regulatory Board (AERB)

- **Established:** by the President in 1983 as per the **Atomic Energy Act, 1962**.
- **Mission**: To ensure use of ionizing radiation & nuclear energy in India does not cause undue risk to the health of people and the environment.

About the First Approach to Criticality

- **Criticality** refers to the **initial process of bringing** a reactor to a self-sustaining chain reaction for the first time.
- The completion of **core loading** will effectively mark the **first approach to 'criticality'.**
  - **Core loading** is the process of **placing nuclear fuel assemblies inside the core** of a nuclear reactor.

What is a Fast Breeder Reactor?

- A nuclear reactor that uses fast neutrons to **generate more nuclear fuel than it consumes** while generating power.
  - FBR will use **Uranium-Plutonium Mixed Oxide** (MOX) fuel.
- **Uranium-238 "blanket"** surrounding the fuel core undergoes **nuclear transmutation** (conversion of one element to another) to **produce more fuel,** which is why they are termed "**breeders**."
- **Significance:** The **operationalization of PFBR** will mark the start of **stage II** of India's **three-stage nuclear power program**.
  - By **transmutation**, Thorium will create fissile U-233 which will be used as fuel in the **third stage**.
  - World's first thorium-based nuclear plant "**Bhavni**" using Uranium-233 is being set up at Kalpakkam.

India's 3 stage Nuclear Power Program

- **Dr. Homi J Bhabha, father of India's nuclear program**, devised a **three-stage nuclear power program in the 1950s** to make the most of India's limited uranium reserves and abundant thorium reserves.
  - India holds only **about 2-3% of the world's uranium reserves**, but it possesses one of the largest shares of global thorium reserves.

India's Three-Stage Nuclear Power Program

Stage 1: Pressurised heavy water reactors (PHWRs)

- Natural uranium (consisting of **0.7 per cent U-235),** undergoes fission to release energy.
- The **remaining 99.3 per cent is U-238,** is converted into **Pu-239.**

Stage 2: FBRs using plutonium as fuel

- Fuelled by a **mixed oxide of Pu-239 and U-238.**
- **Pu-239 undergoes fission,** producing energy and more Pu-239.
- **Th-232** will be introduced once sufficient inventory of Pu239 is built up.

Stage 3: Advanced Heavy Water Reactor (AHWR)

- **Fuelled** by a mix of **Thorium** and **Uranium.**
- **Th-232 transmutates to U-233** which powers the reactor

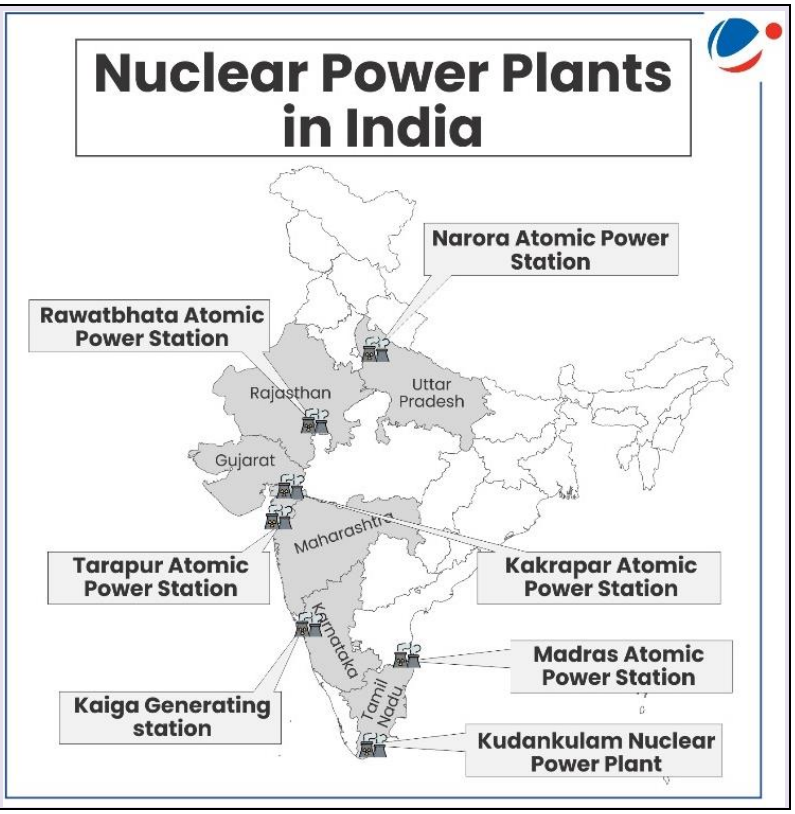
Thorium Reserves in India

- Nearly **25% of the world's thorium** ore **(Monazite)** is available in India
- These are found in beach and river sands in **Kerala, Tamil Nadu, Odisha, Andhra Pradesh, West Bengal, Jharkhand** etc.

Related News

Kakrapar Nuclear Power Plant

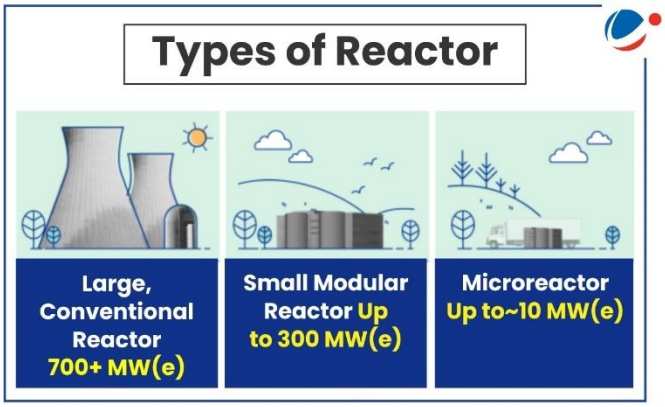
- Unit 4 of Indigenous 700 MWe Kakrapar Nuclear Power Plant (KAPP 4) starts working at full capacity.
- **About Plant**
  - KAPP-4 (in Gujarat) is a **Pressurised Heavy Water Reactor (PHWR)** that uses natural uranium as fuel and heavy water as a **moderator**.
  - **Unit 4** addresses the issue of **excess thermal margins.**
    - > 'Thermal margin' refers to the extent to which the **reactor's operating temperature** is **below its maximum operating temperature.**



7.1.2. SMALL MODULAR REACTORS (SMRS)

Why in the News?

Budget 2024-25 announced that **the Union Government** will partner **with the private sector** to develop **Bharat Small Reactors (BSRs).**



More on the News

- The announcement marks a historic shift in India's nuclear policy, as the **Atomic Energy Act of 1962** did not permit private sector participation in nuclear energy generation.

About Bharat Small Reactors (BSRs)

- BSR will be based on the **Small Modular Reactors (SMR).**
- Unlike **SMRs,** which involve **factory-made, easily assembled reactors, BSRs** are based on India's **PHWR technology.**
- They can enhance the contribution of **nuclear energy to India's energy basket** (its current share **is 1.6%).**

About Small Modular Reactors

- **Advanced nuclear reactors** that have a power capacity of up to **300 MW(e) per unit.**
- **SMRs**:
  - **Small**- Physically a fraction of the size of a conventional nuclear power reactor.
  - **Modular**- Systems and components to be factory-assembled and transported as a unit to a location.
  - **Reactors**- Harness nuclear fission.

7.1.3. TOKAMAK

Why in the News?

Korea Superconducting Tokamak Advanced Research (KSTAR) fusion reactor reached temperatures seven times that of the Sun's core.

More on the News

- **KSTAR** created a new world record for a 48-second-long operation at 100 million degrees.

About Tokamak

- An experimental machine (donut-shaped reactor) designed to harness the energy of fusion.
- Inside a tokamak, a **fusion plasma** is created and confined by strong magnetic fields.
  - Also called **artificial Sun** because it **replicates the** reaction of **nuclear fusion** taking place in the Sun.

- **Joint European Torus (JET)** was the first device to achieve controlled fusion power.
- The **International Thermonuclear Experimental Reactor (ITER)** will be the **largest Tokamak device.**

About ITER

- A **global scientific partnership** of 27 European Union countries plus **China, Japan, India, the Republic of Korea, Russia,** and **the US.**
  - ITER-India is a special project under the Institute for Plasma Research.
    - > It is responsible for the delivery of ITER packages such as Cryostat, In-wall Shielding, etc.
- **Status**: Currently under construction in **France.**

Other Major Tokamak-related Developments

- China has made the world's **first high-temperature superconducting Tokamak device - 'HH70'**.
- **European Union and Japan** inaugurated **JT-60SA,** the **world's largest and most advanced Tokamak fusion reactor.**
- India has also constructed its indigenous **tokamak ADITYA** and semi-indigenous **Steady State Superconducting Tokamak (SST-1)**.

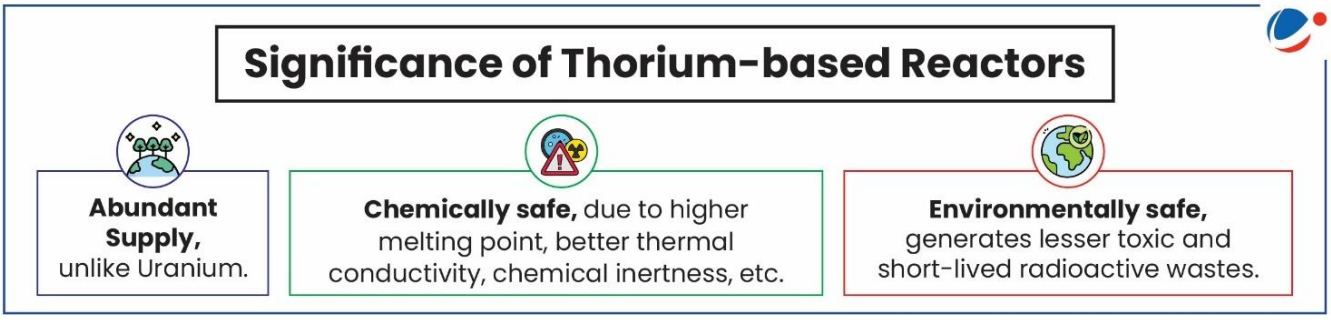
7.1.4. RELATED DEVELOPMENTS

7.1.4.1. THORIUM MOLTEN SALT NUCLEAR PLANT

World's first thorium molten salt nuclear power plant will be launched in Gobi Desert by China in 2025.

About Thorium Molten Salt Nuclear Power Plant

- Instead of Uranium, this nuclear power station uses **thorium as fuel.**
- The reactor **does not need water** for cooling because it **utilizes liquid salt or carbon dioxide** to transfer heat and make electricity.
- Unlike the water-cooling model, this design **significantly reduces the chances of meltdowns.**



7.1.4.2. NUCLEAR ENERGY SUMMIT

The first-ever **Nuclear Energy Summit** was held in **Brussels (Belgium).**

About Summit

- **Objective**: Promoting the development of **nuclear energy**
- **Hosted by:** the **International Atomic Energy Agency (IAEA)** and the Belgian government
- **Participants:** Representatives from 32 countries (including **India**).

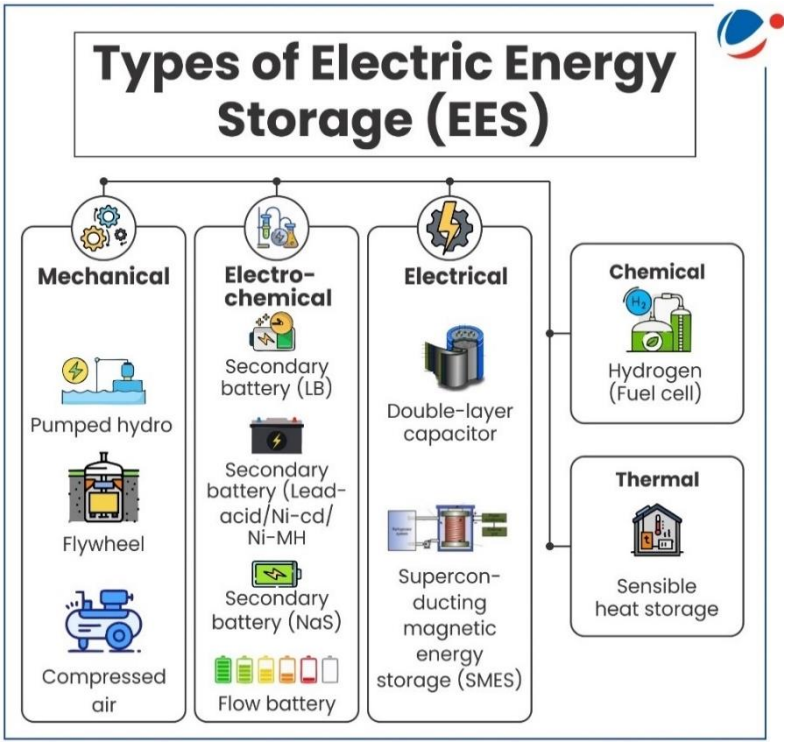
7.2. BATTERY ENERGY STORAGE SYSTEM (BESS)

Why in the News?

India's Battery Energy Storage System (BESS) ecosystem is estimated to receive funding of ₹3.5 lakh crore by FY2032, according to a report by SBI Capital Markets.

About Battery Energy Storage System (BESS)

- **Categorized** under the **electrochemical storage system (ESS)** which uses different **electrochemical reactions to store electricity**.
- **Key examples of BESS:**
  - Lead-Acid (PbA) battery
  - Nickel-cadmium (Ni-Cd) battery
  - Lithium-Ion (Li-Ion) battery
  - Sodium-sulfur (Na-S) battery



Key Initiatives taken to promote BESS

- **Viability Gap Funding (VGF) scheme** for the development of 4,000 MWh of BESS projects by 2030-31.
- Production Linked Incentive Scheme for **National Programme on Advanced Chemistry Cell Battery Storage**.
- **National Framework for Promoting Energy Storage Systems** by Ministry of Power.

7.3. OTHER IMPORTANT NEWS

7.3.1. SODIUM ION BATTERY

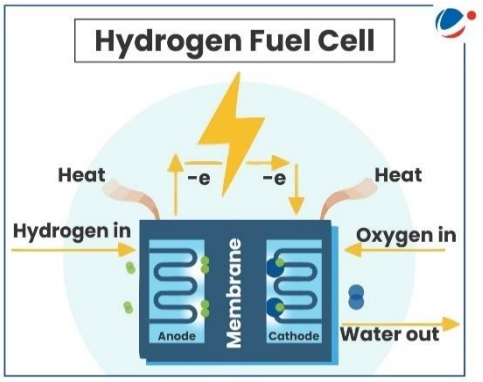
South Korean scientists developed a sodium-ion battery that can be charged in seconds.

- **The technology** is a high-power **hybrid sodium-ion battery** capable of rapid charging.
- It is being **conceived as a cheaper and potentially more feasible source of energy** than Lithium-Ion batteries.

Comparison between Sodium Ion Battery and Lithium-Ion Battery

Specifications	Sodium Ion Battery	Lithium-Ion Battery
Occurrence	**Sodium is 500-1000 times more abundant** than lithium.	**Lithium availability** is **limited** to **few countries**.
Charging time	Charges faster	Slow charging rate
Safety	**Safer**, as they do not explode or catch fire easily	**Less safe,** prone to catching fire or exploding
Operation and use	**Higher operating temperature range** and thus can be used in more extreme temperatures	**Lower operating temperature range** and can cause fire if operated in higher temperatures.
Applicability	Can be used in **small as well as large-scale energy storage applications**	**Suitable** for **portable devices and electric vehicles.**

7.3.2. HYDROGEN-FUEL CELLS



MV Sea Change, the **world's first commercial passenger ferry** powered by **100% zero-emission hydrogen fuel cells** has been launched.

About Hydrogen Fuel Cells (HFC)

- **Produces electricity by combining oxygen and hydrogen** in an electrochemical reaction.
- HFC vehicles are **completely free from tailpipe pollutant emissions**, including particulates, oxides of nitrogen, carbon monoxide, and carbon dioxide**.**

7.3.3. ZINC AIR BATTERIES

CSIR develops durable batteries for energy solutions in remote sub-zero conditions.

About Zinc Air Batteries

- Type of metal-air battery that consists of a zinc negative electrode and an air (oxygen) positive electrode.
  - It has been developed by combining an efficient durable cathode catalyst and an anti-freezing electrolyte fabricated for zinc-air batteries.
  - It used CoFe/Fe3C alloy/carbide hybrid structure.
- **Benefits**: Portable, flexible, lightweight, and can be **used in extreme cold conditions.**

7.3.4. TRIBO-ELECTRIC NANOGENERATOR (TENG) TECHNOLOGY

IIT Indore has developed footwear for military personnel based on TENG technology.

About TENG Technology

- Converts the **mechanical energy generated from walking and converts it into electrical energy** using the **triboelectric effect**, which is then stored in a device embedded in the system.
  - **Triboelectric effect** refers to a charge of electricity generated by friction.
- Stored energy can **power small electronic devices,** wearable devices, IoT (Internet of Things) devices, medical devices, etc.

8. DEFENCE

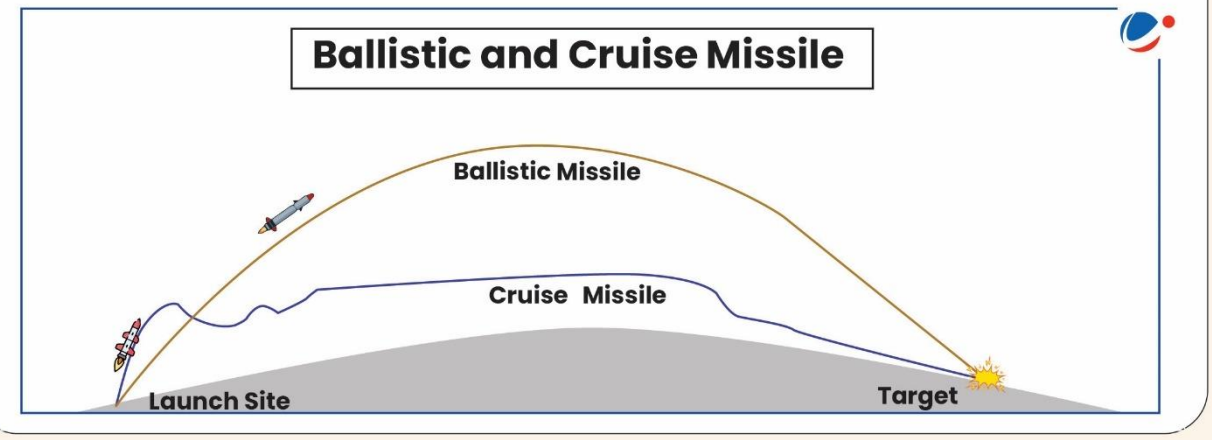
8.1. CRUISE AND BALLISTIC MISSILE

Cruise and Ballistic Missile

CONCEPT CORNER

Comparison between Cruise and Ballistic Missile

Parameter	Cruise Missile	Ballistic Missile
About	Powered by **jet engines** for continuous flight throughout their journey. » **Types:** • **Subsonic cruise missile** (speed around 0.8 Mach) • **Supersonic cruise missile** (speed of around 2-3 Mach) • **Hypersonic cruise missile** (speed of more than 5 Mach)	Rocket-powered for the initial boost phase, then coast unpowered for most of their flight » **Types:** • Vary from **Short-range** (traveling less than 1,000 kilometers) to **Intercontinental ballistic missiles (ICBMs)** (traveling more than 5,500 kilometers)
Path	Flies at relatively **low altitudes** (within the earth's atmosphere)	Follows a **ballistic trajectory,** arcing upward into the atmosphere before descending.
Range	Typically have **shorter ranges** but can loiter or change course more easily.	Generally, have longer ranges and higher top speeds.
Payload	Usually **carry smaller**, single warheads (conventional or nuclear).	Can **carry larger** payloads, including multiple warheads.
Interception	Harder to detect but easier to intercept after detection.	Easier to detect early but harder to intercept due to their speed
Example	BrahMos missiles	Prithvi and Agni Series of missiles



8.1.1. AGNI PRIME

Why in the News?

Agni-prime the new generation ballistic missile flight tested successfully.

More on the News

- The test was conducted by **Strategic Forces Command (SFC)**, along with the **DRDO** from Dr. APJ Abdul Kalam Island.
- SFC is responsible for the management and administration of the **country's tactical and strategic nuclear weapons stockpile.**

About Agni Prime

- A **nuclear-capable advanced variant** of the Agni class of missiles.
  - **Agni Missiles** are **Surface-to-surface** ballistic missiles and uses solid propellant. **They have** a medium- to intercontinental range.
- **Stage:** Two-stage canisterised solid propellant ballistic missile.
- **Range**: 1,000 to 2,000 km
- Lighter than **all the earlier Agni series of missiles and** will be guided by **Inertial Navigation Systems (INS)**.
  - **INS** is an electronic system that can detect and measure changes in the motion of an object.
- First of the new generation of missiles after the end of the **Integrated Guided Missile Development Program (IGMDP).**

About IGMDP

- Started in 1983 to enable India to attain **self-sufficiency in the field of missile technology.**
- **The missiles developed under the program were**
  - **Prithvi**: Short-range surface-to-surface ballistic missile**.**
  - **Agni**: Intermediate-range ballistic missile (Agni V has a range of over 5,000 km).
  - **Trishul**: Short-range low-level surface-to-air missile**.**
  - **Akash**: Medium-range surface-to-air missile**.**
  - **Nag**: Third-generation anti-tank missile**.**

8.1.2. OTHER MISSILES IN NEWS

Missile	Detail/features
BrahMos Missile 	⊛ Developed under the joint venture agreement between **India and Russia.** ➜ It is a **two-stage Supersonic Cruise Missile.** ⊛ **Key Features:** ➜ **Fire and Forget** principle of operation. ➜ **Long flight range (290km)** with varieties of flight trajectories. ➜ **Low radar** signature.
RudraM-II 	⊛ Indigenously **developed solid-propelled** air-launched missile. ⊛ **Developed by:** DRDO ⊛ **Type:** Air-to-surface ⊛ In 2020, RudraM, a new-generation **anti-radiation missile (NGARMs)** was tested. ➜ It is the first indigenous ARM of the Indian Air Force. ➜ It is equipped with the **Inertial Navigation System (INS)**-Global Positioning System (GPS) navigation system and **Passive Homing Head (PHH).** ○ **PHH** can detect, classify, and engage targets over a wide band of frequencies as programmed.
Astra Missiles 	⊛ A **Beyond Visual Range (BVR) class of Air-to-Air Missile (AAM)** system designed to be mounted on fighter aircraft. ⊛ **Developed by:** DRDO and manufactured by Bharat Dynamics Limited. ⊛ **Range:** 80 to 110 km. ⊛ **Features:** Designed to engage and destroy highly **manoeuvring supersonic aircraft.**

8.2. INDIA'S BALLISTIC MISSILE DEFENCE PROGRAM

Why in the News?

DRDO successfully conducted flight tests of the **Phase-II Ballistic Missile Defence (BMD) System**.

More on the News

- Phase-II Air defence **Endo-atmospheric missile** is an **indigenously developed 2-stage solid propelled ground-launched missile system**.
- It is meant to neutralize enemy ballistic missile threats in the **altitude bracket of endo to low exo-atmospheric regions**.

About Ballistic Missile Defence (BMD) Systems

- BMD systems seek to **defend against aerial attacks** like drones, fighter jets, and ballistic and cruise missiles by launching interceptors.
- Other important missile defence systems in the world **include THAAD (USA), Iron Dome (Israel), Patriot (USA), S-400 Triumf (Russia), etc.**

About India's BMD Program

- **Background: Sanctioned in 2000** in the backdrop of growing threats from China and Pakistan.
- **Phases:**

- **Phase I:** Designed to intercept missiles with a range of up to 2000 km.
  - > It includes 3 things - **Prithvi Air Defence (PAD)**, **Ashwin Advanced Air Defence** (AAD), and **Swordfish RADAR** (long-range tracking radar developed for the BMD system).
  - > Phase 1 has been **successfully deployed.**
- **Phase II:** It can intercept missiles with a range of up to 5000 km. It consists of
  - > **AD-1**: A **long-range** interceptor missile designed for **both low exo-atmospheric and endo-atmospheric interception** of long-range ballistic missiles as well as aircraft.
  - > **AD-2: Meant to intercept intermediate-range ballistic missile targets** with a range between **3000-5500 km**.

8.2.1. OTHER AIR DEFENCE SYSTEMS IN NEWS

Defence System	Detail/features
VSHORADS 	⊛ **Very Short-Range Air Defence System (VSHORADS) is an** indigenously developed **Man-portable Air Defence System (MANPAD).** ⊛ **Neutralizes low-altitude** aerial threats at short ranges. ⊛ Employs a **dual thrust solid motor** and a **state-of-the-art uncooled imaging infrared seeker.**
Akashteer Systems 	⊛ Advanced **Air Defence Control and Reporting Systems (ADCRS)** which will safeguard from aerial threats, including missile and rocket attacks. ⊛ **Developed by:** Bharat Electronics Limited (BEL)
C-Dome defense System 	⊛ A **naval version of the Iron Dome air defense system** used to shield against advanced ballistic, aerial, and surface-to-surface threats. ➝ **Iron Dome is a missile defense system** that can be deployed against a wide range of indirect and aerial threats.

8.3. DIRECTED ENERGY WEAPONS (DEWS)

Why in the News?

Recently, significant investments have been made by India in the field of Directed Energy Weapons.

About Directed Energy Weapons (DEWs)

- **DEWs** are ranged weapons that **use concentrated energy** from **electromagnetic** or **particle technology,** rather than **kinetic energy,** to incapacitate, damage, disable, or destroy enemy equipment, and facilities.
  - **These weapons** include **high-energy lasers** and other high-power electromagnetic (such as millimeter wave and high-power microwave weapons).
- **DEWs expand** the range of **Electronic Warfare**.
  - **Electronic warfare** includes any strategic use of the **electromagnetic spectrum** in a military conflict.

- **Types of Directed Energy Weapons:** High Energy Lasers (HEL), High Power Microwaves (HPMs), Millimeter waves, and Particle Beam Weapons.

Steps taken by India for DEWs

- **Directionally Unrestricted Ray-Gun Array (DURGA)-II Project** and **Project Tri-Netra** by DRDO
- **Kilo Ampere Linear Injector (KALI),** a linear electron accelerator for targeting long-range missiles being developed by DRDO and the **Bhabha Atomic Research Centre (BARC)**.

EW systems of India

- **Shakti EW system:** Provide an electronic layer of defence against modern radars and anti-ship missiles.
- **Integrated Electronic Warfare System (IEWS)**: Designed for plains, semi-desert regions and mountainous terrain.
- **Other**: **Himshakti** (IEWS), **Samyukta** (designed to perform multiple jamming), etc.

8.4. AIRCRAFT/HELICOPTER

Aircraft/Helicopter	Key Detail/Features
Light Combat Aircraft (LCA) Tejas Mark 1A 	⊛ An advanced variant of **LCA Mk-1** (developed by **Hindustan Aeronautics Limited**). ➔ It is a **4.5-generation** single-seat multirole fighter aircraft. ⊛ **Features: Advanced mission computer,** high-performance Digital Flight Control Computer (DFCC Mk1A), etc.
Light Combat Helicopter (LCH) 	⊛ First indigenous multi-role combat helicopter, designed and manufactured by HAL. ⊛ Capable of firing **air-to-ground** and **air-to-air missiles.** ⊛ Possesses modern **stealth characteristics,** robust armour protection, and formidable night attack capability. ⊛ **Capable of operating from high altitude terrain** and carrying out precision strikes at high altitude target areas (like Siachen glacier).

8.5. SUBMARINES/SHIPS

Submarines/Ships	Detail/features
S4* 	⊙ India's fourth **nuclear-powered ballistic missile submarine (SSBN),** → India currently has 2 SSBNs operational i.e. **INS Arihant & INS Arighaat (S3).** ○ Third SSBN **Aridhman (S4)** is currently undergoing sea trials. → **INS Arihant** is India's **first indigenous nuclear submarine.** Apart from India, **SSBN** are operated by only a few countries namely the **US, Russia, China, the UK, and France.** ⊙ S4* submarine is equipped with **K-4 ballistic missiles,** which have a range of 3,500 km.
INS Kiltan 	⊙ An Anti-Submarine Warfare (ASW) Corvette, developed under the **Project 28 (P28).** ⊙ Ships under this project are known as **Kamorta class ships.** ⊙ **Other Ships include** INS Kamorta, INS Kadmatt, and INS Kavaratti.
Abhay 	⊙ Anti-Submarine Warfare Shallow Water Craft (ASW-SWC) corvettes ⊙ Designed **for anti-submarine operations** in coastal waters, **low-intensity Maritime Operations (LIMO), and mine-laying activities.**

8.6. DRONES

Drones	Detail/features
MQ-9B Drones 	⊛ Long Endurance Unmanned Aerial vehicles designed for surveillance, reconnaissance, and precision strike missions. ⊛ Fly over horizon via satellite for upto 40 hours; hit targets on land, at sea, and in air. ⊛ **Two variants: SkyGuardian and SeaGuardian** (maritime variant).
Nagastra-1 	⊛ **India's** first indigenous Loitering Munition. → It can **neutralize hostile threats in 'kamikaze mode'** with **GPS-enabled precision strikes** with an accuracy of up to **2 meters.** → **Kamikaze** refers to members of a J**apanese air attack corps in World War II** assigned to make a suicidal crash on a target (such as a ship). ⊛ Unique features include **abort, recover, and reuse, facilitated** by a parachute recovery mechanism.
Hermes-900 	⊛ A next-generation multi-role, Medium Altitude Long Endurance (MALE) **unmanned aerial system.** ⊛ Also, known as **Drishti-10 drones** ⊛ **Features:** Over-the-horizon, persistent multi-mission, etc.
FWD-200B 	⊛ India's **first indigenous bomber unmanned aerial vehicle (UAV).** ⊛ It comes with **optical surveillance payloads and is integrated with missile-like weapons** for precision air strikes.

8.7. OTHER IMPORTANT NEWS

8.7.1. SEBEX 2

Indian Navy certified a new explosive named 'SEBEX 2', along with **SITBEX 1** and **SIMEX 4**, as per reports.

About SEBEX 2, SITBEX 1, and SIMEX 4

- **SEBEX 2**: A **cutting-edge explosive formulation** and is among the **most potent non-nuclear explosives globally**.
  - Based on **high-melting explosives (HMX)** and offers **approximately 2.01 times the lethality of standard Trinitrotoluene (TNT).**
    - **TNT** is an explosive used in military shells, bombs, and grenades, in industrial uses, etc.
- **SITBEX 1 (Thermobaric explosive)**: Generates **extended blast duration with intense heat**, is suited to target enemy bunkers, tunnels, and other fortified positions.

- **Thermobaric explosive compositions** are fuel-rich formulations capable of creating sustained high temperatures and longer duration overpressure as compared to conventional high explosives.

- **SIMEX 4:** It is a munition that is safer than standard explosives when it comes to storage, transportation, and handling and is more likely to accidentally go off.

8.7.2. ZORAWAR TANKS

DRDO successfully conducts the **first phase of field firing trials of 'Zorawar' tanks.**

About Zorawar tanks

- A light tank designed to provide the Indian army with **enhanced capabilities at high altitude.**
- **Developed by**: **DRDO** and private sector firm L&T.
- Named after the legendary **General Zorawar Singh** who led multiple victories in Tibet.

8.7.3. GAURAV

Defence Research and Development Organisation (DRDO) carries out successful maiden flight test of **Long-Range Glide Bomb 'GAURAV'** from **Su-30 MK-I platform.**

About GAURAV

- An air-launched **1,000 kg class glide bomb** capable of hitting targets at long distance.
  - **Glide bomb** after launch steer towards the target **using highly accurate hybrid navigation scheme** with a combination of **Indian Navigation System (INS)** and Global Positioning System (GPS) data.
  - Designed and developed indigenously by the **Research Centre Imarat (RCI),** Hyderabad.

8.7.4. ABHED (ADVANCED BALLISTICS FOR HIGH ENERGY DEFEAT)

DRDO, along with researchers of IIT Delhi has developed ABHED.

About ABHED

- These are lightweight Bullet Proof Jackets.
- These jackets have been created from **polymers** and **indigenous boron carbide ceramic material.**
  - **Features of Boron carbide**: High specific stiffness, strength, and chemical inertness,
  - **Working:** Armor plates made of boron carbide weaken bullets on impact, causing them to shatter into small, hard particles.

8.7.5. SUPERSONIC MISSILE-ASSISTED RELEASE OF TORPEDO (SMART) SYSTEM

The SMART system was successfully flight-tested from Dr APJ Abdul Kalam Island off the coast of Odisha.

About SMART

- A next-generation **missile-based light-weight torpedo delivery system.**
  - A **torpedo** is a type of missile or bomb fired underwater.
- **Developed by**: DRDO
- It is a **canister-based missile system.**
- The system carries a **parachute-based release system.**

9. MISCELLANEOUS

9.1. NOBEL PRIZE IN CHEMISTRY 2024 (PROTEIN)

Why in the News?

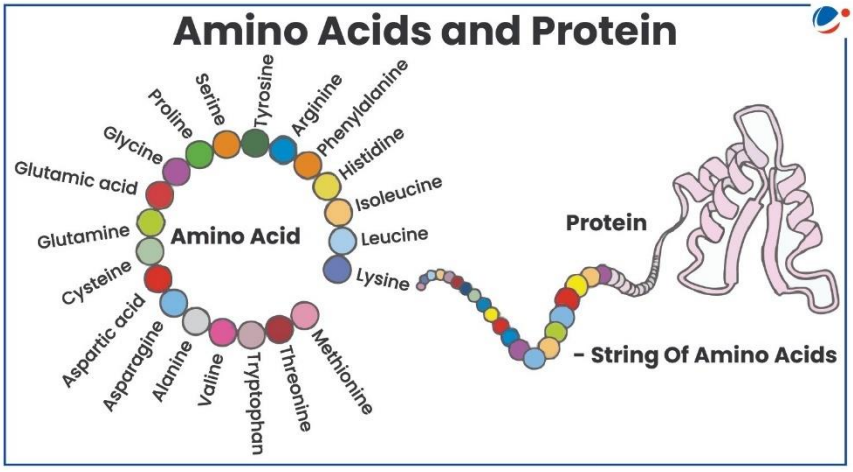
Nobel Prize in Chemistry has been awarded to **David Baker** for **computational protein design** and jointly to **Demis Hassabis and John Jumper** for **protein structure prediction.**

David Baker's work on Computational Protein Design (CPD)

- **CPD aims** to create **new proteins** with **novel functions or properties** not found in **nature using computational methods.**
- **Applications:** Therapeutic proteins, creating more effective vaccines, Nanomaterials, biosensors, etc.

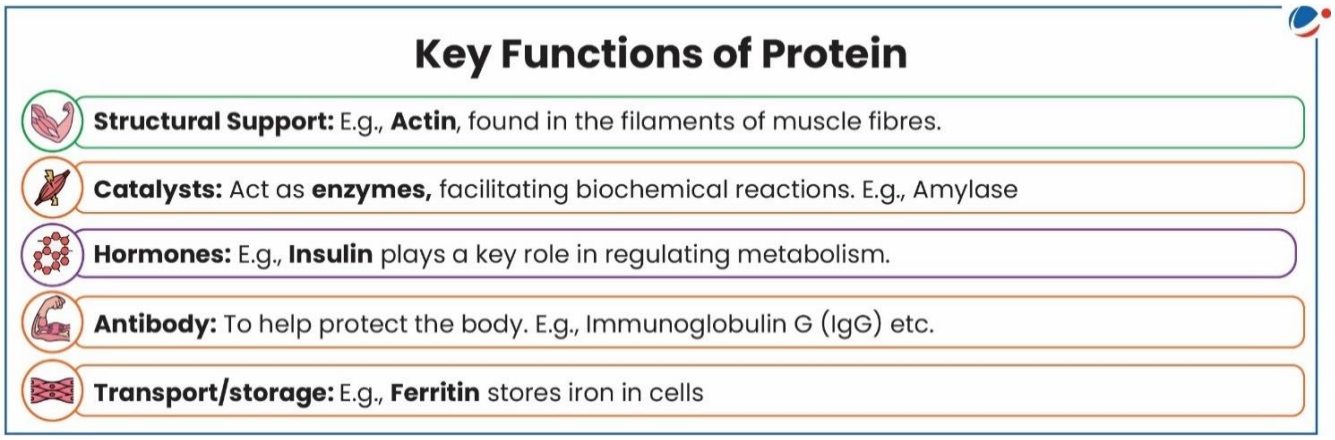
Work of Demis Hassabis and John Jumper on Protein Structure Prediction

- They used an **AlphaFold2** (AI model) for predicting protein's complex structures i.e., how proteins fold into shapes that determine their functions.
    - Recently, **AlphaFold3** has been developed.
- **Applications:** Understanding drug design, antibiotic resistance, developing enzymes to break down plastic, etc.



About Proteins

- One of the **four major types of biomolecules** (**Other:** carbohydrates, lipids, and nucleic acids).
- Composed of linear chains of **20 naturally occurring amino acids**.
    - **Types of Amino Acids:**
        - **Nonessential Amino Acids**: Synthesized in the body
        - **Essential Amino Acids**: Cannot be **synthesized in the body** and must be obtained through diet
- **Collagen** and **Ribulose bisphosphate Carboxylase-Oxygenase (RuBisCO)** are the most abundant proteins in the animal world and the whole of the biosphere, respectively.



9.2. GRAPHENE

Why in the News?

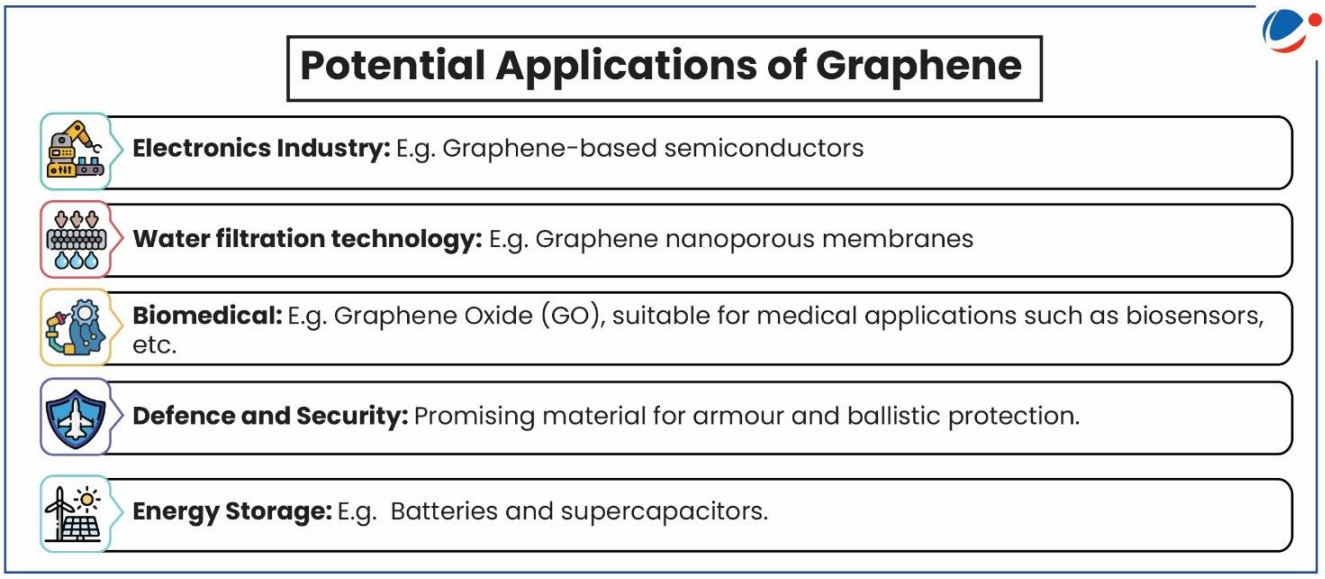
MeitY launched the **India Graphene Engineering and Innovation Centre (IGEIC)**.

What is Graphene?

- A **building block** of Graphite.
  - **Graphite** is a **crystalline allotrope of carbon.** Other carbon allotropes include **Diamond** and **Fullerene**.
- A **single layer (2D-dimensional) of carbon atoms**, tightly bound in a **hexagonal honeycomb lattice**.
- Often called a **wonder material** for its **extraordinary electrical and electronic properties**.

Properties of Graphene

- **Mechanical Strength: 200 times** stronger than steel, yet **6 times** lighter.
- **Optical Transparency:** Absorbs only **2.3% of light**, making it suitable for transparent touchscreens, solar cells, and display technologies.
- **High Thermal Conductivity:** About **5000 W/m/K** at room temperature.
- **Impermeability: Impermeable** to gases, even those as light as hydrogen and helium.
- **Quantum Properties:** The **Quantum Hall effect** in Graphene could also possibly contribute standards in metrology, quantum computing, and advanced electronics.



Related News
Carbon Fiber

- Vice President of India inaugurated the Centre for Carbon Fiber and Prepregs.
- **Prepregs** is a reinforcing fabric that is pre-impregnated with a resin system (thermoset or thermoplastic).
- **About Carbon Fiber**
  - A polymer which is a form of graphite consisting of thin, strong crystalline filaments of carbon.
  - **Properties**: Extremely strong, and light, high chemical resistance; temperature tolerant to excessive heat; and have low thermal expansion. Also, they can be recycled.
  - **Applications:** Manufacturing of components for automobiles, aircraft, etc.

9.3. ELECTRIC VEHICLES

Electric Vehicles & Types

CONCEPT CORNER

Comparison between Electric Vehicles and Internal Combustion Engine (ICE) Vehicles

Parameter	Electric Vehicles	Internal Combustion Vehicles
Technology	Powered by **electric motors** and **batteries** (E.g. Lithium-ion batteries)	Uses ICEs powered by **fossil fuels** (petrol, diesel, or CNG)
Power Transmission	Converts **electrical energy** into mechanical energy	Converts **chemical energy into mechanical energy.**
Energy Efficiency	Have higher energy efficiency (60-80%) as electric motors are more efficient in converting energy into motion.	Energy efficiency is lower (20-30%) due to **heat loss** in combustion and mechanical frictions.
Braking System	**Regenerative Braking** (converts kinetic energy and potential energy of the braking system directly into electrical energy)	Friction Braking

Types of Electric Vehicles

- **Battery Electric Vehicle (BEV):** Fully powered by electricity. More efficient compared to hybrid and plug-in hybrids.
- **Hybrid Electric Vehicle (HEV):** Uses both the ICE and the battery-powered motor powertrain.
- **Plug-in Hybrid Electric Vehicle (PHEV):** Uses both ICE and a battery charged from an external socket (they have a plug).
- **Fuel Cell Electric Vehicle (FCEV):** Electric energy is produced from chemical energy. For example, a hydrogen FCEV.

9.3.1. PM E-DRIVE SCHEME

Why in the News?

Ministry of Heavy Industries has notified the PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) Scheme.

More on the News

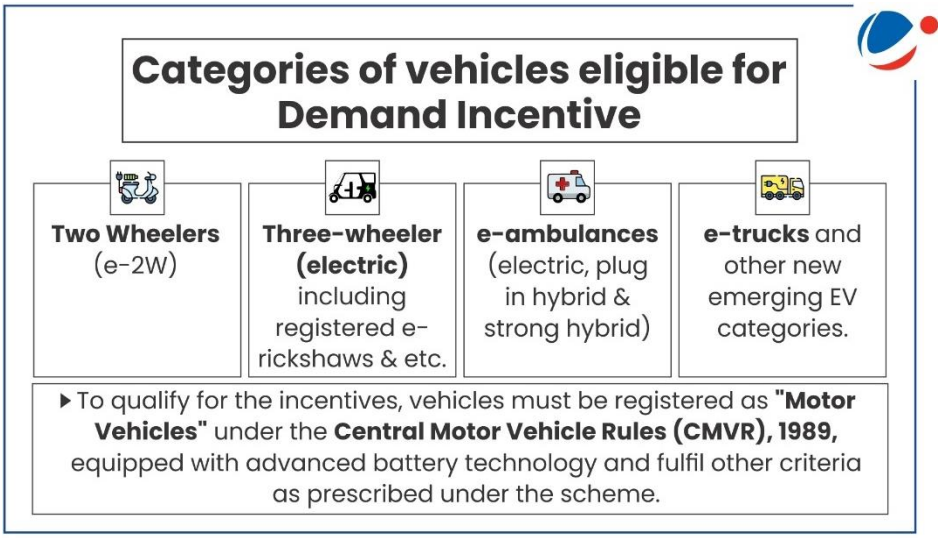
- **The PM E-DRIVE Scheme** has subsumed schemes like **the Electric Mobility Promotion Scheme 2024 (EMPS 2024).**
- **Also,** it will replace **the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles in India (FAME India)** Initiative**.**

About the PM E-DRIVE Scheme

- **Objective:** Expedite the adoption of EVs by providing **upfront incentives** for their purchase and facilitating the **establishment of essential charging infrastructure**.
- **Time Period:** 2024-26
- **Nodal Ministry:** Ministry of Heavy Industries

Key Features of the Scheme

- **Subsidies:** Demand incentives for consumers (refer to the infographic).
- **Grants for creation of capital assets**: Includes **e-buses**, establishment of a network of **Electric vehicle public charging stations (EVPCS)** & upgradation of **identified testing agencies.**
- **Project management agency (PMA):** The Scheme shall be implemented through a PMA, which shall be responsible for providing secretarial, managerial, and implementation support.
- **Other important Features**:
  - **Phased Manufacturing Programme (PMP)** has to be followed by **Original Equipment Manufacturers** and EV charging infrastructure/ public charging stations to be eligible for support.



Other initiatives for the promotion of the EV manufacturing

- **Rationalization of GST** on **electric vehicles from 12% to 5%**
- **'Technology Platform for Electric Mobility (TPEM)'** formed by the Ministry of Science and Technology.
- **PM-eBus Sewa-Payment Security Mechanism (PSM) scheme** for procurement and operation of e-buses by **Public Transport Authorities (PTAs).**

9.4. CRITICAL MINERALS

Why in the News?

Under the **Mines and Minerals (Development and Regulation) Act (MMDRA), 1957**, **the** Central Government **increased the area limit** (set for preventing cartelisation) for **24 critical minerals** listed in part D of the First Schedule to MMDRA.

What are Critical Minerals?

- These minerals are **building blocks of essential modern-day technologies** and are **at risk of supply chain disruptions** due to limited global production and geopolitical factors.
  - **E.g., Lithium, cobalt, nickel, copper, rare earth elements, etc.**
- Government of India has released a **list of 30 critical minerals** for India.
  - These minerals are - Antimony, Beryllium, Bismuth, Cobalt, Copper, Gallium, Germanium, Graphite, Hafnium, Indium, Lithium, Molybdenum, Niobium, Nickel, PGE, Phosphorous, Potash, REE, Rhenium, Silicon, Strontium, Tantalum, Tellurium, Tin, Titanium, Tungsten, Vanadium, Zirconium, Selenium, and Cadmium.

India's Initiatives

- **Khanij Bidesh India Ltd. (KABIL)** is mandated to identify and acquire overseas mineral assets of critical and strategic nature, such as lithium and cobalt.
- Member of **Mineral Security Partnership (MSP)** to bolster supply chains.
  - Also joined **MSP Finance Network.**
- Other **multilateral/bilateral partnerships** such as the agreement between India and Argentina for exploration and mining of 5 lithium blocks in Argentina**.**

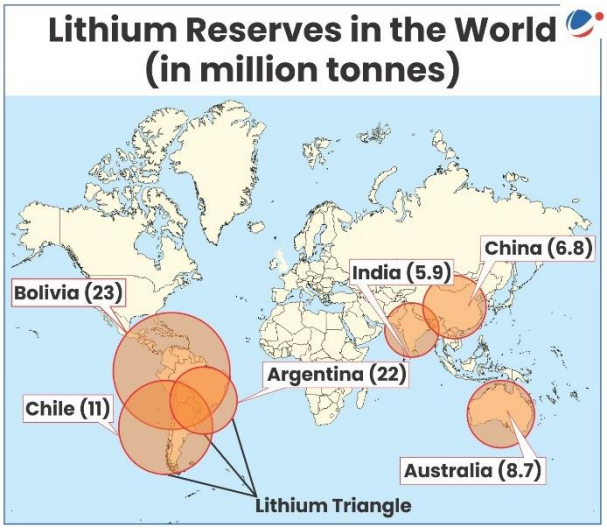
About Tantalum

- A rare metal
- **Characteristics:** Corrosion-resistant, **ductile** (in pure form), etc.
- **Uses:** Making capacitors in electronic devices, surgical equipment & implants, nuclear power plants, aeroplanes, and missiles, etc.

9.4.1. LITHIUM

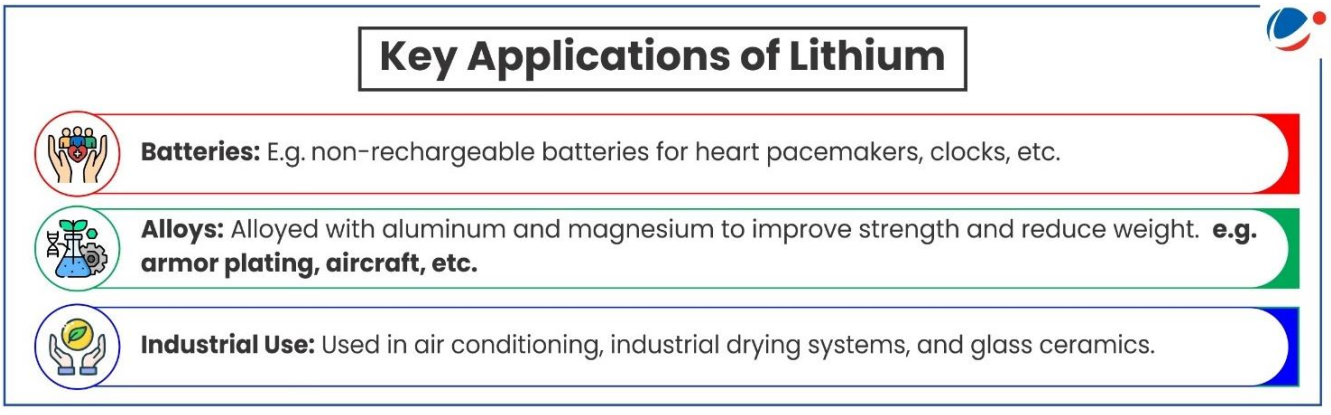
Why in the News?

Atomic Minerals Directorate for Exploration and Research has established 1,600 tonnes of Lithium resources in **Mandya district.**



About Lithium (white gold)

- A **soft, silvery-white alkali toxic metal** with the **lowest density of all metals**.
- Reacts **vigorously with water**.
- Lithium **does not occur as a metal in nature** but is found combined in **small amounts** in **nearly all igneous rocks** and the **waters of many mineral springs**.
  - **Spodumene, petalite, lepidolite, and amblygonite** are important minerals containing lithium.
- The electrolysis of molten lithium chloride and potassium chloride produces the metal.



9.5. ELECTRONIC TOLL COLLECTION (ETC)

Why in the News?

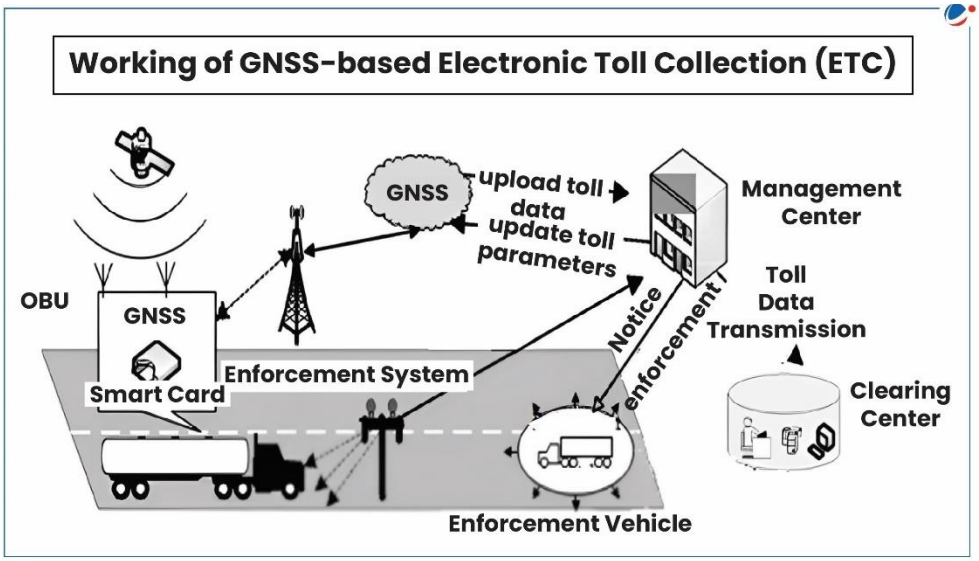
The Ministry of Road Transport and Highways has notified the National Highways Fee Amendment Rules, 2024, under the National Highways Act, 1956, for GNSS-based ETC.

More on the News

- **Global Navigation Satellite System (GNSS)**-based Electronic Toll Collection (ETC) is intended to replace FASTag eventually.

About GNSS-based ETC

- **Working:** Uses **satellite-based imaging** to track the vehicle's position and collect tolls based on the distance travelled.
- **Main components:**
  - **OBU**: GNSS-enabled device installed in a vehicle to determine vehicle route and calculate toll.
  - **ANPR cameras**: Installed on the highways to recognize vehicle number plate and deduct toll money.
- In this system, **geo-fencing** of highways is done.
  - **Geofencing** creates virtual geographic areas that trigger a specific action when a GPS tracking device enters or exits the zone.
- **Benefits:** Decrease the need for roadside tolling infrastructure; reduce congestion; etc.



Comparison between FASTags & GNSS-based ETC

Parameters	GNSS-based ETC	FASTags
Technology	Satellite-based imaging and **ANPR**	Radio Frequency Identification (RFID)
Equipment needed to be installed in Vehicles	OBU with GNSS connectivity	FASTag (RFID Tag) affixed on the windscreen
Calculation of Toll tax	Based on **real-time** vehicle movement data	Fixed rates

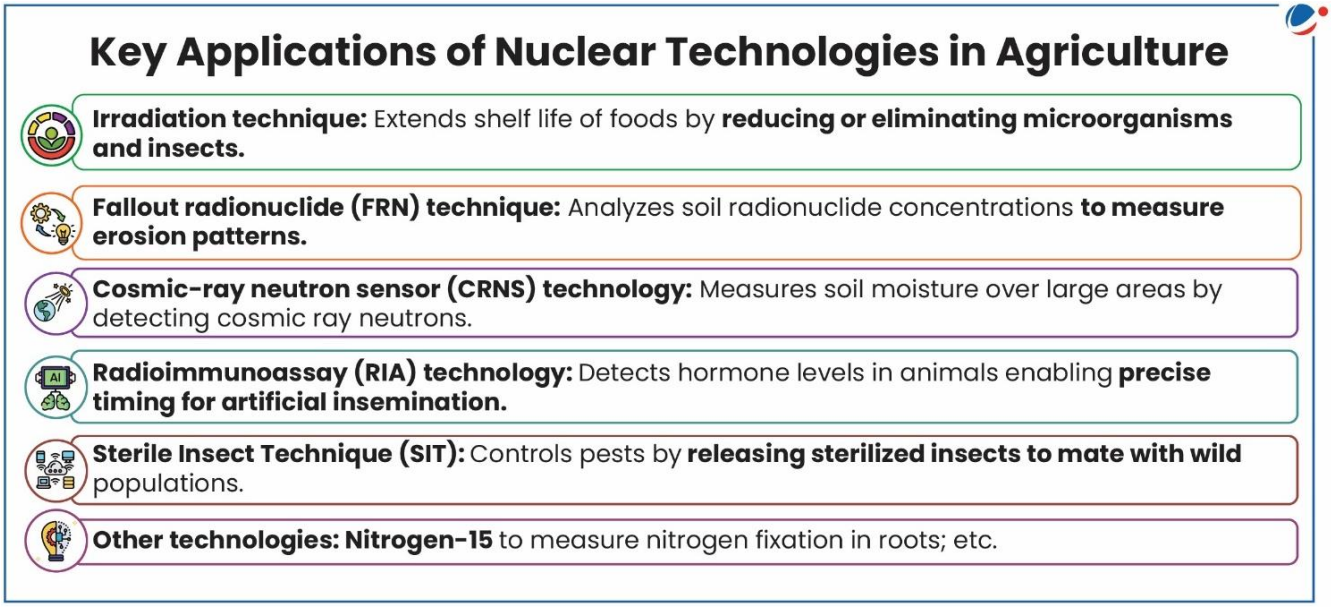
9.6. ATOMS4FOOD

Why in the News?

Bhabha Atomic Research Centre (BARC) participated in the **International Atomic Energy Agency (IAEA)** Scientific Forum 'Atoms4Food'.

About Atoms4Food

- **Genesis:** Jointly launched by IAEA and FAO.
- **Purpose:** To **harness the advantages of nuclear techniques along with other advanced technologies** to enhance agricultural and livestock productivity, etc.



9.7. OTHER IMPORTANT NEWS/DEVELOPMENTS

9.7.1. KAVACH

Indian Railways is rolling out tenders for equipping 10,000 locomotives with Kavach 4.0

About KAVACH

- An electronic system of Safety Integrity Level 4 standards, with a probability of error of 1 in 10,000 years.
- **Developed by**: Research Design and Standards Organisation (RDSO)
- **Key features:** Centralised live monitoring of train movement, Prevention of Signal Passing at Danger (SPAD), Automatic braking to prevent overspeeding, etc.

9.7.2. 3D HOLOGRAM TECHNOLOGY

Japan has issued **new yen banknotes packed with 3D hologram technology to fight counterfeiting**.

- Holograms' **intricate patterns and properties** make them difficult to duplicate completely.

About Hologram Technology

- A **photographic pattern that gives a three-dimensional image** when illuminated by coherent light.
- Holograms show **different images and colors** depending on the angle **at which they are viewed.**
- Formation of Holograph involves **principles of interference and diffraction**.

9.7.3. LIQUID NITROGEN

FSSAI has issued an **advisory on the unauthorized use of liquid nitrogen** in food by food-serving establishments.

About Liquid Nitrogen

- An **inert cryogenic fluid** with a temperature of **−196 °C**.
  - It is **colourless** and **odourless**.
- **Functional use:** freezing agent, propellant, packaging gas & foaming agent'.
- **Health Effects**: Frostbite, burns, asphyxiation, and damage to internal organs.
- As per the **Food Safety and Standards (Food Products Standards and Food Additives) Regulation, 2011**, nitrogen is a **Good Manufacturing Practice (GMP)** additive.

9.7.4. THERMITE

A new type of drone called “dragon drone” has been used recently in the Russia-Ukraine war.

About Thermite

- Releases a substance called **thermite**, a mixture of **aluminum and iron oxide.**
- When ignited, it produces a **self-sustaining reaction that makes it almost impossible to extinguish.**
- **Thermite isn't banned internationally**, but using incendiary weapons in civilian areas is prohibited by the UN's Convention on Certain Conventional Weapons.

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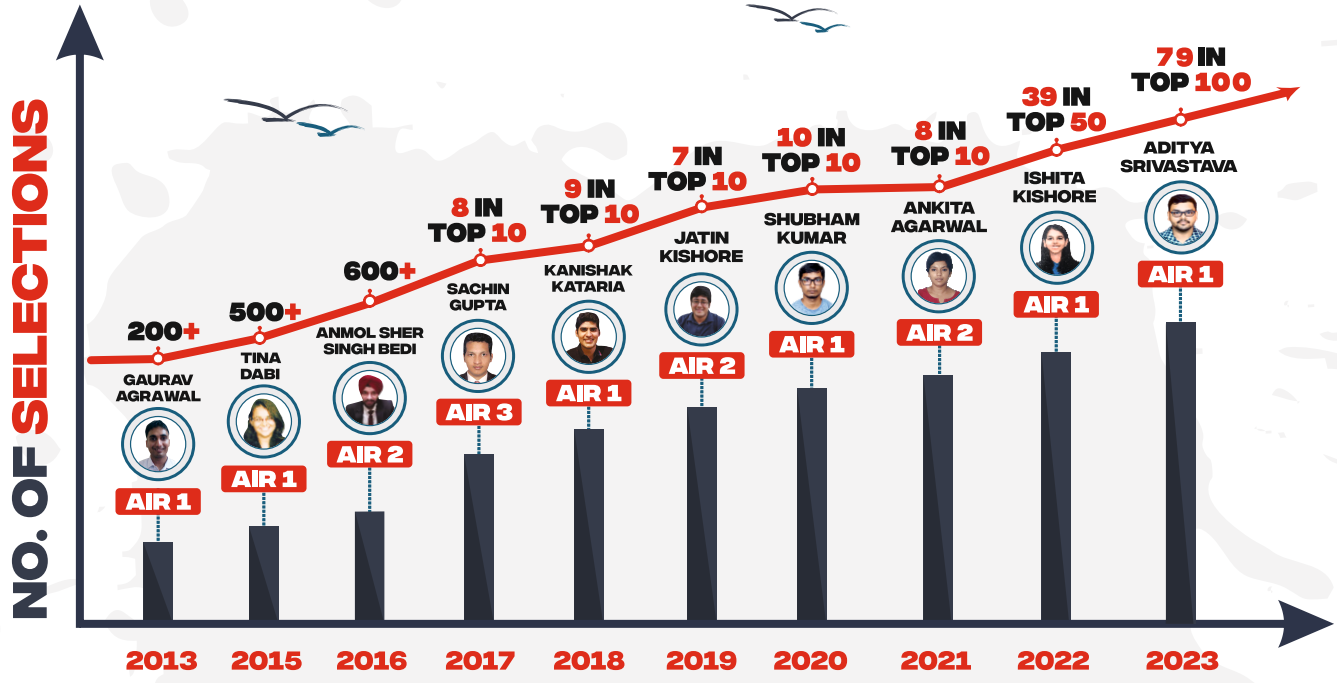

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CIVIL SERVICES EXAMINATION 2020

HEAD OFFICE
Apsara Arcade, 1/8-B 1st Floor, Near Gate-6 Karol Bagh Metro Station
DELHI

MUKHERJEE NAGAR CENTER
Plot No. 857, Ground Floor, Mukherjee Nagar, Opposite Punjab & Sindh Bank, Mukherjee Nagar

GTB NAGAR CENTER
Classroom & Enquiry Office, above Gate No. 2, GTB Nagar Metro Building, Delhi - 110009

FOR DETAILED ENQUIRY
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