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SCIENCE & TECHNOLOGY

MAINS 365

Classroom Study Material 2023

(August 2022- May 2023)

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SCIENCE AND TECHNOLOGY

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Previous Year Questions

A reference sheet of syllabus-wise segregated previous year questions from 2013-2022 (for the Science and Technology Section) has been provided. In conjunction with the document, it will help in understanding the demand of the exam and developing a thought process for writing good answers.

A NOTE FOR THE STUDENTS

Dear Students,

- Understanding current affairs can add depth to your perception of intricate issues and help you form nuanced perspectives, especially in the context of the Mains examination.
- In light of this, Mains 365 documents attempt to simplify your study process by including features that assist in creating answers, reviewing content, and retaining information.

Here are the key features we have integrated in the document:

A Topic at Glance:
This offers a comprehensive view of the topic, seamlessly connecting current and static aspects while providing necessary data and facts.

Enhanced Infographics:
These are designed to effectively revise as well as to be readily used in your answers, making your responses more engaging and informative.

Data Banks:
To help you identify and revise the crucial datasets of topics, we have designed and integrated data banks in the articles.

Appendix:
We have added an appendix of key data and facts at the end of each document, aiming to facilitate quick revision.

Weekly Focus Document List:
A QR code linked list of relevant weekly focus documents has been added at the end of each document, ensuring a smoother journey while approaching these topics.

Previous years questions:
To facilitate efficient revision, a QR code linked syllabus-wise segregated list of previous years' questions is added.

We sincerely hope Mains 365 documents will guide you effectively in your preparation and aid you in scoring better in your Mains examination.

"Learn everything you can, anytime you can, from anyone you can. There will always come a time when you will be grateful you did."

All the best! Team VisionIAS

1. IT, COMPUTER, ROBOTICS

1.1. DEVELOPMENT IN EMERGING TECHNOLOGIES, INFORMATION TECHNOLOGY

1.1.1. EMERGING TECHNOLOGY

EMERGING TECHNOLOGY AT A GLANCE

- Emerging technology commonly refers to **existing or new and innovative technologies under development with unrealized practical applications.**
- They employ **new concepts, methods, and techniques** and promise to find better solutions to the world's challenges.
- **Examples of Emerging Technologies** include Web 3.0, Blockchain, Quantum Technology, AI, Internet of Things (IoT), XR, 5G/6G etc.

Significance of Emerging Technology

- **To create New Economic Opportunities** with **Industry 4.0.**
- **To develop Digital Ecosystems** and **Bring Sectoral Transformation** by making them smart.
- **Provide Immersive Communication and Engagement.**
- **Accelerating** towards **Sustainable Development Goals.**
- **Fuel Innovation and Technological Growth.**
- **Secure Personal Data** as well as **Enhance overall Security of Systems.**

Challenges Posed by Emerging Technologies

- **Legal Complexities** due to lack of oversight and regulatory mechanisms.
- **Lack of IT Infrastructure** to support emerging technology is complicated.
- **Shortage of Existing Skills** related to various emerging technologies.
- **Unpredictable Nature:** Products and services embedded in emerging technologies' solutions evolve quickly and shift from one regulatory category to another.
- **Issues related to data privacy, security,** ownership, and control because of massive digital footprint.
- **Regulatory Dilemma** due to conflict between its potential benefits and the issues of Ethics and Safety.
- **Social Impact** will be mixed as it can help in equality and equity as well as increase wealth inequality, change people behavior etc.

Major Ethical Issues

- **Human vs Machines,** i.e. Autonomous machines replacing humans.
- **Invasion of citizens privacy** and reducing freedom of choice.
- **Misuse of Personal Information** by taking individual control over own data.
- **Environmental Consequences** as it can threaten ecological balance.
- **Discrimination** risk at individual, companies, and community level.
- **Distortion of Reality** through deep fakes, misinformation etc.
- **Other issues** such as **increasing digital divide, Always-On Culture, Use of intrusive technologies** etc.

Way Forward

- **Developing Certain Universal Principles** for global governance and accountability.
- **Framing Pending Domestic Laws and evidence based regulations** to secure data, protecting unity and integrity etc.
- **Utilize current resources** by evaluating technologies and employing current building components like data sources, technology and skill.
- **Address security and privacy concerns** by implementing new security measures, conducting regular audits, and ensuring compliance with relevant regulations.
- **Striving for internationalization of Ethics of Emerging Technology.**
- **Promoting General Good** to protect rights, avoid harm etc.
- **Engage stakeholders** to help in introspection and creating faith in technological development.

1.1.1.1. EMERGING TECHNOLOGIES IN 2023

EMERGING TECHNOLOGIES IN 2023

Flexible batteries	• **Made of lightweight materials** that can be easily twisted, bent, or stretched. • Are **rechargeable and include lithium- ion or zinc-carbon systems** placed on conductive polymer current collectors. • **Applications:** wearable medical devices and biomedical sensors, flexible displays and smartwatches, textile-based electronics.
Designer phages	• Phages are viruses that **selectively infect specific types of bacteria.** Upon infection, a phage **injects its genetic information** into the bacterium. • Using synthetic biology tools, the **genetic information of phages can be reprogrammed** so that infected bacteria execute a bioengineered set of genetic instructions. • **Application:** treating microbiome-associated diseases, enhance the growth of livestock, treat certain plant diseases, and eliminate dangerous bacteria in food supply chains.
Metaverse for mental health	• **Virtual shared spaces are digital environments** where people can interact professionally and socially. The future of these spaces is commonly referred to as the metaverse. • **Gaming platforms** are already being leveraged **for mental health treatment.** For example, DeepWell Therapeutics has created video games to treat depression and anxiety. • Eventually, the **metaverse will also connect to therapeutic neurotechnologies,** such as direct brain stimulation to treat intractable depression.
Wearable plant sensors	• These sensors are **small, non-invasive devices that can be attached to crop plants** for continuous monitoring of temperature, humidity, moisture and nutrient levels. • Data from plant sensors **can optimize yields, reduce water, fertilizer and pesticide use,** and detect early signs of disease.
Spatial omics	• Spatial omics **allows previously unobservable cell architecture and biological events** to be **viewed** in unprecedented detail. • By combining advanced imaging techniques with the specificity and resolution of DNA sequencing, **spatial omics enables the mapping of what, where and when of biological processes** at the molecular level.
Flexible neural electronics	• These **allow electrical signals the brain produces to be captured** by sensor hardware. Algorithms then **decode these electrical signals into instructions** that a computer can understand and execute. • **Brain-machine interfaces (BMIs) like systems are already used** to treat patients with epilepsy, and in neuroprosthetics.

1.1.2. FOURTH INDUSTRIAL REVOLUTION- INDUSTRY 4.0

FOURTH INDUSTRIAL REVOLUTION AT A GLANCE

- Refers to **current and developing era of technological changes** and advancements **characterized by integration of advanced technologies** such as AI, IoT, robotics, big data and more **into various industries and aspects of society.**
- **Industry 4.0 would be Aware** (equipped with sensor technology), **Intelligent** (autonomous decision-making), **connected** (enable interaction and data exchange), **Responsive** (autonomous product adaptation).

Various Industrial Revolutions

Industry 1.0: Mechanization of manufacturing.
Industry 2.0: Application of the principle of mass production along assembly lines.
Industry 3.0: Rise of electronics, telecommunications, and the computers.
Industry 4.0: Manufacturers are integrating new technologies, including IoT, cloud computing, AI etc.

Need for India to adopt Industry 4.0

- **To provide impetus for the next surge in growth** after the 1990 reforms.
- **To harness the potential of Big Data** collected via Aadhaar, passport, PDS, voter card etc.
- **To improve Governance:** by using new age echnologies.
- **Improves Flexibility and Customization of the products** by adopting the Cyber Physical System frameworks.
- **Increases entrepreneurship** along with **better employment** opportunities: in the area of education, e-commerce/m-commerce, financial services, ITES etc.
- **To achieve Geo-political goals:** by leveraging modern technologies to the world.

Constrains in moving to Industry 4.0

- **High Capital Cost:** for creating a new integrated Cyber Physical system, replacing the existing processes.
- **Issues of Cyber and Private Data Security:** in handling huge quantities of private and sensitive data.
- **May fuel Inequality:** as people from specific sector may experience wage growth while several other sectors may experience job loss.
- **Lack of Interoperability** as Industry 4.0 requires seamless integration between different systems and devices.
- **Lack of skilled workforce** who understands the complexity of the process.

Initiatives taken by India

- **Farmer Zone, a cloud-based platform,** being developed by Department of Biotechnology to provide smart solution to farmers.
- **Centre for the Fourth Industrial Revolution (C4IR)-India,** Mumbai to exchange ideas in partnership with NITI Aayog and WEF.
- **AICTE** and several sector skill councils framed **for National policies on Industry 4.0.**
- **Smart Advanced Manufacturing and Rapid Transformation Hub (SAMARTH) -Udyog Bharat** an Industry 4.0 initiative of the Department of Heavy Industry.
- **Digital Twin technology** for creating similar virtual models of various physical things.

Way forward

- **Enhancing regulatory framework** while also protecting the rights and privacy of individuals.
- **Developing ethical guidelines:** to ensure that technologies are used for the benefit of society.
- **Promoting digital literacy:** particularly among those who may not have access to technology.
- **Emphasizing on cyber security:** to protect data and intellectual property.
- **Investing in up skilling and reskilling:** Government and the industries should focus on bridging this gap.

1.1.3. WEB 3.0

WEB 3.0 AT A GLANCE

Web 3.0 is a **possible future version of the internet,** which **is user- centric, user- driven, and user- controlled.**

Key features of Web 3.0

Decentralized data networks for storing data within a peer-to-peer interconnection using blockchain.

Permissionless will allow everyone to participate on the platform without authorization.

Semantic Web i.e., search and analysis by understanding the meaning of words rather than by keywords or numbers.

Ubiquitous as Web 3.0 could be accessed from anywhere with anything.

Potential of Web 3.0

- **Enabling users to directly interact** with any individual or machine in the world.
- **Users gaining control over their data.**
- **Ensured privacy and security of the user** with absence of central authority and cryptographic security respectively.
- **Richer user experience** with semantic web, higher degrees of connectivity, mixed reality, and faster computing speeds.
- **Removing platform dependence and control** by making digital activity platform transferable.
- **Creating local networks,** basing its architecture on local context and needs.

Challenges with Web 3.0

- **Difficult to regulate** due to decentralized structure. It could lead to a rise in issues like cybercrimes, hate speech, and misinformation.
- **Limited Accessibility and slow adoption due to higher usage costs** and other entry barriers like technical know-how.
- **Potential environmental implications** like high energy consumption, excessive mining etc.
- **Scalability issue** as Blockchain technology can handle only around 15 transactions per second.
- **Limited Global collaboration** due to rising Techno-geopolitics.

Opportunities and Challenges for India

- **Opportunities:**
  - Large and **growing digital user-base** with one of the highest numbers of interest users.
  - Availability of a large **developer community** as India is already a software hub.
  - Development of **new and emerging economic sectors** like FinTech and Gaming Industry
- **Challenges:**
  - Fear of **aggravation of already prevalent Digital Divide.**
  - Prevalence of **uncertainty and risk-aversion in policymaking.**
  - **Signs of brain drain** as Indian Web 3.0 entrepreneurs have already started moving to Dubai and Singapore.

Way forward for India

- **Dedicated and integrated program** which provides financial support and enables national-level coordination.
- Creating a **technological and infrastructural base** with reliable electricity connection, internet connectivity etc.
- **Creating conducive conditions** to encourage and support innovation via promoting Ease of Doing Business, incentives etc.
- **Development of India-centric solutions** on the lines of Aadhaar, Jan Dhan, UPI, CoWin etc.

1.1.4. BLOCKCHAIN TECHNOLOGY

BLOCKCHAIN TECHNOLOGY AT A GLANCE

About Blockchain Technology

A Database
A list of record/transaction, like a ledger, that keeps growing as more entries are added.

Which is Distributed
Copies of the entire database are stored on multiple computers on network, syncing within minutes/seconds.

Transparent
Records are made visible to stakeholders without risk of alteration.

Highly secure and immutable
Algorithms make it impossible to change/delete any data once recorded and accepted.

Significance

- **Decentralised mechanism:** eliminating need for a third party to validate the transactions.
- **Bringing transparency and efficiency:** as any asset of value can be represented and tracked.
- **Fraud prevention** as data stored in several places is not easily accessible.
- **Blockchain Business Value:** WEF anticipates that 10% of global GDP will be stored on blockchain by 2025.
- **Applicability in diverse domains:** such as education, governance, finance & banking, healthcare, logistics, cyber security, power sector, etc.

Challenges in adoption

- **Technological Challenges**
  - **Scalability:** Variable requirements for processing power, network bandwidth, block size, Consensus etc. affect their scalability.
  - **Storage** as stored data becomes perpetual and is replicated at all the nodes.
- **Legal & implementational Challenges**
  - **Privacy & Regulation:** Decentralized storage on every node creates privacy challenges.
  - **Localization hurdles:** As data redundancies are stored across all nodes on a blockchain network.
- **Lack of Skill set and customer awareness.**

Key recommendations by National Strategy on Blockchain

- **A National Level Blockchain Framework (NLBF)** for scaling deployments for developed applications, creating shared infrastructure, enable cross domain application development etc.
- **Integration of important National Level Services to Blockchain** such as eSign, e-Pramaan, DigiLocker etc.
- **Focus on research** in the domains of standards & interoperability, scalability & performance, consensus mechanisms, security & privacy etc.
- **Capacity building** by conducting short term courses or bootcamps.
- **Explore the potential** in various **sectors like Agriculture, Health, Energy etc.**

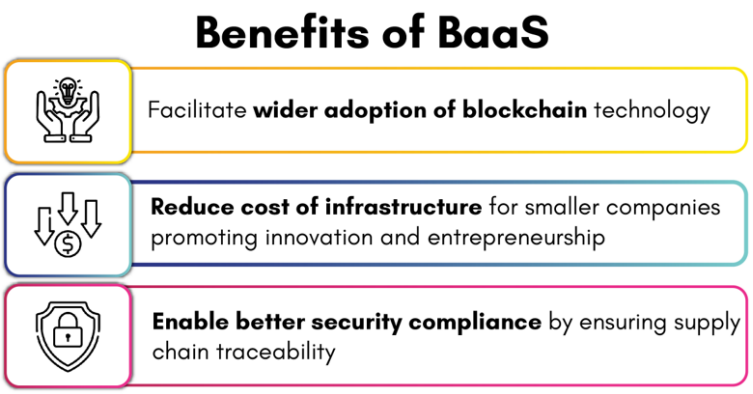
Examples of potential applications

- **E-Governance:** This includes Property Record Management, Digital birth, death and education certificates Management etc. For e.g. **Smart Dubai initiative of UAE.**
- **Banking:** Avoiding risk of payment losses involved in banking transactions, reduces cross-borders transaction fees, corporate payments and remittances etc.
- **Supply Chain:** Can create a tamper proof record to check real time information about product journey.
- **Healthcare:** By establishing a secure chain of network blockchain can help in handling the patient records, consent forms, billings and public health monitoring.
- **E-Courts:** Data from police, judiciary, legal department, etc. can be stored in a coordinated manner.
- **Other areas** such as **Automotive, Tourism, Insurance, Real Estate etc.**

1.1.4.1. BLOCKCHAIN PROJECT

Why in News?

Government launched Blockchain Project to explore potential of Web3.



About the Project

- Project is titled **'Design and Development of a Unified Blockchain Framework for offering National Blockchain Service and Creation of Blockchain Ecosystem'**.
  - It is a part of government's effort towards **realizing Web3.**
  - It will facilitate the creation of Open Application Programming Interfaces (APIs) for **smooth integration and provision of blockchain-as-a-service (BaaS) over distributed infrastructure.**
- BaaS refers to **third-party cloud-based infrastructure and management for companies..**
  - It allows Government Departments to **leverage Blockchain services to build, host and use their own blockchain apps, smart contracts and functions** on blockchain.
- Project has been launched in accordance with objectives of **National Strategy on Blockchain, 2021 (**launched by Ministry of Electronics and Information Technology).
  - It creates a **trusted digital platform** by evolving a national Blockchain infrastructure.

Conclusion

Governments have been trying to implement blockchain, considering its benefits over traditional technologies. **Finding the right use cases,** however, can help agencies **realize the technology's full potential.**

1.1.4.2. CRYPTO MINING

Why in news?

Recently, Bhutan and Singapore-based Bitdeer have announced plans to **raise $500 million to set up crypto mining operations in the Himalayas that is free of carbon,** thus tapping into Bhutan's abundant hydroelectric power.

About Crypto Mining

- It is the process that several cryptocurrencies **use to generate new coins and verify & process new transactions.**
  - Presently, **huge amounts of electricity are needed to power the vast computer farms that mine for cryptocurrency.**
- It involves **vast, decentralized networks of computers** around the world that verify and secure blockchains.
- Crypto mining is **fundamental to proof-of-work (PoW) cryptocurrency** networks like **Bitcoin (BTC).**
  - PoW and proof of stake (PoS) **use algorithms to validate cryptocurrency on a blockchain network.**

	Proof-of-Work (PoW)	Proof-of-Stake (PoS)
About	Mechanism bitcoin uses **to regulate creation of blocks** through the process of mining.	An alternative consensus mechanism that **delegates control of the network to the owners of a given token.**
Working Mechanism	**PROOF OF WORK** To add each block to the chain, miners must compete to solve a difficult puzzle using their computers processing power. In order to add a malicious block, you'd have to have a computer more powerful than 51% of the network. The first miner to solve the puzzle is given a reward for their work.	**PROOF OF STAKE** There is no competition as the block creator is chosen by an algorithm based on the user's stake. In order to add a malicious block, you'd have to own 51% of all the cryptocurrency on the network. There is no reward for making a block, so the block creator takes a transaction fee.
Energy Consumption	**PoW consumes more energy** since it allows all miners on a network to try and validate a transaction.	**PoS replaces miners with validators** and rewards only the top stakeholders, **resulting in less energy consumption.**

- **PoW and PoS** are **protocols intended to validate transactions** and keep the blockchain network decentralized and secure.

- **Different types of Crypto Mining**
  - **Central Processing Units (CPUs) mining:** CPU mining **uses processors to mine cryptocurrency.**
  - **Graphics Processing Units (GPUs) mining:** GPU mining **uses one or more graphics cards to mine crypto.** GPU mining of Bitcoin launched in 2010 was short lived and got replaced by a new kind of hardware- ASIC.
  - **Application-Specific Integrated Circuits (ASICs) mining:** ASICs, explicitly designed for PoW computations, **perform far faster than general-purpose computing devices like GPUs or CPUs.**
  - **Other types** include Field-Programmable Gate Array (FPGA) mining, Cloud Mining etc.
- Crypto mining is **not always profitable due to intense competition,** expensive mining equipment and high electricity prices.
  - It requires **setting-up of Powerful Hardware Resources & software to solve the complex puzzles efficiently.**
  - The explosive growth in cryptocurrency mining **consumes high energy grids,** and **increases total carbon emissions and local air pollution, raises retail electricity rates etc.**

Conclusion

Crypto-assets can **require considerable amounts of electricity usage**, which can **result in greenhouse gas emissions, as well as additional pollution**, noise, and other local impacts to communities.

Rather than a PoW verification process, which requires vast amounts of energy, climate activists are arguing for **a less energy-intensive verification process** that isn't reliant on speed, **such as PoS**, used by ethereum – another cryptocurrency.

1.1.5. QUANTUM TECHNOLOGY

QUANTUM TECHNOLOGY AT A GLANCE

- An emerging field **powered by the principles defined by quantum mechanics,** a subfield of physics that explains the **nature and behaviour** of matter and energy **on the atomic and subatomic level.**

Quantum Technology Principles

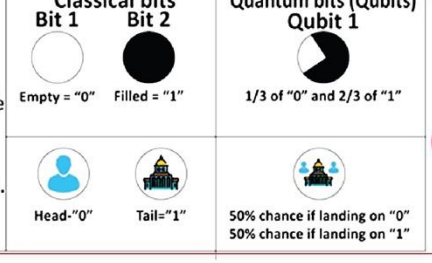
Qubit

Just like a **binary bit** (0 and 1) is the basic unit of **information in classical** (or traditional) computing, a **qubit (or quantum bit - a combination state of 0 and 1) is the basic unit of information in quantum computing.**

Physical vs. logical qubits

A physical qubit is a physical device that behaves as a **two-state quantum system,** used as a **component of a computer system.** E.g., an atom of Hydrogen existing in multiple energy levels.

Logical qubits are groups of physical qubits **working together to perform a computation.**



Key principles

Superposition: It is the ability of a quantum particle to be in multiple states at the same time until it is measured

Entanglement: It refers to a situation in which two or more quantum particles are linked in such a way that it is impossible for them to be described independently.

Significance of Quantum technology for India

- **Staying ahead of the disruption** and achieving a beginner's edge in this emerging field.
- **Preparing for tackling National security risks** posed by adversarial use of quantum computers.
  Boosting Translational research.
- **Fostering economic growth** by developing market for quantum R&D, software development, and equipment manufacturing.
- **Driving societal progress and improving the overall quality of life** enabled by applications of Quantum technology.
- **Encouraging entrepreneurship** and start-up ecosystem development.

Measures taken in India to strengthen quantum industry

- **National Quantum Mission** approved at a total cost of about Rs. 6000 crores
- **National Mission on Quantum Technologies & Applications (NMQTA).**
- **Quantum-Enabled Science and Technology (QuEST) initiative**
- **QSim – Quantum Computer Simulator Toolkit**
- **Quantum Frontier mission**
- **Setting up of dedicated labs and centres** like quantum computing laboratory and an AI centre at a military engineering institute at Mhow, Madhya Pradesh.

Constraints faced by India

- **Loosely built research ecosystem** with limited participation of private sector.
- **Unstructured research** and **small pool of skilled professionals in the field.**
- **Absence of indigenous development** of critical quantum components.
- **Industry-academia gap** hindering translation of research into scalable applications.
- **Technological challenges:**
  - **Difficulty in achieving** and maintaining quantum **superposition and entanglement** long enough to complete a task.
  - **Challenges in upscaling the number of qubits** on a processor chip.
- **Other issues:** Low patent applications, Lack of protocols for global governance, Low international collaborations etc.

Way Forward

- **Creation of a dedicated quantum community** through Entrepreneurship, innovation, university courses, scholarships, training programmes etc.
- Establishing **dedicated centres for research to translate research into real-world applications.**
- **Facilitating international cooperation.**
- **Setting priorities to safeguard national security** such as investing in post-quantum cryptography.
- **Promoting domestic manufacturing facilities** and units for development of quantum components.
- **Revisit and rework National policies** like military doctrines, ethical guidelines etc.

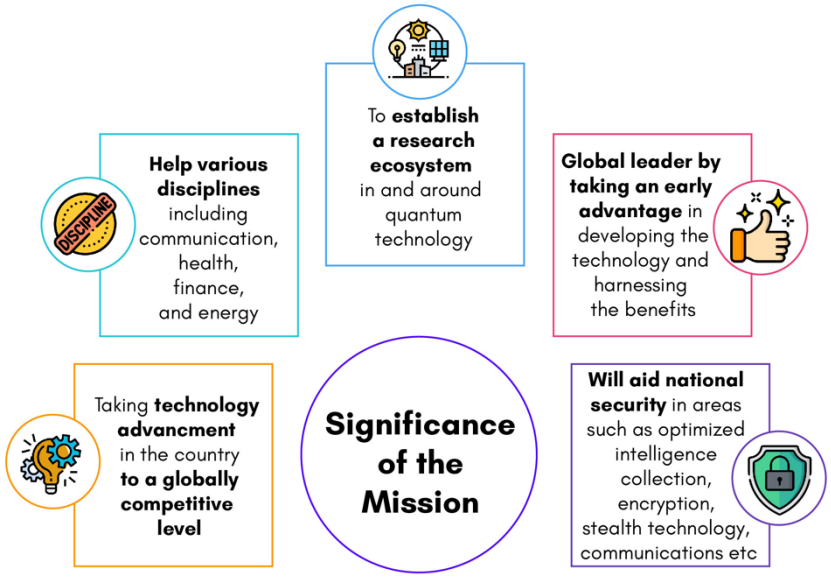
1.1.5.1. NATIONAL QUANTUM MISSION (NQM)

Why in News?

Recently, National Quantum Mission received cabinet approval at a total cost of about Rs. 6000 crores.

About the Mission

- **Aim:** To seed, nurture and scale up scientific and industrial R&D and create a vibrant & innovative ecosystem in Quantum Technology (QT).
- **Implementing agency:** Department of Science & Technology (DST).
- **Mission duration:** From 2023 to 2031.
- **Targets:**
  - **Developing intermediate-scale quantum computers** with 50-1000 physical qubits in 8 years.
  - **Satellite-based secure quantum communications** between ground stations over a range of 2000 kilometers within India and with other countries.
    - ✓ Also, inter-city **quantum key distribution** over 2000 km.
- **Applications areas:**
  - **Magnetometers with high sensitivity** in atomic systems.
  - **Atomic Clocks** for precision timing, communications, and navigation.
  - **Design and synthesis of quantum materials** such as superconductors, novel semiconductor structures, and topological materials for the fabrication of quantum devices.
  - **Single photon sources/detectors, and entangled photon sources** for quantum communication, sensing, and metrological applications.
- **Themes**
  - **It includes setting up four Thematic Hubs (T-Hubs)** in top academic and National R&D institutes in the domains-
    - ✓ Quantum Computing,
    - ✓ Quantum Communication,
    - ✓ Quantum Sensing & Metrology, and
    - ✓ Quantum Materials & Devices.



Conclusion

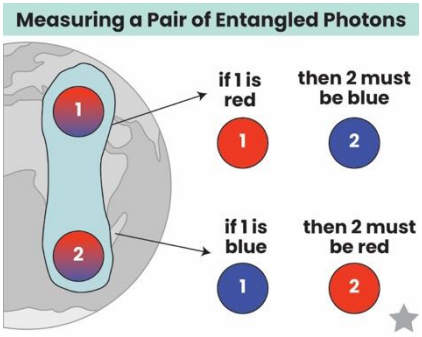
National Quantum Mission is **a giant stride in the future**. To realise its potential, a **collaboration between businesses, universities, and government must happen.** This will help address the financial and human resource gaps and at the same time, **aid in the creation of a national quantum research ecosystem.**

1.1.5.2. NOBEL PRIZE IN PHYSICS 2022

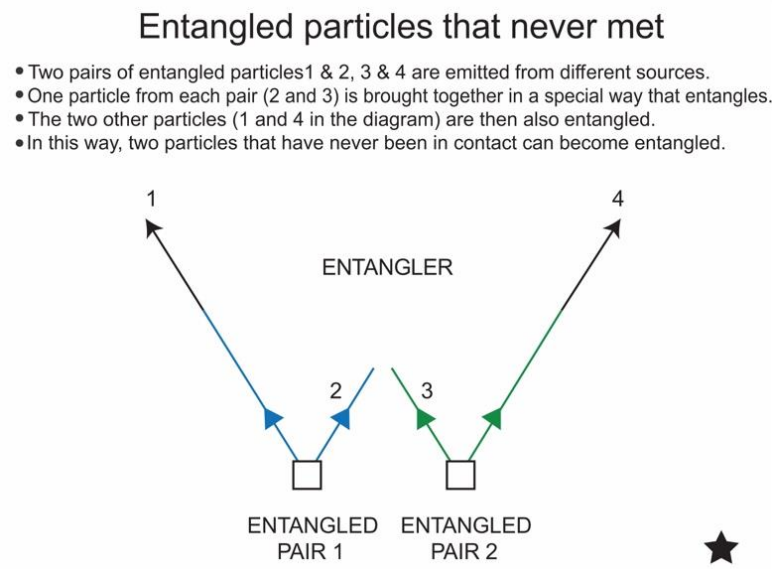
Prize awarded for: experiments with entangled photons, establishing the violation of Bell inequalities and **pioneering quantum information science.**

Awardees: The prize was given to **Alain Aspect (France), John F. Clauser (USA)** and **Anton Zeilinger (Austria).**

About Quantum experiments and Bell inequalities

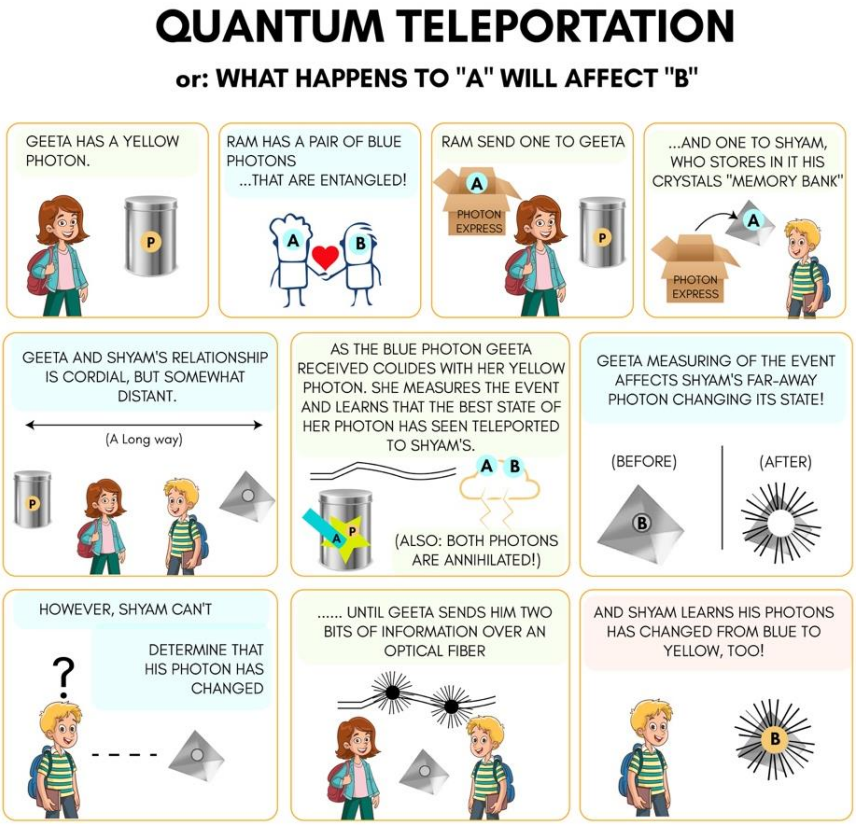


- They demonstrated the **potential to investigate** and **control particles** that are in **entangled states,** laying the foundation for a new era of **quantum technology**.
  - By **measuring the property of one particle** we can immediately determine the **result of an equivalent measurement** on the other particle, without any check (see **image**).
- They also demonstrated a phenomenon called **Quantum Teleportation –** the only way to transfer quantum information from one system to another without losing any part of it.
  - It **uses features of entanglement** which can be used to **transport information,** carried by the object, to another place where the object is then reconstituted.
  - **Anton Zeilinger** group also demonstrated **entanglement swapping,** i.e. two pairs of entangled particles that never met (see **image**).



- Another important part of their research was theoretical insight on **Bell inequalities**.
  - Bell inequalities make it possible to **differentiate between quantum mechanics' indeterminacy and an alternative description** using secret instructions, or hidden variables.

Significance of the Work



- Entangled quantum states hold the potential for **new ways of storing, transferring and processing information.** It will have implications in:
  - **Constructing** quantum computers,
  - **Build** quantum networks, and
  - **Establish secure quantum cryptography,** creating avenues for secure quantum encrypted communication.
- These experiments and other similar experiments lay the foundation for research in **Quantum Information Science (QIS).**
  - QIS is an **interdisciplinary field that seeks to understand the analysis, processing, and transmission of information using quantum mechanics principles.**
  - It **investigates several themes** such as **Quantum Information Theory, Quantum algorithms and complexity** etc.

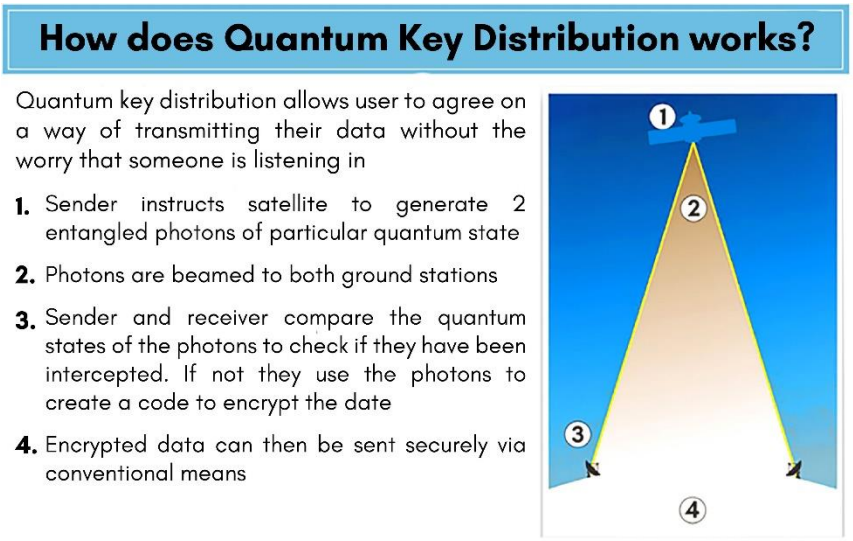
1.1.5.3. QUANTUM KEY DISTRIBUTION (QKD)

Why in News?

Bengaluru-based start-up QNu labs recently innovated advanced secured communication through quantum key distribution (QKD) systems.

About quantum key distribution (QKD)

- QKD is a secure **communication technology that uses quantum physics** to construct a cryptographic protocol.
  - It **allows two parties to generate a shared secret key** that can be used to encrypt and decrypt messages.
- **In traditional cryptography,** security is usually based on the fact that an **adversary is unable to solve a certain mathematical problem** while in QKD, **security is achieved through laws of quantum physics.**



Related Concepts

Quantum Communication

- A highly secured link, **developed by Centre for Development of Telematics (C-DOT)**, under Department of Telecommunications, was **established for the first time** in India.
- **Quantum Communication** refers to communication channels that **leverage laws of quantum physics to protect data** and make it more secure than traditional transmission.
- In **traditional key-based cryptography, data and keys are sent as classical bits** (**representing 1 and 0**) as a stream of electrical or optical pulses**.**
  - However, in a **quantum communication network, data is transmitted via qubits**.

Quantum Coherence

- It is the **ability of a quantum state to maintain its entanglement and superposition** in the face of interactions.
  - It deals with the idea that **all objects have wave-like properties.**
  - **If an object's wave-like nature split in two**, then two **waves may coherently interfere with each other** in such a way to form a single state that is a superposition of 2 states**.**
- Spin-photon interfaces are **elementary building blocks** for quantum networks that allow converting stationary quantum information (such as the quantum state of an ion or a solid-state spin qubit) into light (**namely photons**) that can be distributed over large distances.
  - **A major challenge** is to find **an interface** that is both good at storing quantum information and efficient at converting it into light.
- Optically active semiconductor **quantum dots are the most efficient spin-photon interface** known to date **but extending their storage time beyond a few microseconds** has puzzled physicists in spite of decade-long research efforts.
  - Recent research provides a solution to the problem that **improves the storage of quantum information beyond hundred microseconds.**
- **Quantum dots (QDs) are a unique type of nanocrystalline semiconductor** whose electronic and optical properties are dependent on the size and shape of the dots.
  - For spins in quantum dots, short coherence times were the biggest roadblock to applications in quantum technology.

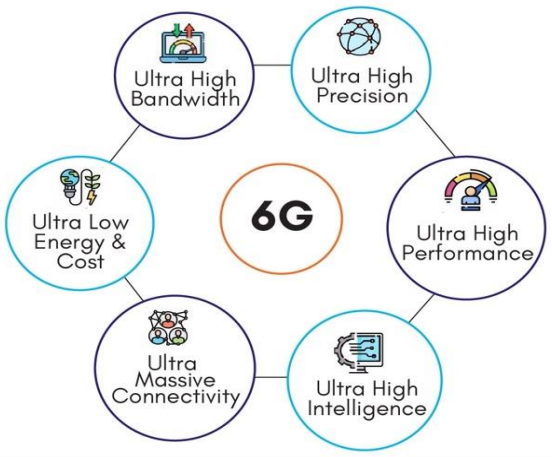
1.1.6. 6G TECHNOLOGY

6G TECHNOLOGY AT A GLANCE

- 6G is the **successor of 5G which offers ultra-low latency** with **speed up to 1 Tbps** by using higher end of radio spectrum.
- 6G enhances solutions based on AI and machine learning, extreme connectivity needs.

Difference between 5G and 6G Network

Features	5G	6G
Frequency Bands	Allocated for **low band and high band frequencies** – sub-6 GHz (Gigahertz) and above 24.25 GHz respectively.	**Operative at the frequency range 95 GHz to 3 THz (Terahertz).**
Data Rate	1 Gbps to 20 Gbps (Downlink Data Rate – 20 Gbps, Uplink Data Rate – 10 Gbps).	Upto 1 Tbps (100 times faster than 5G)
Latency (End to End Delay)	5 milliseconds	< 1 milliseconds
Traffic Capacity	10 Mbps/m²	1 to 10 Gbps/m²



Fields of Applications

E-Health
- Robotics Surgery Online Clinical treatment
- Automated labs & pathology

E-Education
- Digital Schools
- Smart Classes
- Real Time Distance Education

Technology
- High-altitude platform systems (HAPS)
- Artificial Intelligence/ Machine Learning, IoT Platform
- Analytics Engine

Entertainment
- Metaverse Experience
- Real-time Gaming Experience
- Teleoperated Driving Experience Intelligent Bots

Significance of 6G technology

- **Better connectivity:** will help in the provisioning of e-services for urban and rural populations.
- **Economic development:** by improving infrastructures and providing alternatives to rural exodus, mass urbanization, and its related problems.
- **Technological Advancement:** 6G will include non-terrestrial networks (NTNs), which is a key development that enables conventional 2D network architectures to function in 3D space.
- **Push for industries:** biggest use cases in terms of pushing Industry 4.0 and Industry 5.0.

Challenges associated with 6G technology

- **Low investment on R&D:** India spent just 0.7% of its GDP on R&D in 2020, compared to 2.4% in China and 2.3% in the EU.
- **Terahertz (THz) communication:** THz signal attenuates considerably in the air, restricting the transmission range and making it easily blocked by obstructions.
- **Ensuring sustainability:** While 6G promises growth, it will simultaneously have to be balanced with sustainability as 6G devices can have a significant carbon footprint.

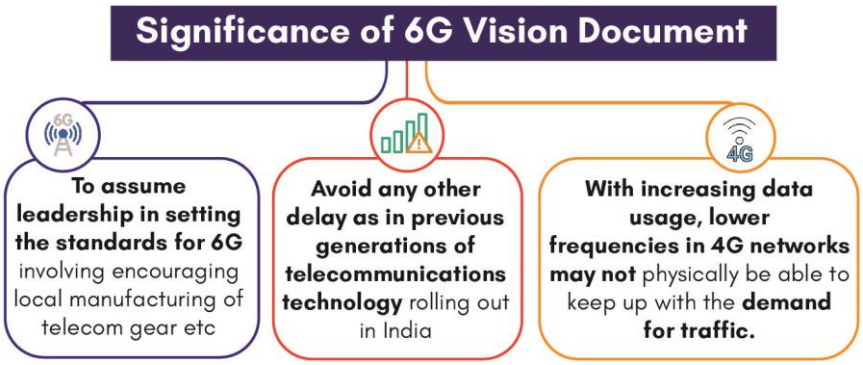
Conclusion

India has the **necessary wherewithal to drive the 6G wave globally** and leverage this powerful force multiplier to transform itself **into a leading global supplier** of advanced, relevant, and affordable telecom systems and solutions. Further, **India must focus on aligning its research on technologies** in the coming decade that would bolster and propel the implementation of 6G and assist us in efficiently allocating resources **to ensure that India becomes a key role player in 6G technology implementation and adoption.**

1.1.6.1. BHARAT 6G MISSION

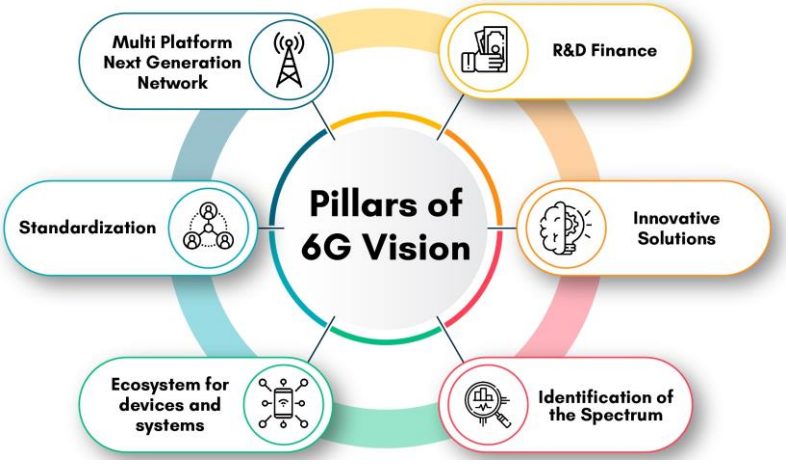
Why in news?

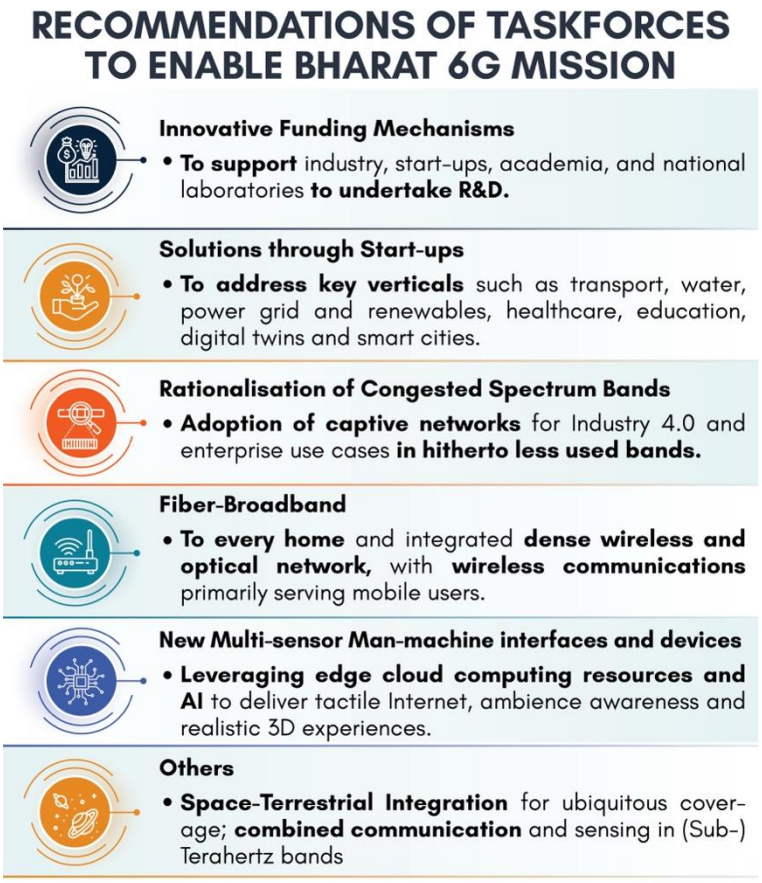
Recently, India released "Bharat 6G Vision" document which **eyes 6G services rollout by 2030 and** launched the 6G research and development test bed.



About the Bharat 6G Vision

- Vision document is prepared by **the Technology Innovation Group on 6G (TIG-6G),** constituted in 2021 by **Department of Telecommunications (DoT).**
- **India will launch a 6G Mission that holistically combines all associated technologies,** supported by an adequate financial backup.
- **Bharat 6G mission will be divided into two phases:**
  - **Phase 1 (2023-2025):** The **ideation phase to understand the inherent potential and risk associated** with the pathways ahead and test proof-of-concept implementations.
  - **Phase 2 (2025-2030): To conceptualizing and delivering potential technology solutions** to serve India and the global community.
- **An apex body is to be constituted** to oversee the Mission and approve the budget for the Mission and lay down the **Phase-wise objectives.**
  - It will **oversee the project, focusing on standardisation, identification of spectrum for 6G, creating an ecosystem** for devices and systems, determining finances for R&D, etc.
  - Key focus will be on **new technologies such as Terahertz (THz) communication, radio interfaces, tactile internet, artificial intelligence for connected intelligence, new encoding methods** and waveforms chipsets for 6G devices.





Conclusion

Though 6G networks is still non-existent but **vision document ensures that India takes its rightful place** in the world as a leading **supplier of advanced telecom technologies and solutions** that are affordable and contribute to the global good.

1.1.7. 5G TECHNOLOGY

5G TECHNOLOGY AT A GLANCE

- Designed to **address speed, latency, and utility issues** of earlier/ current generation of mobile networks.
- **Enhanced throughput to handle more simultaneous connections** at a time.
- **Works in 3 bands:** low, mid and high frequency spectrum.

Significance of 5G technology for India

- **Economic growth:** 5G network rollout estimated to add $450 billion to the Indian economy.
- **High speed:** of about 10Gbps with having the cheap telecom data charges.
- **Creation of job:** in agriculture, health, education, infrastructure, and logistics.
- **Ease of doing business** by improving governance of the country.
- **Self-reliance** in critical and modern technologies.

Steps taken by Government

- **Launch of 5G services** in select cities.
- **DoT has offered the usage of 5G Test Bed free of cost** to the Start-ups and MSMEs recognised by the Government of India up to January 2024.
- **Indian Telegraph Right of Way (Amendment) Rules,** 2022, to enable speedy 5G rollout.
- **5G India Forum by** Cellular Operators Association of India (COAI).
- **'National Digital Communication Policy-2018** (NDCP-2018) also lays out objectives with respect to 5G services in India.

Challenges in implementation of 5G

- **Low fiberisation footprint:** Only around 33% of India's telecom towers are connected by fibre connection.
- **Hardware challenge:** Indian communications service providers are mostly dependent on foreign telecom OEM.
- **Globally harmonised spectrum allocation:** across a range of frequencies requires coordination among the global community.
- **High spectrum pricing:** Several times costlier than the global average.
- **Challenge to net neutrality:** due to network slicing (preferential or differential treatment).
- **Others:** Telcos issue (low average revenue per user, lack of skillset etc.), Consumer Constraints (Network coverage issue, Handset availability, data privacy etc.).

Way forward

- **Doubling of fibre connectivity:** from around 33% for an efficient 5G launch and adoption.
- **Boost local 5G hardware manufacturing** at an unprecedented rate.
- **Rationalization of prices:** to make 5G services globally competitive.
- **Balanced allocation of bands** to enhance futuristic 5G technology applications.

1.1.7.1. 5G SPECTRUM AUCTION

Why in News?

A record over ₹1.5 lakh crore worth of 5G telecom spectrum was sold in recently held auction.

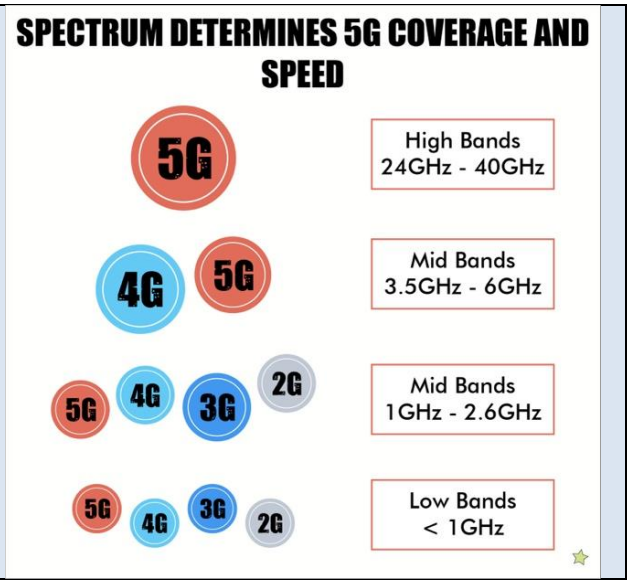
About 5G spectrum

- Spectrum relates to the **radio frequencies allocated to the mobile industry and other sectors for communication** over the airwaves.
- **Union government owns** various publicly available assets, which also include airwaves.
- Union government **through Department of Telecommunications (DoT) auctions spectrum** from time to time.
- Operators around the world are most likely going to have **to use a mix of low-band, mid-band, and high-band spectrum** to deliver the type of 5G experience that their customers demand.

About Network Slicing

- It is a new network architecture that **provides multiple logical networks** on the **same shared network infrastructure.**
  - Each logical network **serves a specific service type or industry user.**
- **Benefits of Network Slicing**
  - **Reduce the cost** of constructing multiple private networks.
  - **Provide highly flexible network services** that can be scheduled and allocated on demand based on service requirements.

5G Spectrum	Features
Low-band	• Will make it **possible for operators to provide a wide swath of coverage** but **speed and latency will only be incrementally better** than 4G networks. • Much of the 5G network's **performance will depend upon proximity to the cell site.** • It is essential **to build coverage in thinly populated areas** and provide indoor coverage in built-up areas.
Mid-band	• Considered **ideal for 5G because it can carry plenty of data** while also **traveling significant distances.** • Provides high-capacity city-wide 5G.
High-band	• It **delivers super-fast speeds over short distances.**



Significance of spectrum

- India requires more spectrum **to capture the advantages of new opportunities for social and economic development.**
- **Spectrum is the foundational feature that will be needed for:**
  - **New mobile applications,** particularly in areas such as education, health care, transportation, and commerce.
  - **Major flagship programs** like Digital India and Smart Cities.
  - **To overcome rural/urban disparities** and bring content-rich resources to underserved areas.

Department of Telecommunication released National Frequency Allocation Plan (NFAP) 2022

- **Central theme of NFAP** is the **allocation of radio-frequency spectrum** to different radiocommunication services including **cellular mobile service, Wi-fi, sound and television broadcasting, radionavigation for aircrafts and ships, defence and security** communications, **disaster relief** and emergency communications, **satellite communications and satellite-broadcasting** etc.
  - It is an important policy document **for spectrum managers, wireless users and telecom equipment manufacturers**.
- **Key Highlights of NFAP**
  - Provides **necessary information regarding usages of frequency bands** from 8.3KHz to 3000 GHz, for variety of radio services.
  - **Provides additional spectrum for implementing 5G** in all three segments of radio spectrum i.e. below 1 GHz, between 1-6 GHz and above 6 GHz.
  - **Provides required protection to science facilities, promoting innovation and research** in the fields of Radio Astronomy and Deep Space communications.
  - **Lists the license exempted frequency ranges**. These **frequency bands support short range communications** for socioeconomic benefits using latest technologies such as Machine to Machine communications, Internet of Things and Inductive applications.

Challenges in spectrum allocation in India

- **High spectrum costs:** It lower the incentives to invest in network expansion and upgrades and can also significantly delay the rollout of new services.
- **Managing spectrum amid a new space race:** Growing number of satellite projects has increased volume of new satellite system notifications submitted to International Telecommunication Union (ITU).
  - All users of radio frequencies in space, whether by states or private entities, must be notified ITU to comply with the Radio Regulation.
- **Inadequate availability:** It is argued that too much spectrum is occupied by Ministry of Defence and is also underutilized, creating an artificial scarcity of spectrum.
- **Policy uncertainty:** foreign investors might be reluctant in investing further due to delay in policies and uncertain and ambiguous market environment.
- **Inefficient usage:** Less availability of spectrum in India (much lower than U.S. and Europe) results in inefficient use of spectrum with fewer customers on one hand and congested networks on the other.

Way Forward

- **Operators should be pre- informed about the availability of spectrum** to enable them to take bidding decisions based on facts and information and not desperation.

- **Harmonization of spectrum at International, National and Regional level** is imperative to avoid wastage of spectrum.
- **Government must provide smooth approval processes,** single window clearance to enable faster deployment of network and services.
- **Government must make efforts to free up spectrum** which would help in meeting up the demands of the telecom service providers.

Conclusion

Licensing approaches **will affect the impact of 5G on societies and economies** and **high 5G spectrum prices threaten** affordable, high-quality **mobile broadband services for 5G or other generations**.

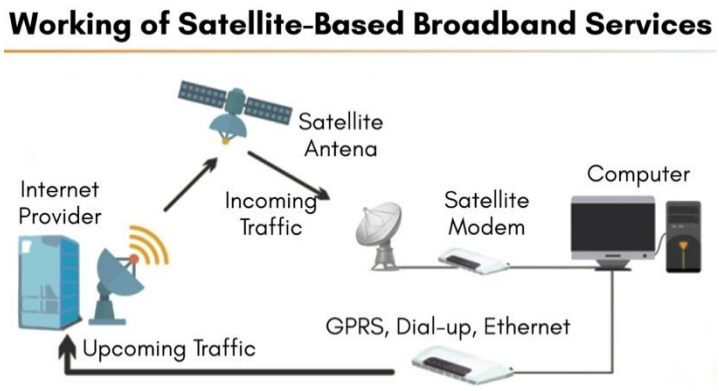
Robust licensing approaches which **prioritise mobile broadband services above revenue maximisation** are **vital to delivering 5G for all** businesses and consumers, creating digital inclusion and lowering the mobile usage gap.

1.1.8. SATELLITE-BASED BROADBAND

Why in News?

Telecom secretary recently stated that Indian users will likely be able to access satellite-based broadband connectivity by the middle of 2023.

About Satellite-based broadband



- It is a **wireless internet connection which uses satellites in space** to get an internet signal from the Internet Service Provider (ISP) to users.
- **27.5 Ghz – 29.5 Ghz frequency band** is globally earmarked for satellite communications.
- Telecom companies **use geostationary (GEO), medium earth orbit (MEO) and low earth orbit (LEO) satellites** to provide internet services.

Type	Advantage	Disadvantage
LEO	• Cheaper to make and deploy. • Move faster and can hence provide global coverage. • Low Latency in signal transmission compared to GEO/MEO.	• Require a satellite constellation working in sync to offer coverage on earth.
GEO/ MEO	• Serviceable area on Earth is more and require fewer ground stations. • Easier to establish a transmission link with a satellite.	• Larger, deployed in higher orbits, and therefore cost more. • Need for a high inclined antenna for locations away from the equator.

Models for satellite-based connectivity include:

- **Hybrid (LPWAN + Satellite) or Indirect Model:** In this, each sensor and actuator in a network may communicate with the satellite through an intermediate sink node, i.e., Low Power Wide-Area Network (LPWAN) gateway.
- **Direct to Satellite Model:** allows devices to directly communicate with the satellite without the need of any intermediate ground gateway.

How is it different from existing broadband services?

- **Aggregation of all the data generated and transmitted** by users accessing the internet **happens in the sky or space,** that is in the satellite.
  - However, **in cellular networks aggregation happens on the ground,** in the base stations.

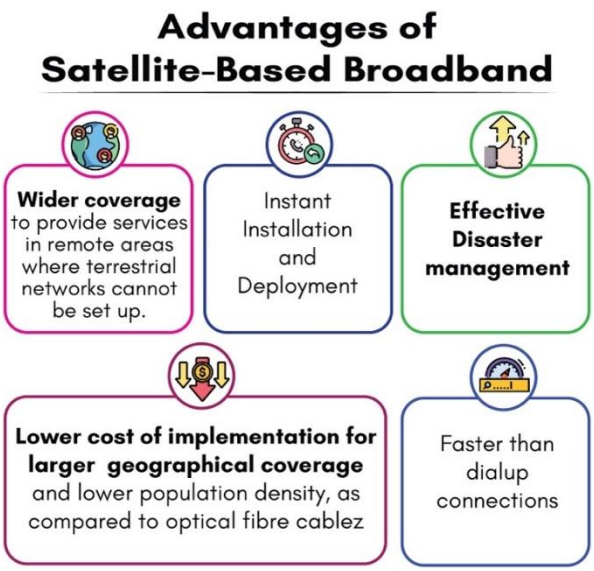
Initiatives taken

- **Indian Satellite Navigation Policy – 2021 (SATNAV Policy – 2021)** to address the growing demands of space-based navigation and timing applications.
- **ISRO,** along with Hughes Communications India (HCI) **has launched a High Throughput Satellite (HTS) broadband internet service** to connect the remotest corners of India.
- Launch of **Satellite-based broadband connectivity for Lakshadweep Islands.**
- **Reliance Jio, Bharti Group-backed OneWeb and Elon Musk's starlink** are the leading contenders in the race to launch commercial satellite broadband services in India.

- **To access satellite services, a dish antenna is needed** just like in the case of TV services, so a normal mobile handset **cannot directly access satellite broadband.**

Challenges faced in Satellite-based broadband

- **Expensive:** than cable or fiber internet as complex equipment like satellite dishes being used to avail these services.
- **Weather can affect satellite:** As weather affects the signal path, minor changes in weather can have a massive impact on both the speed and latency of satellite data.
- **Higher latency and low bandwidths:** compared to cable and fiber internet because of the distances the signals have to travel and all the potential obstacles in between.
- **Privacy issue:** Because of lack of compatibility with virtual private network (VPN) Services that gives online privacy and anonymity by creating a private network from a public internet connection.
- **Others:** increased space debris, increased risk of collisions, and the concern of astronomers that these constellations of space Internet satellites will make it difficult to observe other space objects, and to detect their signals.



Satellite based Communication regulation

- Under Indian Telegraph Act, 1885, Satellite based communication service can be provided within the scope of following licenses/authorisation:
  - **Global Mobile Personal Communication by Satellite (GMPCS) Services:** To provide all types of mobile services including voice, non-voice messages, data services by establishing GMPCS gateways in India.
  - **VSAT Closed User Group (CUG) for commercial service:** To provide data between various sites scattered, within territorial boundaries of India, to a CUG.
  - **In-flight and Maritime Connectivity service authorisation:** To provide wireless data or voice on ships within Indian territorial waters and on aircraft within or above India or Indian territorial waters.
  - **Captive VSAT CUG license:** For internal communication of an organisation and is for non-commercial purpose.
  - **National Long Distance (NLD) service authorisation:** Provides right to licensee to carry inter-circle telecommunication traffic over its NLD network.

Conclusion

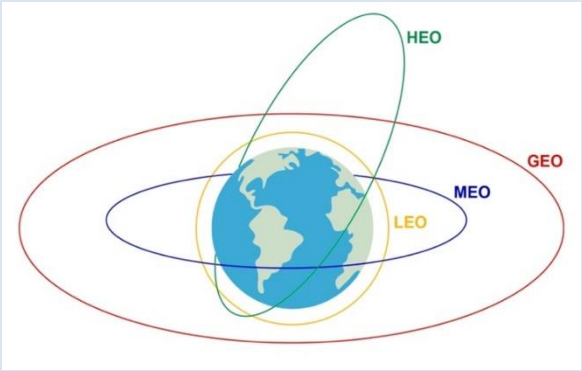
Although the satellite broadband industry in India is still at a nascent stage, **the growing demand for connectivity and Internet** — the Digital India drive — **calls to connect all unserved terrains** and this is what satellite-based broadband can do.

A conducive policy and regulatory environment along with sufficient spectrum allocation, ease of doing business etc, **are of vital importance** to tap satellite internet potential.

Related News

Growth of Commercial Low-Earth Orbit (LEO) Economy

- Recently, One Web launched 36 satellites into LEO from ISRO's launch facility in Sriharikota.
- LEO is an orbit **at an altitude of less than 1000 km but could be as low as 160 km above Earth.**
  - Objects in LEO are **subject to atmospheric drag since they remain within the upper layers of Earth's atmosphere,** specifically the **thermosphere.**
- **Significance of LEO**
  - LEO satellites have **more available routes for satellites in LEO, than in other orbits.**
  - **Used for satellite imaging**, as being near the surface allows it to take images of higher resolution.
  - **Used for International Space Station (ISS),** as it is easier for astronauts to travel to and from it at a shorter distance.
- **Challenges**
  - Individual LEO satellites are **less useful for tasks such as telecommunication** because they move so fast across the sky.
  - LEO has becoming increasingly **congested with space debris.**



1.1.9. ARTIFICIAL INTELLIGENCE

ARTIFICIAL INTELLIGENCE (AI) AT A GLANCE

- Branch of computer science concerned with **making computers mimic human-like intelligence.** AI enables a machine to perceive and respond to its changing environment.
- Potential to boost **national growth rate by 1.3% and add 1 trillion dollars by 2035 to India's economy.**
- **India's Strength in AI:** Large young population, Emerging startup ecosystem, India's "AI for All" strategy, India's digital footprint.

Types of AI

Artificial narrow intelligence (or weak AI)
Refers to the ability of a computer system to perform a narrowly defined task better than a human can.

Artificial general intelligence (also called strong AI or human-level AI)
Refers to the ability of a computer system to outperform humans in any intellectual task.

Artificial super intelligence
Refers to a computer system that would have the ability to outperform humans in almost every field, including scientific creativity, general wisdom and social skills

Benefits and applications of AI

- **Healthcare:** AI driven diagnostic, Early detection, drug research and discovery.
- **Education:** Automation of repetitive task, Practicals using AR/VR, Counselling sessions, Evaluation etc.
- **Agriculture:** AI enabled agricultural robotics, Predictive analysis, AI for intelligent spraying etc.
- **Manufacturing:** Quality checks, Prediction of equipment failure, Inventory management, real time changes in supply chain management etc.
- **Energy:** AI managed smart grids, Anti-theft technologies, Fault prediction, Energy efficient systems using Alexa, Google nest etc.
- **Financial services:** Personalised Banking, Fraud detection, Process automation etc.
- **Law enforcement:** Facial recognition, Speech recognition, Predictive analytics etc.

Challenges with AI

- **Adverse impact on Society:** AI works on the already existing set of data's and there are chances of the existing biases, to be transferred to the AI as well.
- **Lack of Accountability and Transparency:** as it will be difficult to explain on how a decision was made by the AI.
- **Ethical Concerns:** related to equality, justice, and human dignity might pop up.
- **Infringes Intellectual Property rights:** Many artists have claimed that their artworks were indiscriminately recreated by the AI, to create its own image rendering.
- **Privacy Issues:** The use of AI can raise concerns about the collection, storage, and use of personal data.

Initiatives taken in India

- **MeitY's FutureSkills PRIME** in collaboration with NASSCOM, for re-skilling/ up-skilling of IT professionals in 10 Emerging areas including AI.
- **National Strategy for Artificial Intelligence.**
  India is **founding member of the Global Partnership on Artificial Intelligence (GPAI).**
- **National Programme on Responsible Use of AI for Youth.**
- **'National AI Portal',** a repository of AI based initiatives.
- **Responsible AI for Social Empowerment (RAISE)** in 2020.
- **Technology Innovation Hubs** under National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS).

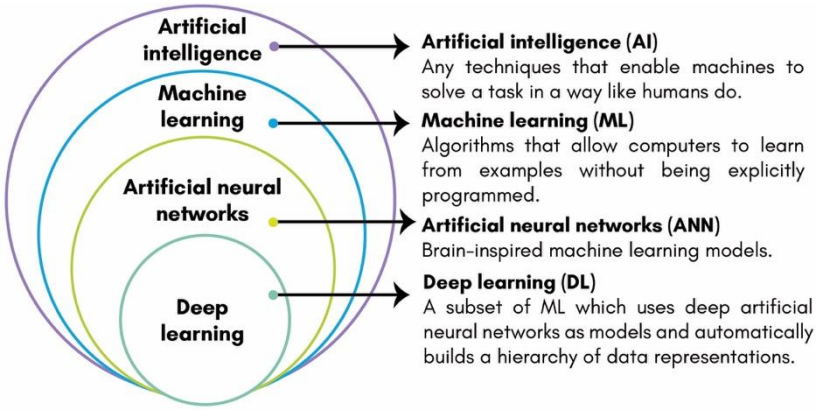
Way Forward

- **Establishing ethical principles and guidelines** for the development and deployment of AI.
- **Instead of open access a regulated usage** could be introduced and critical information data set can be isolated from the advent of AI.
- **Better collaboration and cooperation** with different stakeholders, including government, industry, academia, and civil society.
- **AI systems should be designed and trained on diverse and inclusive data** to minimize biasness and ensure equitable outcomes.

1.1.9.1. GENERATIVE ARTIFICIAL INTELLIGENCE (AI)

Why in News?

Recently, Tech companies around the world are harnessing Generative AI for various use cases.



More about News

- There has been increasing popularity of generative AI programs, such as OpenAI's ChatGPT, Google's BARD AI, DALL-E, Codex, GPT-3 etc.
- These programs are a **conversational AI language based on deep learning model built on the transformer architecture.**
  - It **uses a deep neural network** and is trained on corpus of text data from the internet, allowing it to generate human-like text and to perform various tasks like question answering, and conversation.
  - It represents a significant advancement in the field of **natural language processing** and has the potential to revolutionize the way humans interact with computers.
- There are speculations that **these platforms can replace Google search and more so humans in the future.**

Related Terms

Large Language Models (LLMs)

- LLM is a **type of AI algorithm that uses deep learning techniques** and massively **large data sets** to understand, summarize, generate and predict new content.
  - Deep learning is a **subset of machine learning**, which is essentially **a neural network** with three or more layers.
  - These neural networks **attempt to simulate behavior of human brain** allowing it to learn from large amounts of data.
- They **work by processing vast amounts of text**, understanding the structure and meaning, and learning from it. **LLMs are 'trained' to identify meanings and relationships between words.**
- **Examples of LLMs include** Generative Pre-trained Transformer (GPT), ERNIE Titan LLM, Yandex YaLM 100B, BLOOM etc.

Transformer

- It is a **two-part neural network.**
- **First part is an 'encoder'** that ingests the input sentence in the source language (e.g. English);
  - Encoder **converts each word to an abstract numerical form** that captures the meaning of the word within the context of the sentence **and stores it in a memory bank.**
- **Second is a 'decoder'** that generates the translated sentence in the target language (Hindi).
  - Decoder **generates one word at a time by looking back at the memory bank** to find the appropriate word.
- **Both these processes use a mechanism called 'attention'.**

Generative artificial intelligence (AI)

- It describes **algorithms that can be used to create new content like audio, code, images, text, simulations, and videos.**
- It is **achieved by training machine learning models on large amounts of data using neural networks** and then using these models to generate new, synthetic data that is similar to the already existing data.
- Until 2022, **the purpose of existing AI was to analyse data, spot anomalies, detect fraud and perhaps,** make recommendations such as movies to watch or best holiday destinations.
  - However, with **generative AI, users can witness brand new content being created from scratch.**
- Presently, there are **3 prominent frameworks or models of generative AI** like **Generative adversarial networks (GANs), Transformer-Based Models (TBMs)** and **Variational AutoEncoders (VAEs).**

Conclusion

AI is a rapidly advancing field with **the potential to transform many aspects of our lives and economies.** However, to fully realize the benefits of AI and avoid negative consequences, **it is important to approach its development and deployment with caution and consideration for ethical and social implications.**

1.1.9.2. AI IN HEALTH

AI IN HEALTH

Benefits of AI in Health

- **Prediction-based diagnosis:** AI could make faster, more accurate diagnoses and prompt detection of conditions such as stroke, pneumonia, breast cancer.
- **Drug discovery and development:** Recently scientists used AI to find a new antibiotic against superbug A. baumannii.
- **Improving efficiency in operations:** By examining data patterns, AI technologies can help healthcare organizations make the most of their data, assets and resources.
- **Health systems management and planning:** From optimization of the medical supply chain, to using chatbots to assume mundane, repetitive tasks or to support complex decision-making.
- **Public health surveillance:** AI can improve identification of disease outbreaks and support surveillance.

Challenges

- **Data Privacy and Security:** as use of AI in healthcare requires large amounts of patient data.
- **AI systems can be biased** if the data they are trained on is not representative of the population they will be used to serve.
- **Lack of regulations:** AI technology itself may not meet the standards of scientific validity and accuracy that are currently applied to medical technologies.
- **Ethical concerns:** as AI use in health surveillance could also give rise to stigmatization of individuals or communities.
- **Lack of skilled personnel:** Without enough AI trained professionals potential benefits of AI will go unrealized.

Conclusion

Health organizations have **accumulated vast data sets** in the form of health records and images, population data, claims data and clinical trial data.

AI technologies are well suited to **analyze this data and uncover patterns and insights** that humans could not find on their own.

1.1.9.3. AI IN AGRICULTURE

AI IN AGRICULTURE

Applications

- **Intelligent crop planning** includes credit planning, micro-irrigation, inputs planning, sowing windows, potential etc.
- **Smart and precision farming:** Mechanization of farms, Wearable sensors for soil analysis, pest prediction, irrigation, hyperlocal weather advisory etc.
- **Farmgate-to-fork:** Quality and traceability, supply chain optimization, Fintech, warehousing supply cold chain, demand prediction etc.
- **AI based surveillance systems** for real-time monitoring of fields and identifying animal or human breaches.
- **Efficient labour:** Robots employing AI can harvest faster, locate and remove weeds more accurately, and thus reduce operating cost and dependence on labour.

Challenges

- **Lack of datasets** needed to train AI models.
- **High investment cost** of various hardware/software used in AI systems.
- **Handling of massive data** in a safe and secure manner.
- **Bridging the gap between farmers and AI engineers** to make AI usable in fields.
- **Lack of technical knowhow and awareness** in farmers, especially in rural areas, of high-tech machine learning solutions in farms.
- **Marginalisation, poor internet penetration rates, and the digital divide** might prevent smallholders from using advanced technologies, widening the gaps between commercial and subsistence farmers.

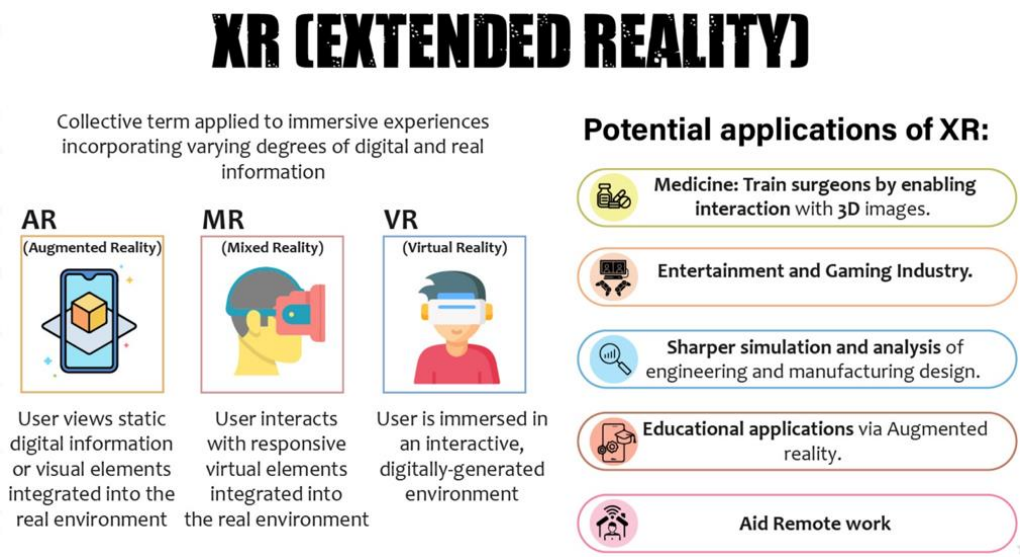
Conclusion

AI in agriculture not only assists farmers in **automating their agricultural operations,** but also changes to **precision cultivation for improved crop output and quality** while using less resources.

1.1.10. EXTENDED REALITY, OR XR

Why in News?

Ministry of Electronics and Information Technology (MeitY) Startup Hub and Meta collaborate to accelerate XR technology start-ups in India.



About Extended reality, or XR

- It refers to **all real-and-virtual combined environments and human-machine interactions generated by computer technology.**
- **Challenges with XR**
  - XR technologies **collect and process huge amounts personal data** which has to be protected.
  - **High cost of implementing** the technology.
  - **Lack of familiarity** with navigating the virtual world.
  - **Gaps in alignment between assessment method** and content being assessed.

Conclusion

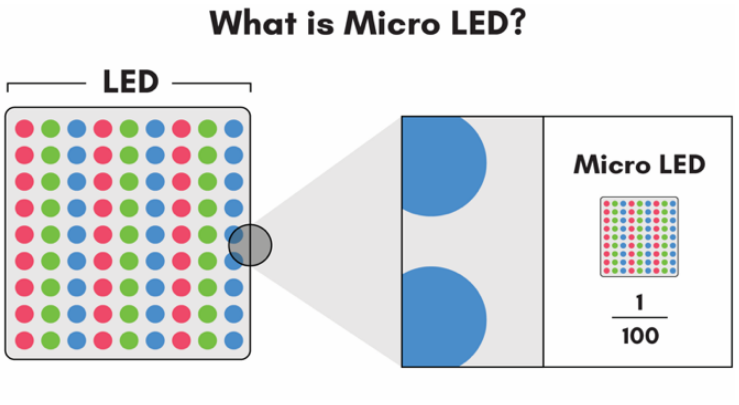
The field of extended reality is **expanding quickly and presents tremendous potential for innovation and growth.** However, there are **still concerns to be addressed**, such as the high cost of hardware as well as the demand for more high-quality, immersive content.

Nonetheless, the **opportunities offered by XR technology are enormous,** and we can anticipate it to become even **more integrated into our daily lives**.

1.1.11. MICROLEDS (LIGHT EMITTING DIODE) DISPLAYS

Why in News?

Recently various electronic companies are showing their interest in **MicroLED (mLED or µLED)** display technology.



About MicroLED (mLED or µLED)

- microLED displays **comprise several microscopic LEDs**, which self-illuminate per display pixel- just like an OLED (Organic LED) panel does.
  - mLED is **as small as cutting a centimetre of hair into 200 smaller pieces.**
  - Each of these mLEDs are **semiconductors that receive electric signals**.
  - Once these mLEDs are gathered, **they form a module.** Several modules are then combined to form screens.
- **Benefits of mLED**
  - **Self-emissive** and have **better colour reproduction** and provide **better viewing angles.**
  - **Limitless scalability**, as they are **resolution-free, bezel-free, ratio-free**, and even size-free.
  - **More efficient and bright**, more durable and with higher colour gamut against LCD and OLED.
- **Challenges:** Higher manufacturing cost, market share for liquid crystal displays remains sizable etc.

Conclusion

MicroLED technology has the **potential to revolutionize the display industry,** offering **superior image quality, energy efficiency, and durability.** While there are **still several challenges that must be overcome,** it is expected that **microLED displays will become increasingly common in the coming years.**

Display Technology	LCD (Liquid crystal display)	OLED	Mled
Pixel types	Back lit display	Self-emissive display	Self-emissive display
LED makeup material	Inorganic LED backlight	Organic LED	Inorganic LED
Brightness	High	Low	Very High
Lifespan	Long	Short	Very Long
Response time	Slow (in milli-seconds)	Medium (in micro-seconds)	Fast (in nano-seconds)

1.2. SUPER COMPUTERS

Why in news?

India's AI supercomputer AIRAWAT has been ranked 75th in the Top 500 Global Supercomputing List, announced at the International Supercomputing Conference held in Germany.

More on News

- **AIRAWAT supercomputer**, at C-DAC Pune, is **India's largest and fastest AI supercomputing system,** with a remarkable speed of 13,170 teraflops.
  - It was installed as part of the government's **National Program on Artificial Intelligence.**
- **Other Indian supercomputers in the Top 500 list:** PARAM Siddhi-AI, Pratyush, Mihir.
- **Frontier from USA** is the **fastest supercomputer.**

National Supercomputing Mission (NSM)

- Launched in 2015.
- **Goal:** to connect R&D institutions and academic institutions in the country using a supercomputing grid with more than 70 high performance computing facilities.
- **National Knowledge Network (NKN):** These supercomputers will be networked on the National Supercomputing grid over the NKN.
- **Objectives**
  - To make **India one of the world leaders in Supercomputing** and to enhance India's capability in solving grand challenge problems of national and global relevance.
  - To **minimize redundancies and duplication of efforts** and optimize investments in supercomputing.
- **3 phases.**

Phase 1	• Install 6 supercomputers with 30% value additions done in India. • Focus to **create an ecosystem for assembly** of system components within the country
Phase 2	• **Manufacturing supercomputers** in the country with an indigenous software stack.
Phase 3	• Focus on design and manufacturing in the country. • Expected to take computing speed to 45 PF.

What is a supercomputer?

- A **high-performance computing system** that delivers exceptional processing power and computational capacity compared to a general-purpose computer.
- **Performance** of a supercomputer **is measured in floating-point operations per second (FLOPS)** instead of million instructions per second (MIPS).
- Supercomputers contain tens of thousands of processors and can perform **billions and trillions of calculations or computations per second.**
- **Indigenous development of supercomputers began in 1980.** India's **first supercomputer, PARAM 8000,** was set up in 1991.

Applications of Supercomputers

- **Cutting edge research:** Such as for **data-intensive and computation-heavy scientific and engineering purposes** such as quantum mechanics, weather forecasting, etc.

- **Aerospace and Engineering:** Processing complex algorithms and Big Data from sensors around the performance of aircraft and the environments they operate in.
- **AI:** ChatGPT was trained on a supercomputer built exclusively for OpenAI by Microsoft.
- **Weather forecasting:** For example, 'Pratyush' Supercomputer at Indian Institute of Tropical Meteorology (IITM), Pune.
- **Energy Exploration:** Supercomputers help to detect and accelerate deeper geological insights; hence improve the exploration and production processes.
- **Health and medicine:** To help find a drug that could work against the Covid-19, supercomputers were employed to look through databases of existing drug compounds.
- **Defence and military:** Applications related to national security, including nuclear weapons design and cryptograph. It helps simulate complex weapons systems.

Challenges of Super Computers

	Massive external storage drives whose bandwidth is fast enough to accommodate the data being analyzed
	They **are extremely costly**, including huge operational costs.
	Consume large amount of electricity. On average, a supercomputer requires about 4 megawatts (MW) of electricity.
	Supercomputer systems are built by **connecting multiple processing units and can require large rooms to store them.**

Conclusion

Thus, countries around the world, including India, have been **ramping up supercomputing capabilities** over the past few years. **For India to become a knowledge-driven, multi-trillion-dollar economy**, which is able to support cutting-edge science to benefit its economy, its society and the businesses, **investment in supercomputing is a necessity.**

1.3. DATA CENTRES

DATA CENTRES AT A GLANCE

- **A dedicated secure space within a building / centralized location where computing and networking equipment is concentrated** for collecting, storing, processing, distributing etc to large amounts of data.
- **Key selection criteria:** Geographic location, favourable climatic conditions, availability of power, proximity to customers, fiber connectivity and real estate costs.
- **Types of Data Centres: Captive** (company owned and operated), **Colocation** (rental of data centre space with basic power), **Hyperscale** (owned and operated by cloud service providers), **Edge** (small data centre facilities).
- As per Nasscom, India is expected to see **investments of around $4.5 billion by 2025.**
- **Demand drivers in India include** push to Digital India, COVID-19 induced demand, fairly stable geography, improved fiber connectivity, growing IT sector, adoption of cloud services etc.

Importance of Data Centres for India

- **Size of digital economy:** in India is estimated to grow from **$ 200 billion in 2017-18 to $ 1 trillion by 2025.**
- **Data localization provisions:** Presence of domestic data centres will allow companies to store critical personal data and sensitive personal information of Indian citizens within India.
- **High growth potential:** India's data centre market is set to play a key role in job creation, bring in foreign investment and contribute to the growth of the country's economy.
- **Meeting digital demands:** of explosion of data through smartphones, social networking sites, e-commerce, digital education, digital payments etc.
- **Suitability for emerging technologies:** such as quantum computing, artificial intelligence, internet of things etc.

Challenges in establishing Data Centres in India

- **Lack of a Data Protection Bill:** will make some stakeholders, especially investors from overseas, hesitant to invest.
- **Locational Constraints:** skill availability for advanced data centre construction and design, delay in approvals, power and land constraints etc.
- **High Power Consumption** by data transmission networks and **Global Pressure to Reduce Carbon Emissions.**
- **Security Threats:** from physical damages; safety of IT Infrastructure from attacks, DDoS attacks, web application attacks, DNS infrastructure exploits and network vulnerabilities.

Initiatives taken in India

- **Draft Data Centre policy by MeitY** to accelerate the growth in the projected Data Centre.
- National Informatics Centre (NIC) has set up **state-of-the-art National Data Centre at NIC Headquarters Delhi, Pune, Hyderabad, and Bhubaneswar.**
- **Infrastructure status to data centres** with more than 5-megawatt capacity of IT load.
- NIC has also set up **small Data Centres at various State Capitals** to provide services to the Government at all levels.
- **States** like Uttar Pradesh and Tamil Nadu have **released their own data centre policy.**

Way Forward

Draft Data Centre Policy, 2020 proposes following strategies:

- **Ease of Doing Business Ecosystem:** Infrastructure Status to the Data Centre Sector, formulation of Data Centre Incentivization Scheme etc.
- **Recognize Data centre** as a separate category **under National Building Code.**
- **Government to set up at least four Data Centre Economic Zones** in the country as a Central Sector Scheme.
- **Collaborate** with Ministry of Skills Development and Entrepreneurship and leading academic institutes to impart **large scale trainings to workforce on Data Centre, Digital and Cloud technologies**

1.4. GEOSPATIAL TECHNOLOGY

GEOSPATIAL TECHNOLOGY AT A GLANCE

- Includes **Geographic Information System (GIS), Remote Sensing (RS) and Global Positioning System (GPS).**
- Enables **acquiring earth referenced data and using it for analysis,** modeling, simulations and visualization.
- Would be **central to information management in India** for great social as well as national relevance.

Application of geospatial Technology

- **Disaster risk reduction and resilience.**
- **Social Development:** Granting land title, satellite-based fishing, precision agriculture, monitoring of crop conditions etc.
- **Energy:** Finding suitability of a location for generating solar energy.
- **Connectivity:** Road Asset Management system, accurate and scientific maintenance planning, planned development of the National Highways.
- **Natural Resource Management:** Water resources, land use management, geophysical data products etc.
- **Informed decision making.**

Challenges in effective use of geospatial information

- **Technological & infrastructural challenges:** lack of supercomputing and quantum computing capabilities.
- **Limited accessibility of space-derived data** to the private sector, and individuals is limited.
- **Digital-technological divide** and **lack of data privacy law.**

GIS based initiatives in India

- **Natural Resource Information System (NRIS):** to provide an integrated database for the use of remotely sensed data.
- **National Spatial Data Infrastructure (NSDI):** It will enhance the accessibility, communication, and use of geospatial data.
- **National Urban Information System (NUIS):** It is a National Mission for generation of 1:10,000 scale urban geospatial database for 152 towns.

Way forward

- **Invest in national experts** for building geospatial applications.
- **Integrate ground and space data, crossover data,** with georeferenced tags and statistical processing.
- **Ensure privacy, safety and ethics of data** by obtaining informed consent whenever possible.
- **Provide open data access** by making use of cloud-based platforms.
- **Collaborate across local and international levels.**

1.4.1. NATIONAL GEOSPATIAL POLICY, 2022

Why in news?

The Ministry of Science and Technology has notified a citizen-centric **National Geospatial Policy (NGP) 2022,** to strengthen the Geospatial sector to support national development.

Vision and Goals

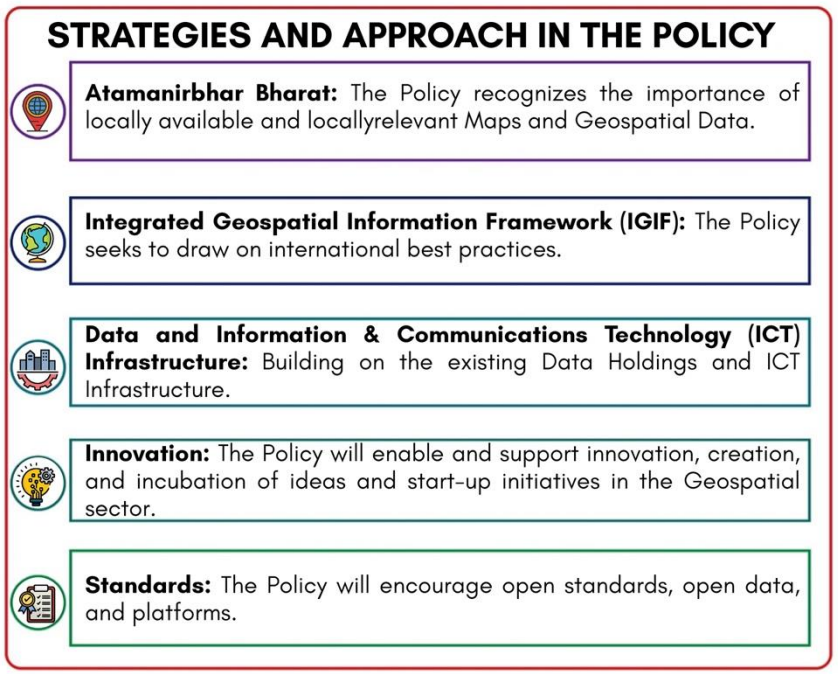
- **Make India a Global leader:** In Global Geospatial space with the best in the class ecosystem for innovation.
- **Integrated Policy:** To leverage it to move towards a digital economy and improve services to citizens.
- **Better utilization of data:** To enable easy availability to businesses and the public.
- **Encouraging participation of the private sector**.

2025	2030	2035
• **Put in place an enabling policy and legal framework** that supports the	• **High-resolution topographical survey & mapping.** • **High-accuracy Digital Elevation Model (DEM)** for the entire country.	• **High-resolution Bathymetric Geospatial** Data of inland waters and sea surface topography of shallow seas - to support Blue Economy.

liberalization of the Geospatial sector • **High accuracy** Geoid for the entire country.	• Develop a **Geospatial Knowledge Infrastructure (GKI)** underpinned by Integrated Data and Information Framework.	• **National Digital Twin** of major cities and towns o The **digital twin** is a virtual replica of a physical asset, process, or service.

Institutional framework

- **Geospatial Data Promotion and Development Committee (GDPDC)**, national level apex body for formulating and implementing appropriate guidelines, strategies, and programs.
- **GDPDC would replace** National Spatial Data Committee (NSDC) and Geospatial Data Promotion and Development Committee.
- **Department of Science & Technology (DST):** nodal Department and GDPDC shall make suitable recommendations to DST.



Strengthening Geospatial Infrastructure

- **Geospatial Data Infrastructure**
  - GDPDC will adopt **14 global geospatial data themes** recognized by United Nations Statistics Division.
  - **National Geospatial Data Registry (NGDR).**
  - **Unified Geospatial Interface (UGI)** to provide consumer-oriented products, applications, services, and solutions.
- **Policy shall replace the National Map Policy**, 2005.
- **Geospatial Knowledge Infrastructure**: will provide the critical Geospatial component to knowledge and automation.
- **An enabling ecosystem** will be provided for industry, academia, and research.
- Advisory body named **as Geospatial Industrial Development Board (GIDB)** will be constituted under GDPDC.

Conclusion

The **next five to ten years will see significant developments** in the maturity and application of already well-established technologies **across the geospatial industry.**

Governments continue to remain highly relevant in the geospatial industry and it will need to take account of and **consider responses to these emerging legal and policy top trends.**

2. BIOTECHNOLOGY, NANOTECHNOLOGY AND ISSUES RELATING TO INTELLECTUAL PROPERTY RIGHTS

2.1. BIOTECHNOLOGY

BIOTECHNOLOGY AT A GLANCE

Area of biology that **uses living processes, organisms, or systems to manufacture products or technology** intended to improve quality of human life.

- **Biotechnology Branches: Blue** (marine and aquatic application), **Green** (agriculture processes), **Red** (medical), **White** (industrial).
- **India among top 12 destinations** globally. **Estimated to increase to USD 150 billion by FY 2025.**
- **Five major segments in India:** Bio-pharma, Bio-services, Bio-agri, Bio-industrial, and Bioinformatics.
- **Growth Drivers in India:** Growing population, rising public health expenditure, skilled human capital, Enhanced policy, and infrastructure support etc.

Significance

- **Food security:** More productive and drought resistant crops, tolerant of other stress like pest, insect etc.
- **Tackling diseases:** finding solutions to Corona/Zika virus, antibiotic-resistant bacteria.
- **Bioenergy:** use of bioethanol and biodiesels.
- **Advancement in drugs:** better innovation and cost effective drugs.
- **Biofortification to improve nutritional quality** of food crops.
- **Animal Biotechnology:** To improve the productivity of livestock.
- Bioremediation: To consume and break down environmental pollutants.
- **Stem cell therapy.**

Challenges

- **Complex Intellectual Property Right regime**
  - **Section 3(d) of the Patents (Amendment) Act, 2005:** strict standards thereby dampening foreign investment.
  - **Compulsory licensing:** allows government power to suspend a patent in times of health emergencies.
- **Lack of Marketisation:** Most of the early research funding runs out before marketisation phase.
- **Lack of public awareness** about modern tools of biotechnology.
- **Less Lucrative** as number and quality of jobs offered is less.
- **Lack of Regulatory mechanism.**

Initiatives taken

- **India's first national repository for life science data** - 'Indian Biological Data Center' (IBDC) **inaugurated** at Faridabad, Haryana.
- **Higher Budget allocation to promote research** and development, agriculture biotechnology, etc.
- **75 Amrit Grants worth Rs. 10-15 crore announced for biotech projects** involving startups, industry, academia, and research organisations working together.
- **100% FDI under the automatic route** for greenfield projects.
- **Biotechnology Parks and Incubators** across the country.
- **Atal Jai Anusandhan Biotech Mission** by DBT.

Way forward

- **Ecosystem of innovation** in which scientists, innovators and future entrepreneurs could be nurtured.
- **Collaboration between government and industry** for improving IP regime.
- **Increase in investment towards R&D** and building human capital.
- **Funding Mechanism for national importance ideas** and Strategic **Road Map for industry-based R&D.**
- **Extending Reach to other fields** of study.

2.1.1. BIOTECHNOLOGY IN PHARMACEUTICAL

BIOTECHNOLOGY IN PHARMACEUTICAL

Benefits of Biopharma

- **Prevention and early detection:** Vaccines and improvements in wellness could help prevent disease.
- **Personalization medicine** could effectively match patients with customized drug cocktails, or design therapies.
- **Curative therapies:** could reduce or eliminate the demand for some prescription medicines.
- **Precision intervention:** Biopharmaceutical products, combined with their ability to address previously untreatable conditions, provides more efficacy and safety.
- **Present fewer side effects** because of their specificity, unlike conventional drugs that affect multiple systems.

Challenges Faced

- **Supply Chain issue:** current production programs are already stretching the industry, with several players failing to deliver to the market.
- **Quality compliance and regulatory scrutiny:** industry has received an unprecedented number of warning letters and remediation programs in the last five years.
- **Capital intensive:** Large-scale biotech-manufacturing facilities require $200 million to $500 million or more to build.
- **Others:** Long process durations, low yields, expensive raw materials, and, not least, the need for a team of highly skilled experts to operate them.

Conclusion

Growing awareness among patients about biopharma's **health benefits and efficacies drives the demand** for biopharma products worldwide. As learnt from the pandemic, **de-risking supply chains, and manufacturing operations while expanding capacity in sensitive APIs and intermediates is** critical.

2.1.2. BIOTECHNOLOGY IN AGRICULTURE

BIOTECHNOLOGY IN AGRICULTURE

Benefits

- **Increased crop productivity:** by introducing such qualities as disease resistance and increased drought tolerance to the crops.
- **Enhanced crop protection:** by making both insect pest control and weed management safer and easier.
- **Improved nutritional value:** flavor, and texture of foods.
- **Environmental benefits:** As reduced pesticide dependence, have less pesticide residues on foods, reduce pesticide leaching into groundwater etc.
- **Health benefits:** For example, golden rice has potential to significantly improve vitamin uptake in poverty-stricken areas.

Challenges

- **Health-related issues:** risk of introducing allergens and toxins into otherwise safe foods, rise in Antibiotic resistance etc.
- **Environmental and ecological issues:** transgenic crops might cross-pollinate with related weeds, possibly resulting in superweeds that become more difficult to control.
- **Ethical concerns:** Unregulated use of GM technology in crop can lead to corporate dominance in agriculture.
- **Economic concerns:** Yields of GM crops (as found with Bt Cotton experience) have turned out to be false.

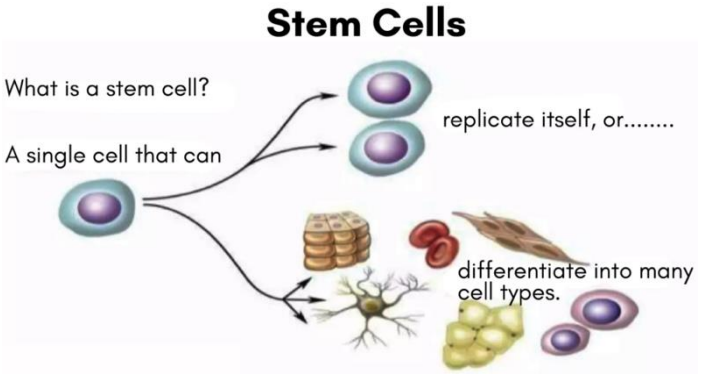
Conclusion

Biotechnology can be used for the betterment of society through **development of crops with improved nutritional quality, resistance to pests and diseases,** and **reduced cost of production.** However, there is a need to ensure that they pose no environmental and health risks.

2.1.3. STEM CELLS

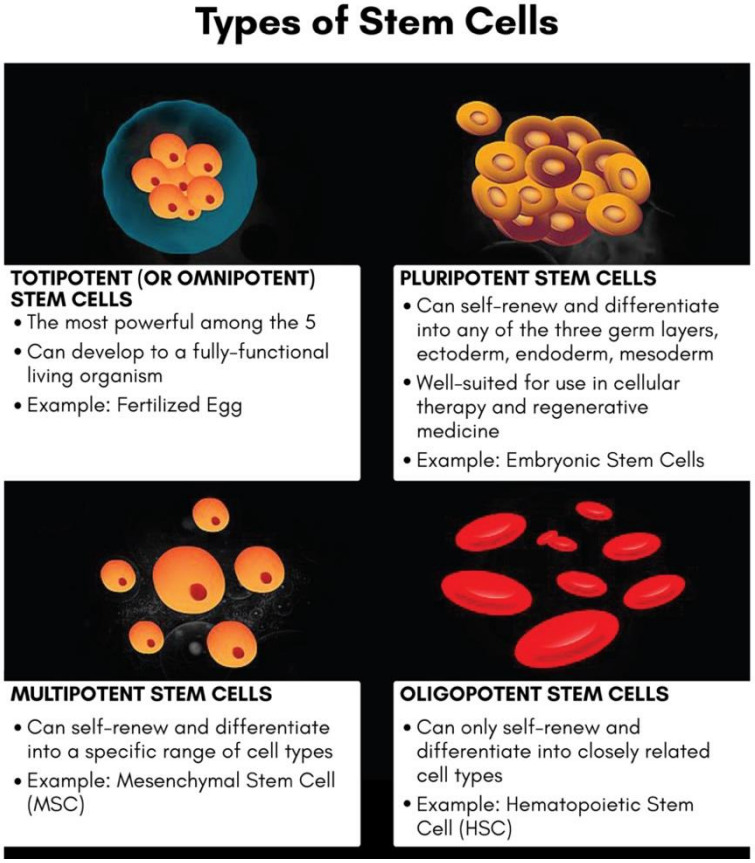
Why in News

A team of scientists in the US and the UK has developed the world's first ever synthetic human embryo-like structures using stem cells.



More about News

- It is a **breakthrough in the world of In Vitro Fertilization (IVF)** and human reproduction.
  - IVF is a type of **Assisted Reproductive Technology** (ART), where **women's egg is combined with man's sperm in a laboratory.**
  - Fertilized egg is **then placed inside women's uterus** in a procedure called embryo transfer.
- This is the **first three-lineage human embryo model** that **specifies amnion and germ cells**, precursor cells of egg and sperm.
  - **Researchers isolated three types of stem cells** from embryos **and cultured them.**
  - **In uterus, an embryo needs three types of stem cells to form:** One becomes the body tissue, another the sac where the embryo develops, and the third the placenta connecting parent and fetus.
- These embryos **resemble natural embryos** in the earliest stages of human development.
- Model structures, each **grown from a single embryonic stem cell, reached the beginning of gastrulation,** when the embryo transforms from being a continuous sheet of cells to forming distinct cell lines and setting up the basic axes of the body.
  - At this stage, they **lack a beating heart or the beginnings of a brain**, they contain cells that **would give rise to the placenta, yolk sac and the embryo.**
- There is **no near-term prospect of the synthetic embryos** being used clinically.
  - It would be **illegal to implant them into a patient's womb**, and it is not yet clear whether these structures have the **potential to continue maturing beyond the earliest stages** of development.



About stem cells

- Stem cells are **special human cells that are able to develop into many different cell types.** Stem cells provide new cells for the body as it grows and replaces specialized cells that are damaged or lost.
- They **have two unique properties** that enable them to do this:
  - They **can divide repeatedly** to produce new cells.
  - As they divide, they **can change into the other types of cells** that make up the body.
- Based on the cell type/tissue of origin, **stem cells are classified as-**
  - **Somatic Stem Cells (SSCs) also known as Adult Stem Cells:** They have limited capacity of differentiation and may be multipotent or unipotent.
  - **Embryonic Stem Cells' (ESCs)** are pluripotent, which mean they can change into any cell in the body.

- ✓ Pluripotent stem cells **can also be generated in lab** and the products thus generated are **referred as Induced Pluripotent Stem Cells (iPSCs).**

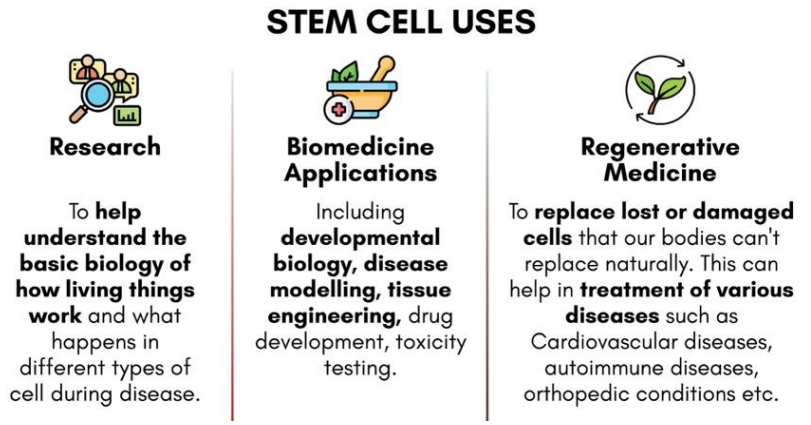
Related News

Third Patient has been cured of HIV (Human Immunodeficiency Virus) after Stem Cell Transplant (SCT).

- Success was **achieved with a bone-marrow transplant** (also called SCT) from people carrying a **specific HIV-resistant genetic mutation** called **CCR5-delta 32 genetic mutation**.
- A bone marrow transplant is a **procedure that infuses healthy blood-forming stem cells into body** to replace bone marrow that's not producing enough healthy blood cells.
  - Bone marrow transplants **may use cells from your own body** (autologous transplant) **or from a donor** (allogeneic transplant).
- **HIV mainly attacks CD4 immune cells** (type of white blood cell) **in human body**, thereby **reducing** a person's **ability to fight off secondary infections.**
  - **CCR5 receptors** on surface of CD4 immune cells **act as a doorway for HIV virus.**
- However, **CCR5-delta 32 mutation** prevents these receptors used by HIV virus from forming on the surface, effectively removing the doorway.

Challenges related to stem cell technology

- **Safety of the patient:** Immune rejection of donor cells by the host immune system post-transplantation is a primary concern.
- **Ethical concerns:** Use of embryos for creating human embryonic stem cell lines may lead to commoditization of human cells and tissues.
- **Limited technology:** To generate large quantities of stem cells. Also, therapies using these avenues are largely new and much more research and testing is needed.
- **Other Concerns:** Challenges related to gene editing/ modification, potential danger of tumorigenicity (it is the tendency for cultured cells to give rise to either benign or malignant growing tumors) of stem cells, possible risk of contamination and genomic changes etc.



Way Forward

- **Better regulation** for basic, clinical research and product development based on categories of research and level of manipulation.
- **Informed consent for trials:** Researchers should describe the risks and prospective benefits in a realistic and easily understandable manner with potential participants.
- **Scientific considerations:** Appropriate measures should be taken to ensure that the stem cell derived product is safe for human application.
- **Addressing ethical dilemma** by developing guidelines (like India's **National Guidelines for Stem Cell Research**) for various stakeholders that comprehensively addresses permissible and impermissible categories of stem cell research.

Status in India

- Stem cells and their derivatives **fall under definition of 'Drug' as per the Drugs and Cosmetics Act 1940 and** are categorized as 'Investigational New Drug (IND)' or 'Investigational New Entity (INE)' when used for clinical application.
- **Regulated by National Guidelines for Stem Cell Research- 2017:** As per these guidelines, **only bone marrow/hematopoietic SCT for blood disorders is permitted** and use of stem cells all other conditions has to be done only under purview of clinical trials in compliance with National Guidelines for Stem Cell Research 2017.
- Some hospitals providing SCT in India are **AIIMs, New Delhi, Tata Memorial Centre, Mumbai** etc.

2.1.4. THREE PARENT BABY

Why in news?

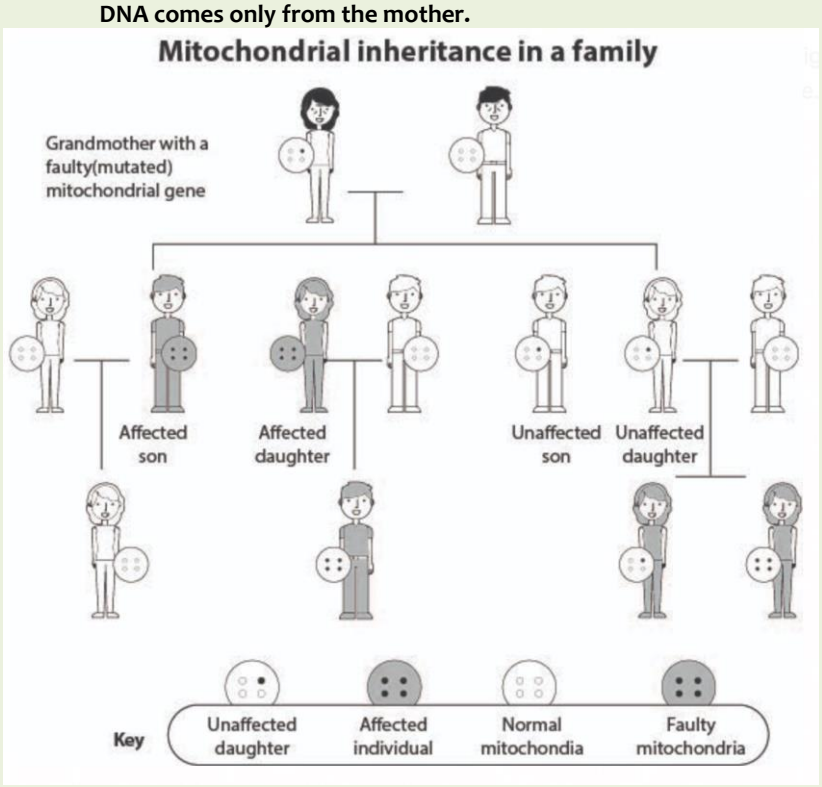
Recently, a baby has been born using three people's DNA in the UK with help of **Mitochondrial Donation Treatment (MDT) procedure.**

About Mitochondrial Donation Treatment (MDT)

- MDT is a technique in which a **child is conceived from IVF (in vitro fertilization)** using the **genetic material of the parents** and the **mitochondrial material of a donor**.
- It works on the **principle** in which the **diseased mitochondria are replaced by healthy mitochondria in order to avoid transfer of mitochondrial diseases** from the **mother to the offspring.**
  - **Passing on mitochondrial diseases** from parent to child can be **prevented by MDT either before or after IVF of the egg.**
- It is also known as **Mitochondrial Replacement Therapy (MRT)** and **Three-parent babies Process** (due to involvement of three persons).
- **Mechanism:**
  - **Embryos** combine sperm and egg from the **biological parents** with tiny battery-like structures called **mitochondria** from the donor's egg.
  - Resulting baby has **DNA** from the **mother** and **father** as usual, plus a **small amount of genetic material (about 37 genes) from the donor.**

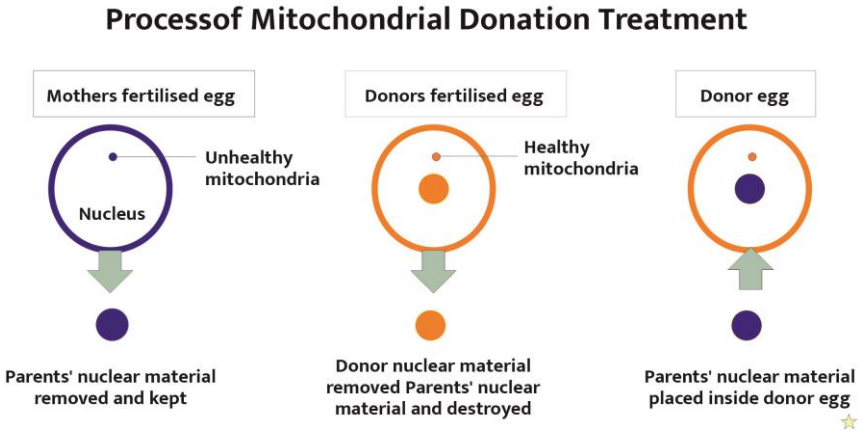
Mitochondria and Mitochondrial Diseases

- **Mitochondria** are basically the **powerhouses of the cells.** They **generate the energy**, and thus are also **responsible for cell function in the human body**.
- **Certain defects might occur** impacting on the way the mitochondria produce energy for the cells and thereby impacting cell function.
  - The **diseases that arise out of such mitochondrial mutations are called mitochondrial diseases**.
  - **When the mitochondria are impaired** and do not produce sufficient energy, that affects how the organs function, leading to a broad assortment of symptoms across the body, including **brain damage, organ failure and muscle wastage.**
  - Unlike nuclear DNA, which comes from both parents, **mitochondrial DNA comes only from the mother.**



Most common techniques in the mitochondrial donation

- There are two common techniques i.e**., MST and PNT.**
  - In both techniques, **eggs or embryos are created using nuclear genetic material** and **healthy donated mitochondria.**
  - In both MST and PNT, the **resulting embryos would contain parent's genetic material.** Both techniques work equally well.



Maternal Spindle Transfer (MST) Technique	Nuclear genetic material is removed from eggs and transferred into donated eggs which have had their nuclear genetic material removed. The eggs are then fertilised with sperm to create embryos.
Pronuclear Transfer (PNT) technique (substitute to MST)	Eggs are fertilised with sperm in a lab to create embryos. The nuclear genetic material within each embryo is then transferred into embryos created using donated eggs and sperm from the sperm provider. Again, the nuclear genetic material will have been removed from the donated eggs.

Benefits of Mitochondrial Donation Treatment (MDT)

- **Disease Prevention:** As there are no effective treatments for mitochondrial diseases that can cause severe health issues, MDT offers a chance for a healthier life for a baby.
  - About **one in 6,000 babies are affected** by mitochondrial disorder.
- **Genetic Connection:** MRT can assist older women with poor quality eggs to have a biologically related child by retaining the woman's nuclear DNA while using mitochondria from a younger donor.
- **Reproductive Freedom:** MRT can benefit same-sex female couples seeking a child genetically related to both, with one woman providing nuclear DNA and the other providing mitochondrial DNA.

Ethical concerns associated with MDTs

- **Potential for 'Designer Babies'**: As MDTs involve genetic modification, they could potentially open the door to the creation of "designer babies" - embryos genetically engineered for preferred characteristics.
  - This brings up a **multitude of ethical concerns related to eugenics and potential misuse of the technology.**
  - **Eugenics** refers to **the selection of desired heritable characteristics** in order to improve future generations, typically in reference to humans.
- **Issue of Mitochondrial Donor's role in child's life:** This creates ambiguity vis-à-vis donor's biological claim on the child or involvement in their life.

Issues with Mitochondrial Donation Treatment:

- **Effectiveness Concerns:** The dynamic nature of mitochondria and potential residual damaged mitochondria after transfer could compromise MRT's effectiveness and long-term benefits.
- **Incompatibility Risks:** Potential incompatibility between donor's mitochondria and receiver's nuclear genome could pose challenges.
- **Lack of Data:** MRT is in its experimental stages with inadequate data on potential adverse effects, making careful application critical.
- **Impact on Child:** There are concerns that MRT could influence a child's personality, including potential neurological changes, and pose risks such as developmental disability and increased cancer risk.
- **Cost Barriers:** MRT is a costly procedure, making it inaccessible to many sections of society.

Conclusion

If MDT technique is to be implemented in the country, there should be a regulatory body that **governs its usage to avoid any unethical practises**. Proper clinical trials are the need of the hour **for data to be collected on the safety and efficacy** of the technique being used.

2.1.5. GENOME SEQUENCING

Why in News?

Human genome project completed 20 years**.**

About Genome sequencing

- Genome sequencing means **deciphering the exact order of base pairs** in an individual.
- **A genome is an organism's complete set of DNA.** It includes all chromosomes, which houses DNA, and genes (specific sections of DNA).
- Human genome contains about 3 billion base pairs that spell out the **instructions for making and maintaining a human being.**

Significance of genome sequencing

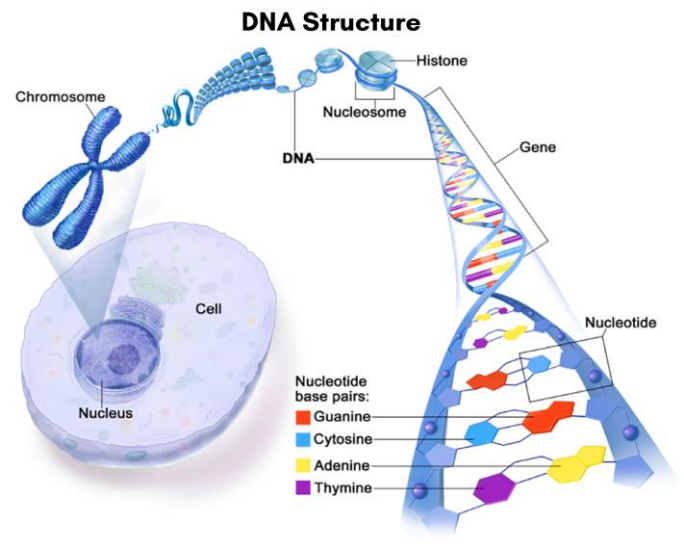
- **Understanding genetic diseases:** and in discovering the causes of rare disorders.

- **Prehistoric trail of Black death** (or the Great Plague) causing bacteria of the 14th century, **has been traced by scientists** using genome sequencing.

- **Agriculture:** To speed up the process of selecting desirable traits in plants and animals.
- **Food safety monitoring:** By whole genome sequencing of bacterial contaminants in food.
- **Human origins ancestry:** Allow us to compare genome sequences among humans, living and long-deceased, and to trace our collective ancestral history.
- **Pharmacogenomics:** Or tailoring a person's medications based on their genome, would be possible.
- **Others:** Genome editing, study of individual and communities of microbes, establishing more robust methods for DNA-based forensic analyses, understand how virus spreads and evolves etc.

Pan-genome

- It **represents the entire set of genes** within a species, consisting of **a core genome and the 'dispensable' genome.**
  - **Core genome** of a species consists of genes **shared by all strains.**
  - **Dispensable genome** is made up of genes **shared by some** but not all strains (accessory genes) and genes **present in only one strain** (unique genes).



Challenges in scaling up genome sequencing projects

- **Technological issues:** Like selection of analytical software tools, the speedup of the overall procedure using High-performance computing technology, data storage solutions.
- **Financial issues:** genetics projects are not as big a priority as national security and social welfare.
- **Privacy:** Information about health risks revealed by individuals' DNA might be abused.
- **Legal issues:** Anonymity of the data and questions of its possible use and misuse.

About Human Genome Project

- Carried out **from 1990–2003,** It was a **highly collaborative international effort** that **generated the first sequence of the human genome** and that of several additional well-studied organisms.
- In 2003, **Human Genome Project** produced a genome sequence that **accounted for over 90% of the human genome**.

Impact of the Human Genome Project

- **More information to functional part of DNA:** Besides those involved in making proteins, others assist in gene regulation, DNA replication, gene expression etc.
- **Identical genomes:** project showed that humans have 99.9% identical genomes, and it set the stage to understand the complex choreography involved in gene expression.
- **Discovery about number of protein-coding genes:** Predictions at the beginning ranged from 50,000 to 100,000. In fact, the figure is about 20,000.
- **Reduced cost of sequencing** a human genome.

Way ahead

While India, led by the CSIR, first sequenced an Indian genome in 2009, it is only now its laboratories have been able to scale up whole-genome sequencing and offer them to the public.

Continued studies of the ethical, legal, and social implications of genomic advances can help to break down barriers and yield a better appreciation of what truly is, and is not, in our DNA - and what that means to us, our families, and communities and society.

VARIOUS INITIATIVES TAKEN FOR GENOME SEQUENCING IN INDIA

IndiGen Programme

- To undertake whole **genome sequencing of a thousand Indian individuals** representing diverse ethnic groups from India.
- It is funded by **Council for scientific and Industrial Research.**

Genome India Project

- Aims to collect **10,000 genetic samples** from citizens across India, to build a reference genome.
- By **Department of Biotechnology**

2.1.6. GENOMIC SURVEILLANCE

Why in News?

With outbreaks of several pathogens and their variants, including COVID-19, monkeypox etc, in recent years, need to build a sustainable system for genomic surveillance is felt.

Genomic Surveillance in India

- **Indian SARS-CoV-2 Genomics Consortium (INSACOG)** was established to expand Whole Genome Sequencing of SARS-CoV-2 across the nation, aiding our understanding of how the virus spreads and evolves.
- **Regional Genome Sequencing Laboratories (RGSL)** serve as the regional hub laboratory for genome sequencing of the relevant region.
- **Indian Tuberculosis Genomic Surveillance Consortium (InTGS)** is proposed on lines of INSACOG.

About Genomic Surveillance

- Genomic surveillance is the process of **constantly monitoring pathogens and analyzing their genetic similarities and differences to identify variants of concern.**
- Genomic surveillance is **critical for stronger pandemic and epidemic preparedness** and response.
  - In the past, genomic surveillance systems have proven to be **instrumental in controlling polio in India and around the globe.**

Significance of Genomic Surveillance

- **To enhance pandemic preparedness:** It serves as an early warning system by integrating with other epidemiological and metadata to provide real-time, actionable insights.
- **To support vaccine development:** It helps to track and analyze circulating strains and informs vaccine development and redesign for emerging and existing infectious diseases.
- **To support diagnostics and therapeutics:** as smart surveillance can provide insights in real-time for development and calibration of diagnostics.

Challenges in Genomic Surveillance

- **Inequity among nations:** The complexities of genomics and the challenges of sustaining capacities in different settings, including workforce needs, means that most countries cannot develop these capabilities on their own.
- **Lack of integration:** Scale, geographic representativeness, timeliness, quality, comparability and integration of genomic surveillance outputs with epidemiological and clinical surveillance findings remain weak.
- **Technological challenges:** Key challenges include how to integrate genomic data with metadata from multiple sources and how to generate efficient computational algorithms to enable robust conclusions.
- **Newer variants of concern:** Upsurge in the newly emerging variants (like in COVID-19) make it difficult to understand nature and trends of the newer variants through existing genomic surveillance tools.

Way Forward

WHO released 10-year strategy for genomic surveillance of pathogens that includes:

- **Improving access to tools** for better geographic representation.
- **Strengthening the workforce** to deliver at speed, scale and quality.
- **Enhancing data sharing and utility** for streamlined local to global public health decision-making and action.
- **Maximizing connectivity** for timely value-add in the broader surveillance architecture.
- **Maintaining a readiness posture** for emergencies.

2.1.7. GENOME EDITING

GENE EDITING AT A GLANCE

- It is a way of **making specific changes to the DNA of a cell or organism.** This allows genetic material to be added, removed, or altered at particular locations in the genome.
- It is a **three-stage complex mechanism of unwinding, cleaving and rewinding of DNA** to bring desirable changes in the genome of any living beings.

HOW IT WORKS?

- It uses a **type of enzyme called an engineered nuclease'** which cuts the genome in a specific place.
- After cutting the DNA in a specific place, the **cell will naturally repair the cut.**
- This **repair process can be manipulated** to make changes (or 'edits') to the DNA in that location in the genome.
- **Various techniques of genome editing:** CRISPR-Cas9, ZFNs (zinc-finger nucleases), TALENS (Transcription activator-like effector nucleases).

CONCERNS REGARDING GENOME EDITING

- **Ethical Dilemma:** including eugenics helping the fittest to survive, religious debate, the possible rise of clones, designer babies, and possibly superhumans.
- **Safety concerns:** What if we manage to wipe out particular disease only to introduce a brand new and even more dangerous one.
- **Potential loss to diversity:** Genetically engineering species might have a detrimental effect on genetic diversity.

ADVANTAGES OF GENOME EDITING

- **For Research:** Can be used to change the DNA in cells or organisms to understand their biology and how they work.
- **Treatment of diseases:** It has been used to modify human blood cells that are then put back into the body to treat conditions including leukaemia and AIDS.
- **Biotechnology:** In agriculture to genetically modify crops to improve their yields and resistance to disease and drought, as well as to genetically modify cattle etc.
- **Therapeutic Cloning:** It is a process whereby embryonic cells are cloned to obtain biological organs for transplantation

WAY FORWARD

- **Altruistic Science:** Research must be designed to increase human health and wellbeing. Early stage and uncertain application should be avoided to minimize the risk.
- **Consensus-based application:** Human genome editing for reproductive purposes should not be attempted until safe and effective research confirms the same and a social consensus is reached.
- **Last Resort to treatment:** Human germline editing should be permitted only when there is no reasonable alternative for disease prevention.
- **The Drugs and Cosmetics Act, 1940** provides that all clinical trials in India should follow the guidelines prescribed in the Belmont report.

2.1.8. CRISPR-CAS 9

Why in the news?

It's been ten years since microbiologist Emmanuelle Charpentier and biochemist Jennifer Doudna published the research that paved the way for CRISPR-Cas9 gene editing.

What is Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR)?

CRISPR is a genetic code or sequence found in bacteria. These are formed due to the activity of the previous bacteriophages that had infected them.

- Bacteria use CRISPR sequence to remember each specific virus that attacks them. They do this by **incorporating the virus' DNA into their own bacterial genome.**
- This method then gives the bacteria protection or immunity when a specific virus tries to attack again.
- **Cas 9** are the genes that are always located nearby.
- Once activated, these genes make special enzymes that seem to have co-evolved with CRISPR. The significance of these **Cas enzymes is their ability to act as "molecular scissors" that can cut into DNA.**
- **Nobel Prize in Chemistry (2020)** was awarded to Emmanuelle Charpentier and Jennifer A. Doudna **for discovering CRISPR-Cas9 genetic scissors.**

How does CRISPR work?

These are the 3 key elements to CRISPR-Cas9 work:

- **Guide RNA:** A piece of RNA that locates the targeted gene. This is engineered in a lab.
- **CRISPR-associated protein 9 (Cas9):** The "scissors" that snip the undesired DNA out.
- **DNA**: The desired piece of DNA that is inserted after the break.

Conclusion

CRISPR is being used to develop new tools to characterize pathogenic agents, diagnose infectious disease, and develop vaccines and therapeutics to mitigate the effects of an outbreak.

If the benefits of CRISPR can be adequately balanced with the risks involved with its use, the biotechnology, public health, and medical communities **will make great strides in strengthening global health security.**

Scientific breakthroughs using CRISPR-Cas9

- **Cancer**: The first ever human trials of CRISPR in China focused **on treating a range of cancers.**
- **HIV**: Scientists from Kobe University in Japan used CRISPR to **block HIV from spreading inside** infected human cells.
- **Parkinson**: US-based biopharmaceutical company Seelos Therapeutics acquired the rights to SLS-004 gene editing therapy for Parkinson's disease.
- **Genetic manipulation**: In 2015, Chinese scientists created super muscular beagles by disabling the myostatin gene, which **directs normal muscle development**.

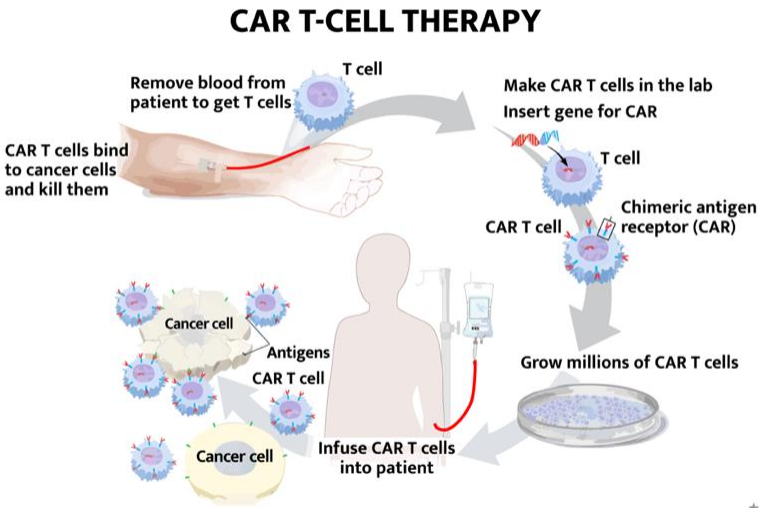
Advancement by India in CRISPR-Cas9 technology

- **Sickle Cell Anaemia**: Scientists at **Delhi's institute of genomics and integrated biology** are trying to find a solution to prevent genetically inherited sickle cell anaemia using the gene-editing tool**.**
- **Agri-food**: Using CRISPR CAS-9 researchers **at National agri-food biotechnology** edited the banana genome to improve its **nutritional quality and pathogen resistance.**
- **Minimize side-effects**: To overcome the **problems of 'off-targeting'**, research is being conducted for deploying naturally occurring bacteria **Francisella novicida instead of widely used streptococcus pyogenes Cas9.**
  - **Off-target effects** can be defined as unintended cleavage and mutations at untargeted genomic sites showing a similar but not an identical sequence compared to the target site.

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

Why in News?

CAR-T therapy, indigenously developed by IIT Bombay and Tata Memorial Centre, **was tested on patients in India for the first time.**



About CAR-T therapy

- CAR-T therapy is a **way to get immune cells called T cells** (a type of white blood cell that attacks foreign pathogens) **to fight cancer by editing them in the lab** so they can find and destroy cancer cells.
  - T cells are **taken from patient's blood** and are changed in lab by **adding a gene for a man-made receptor** (called CAR).

- This **helps them better identify specific cancer cell antigens.** CAR-T cells are then given back to the patient.

- **Benefits of CAR-T therapy**
  - While existing treatments work towards increasing the life of patients by a few years or months, **CAR-T technology holds promise of curing certain types of cancers.**
  - Unlike chemotherapy, CAR-T is **administered only once to a patient.**
  - **Short treatment time** needed and **more rapid recovery.**
- **Challenges:** severe life-threatening toxicities, modest anti-tumor activity, antigen escape, restricted trafficking, limited tumor infiltration etc.

Conclusion

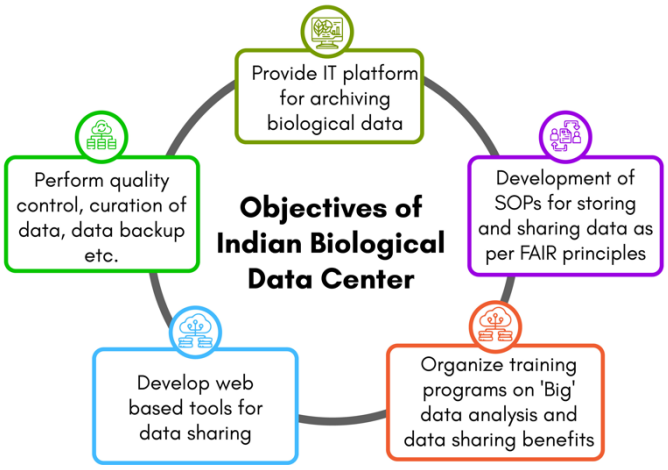
In order to overcome challenges associated with CAR-T therapy, innovative strategies and approaches to engineer more powerful CAR-T cells with improved anti-tumor activity and decreased toxicity are necessary.

2.1.10. INDIAN BIOLOGICAL DATA CENTER

Why in news?

Recently, **Indian Biological Data Center (IBDC) was inaugurated at Faridabad, Haryana.**

About IBDC



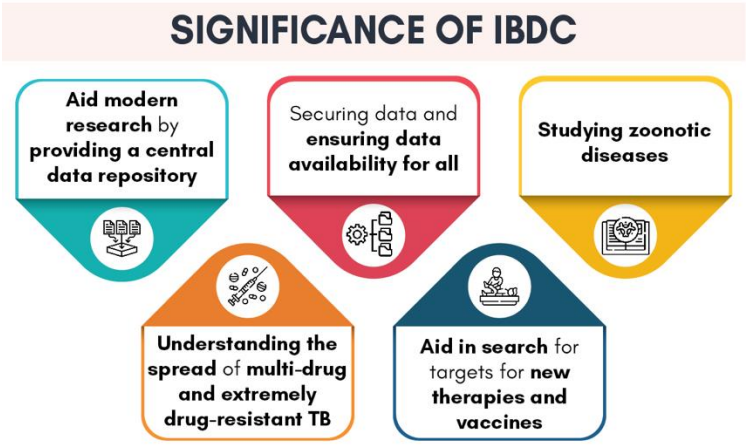
- IBDC is the **first national repository for life science data** in India.
- It is being established at **Regional Centre of Biotechnology (RCB), Faridabad** in collaboration with **National Informatics Centre** (NIC).
- It is supported by **Department of Biotechnology (DBT).**
- IBDC is committed to the **spirit of data sharing as per FAIR (Findable, Accessible, Interoperable and Reusable) principle.**
  - FAIR Data Principles, published in 2016, are **a set of guiding principles to support the reusability of digital assets.**
- The database also contains SARS-Cov-2 genomes sequenced by the **Indian Sars-CoV-2 Genomic Consortium (INSACOG).**
- Under IBDC, currently, **two sections have been developed.** These include:
  - **Indian Nucleotide Data Archive (INDA).**
  - **Indian Nucleotide Data Archive – Controlled Access (INDA-CA).**

What is biological data?

- Biological data means **all information related to living organisms**, including their nucleic acids, protein sequence, metabolites, and other molecular and functional characteristics.
  - Examples include, DNA sequence data, Genotype data, Epigenomic data, Duration of Data, etc.

Biotech PRIDE (Biotech Promotion of Research and Innovation through Data Exchange) Guidelines 2021

- Released by: **Department of Biotechnology (DBT)**
- These guidelines **enable exchange of information** to promote research and innovation in different research groups across the country.
- These Guidelines are **applicable for all biological data** generated through research conducted within the country.



Conclusion

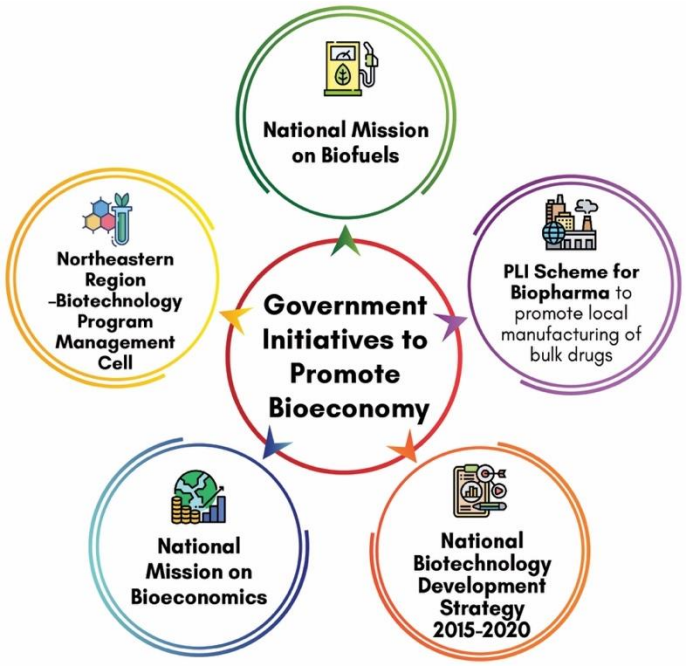
IBDC will a allow digitised repository where Indian researchers will store biological data from publicly funded research, reducing their dependency on American and European data banks.

It will not only provide a platform to researchers to securely store their data within the country, it will also provide access to a large database of indigenous sequences for analyses.

2.1.11. INDIA'S BIOECONOMY

Why in news?

Union Minister of State (Independent Charge) Science & Technology stated that India's bioeconomy is likely to touch 150 billion dollars by 2025 and over 300 billion dollars by 2030.



What is Bio-Economics?

According to FAO, bioeconomy is the production, utilization, conservation, and regeneration of **biological resources, including related knowledge, S&T, and innovation, to provide sustainable solutions**.

- **Food systems** occupy the largest niche in the bioeconomy which includes sustainable agriculture, sustainable fishing, forestry, and aquaculture.
- **Bio-based products** include **bioplastics, biodegradable clothing,** and other products with eco-design.
- **Bioenergy** improves the security of **energy supply and reduces energy** dependence like biomass.

Challenges associated

- **Food vs fuel:** A bioeconomy implemented on a large scale could create competition for limited agricultural land and water resources.
- **Higher cost:** as significant investment needed to transform production processes and products.
- **Intellectual Property Right regime:** There are two main areas of contention for the industry in India's approach to intellectual property in the biotech sector:
  - **Section 3(d) of the Patents (Amendment) Act, 2005**: It sets a higher standard for patentability than mandated by TRIPS (Trade Related Intellectual Property Rights). The industry argues that India's stricter standards for patents discourage innovation and dampen foreign investment.
  - **Compulsory licensing**: It gives the government power to suspend a patent in times of health emergencies. Although India has used this option only once, the industry feels that such regulations keep investors clear of Indian markets.

Way forward

- **Increased investment in research, innovation, and training** via promoting public-private partnerships.
- **Strengthening policy coordination and engagement**.
- **Development of specialized human resources**.
- **Swifter implementation of coordinated policies** for the regulation of the sector.
- **Improving markets and competitiveness** to make the different sectors of the bioeconomy more sustainable.

2.2. NANOTECHNOLOGY

NANOTECHNOLOGY AT A GLANCE

- It is the **study of materials which are in nanoscale range** (size scale range of 1 to 100nm).
- Conversion to nanoscale **results in alteration of its physicochemical, biological, mechanical, optical, electronic, etc. properties.**
- **India among top five nations** in terms of scientific publications in nanotechnology.

Applications of Nanotechnology

- **Energy storage, production, and conversion:** Carbon nanotubes, Nano catalysts for hydrogen generation etc.
- **Agricultural productivity enhancement:** Nanoporous zeolites, Fertilisers, herbicide delivery; Nanosensors for monitoring.
- **Water treatment and remediation:** Nanomembranes for water purification, Magnetic nanoparticles etc.
- **Drug delivery systems:** Nanocapsules for slow and sustained drug release systems.
- **Food processing and storage:** Nanocomposites for plastic film coatings used in food packaging, Antimicrobial nanoemulsions etc.
- **Vector and pest detection and control:** Nanoparticles for new pesticides, insecticides, and insect repellents.

Challenges related to Nanotechnology

- **Impact on Health:** Nanoparticles might be able to disrupt cellular, enzymatic and other organ related functions.
- **Environmental concern:** nanoparticles might form a new class of non-biodegradable pollutants.
- **Lack of information** on the nature and characteristics of nanomaterials, insufficient methods for detecting and measuring nanomaterials etc.
- **Scarcity of skilled manpower** as it is highly specialized field.
- **Ethical consequences:** For instance, nanotechnology may be used in warfare, may invade people's privacy etc.
- **High costs for acquisitions of IPR,** nanotechnology infrastructure etc.

Initiatives taken in India

- **9th Five-Year Plan first time promoted research** in nano materials.
- In 2007 **Mission on Nano Science and Technology** (Nano Mission) was launched.

  Nanoelectronics Centres of international standards have been established at premier institutes.
- **Nanoelectronics Innovation Council** set up by MeitY.
- **Indian Nanoelectronics Users Programme** by MeitY for undertaking research and skill development.
- **National Task Force for regulatory framework roadmap.**

Way Forward

- **Enacting new regulations** for responsible nanotechnology governance.
- **Establishing a regulatory body** to foresee the safe development and commercialisation of products.
- **Labelling of nano-based products** to enable people make an informed choice.
- **Infrastructure development** for basic research and **human resource development.**
- **Coordination with various international/ inter-governmental organizations** for development of standards, safe lab practices and risk governance.

2.2.1. NANO-FERTILIZERS

Why in News?

Nano-fertilizers for sustainable crop production and maintaining soil health report released.

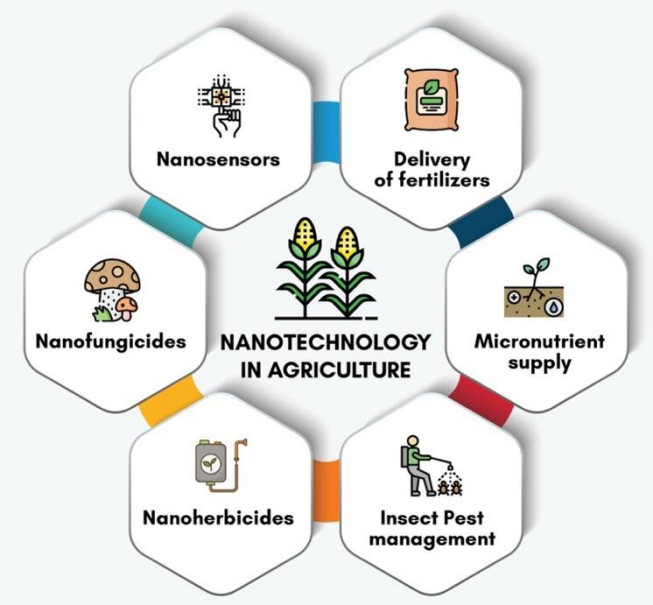
More on News

- Report by a parliamentary Standing Committee **highlighted benefits of using Nano-fertilisers** and suggested **ways to increase its use.**

- **Earlier, IFFCO developed Nano urea and Nano DAP**, nanotechnology-based fertilisers.
- IFFCO has **also developed nano fertilizer macronutrient grades** - Nano Nitrogen and **secondary /micronutrient grades** - Nano Zinc, Nano Copper, Nano Boron, Nano Sulphur, etc.

Benefits of Nano-fertilisers

- **Price Advantage**: Lower input cost for the farmers.
- **Higher efficiency**: For e.g., Nano Urea has 85-90% efficiency compared to about 25% of conventional urea.
- **Ensure better crop productivity** (average 8 % higher crop yield was achieved).
- **Significant reduction** in **urea imports,** government **subsidies and logistics and warehousing** cost.
- **Improved agriculture sustainability** through higher nutrient uptake, lower water consumption and reduction in environmental losses.



Way Forward

Recommendations in report

- **Nano-fertilisers** should be manufactured **by both public and private sector** companies.
- **Bring production** of nano-fertilizers **under production linked incentive (PLI) scheme.**
- **Establish long term agreements and set-up joint venture plants** in countries rich in fertilizers' raw materials.

2.2.2. NANOTECHNOLOGY IN HEALTH

NANOTECHNOLOGY IN HEALTH

Benefits of Nanotechnology in Health

- **Clinical investigation:** Gold nanoparticles are used for the detection of targeted sequences of nucleic acids, as potential treatments for cancer and other diseases.
- **Better imaging tools** for earlier diagnosis, more individualized treatment options, and better therapeutic success.
- **Drug delivery:** Nanotech materials can contain hydrophobic and hydrophilic drugs, protect drugs from chemical and enzymatic degradation etc.
- **Gene sequencing technologies** through design and engineering of advanced solid-state nanopore materials.
- **In treatment of Cardiovascular, Ocular Diseases** because of their small size and highly variable surface properties

Challenges

- **Triggered unwanted allergic and other reactions** that can be potentially harmful to the body.
- **Nanomaterials may help create 'free radicals'** which can cause cell damage and damage to the DNA.
- **Might alter the particles' toxicity** and consequently harm human cells as Nanoparticles might have reactive surfaces.
- **Other limitations:** high cost, controlling their activity in sensitive environments, their environmental impacts, etc.

Conclusion

Nanotechnology will provide **promising therapies** to cope with various severe diseases, and will also provide tools to solve the various bottlenecks in healthcare sectors.
However, different **nanomedicines and nanoformulations** targeting various diseases must be meticulously designed in order to achieve the safest and most efficacious therapeutic regimen.

2.2.3. NANOTECHNOLOGY IN ENVIRONMENT

NANOTECHNOLOGY IN ENVIRONMENT

Benefits of Nanotechnology in Environment

- **Air and soil treatment:** Nanotechnology-enabled sensors and solutions are now able to detect and identify chemical or biological agents in the air and soil with much higher sensitivity.
- **Water treatment:** nanomembranes for separation to enable greater water purification and desalinization, detecting chemical and biological contamination etc.
- **Oil spills:** Researchers have also placed magnetic water-repellent nanoparticles in oil spills and used magnets to mechanically remove the oil from the water.
- **Pollution prevention:** Titanate nanofibers act as good absorbents to remove radioactive ions and radioactive waste.
- **Emissions:** addition of nanoparticles to fuel can improve fuel efficiency, reducing the rate of greenhouse gas production

Challenges

- Nanomaterials have the **potential to form new toxic products** in the environment.
- **Nanoparticles might increase cytotoxicity and oxidative stress** in marine microalgae and organisms.
- Accumulation of nanoparticles in the soil **may reduce the rate of photosynthesis and transpiration** of plants.
- Nanomaterials reaching in the land have the potential to **contaminate soil and migrate into surface and ground waters.**

Conclusion

Nanotech offers an enormous opportunity for environmental technologies including in **sensing and monitoring, selective adsorption, and nanomembranes.**
However, there is a need to balance the needs of the environment and the activity, selectivity, and stability of the nanotechnologies

2.3. INTELLECTUAL PROPERTY RIGHTS

INTELLECTUAL PROPERTY RIGHTS AT A GLANCE

- **42nd rank** amongst 55 countries **in latest International Intellectual Property Index.**
- **More than 50% increase in patent filing** from 2014-15 to 2021-22.
- **Reduction in Time of patent examination** from 72 months in Dec 2016 **to 5-23 months at present.**

Need for IPRs

- **Attracts FDI and boosts research and development** as well as innovation, thus improving ease of doing business
- **Forbid the competitors or anybody for exploiting or misuse the property** without the permission of the creator.
- Get value for **IPRs through commercialization and balance the interests** of rights owners with larger public interest.
- To **strengthen the enforcement and adjudicatory mechanisms** for combating IPR infringements.
- To **strengthen and expand human resources, institutions and capacities** for teaching, training, research and skill building in IPRs.

Measures taken to improve IPRs

- **National IPR policy 2016.**
- **Cell for IPR Promotion and Management (CIPAM)** under DPIIT for implementation of the National IPR Policy.
- **Traditional Knowledge Digital Library (TKDL):** to protect Indian traditional medicinal knowledge and prevent its misappropriation at International Patent Offices.
- **India's Patents Act of 1970, 2003 Patent Rules and the 2016 Patent Amendment Rules** set out the law concerning patents.
- **National Intellectual Property Awareness Mission (NIPAM)** to impart IP awareness and basic training.
- India becoming **recognised member of International Search Authority and International Preliminary Examining Authority.**

Challenges

- **Enforcement of the Copyright act is weak,** and piracy of copyrighted materials is widespread.
- **Traditional knowledge,** especially in the field of medicine, **have been kept out** the reach of patents due to lack of awareness and non-synchronization of laws
- **IPR lacks its roots in remote areas,** such areas are considered hot bed of inventions.
- **Product patent can lead to monopoly.** India being a party to TRIPS has to shift from process to product patent, however, it has a huge bearing on poor strata of society
- **TRIPS flexibilities and their application** such as evergreening of patents, Compulsory Licensing and Data Exclusivity.
- **Delays in granting patent** due to lack of manpower.
- **Fluctuation in IPR policies** making entrepreneurship a riskier affair.

Way Forward

- Strengthening the **institutional as well as infrastructural framework** for better enforcement.
- Encouraging **IPR awareness in Tribal areas and hinterland** through initiatives like TKDL.
- **IPR Facilitation Centers should be established** in the country with a focus on enhancing the awareness of MSMEs, small businessmen and traders.
- **Regular engagement at global level through diplomatic channels** to balance domestic needs and TRIPS compliance.
- Promoting an **environment of innovations in academic curriculum.**
- **Bridge gap between innovation, economic activity and IPR** for employment generation and encourage foreign exchange inflow.

3. AWARENESS IN THE FIELD OF SPACE

3.1. PRIVATE SECTOR IN SPACE

PRIVATE SECTOR IN SPACE AT A GLANCE

- Indian space sector has the **potential to capture 9% of global market** share **by 2030** (from around 2% at present).
- Recently, **Vikram-S, India's first privately built rocket** was launched under **Mission Prarambh.**
- **Enhanced private sector participation will be necessary to penetrate** satellite-based services and ground-based system segments.

Significance of Private Participation in Space

- **Allows ISRO to concentrate on cutting-edge research and development,** exploration missions and human spaceflight programme.
- **Enable shift from supply driven model to demand driven model:** Almost every sector now wants satellite data and space technology.
- **Rapidly rising space industry:** Indian space sector is projected to increase at a ~ 48% CAGR over the next five years to reach US$ 50 billion.
- **Enhance share in global space economy:** Currently, India accounts for **only about two per cent of the space economy.**
- **Innovation and Indigenisation:** Focus on **public-private partnerships, technology transfer** enables sharing of resources, knowledge, and expertise between the public and private sectors.
- **Promote Make in India:** With active private participation, India can aspire to become a satellite manufacturing hub and a launchpad for the world.

Challenges for Private Sector participation

- **Multiplicity of regulations:** For example, approvals needed from Department of Space, ISRO, Antrix etc.
- **Increase in space debris** with growing space economy: Presently, there are around 23,000 pieces of debris larger than 10 cm.
- **Security and strategic concern:** Private sector in this arena can compromise security by possible leak of confidential information.
- **Absence of independent regulator:** Conflict of interest may arise as ISRO is both a regulator and an operator.
- **Issue of liability of private entities:** Multilateral treaties of international law, are outdated and do not correspond well with contemporary reality.

Steps taken for private sector participation

- **In 2020,** government **approved private sector participation** in Space activities.
- Mechanism for **industries to approach** newly created **Indian National Space Promotion and Authorization Centre (IN-SPACe)** for utilizing the ISRO facilities.
- **ISRO and IN-SPACE helped Agnikul** (a startup) in designing **India's first private launch pad.**
- **ISRO completed third batch of UNispace Nanosatellite Assembly & Training (UNNATI)** where over 30 personnel from 19 countries participated.
- **Other measures** include setting up of New Space India Limited **(NSIL),** launch of Indian Space Association **(ISpA)** etc.

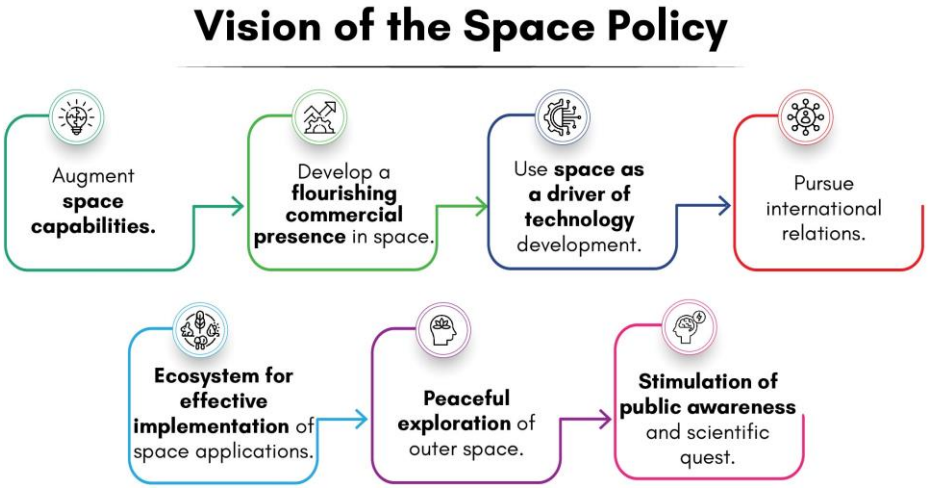
Way forward

- **Regulatory clarity:** to remove barriers for private firms and better synergies with ISRO.
- **Intellectual Property (IP) protections:** Private sector remains concerned about sharing its IP with the government.
- **Promoting satellite manufacturing:** Indian Space Association (ISpA) seeks a PLI scheme for satellite manufacturing.
- **Handhold private sector:** ISRO can act as an enabler by technology transfer, collaborations, and sharing of infrastructure that shall help achieve wider participation from the industry.

3.1.1. INDIAN SPACE POLICY – 2023

Why in news?

Recently, Indian Space Policy-2023 was approved by the Government.



More on News

- The Space policy underlines the **growing importance of Private Sector participation in Space.**
- Government of India had started **reforms in space domain in 2020,** opening the doors for **enhanced participation of Non-Government Entities (NGEs)** with an aim to provide them a **level playing field.**
- Subsequently, Government sought to provide **regulatory certainty to space activities** by various stakeholders.
- Indian Space Policy – 2023 has thus been formulated as an **overarching, composite and dynamic framework to implement this reform vision.**
- It is a **first-ever comprehensive space policy**:
  - **Outlining direction** of India's space program.
  - **Delineating specific roles** for major stakeholders.
  - **Expanding india's participation** in global space arena.
  - **Facilitating technology transfer** and **fostering innovation** through Public-private partnerships.

Strategy outlined in the policy

Stakeholder	Role
Government	• Encouraging advanced **Research & Development** and support to **start-ups.** • Stable and **predictable regulatory framework** to provide a level playing field to NGEs through IN-SPACe. • Using **space as a driver for overall technology development.**

Non-Governmental Entities (NGEs)	• Offer national and international **space-based communication services.**
	• Establish and **operate**
	  ○ **Ground facilities for space objects** operations, e.g. Satellite Control Centres (SCCs).
	  ○ Remote sensing satellite systems.
	• **Commercialise technologies** for enhancing and augmenting the satellite navigation, communication and remote-sensing.
	• Engage in the **commercial recovery of an asteroid resource** or a space resource.

Department of Space (DOS)	• **Nodal department** for implementation of the Indian Space Policy-2023. • Ensure **availability of continuous & improved earth observation capability** and data to fulfil the national requirements. • **Participate in international efforts** by providing critical remote sensing satellite data for disaster management, for sustainable development goals etc. • Establish **framework to ensure safe and sustainable space operations,** in compliance with relevant international space debris mitigation guidelines.

Indian Space Research Organization	• **Role under policy**
	  ○ Focus **primarily on research and development** of new space technologies and applications.
	  ○ **Share technologies, products, processes** and best practices with NGEs
	  ○ Enable **open data access** from remote sensing satellites of ISRO.
	  ○ **Demonstrate human spaceflight capability** and develop a long term road-map for sustained human presence in space.

IN-SPACe-Indian National Space	• Act as the **single window agency** for the authorisation of space activities by govt entities and NGEs. • Work with industry to **establish India as a preferred service** provider at global level.

Promotion & Authorisation Centre	• Ensure a **level playing field for the utilization of all facilities** created using public expenditure. Decisions of INSPACe shall be binding on the operators of such facilities. • **Facilitate the transfer of technologies** developed by ISRO. • Prescribe **guidelines regarding liability of potential damages** due to the space activities.
New Space India Limited (NSIL)	• Responsible for **commercialising space technologies and platforms** created through public expenditure. • The operational part of ISRO's missions will be moved to the NSIL. • **Service the space-based needs** of users.

Conclusion

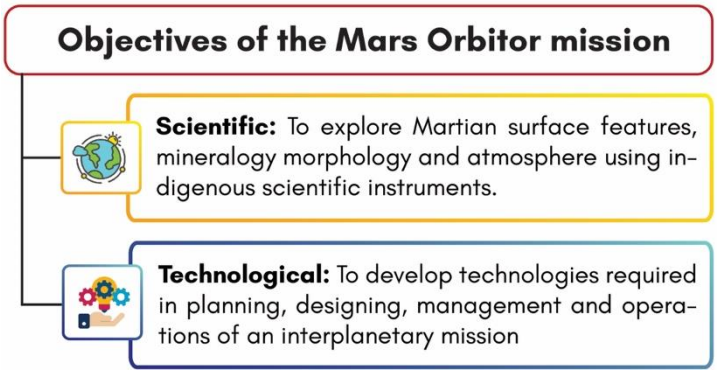
Policy is a **much anticipated step in envisioning** the space sector as a **market and positioning firms and start-ups within it as key players.**

By **playing a strong advisory and consulting role** to the private sector, **ISRO can bank on its legacy of successful space missions** and help firms learn from its failures.

3.2. MARS ORBITER MISSION

Why in news?

India's Mars Orbiter Mission (MOM) spacecraft has lost communication with the ground stations, bringing an end to its life after eight long years.

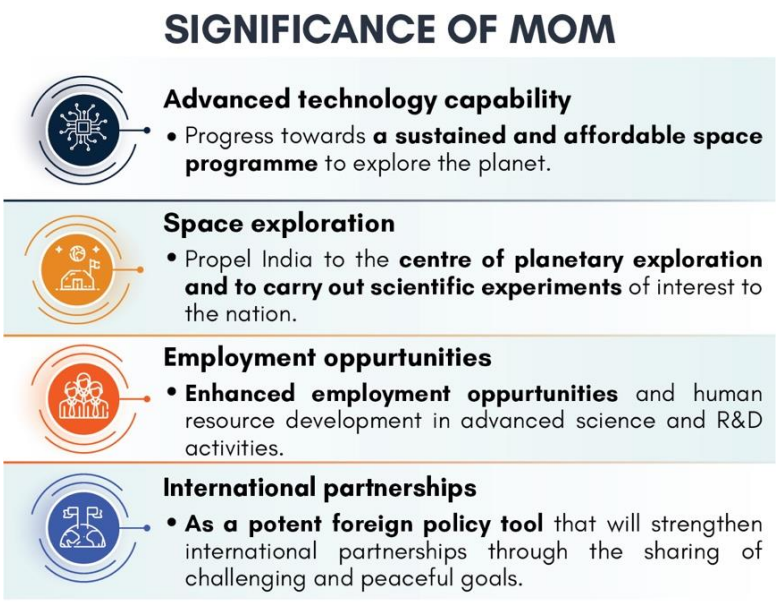


Significance of Mars

- **Search for life:** Evidence suggests that Mars was once full of water, warmer and had a thicker atmosphere, offering a potentially habitable environment.
- **Possible planet that humans can visit or inhabit in long term:** Venus and Mercury have extreme hot temperatures. All planets in outer solar system starting with Jupiter are made of gas and are very cold.

About Mars Orbiter Mission (MOM) or Mangalyaan

- The Rs 450 crore Mission **was launched onboard PSLV-C25** on November 5, 2013.
  - MOM spacecraft was **successfully inserted into Martian orbit** on September 24, 2014, in its first attempt.
  - Mangalyaan was India's **first interplanetary mission.**
- The **mission made India the first Asian country, and the fourth in the world** after Roscosmos (Russia), NASA (US), and the European Space Agency (EU), to get to the planet.
- **Five Payloads of MOM are:** Mars Color Camera, Thermal Infrared Imaging Spectrometer, Methane Sensor for Mars, Mars Exospheric Neutral Composition Analyser, Lyman Alpha Photometer.
- **Recognition:** MOM team won the US based National Space Society's 'Space Pioneer Award', Indira Gandhi Prize for Peace, Disarmament and Development.



Technological Achievements of MOM

- **Understanding of the composition of several gases in the Martian exosphere,** quantified the altitude where the Martian atmosphere has a transition from the CO_2 rich regime to atomic Oxygen-rich regime during the local evening.

- **Discovery of 'suprathermal' Argon-40 atoms in the Martian exosphere,** giving clue on one of the potential mechanisms for the escape of atmosphere from Mars.
- MOM **spacecraft photographed**, for the first time, the **far side of Deimos, one of the natural satellites of Mars.**
- The mission **captured the time-variation of the Martian polar ice caps.**
  - It also measured the Martian apparent albedo that indicated the reflecting power of the Martian surface.
- The mission gave an opportunity to **classify extra-terrestrial landslides using machine learning models.**

Conclusion

The configuration and design of MOM spacecraft have worked perfectly well throughout all the phases of the mission. The excellent working of all the systems of the spacecraft has established the deep space mission heritage. The configuration and design of these systems can also be adopted future interplanetary missions of ISRO.

3.3. OTHER DEVELOPMENTS RELATED TO ISRO

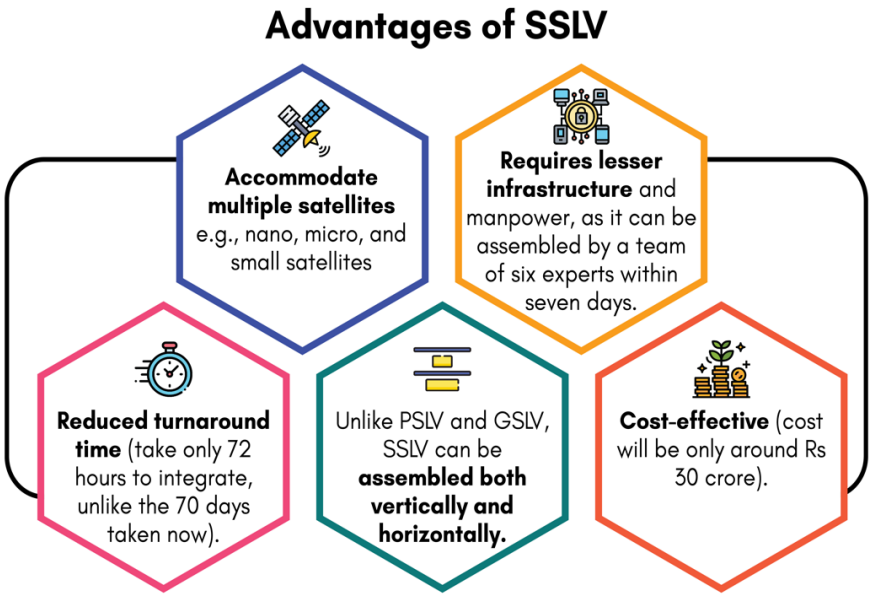
3.3.1. SMALL SATELLITE LAUNCH VEHICLE (SSLV)

Why in News?

Second developmental flight of SSLV — SSLV-D2 — **placed three satellites** in its precise orbit.

About SSLV

- It is a **three-stage all solid vehicle** with the capability to launch up to 500 kg satellite mass into 500 km low earth orbit (LEO).
- It aims to **cater to the emerging market for the launch of small satellites** into LEOs.
- It is the **smallest vehicle** at **110-ton mass at ISRO.**



Other Launch Vehicles of ISRO		
Launch Vehicle	**Stages**	**Payload capacity and Orbits**
Polar Satellite Launch Vehicle (PSLV)	**Four-stage launch vehicle** (1st & 3rd stage: Solid; 2nd & 4th: Liquid)	Up to 1,750 kg to **Sun-Synchronous Polar Orbits,** 1,425 kg into **Geosynchronous and Geostationary orbits**
Geosynchronous Satellite Launch Vehicle (GSLV) Mark II	**Three-stage launch vehicle** (1st: Solid, 2nd: Liquid; 3rd: Cryogenic Upper Stage)	Up to 2,250 Kg into **Geosynchronous Transfer Orbits,** up to 6 tonne in **Low Earth Orbits**
Geosynchronous Satellite Launch Vehicle Mk-III (LVM3)	**Three-stage launch vehicle** (1st: Liquid, 2nd: Solid; 3rd: Cryogenic Upper Stage)	Up to 4 tonne into **Geosynchronous Transfer Orbits,** 8 tonne into **Low Earth Orbits**

3.3.2. PSLV ORBITAL EXPERIMENTAL MODULE-2 (POEM-2)

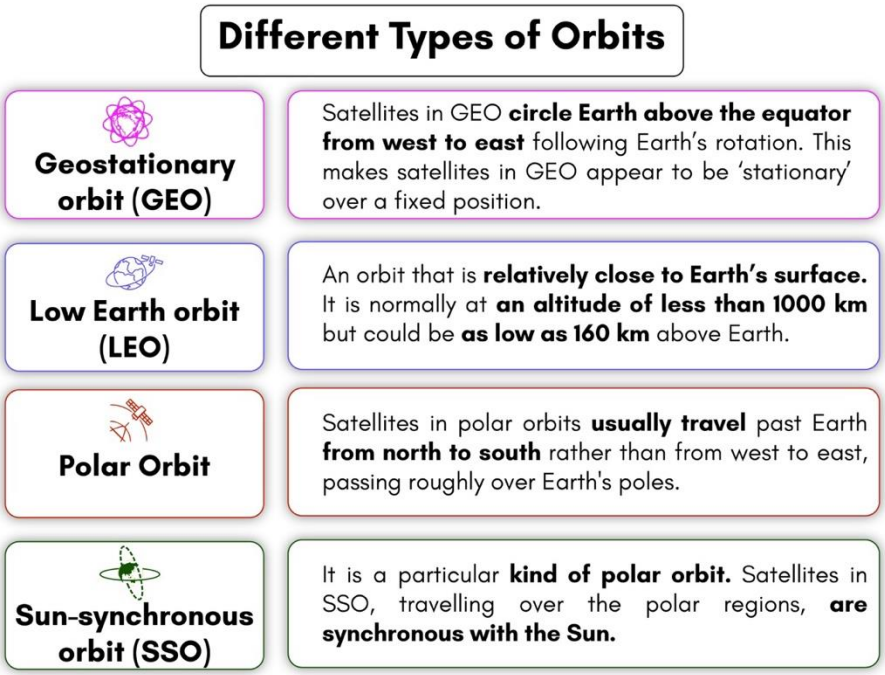
Why in News?

ISRO carried out scientific **experiment using POEM-2 in PSLV-C55 mission.**

About POEM-2

- PSLV-C55 is a **dedicated mission of NewSpace India Limited** (NSIL), for the international satellite customer from Singapore.

- **Mission**, for the first time, **will see solar panels powering PSLV's fourth (final) stage** for conducting month-long experiments.
    - **Usually, fourth and final stage of a rocket** remains in space for only a couple of days before **dropping back into the atmosphere and burning up.**
- **However, PSLV includes PSLV Orbital Experimental Module-2 (POEM-2)** platform **to perform in-orbit experiments** using the **final stage of PSLV**.
    - POEM has a **dedicated Navigation Guidance and Control** system which **acts as platform's brain** to stabilize it with specified accuracy.
    - POEM will derive its **power from mounted solar panels and a Li-Ion battery.**



3.3.3. REUSABLE LAUNCH VEHICLE AUTONOMOUS LANDING MISSION (RLV LEX)

Why in News?

ISRO successfully conducted the Reusable Launch Vehicle Autonomous Landing Mission (RLV LEX).

About Reusable Launch Vehicle Autonomous Landing Mission (RLV LEX)

- RLV LEX test was the **second of five tests** that are a part of ISRO's efforts to develop RLVs or space planes/shuttles under the **Reusable Launch Vehicle Technology Demonstrator (RLV-TD) Programme.**
    - RLV is essentially **a space plane with a low lift to drag ratio** and **can travel to low earth orbits to deliver payloads** and return to earth for use again.
    - This vehicle will be scaled up to become the **first stage** of **India's reusable two-stage orbital (TSTO) launch vehicle.**
- RLV-TD Programme aims at **developing essential technologies** for a **fully reusable launch vehicle** to enable low-cost access to space.
    - It includes technologies like **hypersonic flight (HEX), autonomous landing (LEX), return flight experiment (REX), powered cruise flight**, and **Scramjet Propulsion Experiment (SPEX).**
    - **NASA is using RLV for long time** and private space agencies such as Space X is demonstrating partially reusable launch systems.
- **Advantages**: RLV is considered a **low-cost, reliable**, and **on-demand mode of accessing space.**
- **Challenges: Selection of materials like** special alloys, composites, and insulation materials and the crafting of its parts is very **complex** and demands **highly skilled manpower.**

3.3.4. NAVIC (NAVIGATION WITH INDIAN CONSTELLATION)

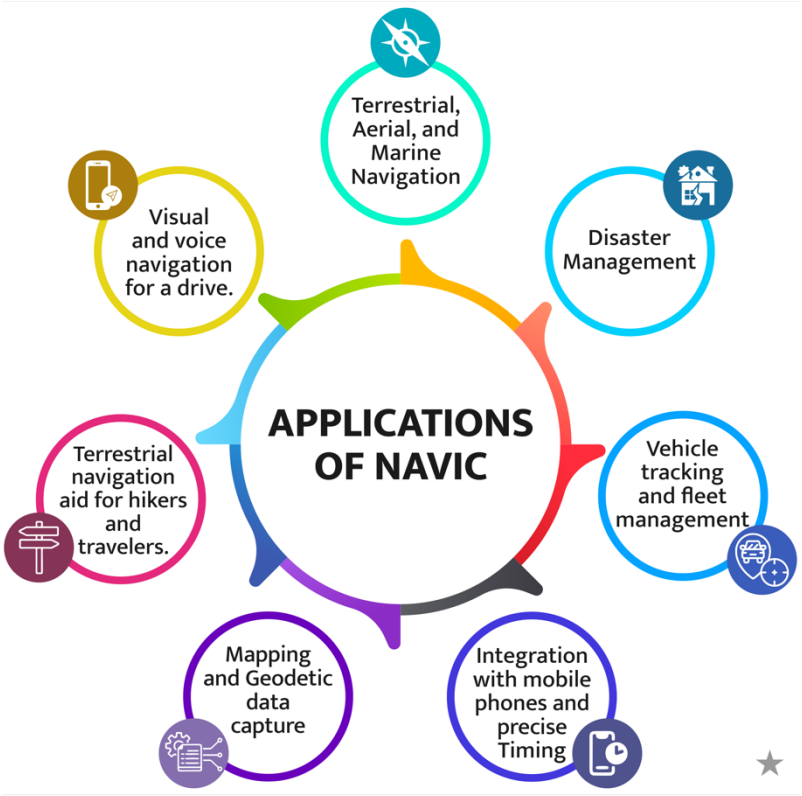
Why in News?

Indian Space Research Organisation (ISRO) **launched next-generation navigational satellite NVS – 01.**

About NavIC

- It is an **independent stand-alone navigation satellite system** developed by the **Indian Space Research Organisation (ISRO).**
    - NVS-01 is **first of the India's second-generation satellites envisaged for NavIC (Navigation by Indian Constellation) services.**

- NavIC **consists of 7 satellites** and covers the whole of India's landmass and **up to 1,500 km** from its boundaries.
- NavIC, **earlier known as Indian Regional Navigation Satellite System (IRNSS),** is designed with **constellation of seven satellites**.
- It **consists of 7 satellites** and covers the whole of India's landmass and **up to 1,500 km** from its boundaries.
    - **Three satellites** are **placed in geostationary orbit** and **four satellites** are placed in **inclined geosynchronous orbit.**
    - **NavIC offers two services** - Standard Position Service (SPS) for civilian users and Restricted Service (RS) for strategic users. These two services are provided in **both L5 (1176.45 MHz) and S band (2498.028 MHz).**



Conclusion

With the successful launch of the NVS-01 satellite and ongoing advancements in India's space sector, the **country's position as a pioneer is further strengthened.**

With further developments and improvements, NavIC is poised to **revolutionize navigation and positioning services in India** and the Indian subcontinent, opening up **new opportunities for scientific research and societal benefits.**

3.3.5. DEVELOPMENTAL ROLE OF ISRO

Developmental Role of ISRO

Food security and Agriculture	• ISRO technology is being **used to carry out crop production forecasts** for major crops and to **improve crop condition and productivity** by using remote sensing satellites data • **FASAL project** (Forecasting Agricultural Output using Space, Afro-Meteorology and Land-based Observation) helps **in agriculture operations.**
Rural Development	• ISRO has launched **Village Resource Centres** (VRCs) to provide space-based services directly to rural areas like **Telemedicine, Tele-education, Panchayat planning,** marketing information etc.
Urban Development	• High resolution satellite data provides **accurate information on current land use practices** in a city or town.
Clean Water	• ISRO is actively involved in several projects **to make inventory and monitoring of the water resources** in the country. • **Satellite with ARGOS and ALTIKA (SARAL)** was launched **monitoring of ocean and continental water surface.**
Resource Management	• ISRO through **Earth Observatory satellites** provides for effective **management of natural resources.**
Fisheries	• **Bulletins on Prospective Fishing Zones,** put out **by the Indian National Coastal Information System** (INCOS), which harnesses space technology **to identify fish-rich zones.**
In Railways	• Applications of space technology are realised in **guarding unmanned railway crossings, detecting obstructive objects on rail tracks** to avoid train accidents etc.
Weather Forecasting	• Given the **impetus provided by INSAT and earth observation satellites,** IMD has **refined its monsoon forecast and daily weather bulletins** to a high degree of accuracy.
Disaster Management	• Using geoportals like **Bhuvan to address various aspects of natural disasters,** using space-based inputs.
Education	• EDUSAT **provided connectivity to schools, colleges and higher levels of education** and also supported non-formal education including development communication.
Navigation	• **NavIC is an independent regional navigation satellite system** developed and maintained by India. Applications include in maritime field, mobile phones, Defence etc.
Infrastructure development	• ISRO is contributing by **offering Satellite Imaging and other Space Technology applications** for better accomplishment of infrastructural projects.

3.4. NASA-ISRO SYNTHETIC APERTURE RADAR (NISAR) SATELLITE

Why in News?

Recently, Indian Space Research Organisation (ISRO) has received the NASA-ISRO SAR (NISAR) satellite from the U.S. space agency.

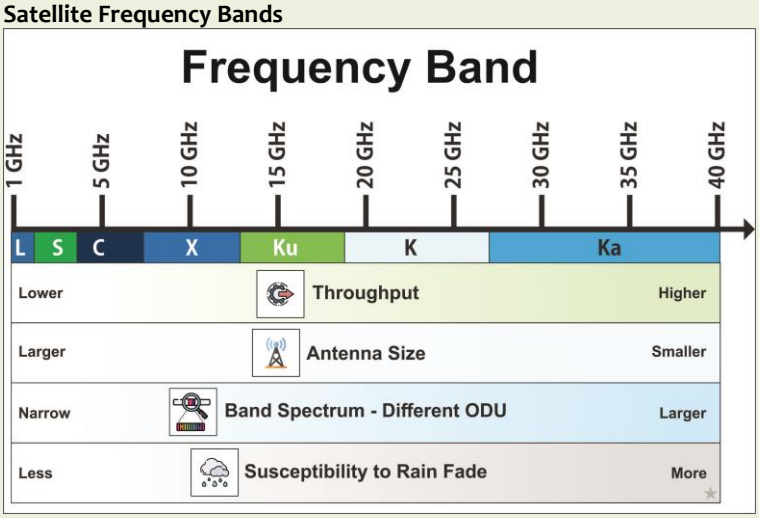
About NISAR Satellite

- NASA-ISRO SAR (NISAR) is a **Low Earth Orbit (LEO) observatory** being jointly developed by NASA and ISRO.
- NISAR **will map the entire globe in 12 days** and provide spatially and temporally consistent data for understanding changes in Earth's ecosystems, ice mass, etc.
- The 2,800 kilograms satellite **consists of both L-band and S-band synthetic aperture radar (SAR)** instruments, which makes it a dual-frequency imaging radar satellite.
    - The **SAR payloads** mounted on Integrated Radar Instrument Structure (IRIS) and the spacecraft bus are together called an observatory.

- **NASA is to provide the L-band radar**, GPS, a high-capacity solid-state recorder to store data, and a payload data subsystem.
- **ISRO is to provide the S-band radar**, the GSLV launch system and spacecraft for the mission.

- NISAR is expected to be launched in **January 2024 from Satish Dhawan Space Centre into a near-polar orbit**.
  - After the commissioning period, the mission will conduct science operations with the L-band radar to satisfy NASA's requirements for **minimum of three years**, while the **S-band radar will be used by India for its specific needs for a period of five years.**
- Synthetic Aperture Radar used **can penetrate clouds and darkness and enable the NISAR to collect accurate data at any weather** and provide high-resolution images.
  - **Usage of two microwave bandwidth regions** (L-band and S-band), enables it to **measure changes in earth surface less than a centimeter across.**
- NISAR will acquire data over the Indian Coasts and monitor annual changes in the bathymetry along the deltaic regions. It will also **observe sea ice characteristics over the seas surrounding India's Antarctic polar stations.**

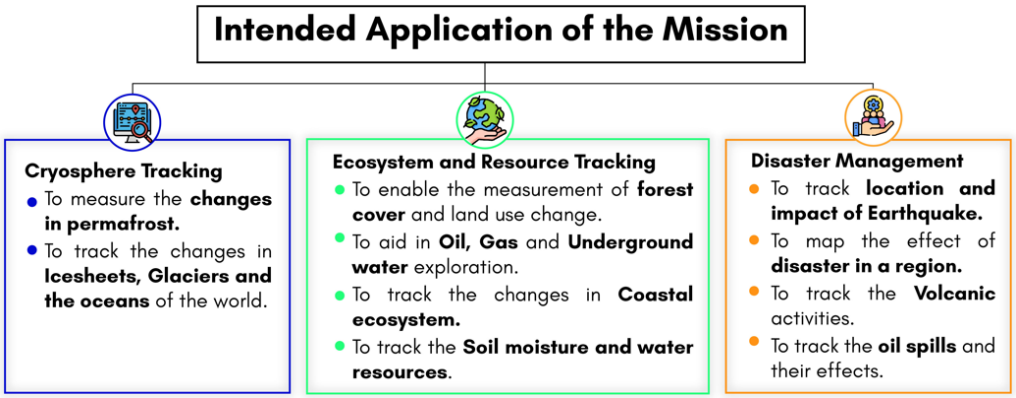
Satellite Frequency Bands



- **L band radars** operate on a wavelength of 15-30 cm and a frequency of 1-2 GHz. L band radars are **mostly used for clear air turbulence studies.**
- **S band radars** operate on a wavelength of 8-15 cm and a frequency of 2-4 GHz.
  - Because of the wavelength and frequency, S band radars are not easily attenuated.
  - This makes them **useful for near and far range weather observation.**
  - The drawback to this **band of radar is that it requires a large antenna dish** and a large motor to power it.

Conclusion

NISAR is a **major milestone in strengthening US-India ties** in space collaboration. It will help in **creating a data bank that will contain all the necessary information related to Earth's surface changes,** natural hazards, and ecosystem disturbances.



3.5. JAMES WEBB SPACE TELESCOPE

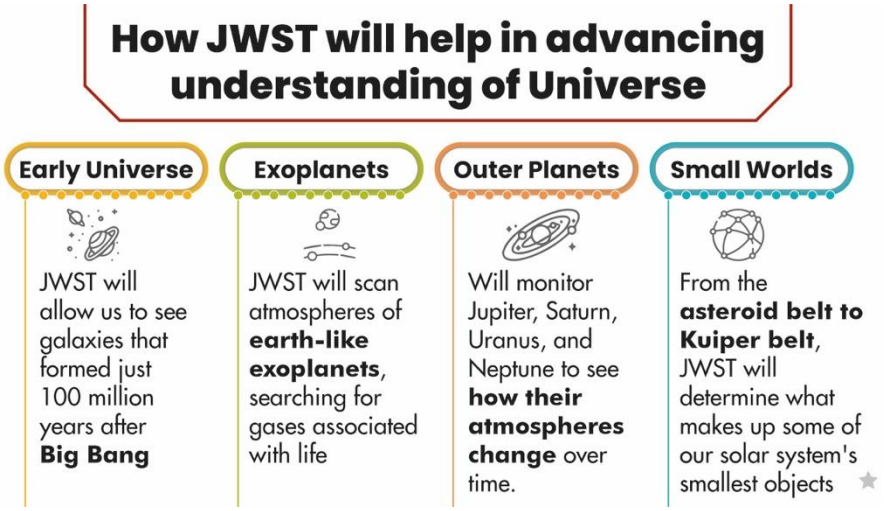
Why in news?

James Webb Space Telescope has provided astronomers with a **glimpse of the early universe** in a new image of a **galaxy cluster called MACS0647**, as well as **distant galaxy MACS0647-JD.**

About James Webb Space Telescope (JWST)

- It is NASA's **infrared flagship observatory.**
- It is an international collaboration between **NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA).**
- **Mission goals are:**
  - **Search for first galaxies** or luminous objects formed after Big Bang.

- **Determine how galaxies evolved.**
- **Observe stars formation** from the first stages to formation of planetary systems.
- **Measure physical and chemical properties of planetary systems,** including our own Solar System, and investigate potential for life in those systems.



- **JWST is placed in Sun-Earth Lagrange Point 2 (L2).**
  - Lagrange points are **positions in space where objects sent there tend to stay put** as gravitational forces of a two-body system (like Sun and Earth) equal the force required for a small object to move with them.
- **Scientific instruments on JWST:** Near Infrared Camera, Near Infrared Spectrograph, Mid Infrared Instrument and Fine Guidance Sensors/Near Infrared Imager and Slitless Spectrograph.
- The **JWST is being considered as the successor** of the Hubble Space Telescope (HST).

	Hubble	Webb	Herschel Space Observatory
Distance from Earth	507 Km	1.5 million Km at Second Sun-Earth Lagrange point	Second Sun-Earth Lagrange point
Primary Mirror Diameter	2.4 M	6.5 M	3.5 M
Searching for	Young Galaxies (12.5 billion years ago)	New Born Galaxies (13.5 billion years ago)	Most actively star-forming galaxies
Serviceable	Yes	No	No
Wavelengths	Visible, UV, Part of near-infrared	Near and mid infrared	Far-infrared and submillimeter

Observations made from images revealed by Webb

- **SMACS 0723 (Called Webb's First Deep Field):** It is a cluster teeming with thousands of galaxies, including **the faintest objects ever observed** in the infrared.
- **WASP-96b (spectrum)**: Detailed observation of this **hot, puffy planet outside our solar system** reveals clear **signature of water**, along with evidence of **haze and clouds** (that previous studies did not detect).
- **Southern Ring Nebula**: This planetary nebula is approximately **2,000 light-years** away.
  - Here, Webb's powerful infrared eyes bring a **second dying star into full view** for the first time.
- **Stephan's Quintet**: Webb's view of this compact group of galaxies, located in **constellation Pegasus** revealed **velocity and composition** of gas near its supermassive black hole.
- **Carina Nebula**: Webb's look at **"Cosmic Cliffs"** in the Carina Nebula unveils the **earliest, rapid phases of star formation** that were previously hidden.

3.6. SPACE TOURISM

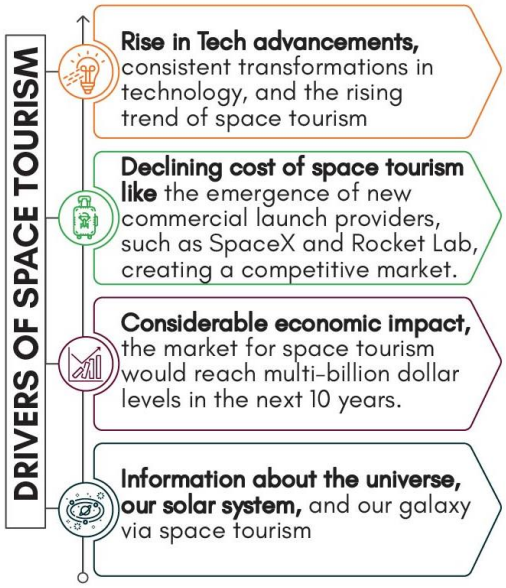
Why in news?

Indian Space Research Organisation (ISRO) is planning space tourism by 2030**.**

About Space Tourism

- It is a **commercial activity related to the cosmos** that includes **going to space as a tourist, watching a rocket launch, stargazing**, or traveling to a space centric destination.
  - **Global space tourism market size** was estimated **at around USD 870 million** in 2022 and is expected to reach USD **1.3 Billion by 2025.**
- **Different types** of space tourism **sub orbital space tourism, Orbital flights, Tourism beyond earth orbit** like Lunar space tourism.
- Various companies Blue Origin, Virgin Galactic and SpaceX have already entered space tourism.

- **Various steps** in line with space tourism have been taken **in India** like **Gaganyaan, IN-SPACe, Reusable Launch Vehicle-Technology Demonstrator** (RLV-TD) etc.



Challenges in space tourism

- **High cost:** Space tourism is prohibitively expensive, with prices reaching tens of thousands of dollars per seat, limiting accessibility for most people.
- **Environmental impact:** The carbon footprint from space tourism flights is significant and may contribute to climate change.
- **Lack of responsibility and regulation:** to ensure the safety of passengers and the environment.
- **Depleting ozone layer:** Aircraft carrying tourists into low-Earth orbit emit large amounts of carbon dioxide, which can damage the ozone layer and increase harmful UV radiation on Earth's surface.
- **Space debris:** Space tourism and satellite deployment have contributed to a significant amount of space debris orbiting Earth, which poses risks to future space missions and the safety of spacecraft.

Ethical Issues in Space Exploration and Space Tourism

- **Involves risks** — including risks to astronauts and tourists; physical and economic threats posed by space debris; and contamination of the ecosystem astronauts visit.
- **Confronting trade-offs**: such as spending on space rather than on improving the health and well-being of people on Earth.
- **Protecting rights** of astronauts, tourists etc. who go to space.
- **Limiting commercial interests:** With entry of private companies there is a risk that the focus of space exploration will shift away from scientific research and toward commercial interests.
- **Impact on society**: with only a small percentage of the world's population able to afford the high costs of spaceflight, this could exacerbate existing social inequalities.

Way Forward

- **Need to formulate laws and legislations** that shall regulate issues of space tourism including the regulation of private players, reducing harmful contamination to outer space etc.
- **Develop sustainable spaceflight technologies and practices**, using renewable energy sources for spaceflight activities, and minimizing debris generated.
- **Need for habitable structure** apart from international space station.
- **Developing programs** that make **spaceflight more accessible** to a wider range of individuals and **Investing in scientific research** and exploration that **benefits all of humanity.**
- **Need for environmental regulation** including **Environmental impact assessments** to reduce the climatic damage from this fast-growing industry.

Conclusion

It is likely that the space tourism industry will evolve during the next decade, as barriers to entry will be reduced, competition will grow, costs will be lowered, and eventually, space travel will be affordable for everyone.

3.7. JUPITER ICY MOONS EXPLORER (JUICE) MISSION

Why in News?

European Space Agency (ESA) has launched **JUICE** from Europe's spaceport French Guiana on an **eight-year-long voyage** to **Jupiter** and its **moons** through **Ariane-5**.

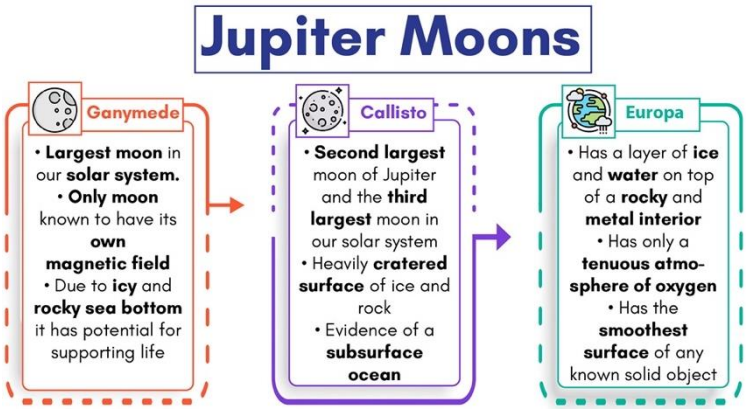
More on News

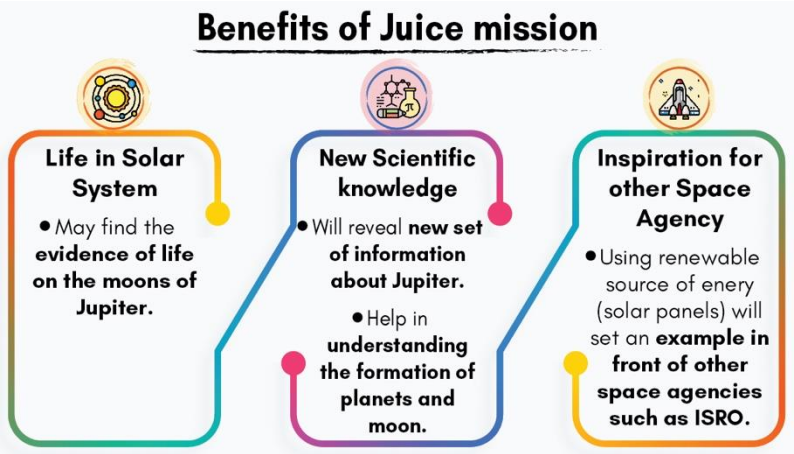
- Spacecraft will complete fly-bys of **Venus, Earth,** and the **Earth-Moon system** to arrive at its destination in **2031.**
- It is the first large-class mission in ESA's **Cosmic Vision 2015-2025 programme.**
- For the first time that the **ESA** has sent a spacecraft beyond the asteroid belt.

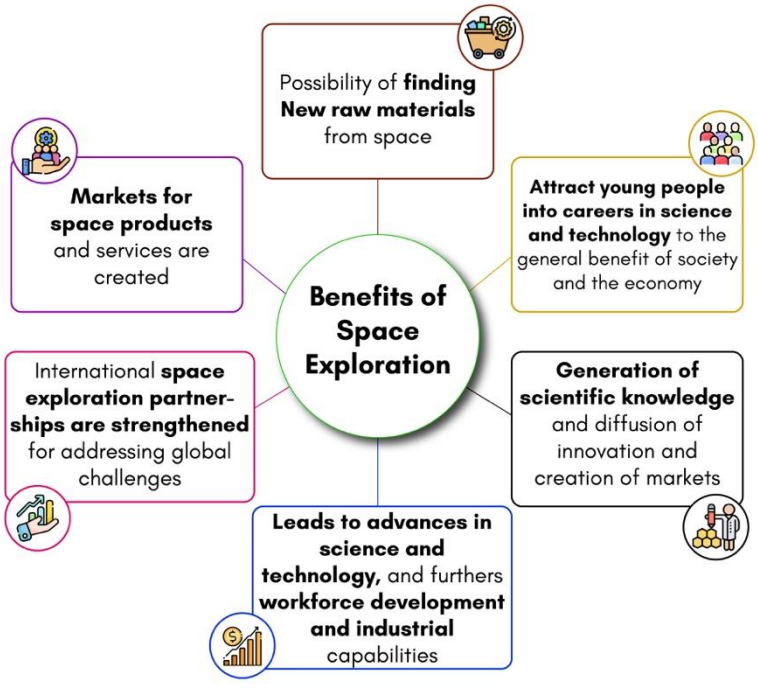
- It is a product of **"global" cooperation** between 23 countries, academic institutions, and private companies.

About JUICE Mission

- **Objectives:** It will make detailed observations about Jupiter and its three **large ocean-bearing** moons – **Ganymede, Callisto and Europa.**
  - It will inspect and analyse the **moons' weather, magnetic field, gravitational pull** and other elements.
- **Time Period:** It will spend at **least three years** studying the gas giant and its moons.
- **Spacecraft:** It has a record **85 square metres of solar panels,** which stretch out to the size of a basketball court.
- It will collect as much energy as possible near Jupiter, **where sunlight is 25 times weaker** than on Earth.
- **Payload:** It includes **GALA** (GAnymede Laser Altimeter), **MAJIS** (Moons and Jupiter Imaging Spectrometer), **UVIS** (UV imaging Spectrograph) etc.
- **Challenges in JUICE Mission:** Complex **manoeuvres, Extreme Atmospheric Condition, Gravity-assisted flyby** of **Venus, Earth,** and the **Earth-Moon** system **may change the trajectory** of the mission etc.







Conclusion

Mission will answer several questions on Jupiter's atmosphere, its magnetic field and how these factors **influence the planet's moons.**

It will help scientists better **understand the fundamental physics of planetary environments** and eventually figure out **whether life on one of Jupiter's moons would be possible.**

3.8. LIGO-INDIA PROJECT

Why in news?

Union Cabinet has approved the **Laser Interferometer Gravitational-Wave Observatory, or LIGO, project** to build an advanced gravitational-wave detector.

More on News

- **Components will be made in India**- improving the technological expertise of Indian scientists and engineers.
- The project will have **multidisciplinary benefits on India's Astrophysics research,** high end technological development.

About the project

- LIGO - India is a planned **advanced gravitational-wave observatory** to be located in India as part of the worldwide network.
  - It is a **collaborative project** between a consortium of Indian research institutions and the LIGO Laboratory in USA. The US will provide key components for the lab.
- **Genesis:** The project was given "in principle" approval in 2016 to be **completed by 2030.**
- **Location:** Hingoli district in Maharashtra.
- **Funding:** Department of Atomic Energy (DAE) and the Department of Science and Technology (DST).
- **Several institutions and departments involved:** Department of Atomic Energy, Department of Science and Technology, U.S. National Science Foundation, Institute For Plasma Research, Gandhinagar etc.

What is LIGO and how it works?

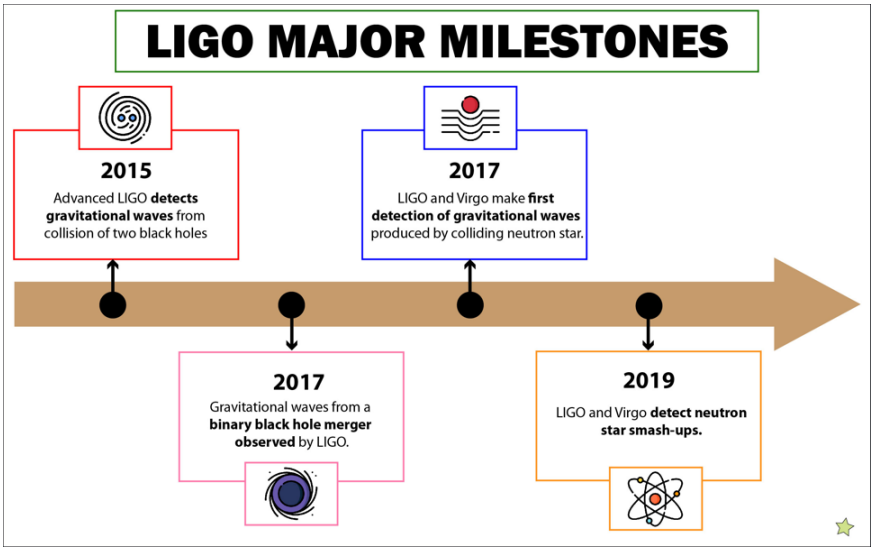
- LIGO is a tool to **detect gravitational waves** with the use of laser interferometers.
- LIGO detectors consist of **two 4-km-long vacuum chambers**, arranged at right angles to each other, with mirrors at the end.
- The experiment works by **releasing light rays simultaneously** in both chambers.
- Normally, the **light should return at the same time in both chambers**.

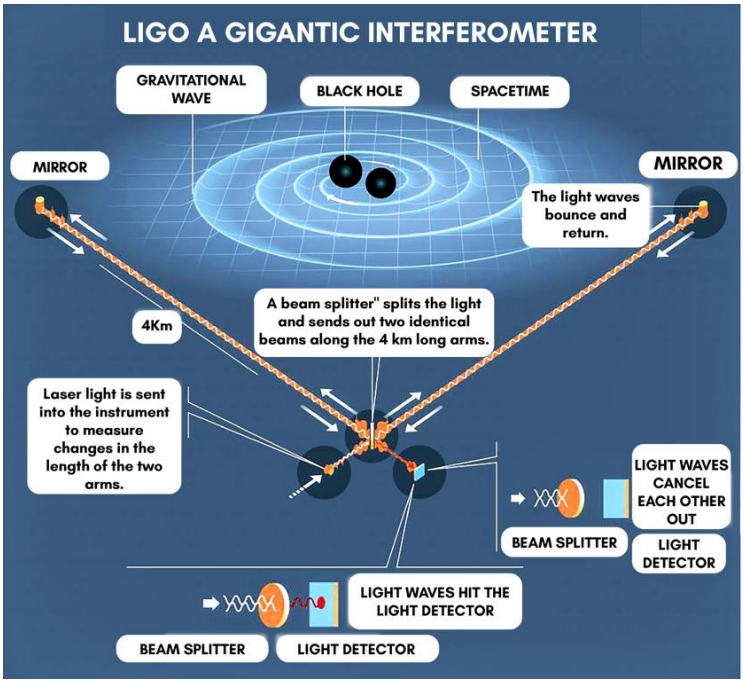
Current LIGO facilities

- **LIGO-India will be the third observatory** of its kind.
- Currently, LIGO consists of two widely separated installations within the United States -- **one in Hanford Washington and the other in Livingston, Louisiana.**
- The instruments at these observatories are **so sensitive** that they can **easily get influenced by events like earthquakes, landslides,** or even the movement of trucks, and produce a false reading.
- That is why **multiple observatories are needed to revalidate** the signals.
- Also, multiple detectors can help **tap all possible sources of gravitational waves,** and to **improve the quality and accuracy of information.**

LIGO sister facilities

- **Virgo:** Located in Italy, Virgo is gravitational wave interferometer with arms 3 km long (LIGO's are 4 km long). It is funded by the European Gravitational Observatory (EGO), a collaboration of the Italian and French governments.
- **GEO600:** It is a 0.6 km (600 m) interferometer located near Hannover, Germany, funded by both the German and British governments.
- **KAGRA:** Japan is currently building a 3 km interferometer inside of the Kamioka mine.



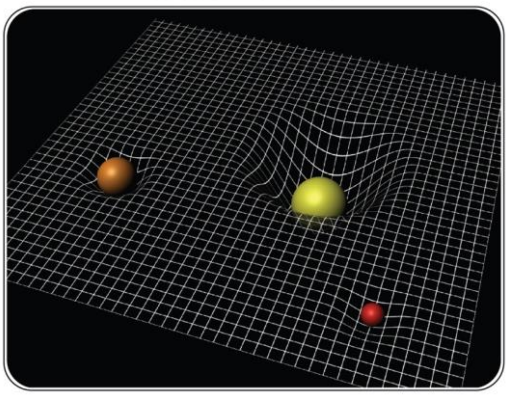


- However, if a gravitational wave passes through, **one chamber gets elongated while the other gets squeezed**, resulting in a phase difference in the returning light rays.
- Detecting this phase difference confirms the **presence of a gravitational wave**.

What are gravitational waves?

- Gravitational waves are **'ripples' in space-time** caused by some of the most violent and energetic processes in the Universe.
- Gravitational waves are **invisible**.
- They **travel at the speed of light (186,000 miles per second).**
  - Gravitational waves **squeeze and stretch anything** in their path as they pass by.
- **Albert Einstein** predicted the existence of gravitational waves in 1916 in his **general theory of relativity.**
- One of the main conclusions of general theory of relativity is that **objects of mass warp the very fabric of spacetime.**
- The greater the mass of an object the more extreme the warping of space it causes, so a **star warps spacetime more than a planet, and a black hole warp it more than a star**.
- Most powerful **gravitational waves are created** when **objects move at very high speeds**. Some examples of events that could cause a gravitational wave are:
  - When a star explodes asymmetrically (called a supernova).
  - When two big stars orbit each other.
  - When two black holes orbit each other and merge.
  - Black hole-neutron star merger
- The **first ever detection of gravitational wave happened in 2015**, by two U.S. based LIGO detectors.
  - These were produced **by merger of two black holes** and the achievement was **rewarded with Nobel Prize in 2017.**

Illustration of how mass bends space



About Spacetime

- In our everyday lives we think of three-dimensional space and time as completely separate things.
- But Einstein's theory showed that the **three spacial dimensions plus time are actually just part of the same thing:** the four dimensions of spacetime.
- Not only are space and time part of the same thing, but **they are both warped by mass or energy, causing a curved spacetime.**

Conclusion

Detection of gravitational waves **help understand black holes, neutron stars, supernovae, even the Big Bang**. Extracting the information carried by the waves addresses the questions in both physics and astronomy.

3.9. DARK MATTER MAP

Why in News?

Astronomers have made the **most detailed map of dark matter** showing that both the **'lumpiness' (piece of a solid substance, usually with no particular shape) of the universe** and the rate at which the universe is **growing.**

Big Bang Model

- It is the only model that is able to explain the existence of the Cosmic Microwave Background (CMB).
- According to this model, the Universe **started** with a very **dense** and **hot phase** that **expanded** and **cooled** itself; for several hundreds of thousands of years the temperature was so high that neutral atoms could not form.
- Matter consisted mostly of **neutrons** and **charged particles (protons and electrons)**.
- Electrons interacted closely with the light particles, and therefore **light and matter were tightly** coupled at **that time** (that is, **light could not travel** for a **long distance in a straight line**).
- **Light** could therefore **not propagate** and the **Universe** was opaque.
- It took about 300 000 years for the Universe to **cool down** to a **temperature** at which atoms can **form (about 3000°C)**.
- Matter then became **neutral**, and allowed the light to travel freely, then Universe became transparent.

More on News

- They have created a map by using the **microwave detector** of the **Atacama Cosmology Telescope (ACT).**

- Astronomers were observing the data collected by the ACT to find out whether **Einstein's predictions in his theory are correct** regarding the **expansion of the Universe**.
- They also observed the sanctity of the **standard model of cosmology (SMC)**.

Observation Made by Astronomers

- **Invisible world:** Features of the **invisible world** (dark matter and energy) were observed which are hundreds of **millions of light-years across**.
- **Cosmic Microwave Background (CMB) radiation: Gravitational pull** of large, heavy structures including dark matter warps the **CMB radiation** on its 14-billion-year journey to Earth.
  - **CMB** or **fossil radiation** is the **cooled remnant** of the **first light (or leftover of the Big Bang)** that could ever travel freely throughout the Universe.
  - The CMB light **gets deflected** by **dark matter**, just like a **magnifying glass** deflects **light that passes through it**.

Einstein's Theory of Relativity
- It was propounded by him in **1915**.
- In this theory, he **contradicted Isaac Newton's concept** of space who **saw space and time as fixed**.
- But according to his theory, space is **fluid and malleable**.
- Gravity is not a force, but rather a distortion of time and space.
- **Tiny ripples** are caused by colliding **black holes.**

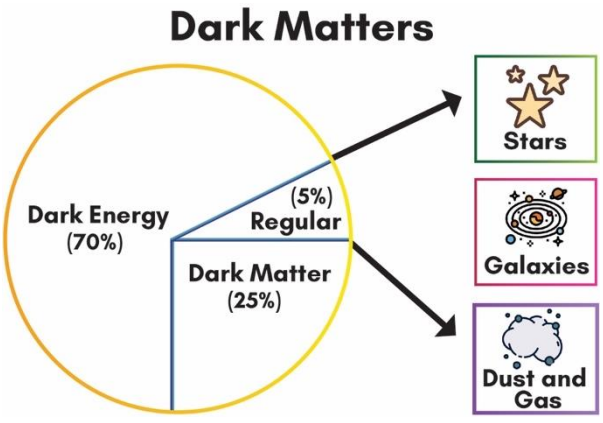
- **Lumpiness:** Measurements showed that the 'lumpiness' of the universe is of the **exact right size as per SMC.**
- **Expansion:** Rate at which it is growing is just what was expected from our SMC based on Einstein's theory.
- **Gravitational lensing:** It was observed while recording the movement of the CMB.
  - It is a phenomenon in **which light moving through a region of** space-time warped (bend or twist out of shape) by **powerful gravitational fields** travels, in a curve until it emerges as a stretched-out arc called an **Einstein ring**.
  - **Gravitational lensing** helps in detecting dark matter.

Composition of the Universe
- Unlike **normal matter**, dark matter **does not interact** with **electromagnetic force**.
  - This means it does not **absorb**, **reflect** or **emit light**, making it extremely **hard to spot**.
- Researchers **have been able** to infer the **existence of dark matter only** from the **gravitational effect it seems to have on visible matter.**
- It seems to outweigh **visible matter roughly six to one**, making up about **27%** of the universe.
- Astronomer **Fritz Zwicky** first used the term **"dark matter"** in the 1930s.

Dark Matter	Visible Matter
• It makes up approximately **68%** of the **universe** and appears to be **associated** with the vacuum in space. • It is **distributed** evenly throughout the **universe**, not only in space but also in time.	• It makes **up 5%** of the Universe. • It **includes** Earth, the sun, other stars, and galaxies. • It is made of **protons**, **neutrons**, and **electrons** bundled together into atoms.

Einstein's Prediction in the Theory of General Relativity (GR)

- **Motion in Space: Concentrations** of **mass** and **energy** curve the **structure of spacetime**, affecting the motion of anything passing near, including light.
  - He expected a **beam of starlight** should **bend** when **passing through the sun's gravity.**
- **Expansion of Universe:** He provided the mathematical framework for **describing** the **structure** and **evolution** of the universe (once hotter and denser than it is today) from its beginnings 13.8 billion years ago and into the future.
  - Galaxies are moving away from each other.
  - Also, he predicted that the **universe is lumpy.**



How does the new map confirm Einstein's Prediction?

- **Crisis in Cosmology: Previous maps** indicated that the **lumpiness of** the universe **was not as dense as** Einstein's theory had proposed, under the **standard model of cosmology** and led to concerns that the model may be broken.
  - These findings used a **different background light**, one emitted from stars in galaxies rather than the CMB.
  - However, the latest results from **ACT** were able to precisely assess that the **lumpiness seen are as per Einstein's theory**.
- **Standard Model of Cosmology (SMC):** Findings proved that the **expansion of the universe is as per the SMC.**
  - It is also called the "**Concordance Cosmological Model**" or the "**ΛCDM (Lambda cold dark matter) Model,**".
  - It is based on the principle that the universe **was created by the "Big Bang"** from pure energy.
  - Also, it believes that Universe is composed of about **5%** ordinary matter (visible), about 25% dark matter, and around 70% dark energy.
- Presence of **CMB** shows that Universe started with a **very dense** and **hot phase** that expanded and cooled itself and later released CMB. Its movement depicts it is Universe is still expanding.
  - Also, its deflection by Massive object upheld that Gravity is not a force, but rather a distortion of time and space.

Conclusion

The latest finding with the help of the ACT has upheld the SMC and solved the crisis in cosmology up to a large extent. It will give new opportunities to astronomers and researchers for space-related research. Space agencies such as NASA, ISRO, etc. can use these findings for their space exploration programs.

3.10. DIFFERENT SPACE RELATED PHENOMENON

	About	Importance
Fast Radio Burst (FRB)	• FRBs are **bright flashes of light** that appear **for a few milliseconds** and then vanish. • Their **origins are unknown**, and their appearance is unpredictable.	• FRBs can **reveal the total amount of matter that they encounter** as they travel. • FRBs can be used **to study the three–dimensional structure of matter** in the universe. • FRBs could be used **to learn early moments in the evolution** of the universe.
Nebula	• It is a **giant cloud of dust and gas** in space. • Some nebulae (more than one nebula) come **from the gas and dust thrown out** by the explosion of a dying star, such as a supernova. • Other **nebulae are regions** where **new stars are beginning to form.** • **Nebulae exist in the space between the stars**—also known as interstellar space.	• They play a **crucial role in understanding the chemical evolution** of the galaxy. • They act as objects **observable enough to yield** useful information **about chemical abundances** in space.
Neutron stars	• Neutron stars are formed when **a massive star runs out of fuel and collapses.**	• Act as **laboratories for extreme physics** and conditions that **cannot be reproduced here on Earth.** • **Better understanding of events like Supernovae, FRBs etc** as these are tied to neutron stars (as they are the explosive events that create them). • Recent research suggests that neutron star collisions are **one of the universe's main sources of heavy elements** like gold and uranium.
Magnetar	• It is a **type of Neutron Star**. • In a typical neutron star, the magnetic field is trillions of times that of the Earth's magnetic field; however, **in a magnetar, the magnetic field is another 1000 times stronger.**	
Pulsars	• **Pulsars are rotating neutron stars** observed to have pulses of radiation at very regular intervals that typically range from milliseconds to seconds.	
Cepheids	• Also called Cepheid Variables, are **stars which brigthen and dim periodically.**	• Used as **cosmic yardsticks out to distances** of a few tens of millions of light-years.

4. HEALTH

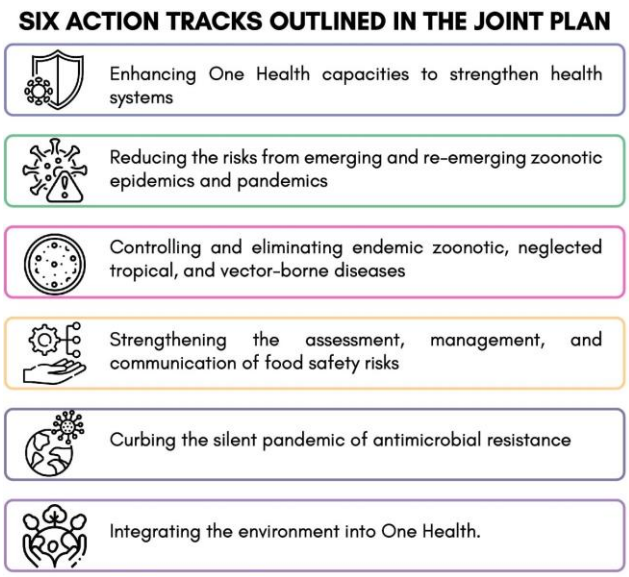
4.1. ONE HEALTH

Why in news?

Recently, four multilateral agencies have **launched a One Health Joint Plan of Action (2022-2026) (OH JPA).**

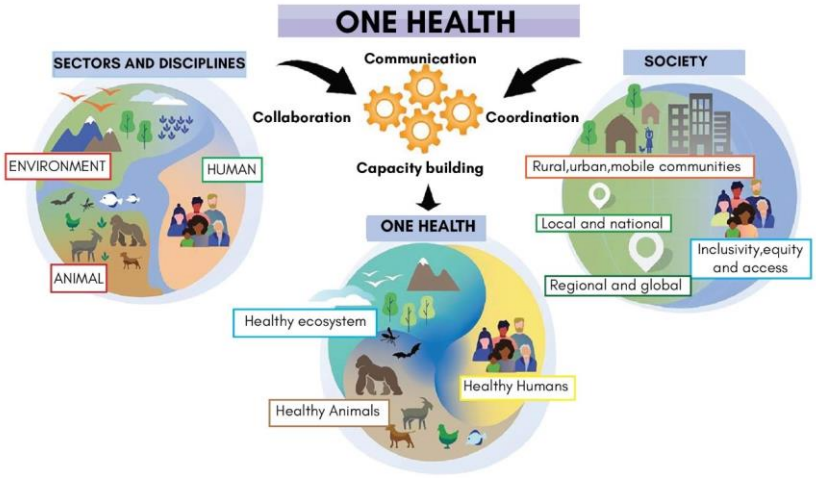
About One Health Joint Plan of Action (2022-2026) (OH JPA)

- **Launched by** FAO, UNEP, WHO and World Organisation for Animal Health.
- The plan is valid from 2022-2026 and is **aimed at mitigating the health challenges at global, regional, and country levels.**
- It **will create a framework and integrate systems and capacity** to collectively better prevent, predict, detect and respond to health threats to all living beings as well as the environment.



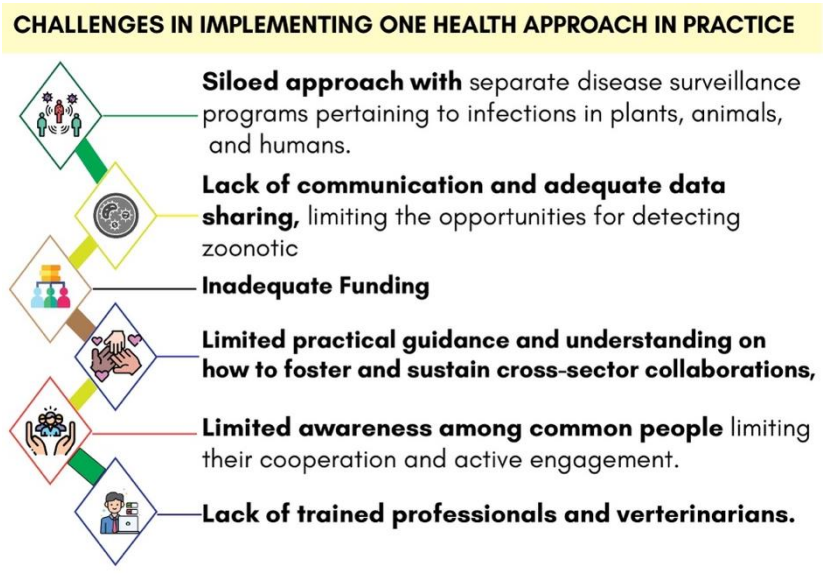
About One health Concept

- One Health calls for a **holistic, integrated and systems-based approach** that recognizes the interconnection between the health of humans, animals, plants and the environment.
- It is the primary approach for **addressing the complex health challenges facing our society,** such as ecosystem degradation, food system failures, infectious diseases and antimicrobial resistance (AMR).



Driving factors for the need for one health approach

- **Tackle Emerging infectious diseases ("Disease X" as highlighted by WHO):** 75% of Emerging infectious diseases and almost all recent pandemics **are zoonotic in nature.**
- **Extension of Human activities:** like encroachment into natural habitats, expansion of human populations into new geographic areas, rising International Travel & Trade etc.
- **Urbanization and climate change:** are providing new and more suitable conditions for pathogens and diseases to develop and spread.
- **Growing threat of antimicrobial resistance.**
- **Increasing inequality, fragility, and violence:** heightens the risk of disease transmission.



Steps taken in India to implement One health approach

- **Collaboration at national and state levels** such as the national influenza pandemic committee to control avian influenza, rabies in the Tamil Nadu and other states.
- **Institutional collaboration:** ICMR and Indian Council of Agricultural Research (ICAR) have collaborated for joint research priorities to control disease outbreaks.
- **One Health Support Unit,** initiated by Department of Animal Husbandry and Dairying, to develop a national One Health Framework aimed at improving national and State-level resource allocation and policy ecosystem on zoonotic diseases.
- **National Mission on Biodiversity and Human Well-being:** by Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC).
- **'One Health' project:** It envisages carrying out surveillance zoonotic as well as transboundary pathogens in India.
- **Regional One Health Initiative**: with a focus on low and middle-income countries across south and southeast Asia and sub-Saharan Africa.

Why One Health matters?

- **People's Health**
  - 60% of pathogens that cause human diseases like Covid-19 originate from domestic animals or wildlife.
  - 75% of emerging human pathogens are of animal origin.
  - 80% of pathogens that are of bioterrorism concern originate in animals.
- **Food Security**
  - More than 70% additional animal protein will be needed to feed the world by 2050.
  - More than 20% of global animal production losses are linked to animal diseases.
- **Environment**
  - Humans and their livestock are more likely to encounter wildlife (this may increase the transmission of diseases) when more than 25% of an original forest cover is lost.
  - Human actions have severely altered 75% of terrestrial environments and 66% of marine environments.
- **Economy**
  - Animal diseases pose a direct threat to the **incomes of rural communities that depend on livestock production.**

Way ahead

Operationalizing a One Health approach requires improving coordination, communication, and collaboration between sectors, reinforced by sustained capacity strengthening. This requires:

Other Global initiatives

- **The Pilanesberg Resolution, 2001:** It was targeted at multilateral and bilateral donors and governmental authorities to consider potential wildlife health impacts in development projects.
- **One World-One Health:** Introduced by The Wildlife Conservation Society (WCS) in 2007 along with 12 recommendations (**Manhattan Principles**) that focused on establishing a more holistic approach to preventing epidemic disease and maintaining ecosystem integrity.
- **National Framework for One Health, 2021** by FAO guides towards overcoming the systemic barriers to implement the One Health approach.

- **A shift from largely vertical programs** focused on specific diseases to those that can strengthen overall systems and their collaboration across sectors.
- **Developing databases and models** with a consolidated approach of ecologists, field biologists, epidemiologists and other scientists.
- **Strong Nexus** of science, social science, indigenous knowledge and policy at national, state and local levels.
- **Integration of one health approach in Pandemic prevention plans.**

4.2. TRANSFAT

Why in News?

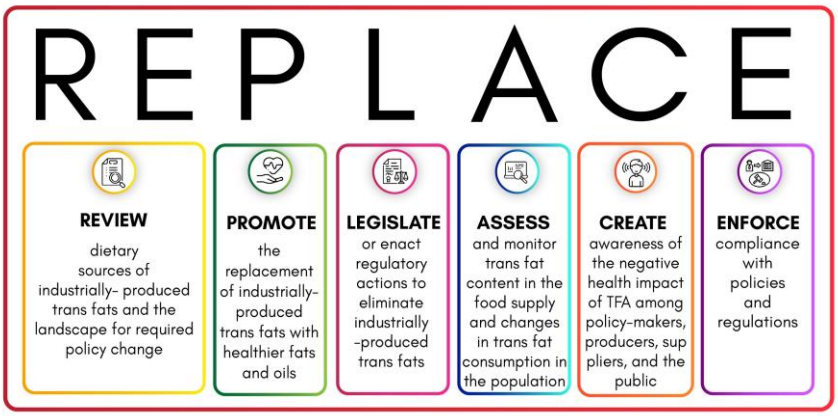
Recently, WHO released a report titled Countdown to 2023: WHO report on global trans-fat elimination 2022 that monitors global progress towards the 2023 target for global elimination of industrially produced trans-fatty acids (TFA).

- **Key highlight of the report**
  - **Five billion people globally are exposed to harmful trans-fat,** increasing their heart disease and death risk.

- **Mandatory TFA limits or bans** on partially hydrogenated oils (PHO) are **currently in effect in 60 countries.**
- In 2022, three countries – **India, Oman and Uruguay** – implemented best-practice TFA policies, **doubling the size of the population that is protected by best-practice TFA policies** to 2.8 billion people.

Global Initiative

- **REPLACE initiative:** by WHO to support governments in ensuring elimination of industrially produced TFA from the food supply by 2023.
- **WHO Certification Programme for Trans Fat Elimination:** to recognize countries that have eliminated industrially produced TFA from their national food supplies.



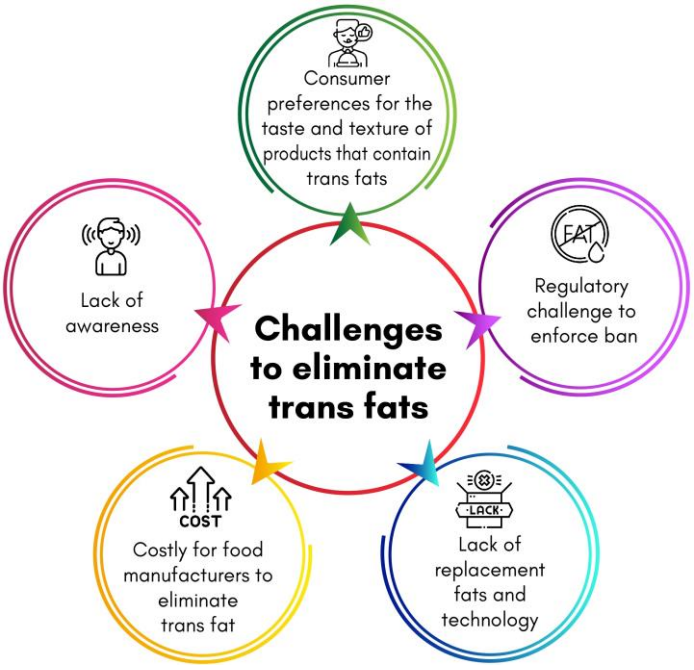
About Transfat

- These are unsaturated fatty acids that **come from either natural or industrial sources.**
  - **Naturally occurring trans-fat** come from ruminants (cows and sheep).
  - **Industrially produced trans-fat are formed in an industrial process** that adds hydrogen to vegetable oil converting the liquid into a solid, resulting in "partially hydrogenated" oil (PHO).
- The use of trans fats in the food industry has been popular because they are **inexpensive, have a longer shelf life, and can improve the texture and taste of foods.**
- Trans fats **increase bad cholesterol**, i.e., Low Density Lipoproteins (LDL) cholesterol and decrease High Density Lipoproteins (HDL) cholesterol, which can **increase the risk of heart attack or stroke.**
- Health authorities recommend **limiting consumption of trans fat (industrially produced and ruminant) to less than 1% of total energy intake,** which translates to less than 2.2 g/day for a 2,000-calorie diet.

Best-practice TFA policy

Legislative or regulatory measures that limit industrially produced TFA in foods. The two best-practice policies for TFA elimination are

- **Mandatory national limit of 2 g of industrially produced TFA** per 100 g of total fat in all foods.
- **Mandatory national ban on the production or use of PHO** as an ingredient in all foods.



Initiatives taken to eliminate industrially produced TFA

- **Regulatory measures:** FSSAI **has notified several crucial regulations to regulate transfat** in industrial products, encouraged edible oil industry and food business operators to eliminate transfat from their products.
- **Best-practice policy:** India became the first lower-middle-income country to implement a best-practice policy in 2022.
- **Mass media campaign**: FSSAI has launched a **mass media campaign "Heart Attack Rewind"** to **create awareness** about the harmful effects of trans fat.
- **Mandating Food Labeling:** of TFA by FSSAI on packaged foods, making it easier for consumers to make informed choices about the foods they consume.

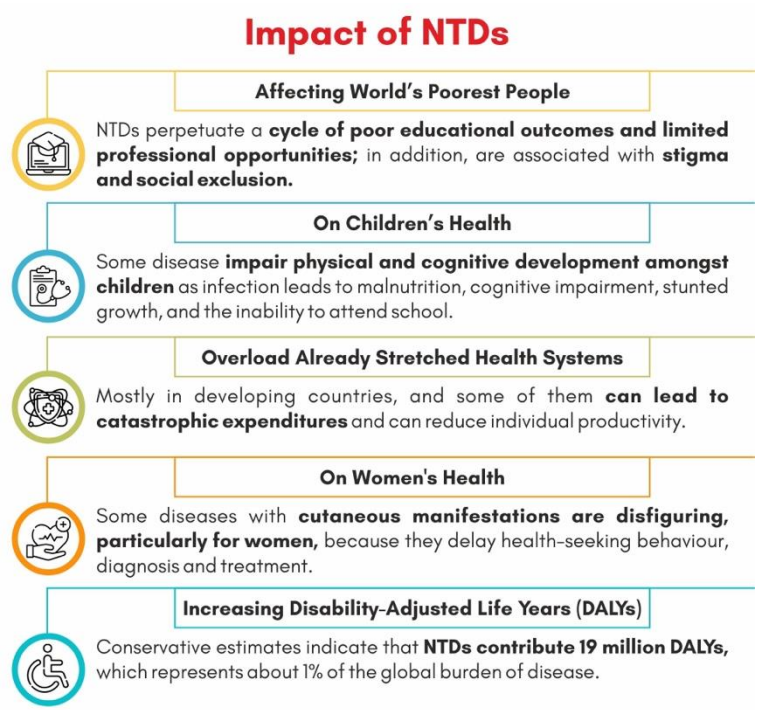
Way forward

- **WHO recommends following actions** to eliminate TFA.
  - **Invest in monitoring and surveillance mechanisms** to measure TFA content in foods.
  - **Country-specific alternative techniques** and develop a replacement roadmap.
  - **Advocate for regional or subregional regulations** to expand the benefits of TFA policies.
- **Implement trans-fat bans:** FSSAI need to pursue local governments to improve surveillance, inspection of food premises, sampling of food products, regular training of officers, upgradation of food labs, etc.
- **Encourage restaurants to eliminate trans fats:** For example, McDonald's and KFC have both pledged to phase out the use of trans-fats in their fried foods.
- **Educate the public** to choose healthier alternatives.

4.3. NEGLECTED TROPICAL DISEASES

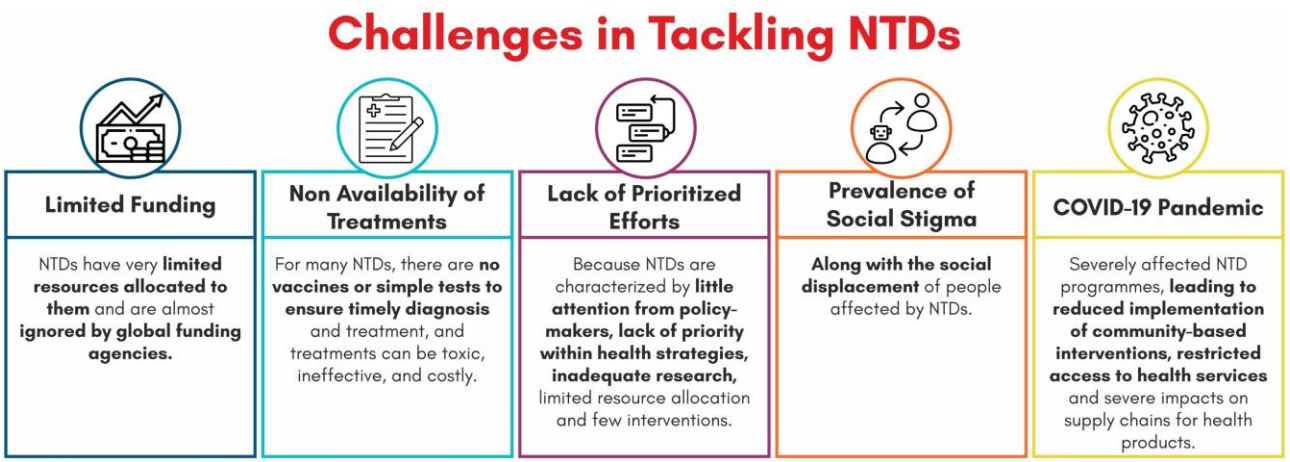
Why in News?

World Health Organization (WHO) released Global report on neglected tropical diseases 2023.



About Neglected tropical diseases (NTDs)

- NTDs are a **diverse group of 20 conditions mainly prevalent in tropical areas**.
  - They are 'neglected' because they are **almost absent from the global health agenda**.
- **NTDs are caused by a variety of pathogens** including viruses, bacteria, parasites, fungi, and toxins.
- NTDs **tend to affect regions without quality healthcare, leaving poor populations vulnerable** to these often-debilitating diseases and newly emerging threats.
- As per **Global Report on NTD 2023 16 countries account for 80% of global NTD burden** and 47 countries eliminated at least one NTD.
- **India has the world's largest absolute burden of at least 10 major NTDs**, including dengue, lymphatic filariasis, leprosy, visceral leishmaniasis or kala-azar and rabies.
- **India has already eliminated several NTDs,** including guinea worm, trachoma, and yaws.



Way Forward

- The report **recommends to**
  - Invest in **innovative operations and financing solutions** that foster integration and cross-sectoral collaboration.
  - Boost **global support for countries** with highest burdens.
- **NTD interventions can be made more efficient by:**
  - **Addressing all NTDs cohesively** through a whole-health-system approach.
  - **Scaling up cross-cutting interventions** outside the health sector (education, nutrition, water, sanitation and hygiene (WASH), animal and environmental health).
  - **Filling operational gaps**, for example, through the development of better medicines and better diagnostic tools.
- **Greater efforts and investments are required** to reverse delays caused by COVID-19.

- **A steady flow of resources is required** to support NTD programmes within the wider framework of primary health care and health system strengthening.

Initiatives Taken

Global

- **WHO's first NTD road map (2012–2020)** delineated milestones and targets, the **new roadmap for 2021–2030** sets out key actions to drive progress towards a world free of NTDs by 2030.
- **World NTD Day observed on January 30** every year.
- **Adoption of the Abu Dhabi Declaration** on Eradication of Guinea Worm Disease.
- **Adoption of the Kigali Declaration** on NTDs.
- **London Declaration** on NTDs.

In India

- **Accelerated Plan for Elimination of Lymphatic Filariasis (APELF).**
- **Bangladesh, India, and Nepal** jointly **established a regional alliance to eliminate kala-azar**, supported by WHO.
- **National Vector Borne Diseases Control Programme** for prevention and control of vector borne diseases namely Malaria, Japanese Encephalitis, Dengue, Chikungunya, Kala-azar and Lymphatic Filariasis.
- Recently, **Mass Drug Administration (MDA) was launched to eliminate LF by 2027.**
- State and central governments have also **introduced wage compensation schemes for those suffering from Kala-Azar.**

4.4. ANTI-MICROBIAL RESISTANCE (AMR)

Why in news?

Recently, WHO in partnership with the Global AMR R&D Hub, has released 'Incentivizing the development of New Antibacterial Treatments 2023' Report.

Key highlights of Report

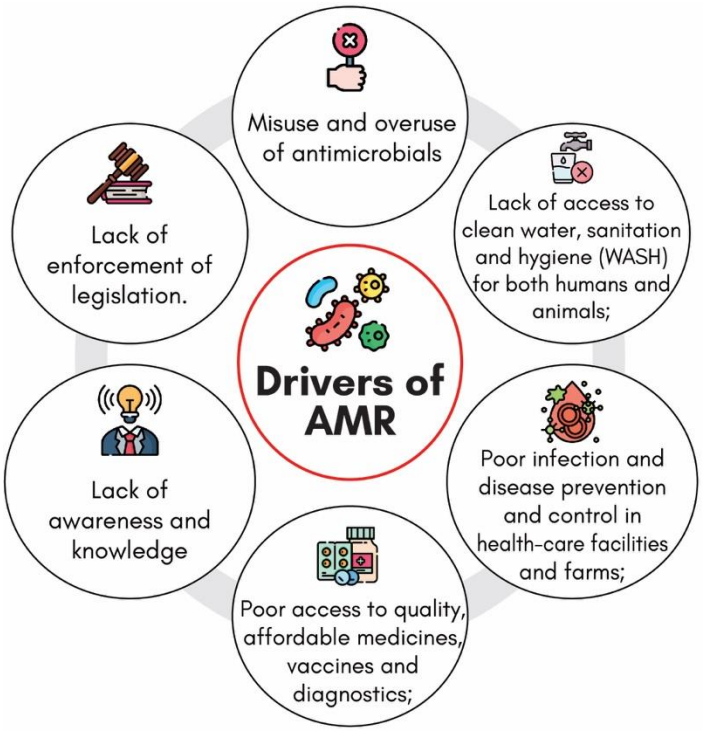
- **AMR Among the top 10 global public health threats** facing humanity and is associated with the **deaths of 4.95 million people in 2019** which is more than HIV or malaria.
- **AMR could cost** the world's economy **USD 100 trillion** by **2050**.

About Antimicrobial Resistance (AMR)

- AMR occurs **when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines** making infections harder to treat and increasing the risk of disease spread, severe illness and death.

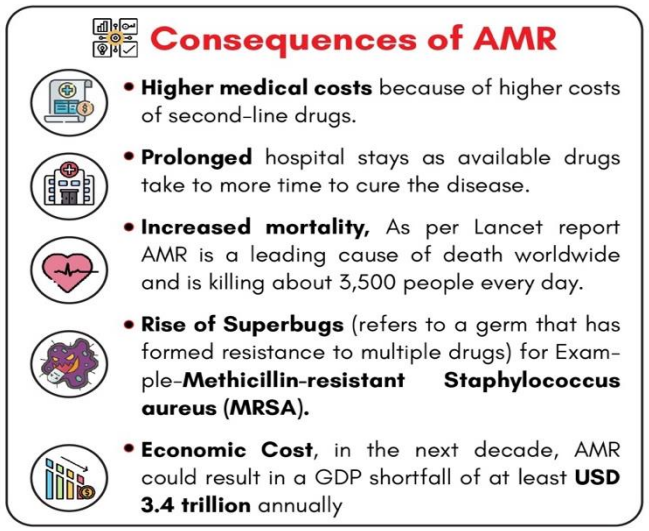
- Antimicrobials – including **antibiotics, antivirals, antifungals and antiparasitics** – are **medicines used** to prevent and treat infections in humans, animals and plants.

- **India tops the list of the countries with highest antibiotic consumption** and one of the worst AMR hit country.
  - Many patients in India **may no longer benefit from carbapenem** (antibiotic administered to treat pneumonia and septicemia) and **resistance to Imipenem** (used to treat infections caused by bacteria E coli**) has also increased.**



Reasons for AMR

- **Inappropriate or excessive use** of antimicrobials.
- **Triple planetary crisis**
  - **Environmental pollution:** Effluent from the **pharmaceutical industry, hospitals, human waste and agriculture** increases resistance chances in germs.
  - **Climate change:** as higher temperatures can **encourage the rate at which genes are transferred** from microbe to microbe.
  - **Loss of biodiversity**.
- **Covid 19 Pandemic**: has accelerated AMR because of the widespread consumption of antibiotics during the various waves.
- **Anti-Biotic use in Animals reared for Human Use:** leads to AMR.



Way Forward

- **Reduction of pollution:** Preventive steps are needed by the key polluting sectors like:
  - **Pharmaceutical companies:** Upgrade manufacturing processes to reduce runoff.
  - **Farmers**: Avoid using certain antibiotics.
  - **Hospitals:** Consider on-site treatment of antimicrobial pollutants in wastewater.
- **Improve integrated water management** and promote safe water, sanitation and hygiene (WASH) to limit the development and spread of AMR.
- **'One Health' approach**: will help address the triple planetary crisis.

Initiatives to tackle AMR in India

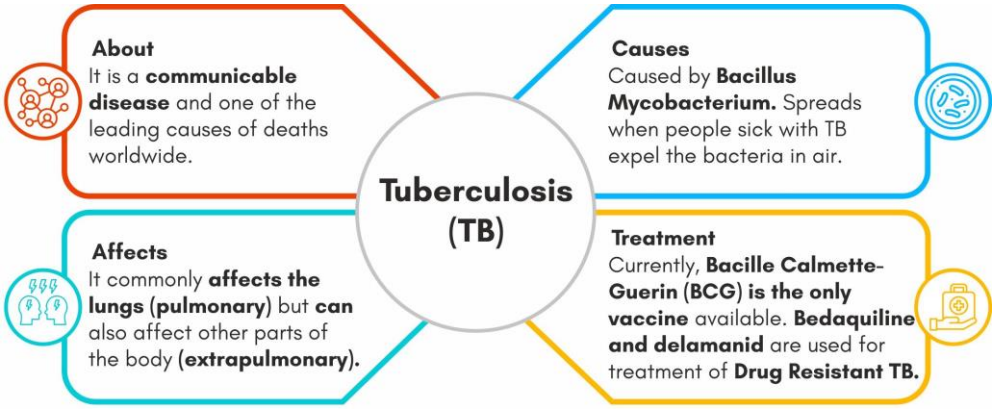
- **National Action Plan for AMR (2017-21)** to reduce the impact of AMR though focusing on One Health approach.
- **AMR Surveillance Network:** to generate **evidence and capture trends and patterns of drug resistant infections i**n the country.
- Joint **Indo-German collaboration** for research on AMR
- India agreed to join the **International Centre for Anti-Microbial Resistance (ICARS)- research platform to tackle AMR in Low and Low Middle-Income Countries** as **mission partner.**
- **Initiatives to control overuse or misuse of antibiotics:**
  - **Antibiotic stewardship program (AMSP)** by ICMR.
  - Drug Controller General of India (DCGI) has banned **several fixed dose combinations (FDCs)** which were found inappropriate.
  - DCGI **to ban use of Colistin as growth promoter in animal feed in poultry.**

- **Research and Development (R&D):** Establish international standards for what are good microbiological indicators of AMR from environmental samples.
- **Participative approach:** Tackling AMR will require all hands-on deck: government, civil society, international organizations and the private sector.

4.5. TUBERCULOSIS

Why in news?

Recently, World Health Organization (WHO) released new guidance to support **National Strategic Planning (NSP) for the tuberculosis (TB).**

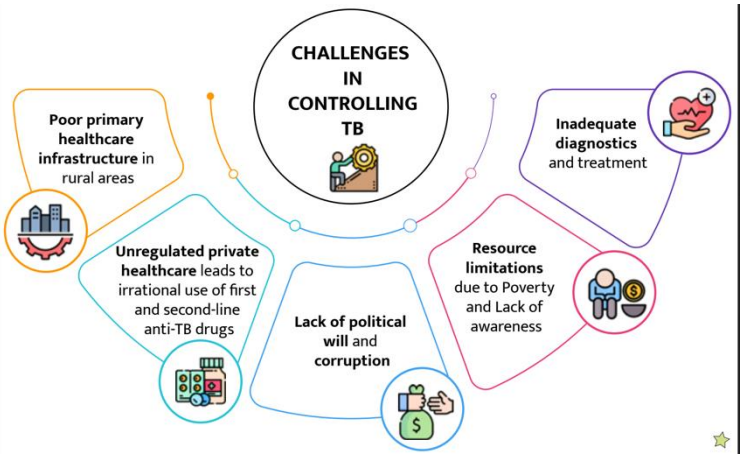


More on news

- NSP for TB is a key document that **guides national authorities and stakeholders on how to comprehensively address the TB epidemic** through goal(s), strategies, priority interventions within health and across other sectors.
  - Each goal must be defined in line with **SMART (specific, measurable, attainable, realistic and time-bound) criteria.**
  - Current document is an **update to 2015 Toolkit to develop a NSP for TB prevention, care and control.**

Drug Resistant TB:
- **Multi- Drug Resistance TB (MDR- TB):** It is TB that does **not respond to at least isoniazid and rifampicin** (2 of the most powerful first line drugs).
- **Extensively Drug Resistant TB (XDR- TB)**: It is resistant to at least four of the core anti-TB drugs. It involves MDR-TB, in addition to resistance to any of the **fluoroquinolones (such as levofloxacin or moxifloxacin)** and to at least one of the three injectable second-line drugs (amikacin, capreomycin or kanamycin).
- **Totally drug-resistant tuberculosis (TDR-TB):** TB which is resistant to all the first- and second-line TB drugs.

Steps taken to eliminate Tuberculosis



- **India's efforts:**
  - **National Strategic Plan (NSP), 2017-2025:** to eliminate TB by 2025, five years ahead of the target for TB set by SDG, 2030.
  - **National Tuberculosis Elimination Program (NTEP):** has expanded both the laboratory network as well as diagnostic facilities to cover the entire country.
    - ✓ Earlier, it was known as **Revised National Tuberculosis Control Program (RNTCP).**
  - **NIKSHAY Portal:** It is the **National TB information system** to manage information of patients and monitor program activity throughout the country.
  - **NIKSHAY Poshan Yojana (NPY)**: provides direct benefit transfer (DBT) for all TB patients.
  - **TB Free India Campaign** launched by PM to eliminate Tuberculosis in India by 2025.
  - **Pradhan Mantri TB Mukt Bharat Abhiyan, 2022**- Also known as **Ni-kshay Mitra Initiative.** One can **adopt TB patients** (so far 10 lakhs adopted) and provide them with monthly nutritional support.
  - **New Diagnostic Test:** CB-NAAT (cartridge-based nucleic acid amplification test), TrueNat (rapid testing for TB) etc.
  - **India is the first country in world** to develop **a sophisticated mathematical model** to track spread of TB disease.

Innovative Methods adopted By States/UT
- **Chhattisgarh**- Involving **village health committee** for TPT.
- **Tamil Nadu**- Local procurement of shorter 3HP TPT drugs
- **Maharashtra** and **Rajasthan**-Introduction of TPT in prison inmates, other risk groups and integration during Active case-finding (ACF).

- **Global efforts to eliminate TB**
  - **Moscow Declaration, 2017**: to increase multisectoral action and enhance accountability in the global TB response towards ending TB by 2030
  - **WHO End TB Strategy:** It serves as a blueprint for countries to **reduce TB incidence by 80%, TB deaths by 90%,** and to eliminate catastrophic costs for TB-affected households by 2030.
  - **Find. Treat. All. #EndTB**: It is the joint Initiative of WHO, Stop TB Partnership, and Global Fund to **diagnose treat and report 40 million people with TB**.

Key Findings of India TB Report 2023

- TB **patient registration has improved** by **56%.** 722 (94%) districts of India have expanded TPT.
- Highest incidence of cases was in **Delhi (546 per lakh population)** and the lowest in **Kerala (67 per lakh population).**
- The treatment initiation rate among the notified cases for 2022 was **95.5%.**
- 2022 saw an increase in the **Multidrug-resistant tuberculosis (MDR-TB)/ Rifampicin resistant (RR) TB.**
- **Reasons identified for high burden of TB:** Delay in Diagnosis & treatment, lack of the latest Equipment, long-term exposure to particulate matter etc.

Recent initiatives Launched by Ministry of Health and Family Welfare at One World TB Summit		
TB-free Panchayat	**Shorter TB Preventive Treatment (TPT)**	**Family-centric care model for TB**
All the elected public representatives of villages **will together take a resolution** that every **patient in the village will be kept healthy.**	It will use the shorter **3HP [(12 once-weekly doses of isoniazid (H) and rifapentine (Priftin) (P)]** regimen across the country.	It includes easy-to-use tools for **counselling** and **capacity building** in the form of videos, animations, and brochures in local languages offered on Internet and mobile phone-based platforms.

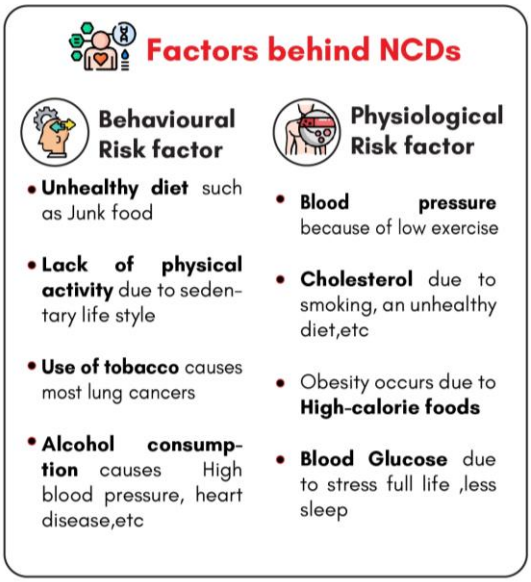
Way Forward

- **Integrated approach:** It should include a **hygienic lifestyle, nutritional food** uptake, and better **health care services**.
- **Human Resource Development:** Physical training **at National TB Institute (NTI)**, Bengaluru and other institutes shall be promoted.
- **Early Diagnosis and Monitoring:** By adopting the latest technologies, creating awareness etc.
- **Community Participation:** Will support government initiatives such as Ni-kshay Mitra Initiative.

4.6. NON-COMMUNICABLE DISEASES

Why in News?

Ministry of Health and Family Welfare (MoHFW) released **Strategic Operational Guidelines for National Programme for Prevention & Control of Non-Communicable Diseases (NP-NCD)** for the management of non-communicable diseases in India.

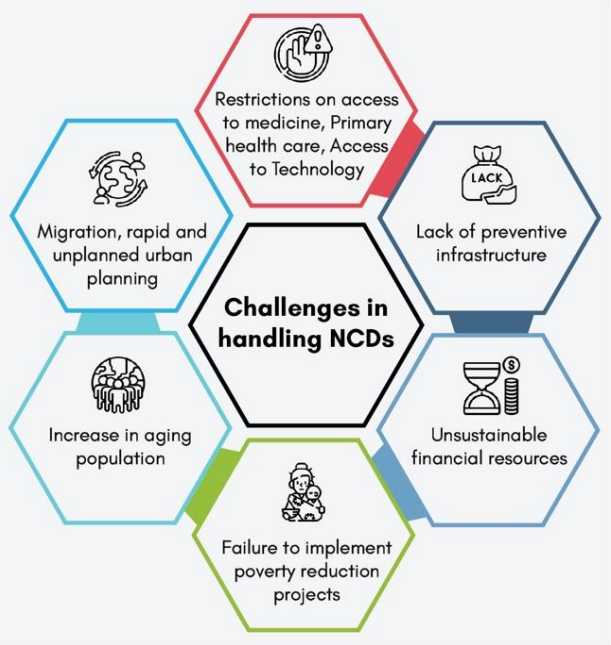


- **Key Highlights of the Guidelines**
  - **Focus** on **primary and secondary prevention clinical** support for NCDs.
  - The existing **National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke** (**NPCDCS**) programme **has been renamed** National Programme for Prevention & Control of Non-Communicable Diseases (NP-NCD).
    - ✓ **Also, widening the ambit of the programme** by including Chronic Obstructive Pulmonary Disease (COPD) and Asthma, Non-Alcoholic Fatty Liver Disease (NAFLD), Pradhan Mantri National Dialysis Programme (PMNDP) etc.
  - **Comprehensive Primary Healthcare Non-Communicable Disease (CPHC NCD IT)** portal renamed as **National NCD Portal.**

About Non-Communicable Diseases (NCDs)

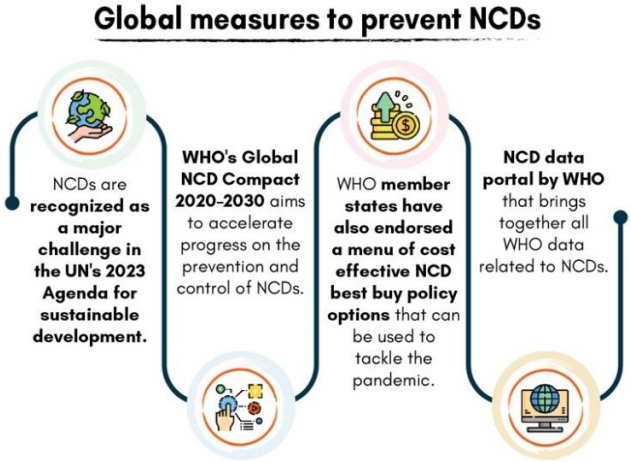
- NCDs, also known as chronic diseases, **tend to be of long duration and are the result of a combination of genetic, physiological, environmental and behaviors factors.**

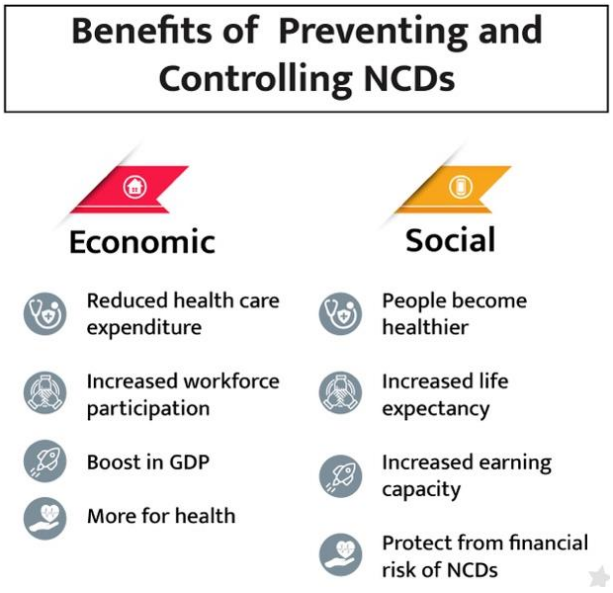
- NCDs are **not transmitted from person to person.** These diseases **persist for a long time** and are generally **slow to progress.**
- **NCDs** including heart disease, stroke, cancer, diabetes and chronic lung disease, **are collectively responsible for around 74% of all deaths worldwide.**



Measures taken by India to prevent NCDs

- **National Programme for Prevention and Control** of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS).
- **National Action Plan:** By Ministry of Health and Family Welfare launched in response to the **"WHO Global Action Plan for the Prevention and Control of NCDs 2013-2020"**.
- **Preventive aspect of NCDs is strengthened** through **Ayushman Bharat Health Wellness Centre scheme.**
- **FSSAI has banned sales and advertisements of junk foods** in school canteens and within 50 metres around school campuses.
- **FSSAI has launched 'Eat Right India' movement** to fight lifestyle diseases.
  - It also launched a **mass media campaign 'Heart Attack Rewind'** for the elimination of industrially produced trans-fat in the food supply.
- **Government** has for the first time **introduced hypertension and diabetes treatment as output indicators** (Budget 2023-24).





Way Forward

- **International cooperation and advocacy:** to increase the visibility of NCDs and highlight what can be done to tackle them.
- **Stronger health care delivery:** including strengthening a country's health workforce, ensuring that health workers all have the knowledge and resources they need to address NCDs.

Some successful interventions

- **Zambia's effort to integrate national HIV services and cervical cancer** prevention was helpful in screening more than 100,000 women for cervical cancer.
- **Many countries,** including Malaysia, South Africa etc. have used **taxation to reduce the consumption of sugar-sweetened beverages** and thereby tackling obesity and other NCDs.

A recent WHO report on NCDs made following recommendations:

- Emphasis on the **NCD Implementation Roadmap for the Global Action Plan 2023–2030.**
- Integration within **primary health care** and **support universal health coverage.**
- NCDs services should be included in the **basic benefits package for universal health coverage.**
- **Restrict the advertising on unhealthy food** or **impose a tax on unhealthy products.**

- **Health-in-all-policies approach** will play an important role in rendering visibility to the need for dialogue and consensus on the impact of policies on health in general and the NCD epidemic in particular.
- **Promoting high-quality R&D:** It can provide guidance and best practices for the planning, implementation and evaluation of various health programmes.
- **Reduce the major modifiable risk factors**, such as tobacco use, harmful use of alcohol, unhealthy diets, and physical inactivity.

4.7. GENERIC DRUGS

Why in News?

Recently, **Ministry of Health and Family Welfare** issued an alert to all the doctors in the Central Government Hospitals/ Central Government Health Scheme (CGHS) Wellness Centres / Polyclinics to prescribe generic medicines only.

Status of Pharmaceutical in India

- Pharmaceutical industry is the **3rd largest** in the world in terms of volume **and 14th largest** in terms of value.
- India is the **largest provider** of generic medicines globally, occupying a 20% share in global supply by volume.
- **Economic Survey 2022-23** estimated India's domestic pharmaceutical market **to touch $130 billion by 2030.**

About Generic Medicine

- A generic Medicine/drug is **a medication created to be the same as an already marketed brand-name drug** in dosage form, safety, strength, route of administration, quality, performance characteristics, and intended use.
- It works in the **same way and provides the same clinical benefit as the brand-name medicine.**
- Presently, there is **no definition of generic or branded medicines under the Drugs & Cosmetics Act, 1940 and Rules, 1945.**
- **Regulation of Generic Medicines in India**
  - **Indian Medical Council (Professional Conduct, Etiquette and Ethics) Regulations, 2002 by Medical Council of India:** It prescribes that every physician should prescribe drugs with generic names legibly ensure that there is a rational prescription and use of drug.
  - **National Medical Commission Act, 2019:** Empowers the appropriate **State Medical Councils** or **Ethics and Medical Registration Board (EMRB)** of the Commission, to take disciplinary action against a doctor for violation of the provision of the aforesaid Regulations.
  - **Drugs Technical Advisory Board of India (DTAB):** It allows pharmacies to sell generic medicines to patients even if the prescriptions specify the branded versions.

Initiatives to promote Generic Medicines

- **Pradhan Mantri Bhartiya Janaushadhi Pariyojana (PMBJP) in 2008 by Ministry of Chemicals and Fertilizers**: Under which PMBJP Kendras across the country will make quality generic drugs and implants accessible at affordable prices.
- **National Health Mission (NHM):** Support is provided for provision of essential generic drugs free of cost in public health facilities.
- **Production Linked Incentive (PLI) Scheme** for Promotion of Domestic Manufacturing of critical Key Starting Materials (KSMs)/ Drug Intermediates and Active Pharmaceutical Ingredients (APIs).

Reasons for promoting Generic Medicines

- **Improve medicine affordability:** Generic medicines cost less than brand-name medicines and have the same **therapeutic effect**.
  - **As per Economic Survey 2022-23, about 48.2% (2018-19) of total health expenditure** in India is financed by household out-of-pocket expenditure.
  - Medicines constitute **20% to 60%** of total healthcare expenditure.
- **Creates competition:** and creates more options.
- **Expanding geriatric population and rising comorbidities:** It helps in improving the accessibility and availability of critical medicines.
- **Expanding Generic medicine export market:** Currently, India supplies over **50% of Africa's** requirement for generics, **~40% of** generic demand in the **US** and **~25%** of all medicine in the **UK.**

Challenges in promoting Generic Medicines

- **Illegitimate drugs:** In 2018, the Central Drug Standard Control Organization (CDSCO) identified nearly **4.5%** of all generic drugs circulated in the **domestic market to be substandard.**

- **Lack of quality testing facilities:** Drug control procedures in India suffer from the lack of fund, resources, and manpower.
- **Counterfeit medicines sellers:** They operate at the retail level and procure the substandard medicines from **dubious suppliers**.
- **Perception of Patient:** There is negative perception in the patient that the quality of the medicine directly depends on the cost of it.
- **Ever-greening of Patents:** Big pharmacy companies maintain their monopoly on drug and revenue by doing minor reformulations or other iterations of the drug, **without necessarily increasing the therapeutic efficacy.**
- **Import dependency for Key Starting Materials (KSMs)/Active pharmaceutical ingredients (API):** Example- around 70-80% of the APIs are imported from China.

Way Forward

- **Clear categorization:** Drugs Controller General of India (DCGI) must state clearly whether the drug is of poor quality or is it a counterfeit drug. This can help to great extent address the issue of fake drugs.
- **Use of New Technology:** to assist with product authentication, tamper-resistant packaging and track and trace technology.
- **Awareness about Generic drugs:** among the patient about the drugs and **Pradhan Mantri Bhartiya Janaushadhi Pariyojana (PMBJP**) Kendras.
- **Strong Regulatory Framework:** that not only ensures people in the country have access to quality generic drugs but also promises the inflow of innovative drugs and medicines from across the world.
- **Providing Compulsory licensing:** Right to access of generic drugs is a human right and not granting compulsory licensing to such drugs would lead to restricting their production and access.
  - **Compulsory licensing** is when a government allows someone else to produce a patented product or process without the consent of the patent owner or plans to use the patent-protected invention itself.
  - It is included in the **TRIPS Agreement**.
- **Realigning Production Linked Incentives (PLI) for pharmaceuticals in 2021.**

4.8. WHO'S PANDEMIC TREATY

Why in News?

Recently, Members of the WHO held the first round of negotiations towards the pandemic treaty.

More about the News

- WHO is leading **two major international initiatives to address on the threat of future pandemics.**
  - **Revising the International Health Regulations (IHRs)** to improve global health alerts' speed and efficiency.
  - **Negotiating a new Pandemic Treaty** to provide a more efficient and equitable response to pandemics in the future.

International Health Regulations (IHR)-2005

- It is the **mechanism through which the WHO has handled the pandemics in the recent past,** the outbreak of COVID-19, has highlighted the flaws it contained and hence the call for a New Pandemic Treaty, became more prominent.
- These are an **instrument of international law that is legally-binding on 196 countries, including the 194 WHO Member States**.
- They **create rights and obligations for countries, including the requirement to report** public health events at regular interval.
- The Regulations also **outlines the criteria to determine whether or not a particular event constitutes a "public health emergency of international concern".**

Related News
Financial Intermediary Fund (FIF)

- A new **FIF for pandemic prevention, preparedness, and response (PPR) has been established** internationally, with financial commitments from multiple countries including India.
- **Hosted by World Bank** and with **technical support from WHO**, FIF will:
  - **Provide long-term financing** to strengthen PPR capabilities in low- and middle-income countries
  - **Address critical gaps** at national, regional, and global levels.
- FIF will help in **strengthening PPR capacity in areas such as zoonotic disease surveillance, laboratories, emergency communication,** critical health workforce capacities etc.

About the Pandemic Treaty

- WHO published a **'zero-draft' of the pandemic treaty this year**. With this, negotiations will officially begin on what the final document,

due to be presented at the World Health Assembly in 2024, will entail for global- and national-level pandemic preparedness.
    - Earlier, WHO's World Health Assembly (WHA) established an **Intergovernmental Negotiating Body (INB) to draft and negotiate a WHO convention to handle pandemic better.**
- It will **entail for global- and national-level pandemic preparedness**.
- The **draft opens the path to major multilateral negotiations** and has invited inputs from member groups.
- It aims to **prevent pandemics, save lives, reduce disease burden and protect livelihoods, through strengthening the world's capacities for preventing**, preparing for and responding to, and recovery of health systems from, pandemics.

Key highlights of the Zero draft:

- **Setting up a Global Pandemic Supply Chain and Logistics Network** to deliver the vaccines and required medicines in the event of a breakdown, to all member countries.
- **Ensuring Equality:** It **calls for reducing the inequitable access** to pandemic-related products by **increasing manufacturing capacity** that is more equitably, geographically and strategically distributed to all.
- **Empowering Innovations:** It **recognises the need to build and strengthen capacities and institutions for innovative research and development** for pandemic-related products, particularly in developing countries.
- **Establishment of the WHO Pathogen Access and Benefit-Sharing System** (the PABS System).
- **Establishment of a governing body:** comprising of:
    - **The Conference of the Parties (COP),** which is to act as the sole decision-making organ and
    - **The Officers of the Parties**, which is to act as the administrative organ of the Governing Body.
- **Expansion of WHO's authority**: to declare a pandemic and, thereby, trigger provisions in the treaty that would reallocate resources and encourage governments to waive intellectual property rights as per requirements.
- **Strengthening of the health infrastructure:** empowering the Health workforce, Protection of Human rights, Encouraging Cooperation among member countries, implementing One Health approach.

Concerns Raised

- One of the **major points of contention is intellectual property rights**- an issue that has caused a major rift between north and south.
- **Human rights are not adequately reflected and protected** in the negotiations underway around the Pandemic Treaty.
- Another contentious issue is **putting in place a system for sharing pathogens** with potential for pandemics.
- While there are measures to prepare and respond to future global health emergencies, **prevention strategies regarding spillover events are not addressed properly.**
- **Issues around data and technology sharing** are also being raised.

Conclusion

With the deadline set for 2024, the clock is ticking fast. On one hand, it **responds to the sense of urgency** for the matter at hand.

On the other hand, it **raises questions about whether countries will be able to overcome such huge divergences** in a little over a year and reach the needed consensus.

There is a **need to ensure effective and meaningful participation by all stakeholders** to have a strong treaty to act against future pandemics.

4.8.1. GLOBAL HEALTH ARCHITECTURE AT A GLANCE

GLOBAL HEALTH ARCHITECTURE AT A GLANCE

- Broadly thought of as the **world's endeavour to organise itself in health-related matters** that go beyond individual state boundaries.
- Refers to **systems and policies that prioritize allocation of resources,** coordinate different actors' **initiatives and policies, incentivize innovation and collaboration, and govern the participation of different state and non-state actors.**
- It pertains to **issues of global health governance** with political, financial, technical and operational implications.

Need for a Global Health Architecture

- **Global health system's failure to prevent the COVID-19 pandemic** has brought urgency to efforts to strengthen the way countries and the world prepare for, prevent, detect and respond to health emergencies.
- **In the globalised world,** addressing the global burden of disease, and promoting healthy lives, **needs cross-sectoral action.**
- There are also **large inequalities** among nations in **the distribution of health risks** and the **resources to address them.**

Challenges for a Global Health Architecture

- **Global health marketplace has become too fragmented** and unwieldy to be effective, imposing significant transaction costs on those engaging with it.
- **Countries with greatest command** over resources have **tended to hold the greatest sway** over agendas and implementation.
- **The emergence and re-emergence of epidemic-prone diseases** continues to accelerate; **ecological degradation and climate change** continue to intensify; and social and economic inequalities continue to widen.

Initiative taken for a Global Health Architecture

- **Intergovernmental Negotiating Body** to draft and negotiate a WHO convention, agreement or other international instrument on pandemic prevention, preparedness and response.
- WHO held the **first round of negotiations** towards the **pandemic treaty.**
- WHO Member States considering targeted **amendments to the International Health Regulations.**

Way Forward

- **Strengthening the central role of WHO** to set rules, coordinate initiatives and to guide health policy and programmes through its important regional and country work.
- **Managing diversity in health systems** for more coordination between initiatives and greater alignment with country systems and processes are highly desirable.
- **Enabling systematic and meaningful participation by non-state actors** not only to strengthen the legitimacy of decision-making but also because more diverse perspectives can enhance the quality of results.
- **Country ownership and 'country-led global health'** as there is stronger collaboration between countries and at the regional level, both politically and in implementation.

4.9. TRADITIONAL MEDICINE

TRADITIONAL MEDICINE AT A GLANCE

- It is the **sum total of the knowledge, skill, and practices** based on the theories, beliefs, and experiences **indigenous** to different cultures, whether explicable or not, used in the maintenance of health as well as in the **prevention, diagnosis, improvement or treatment of physical and mental illness.**
- **Major traditional and complementary medicines(T&CM) in India include:** Ayurveda, Yoga, Siddha, Unani, Sowa-Rigpa, Naturopathy etc.

Advantages of mainstreaming T&CM

- **Less capital intensive:** Relatively low levels of technological inputs are required.
- **Enhancing the accessibility to public health facilities in remote areas:** As proportion of Ayush doctors in some of the poorest part of the country is high.
- **Holistic approach to treatment:** So, to treat any illness, the system takes- body, mind, soul and senses- all into account.
- **Improving doctor to patient ratio:** In India, the **ratio of the doctor-patient is about 1:1400** (WHO recommends 1:1000) if we consider only allopathic doctors; the ratio will **come to 1:800 if the AYUSH practitioners are added.**
- **Effective in managing chronic diseases:** Scientific studies show their use is effective, e.g., for HIV/AIDS and cancer patients.

Challenges in mainstreaming T&CM

- **Unregulated:** Traditional Medicine products raise concerns about safety and quality of medicinal products.
- **Skewed financing:** In Budget 2023-24, Ministry of Health and Family Welfare was allocated about ₹ 89,155 crore whereas the Ministry of AYUSH was allocated only ₹ Rs 3,647.50 crore.
- **Low acceptance of AYUSH:** As per National Sample Survey adoption rate of AYUSH decreased to 4.54% in 2017-2018(from 6.43% in 2014).
- **State subject:** Health being a state subject adds an extra layer of complexity to any national level initiative.

Initiatives taken to promote traditional medicine system

- Centrally Sponsored Scheme of **National AYUSH Mission (NAM).**
- **Ayush Export Promotion Council** (AEPC) to stimulate exports.
- **AYUSH Information Cell** have been set up in over 30 countries.
- Ministry of AYUSH has signed **MoUs for setting up AYUSH Academic Chairs** with foreign Universities/ institutes and **for cooperation in field of Traditional Medicine and Homoeopathy.**
- Scheme for **Voluntary Certification of Yoga Professionals.**
- **International Day of Yoga** and Ayurveda day is celebrated in many countries.
- **Incentives are provided to AYUSH drug manufacturers,** entrepreneurs, AYUSH institutions, etc.

Way ahead

- **Bridging the financing gap:** by giving equal emphasis to both AYUSH as well as Allopathy system. PPP could also be utilised to ensuring adequate funding of both the system.
- **Developing international standards & guidelines:** to promote the safety, efficacy and quality of T&CM.
- **Integration into national health system:** will enable consumers to have a wider choice when they wish to use such services.
  - **In 2020,** the Central Council of Indian Medicine decided to **allow the PG students of Ayurveda to practice various types of general surgery.**

4.10. TRADITIONAL KNOWLEDGE DIGITAL LIBRARY (TKDL)

Why in News?

Cabinet approves widening access to Traditional Knowledge Digital Library (TKDL) to users, besides patent offices.

About Traditional Knowledge (TK)

- TK is **knowledge, know-how, skills and practices that are developed, sustained and passed on from generation to generation** within a community, often forming part of its cultural or spiritual identity.
  - Until now, access to **complete TKDL database is restricted to 14 Patent Offices worldwide** for purposes of search and examination.

About TKDL

- TKDL, **first of its kind globally**, is a database of **Indian traditional knowledge established in 2001**, by Council of Scientific and Industrial Research **(CSIR) and Ministry of AYUSH**.
- It **contains information** related to **Ayurveda, Unani, Siddha, Sowa Rigpa, and Yoga in five international languages** (English, German, French, Japanese and Spanish).
- It seeks to **prevent misappropriation of country's traditional medicinal knowledge through patenting worldwide.**
  - TKDL is an **effective deterrent against bio-piracy**.
- **Significance**
  - **Inculcate thought and knowledge leadership through Bharatiya Gnana Parampara**, under New Education Policy 2020.
  - **Boost research and development and innovation** based on India's valued heritage across diverse field.
  - **Provide safer and more effective solutions** for healthier and technology endowed population.
- **Steps taken by government for TK**
  - **Biological Diversity Act, 2002** for preservation, maintenance of TK along with equitable sharing of benefits arising from use of TK with communities.
  - **India is a signatory to Convention on Biological Diversity** and **Nagoya Protocol**, which are concerned with trade-in bioresources and use of TK.

Conclusion

TKDL is proving to be an **effective deterrent against bio-piracy** and has been **recognized as a unique effort**. It has been **preventing the grant of wrong patents** by ensuring access to TK related prior art for patent examiners **without restricting the use of traditional knowledge.**

5. ACHIEVEMENTS OF INDIANS IN SCIENCE & TECHNOLOGY; INDIGENIZATION OF TECHNOLOGY AND DEVELOPING NEW TECHNOLOGY

5.1. ACHIEVEMENTS OF INDIANS IN SCIENCE & TECHNOLOGY

5.1.1. ACHARYA JAGADISH CHANDRA BOSE (J.C. BOSE)

Why in News?

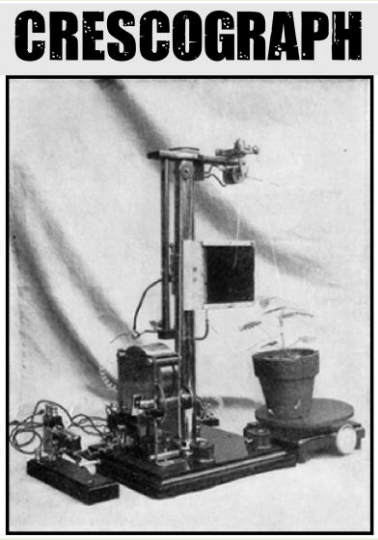
Ministry of Culture organized an international conference on the occasion of **164th birth anniversary** of **the Indian scientist Acharya Jagadish Chandra Bose (J.C. Bose**)

About J.C. Bose (1858-1937)

- **He was an Indian Physicist and plant physiologist.**
- Born in **Munshiganj, Bengal Presidency**, British India (currently, **in Bangladesh**). J.C. Bose did his **B.A in Natural Sciences** from **Cambridge University and on his return to India in 1885,** he was appointed **professor** at **Presidency College, Calcutta**.
- Inspired by **nationalist ideals, he** founded **the Bose Institute in 1917.**
  - It was **Asia's first modern research centre** which focussed on **interdisciplinary research**.
- He was **the first Asian** to be awarded **a US patent in in 1904** and **first Asian along with Srinivasa Ramanujan FRS,** to become **the fellows of the Royal Society (FRS) in 1920**.
- He was **the president of the 14th session** of the **Indian Science Congress in 1927.**

Crescograph

- Bose **invented** the instrument Crescograph which demonstrated **the minute movements of plants** subjected **to external stimuli** and **measure their rate of growth.**
- It can detect movement as small as **1/100,000 of an inch.**



How Acharya J.C. Bose proved that plants have life?

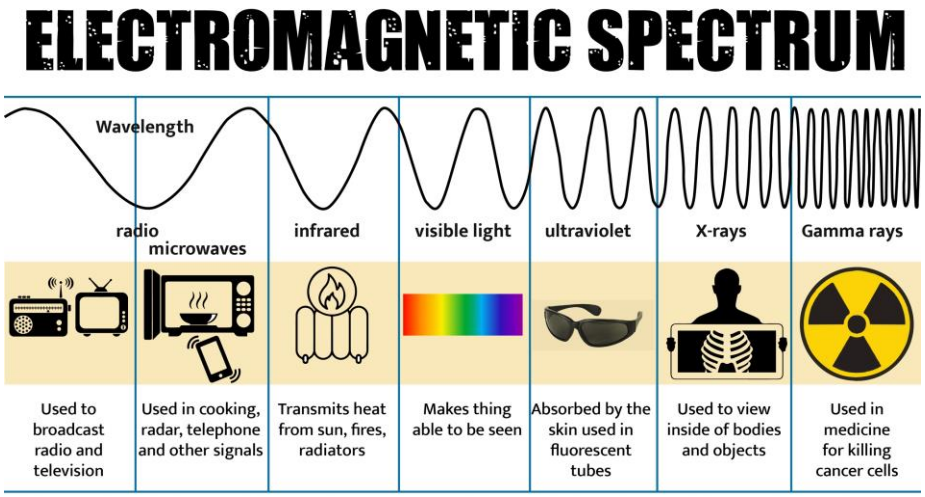
He established the following through his experiments-

- **Plants live and die**: In one of his experiments, the plant was dipped in bromide (a poison). The **pulse beat** of the plant (similar to pulse of an animal) measured by **Crescograph** became **unsteady** once the plant started taking in the poison, **proving that plants have life.**
- **Plants feel pleasure and pain:**
  - He wrote how plants grew **more quickly** when exposed **to nice music and gentle whispers**, and **poorly** when exposed **to harsh music and loud speech.**
  - He also mentioned **how plants became depressed** when exposed to **polluted air and darkening skies.**

Other contributions of Acharya J C Bose

- **Contributions in Physics:**
  - He was a pioneer in research **on millimeter waves** (it is the band of spectrum with wavelengths between 10 mm and 1 mm) and in the arena **of microwave devices.**
  - He developed **the World's first wireless communication link at 5-mm wavelength** using **a spark transmitter** (generates radio waves by means of electric spark) and **a spiral 'coherer'** (an instrument that detects radio waves) **as the receiver**.
    - ✓ **Bose's coherer** was used by **Guglielmo Marconi** to build an **operational two-way radio.**
  - Since the science behind radio technology was first explained by Bose **the Institute of Electrical and Electronics Engineers (IEEE**) called him the '**Father of Radio Science**'.

- **Contribution in Biology:**
  - He researched the **seasonal effect on plants** and also **the effect of chemical inhibitors (substances which slow down chemical reactions) and temperature on plants.**
  - He showed that **the living cells of the innermost layer of the cortex** (an outer layer of a stem or root in a vascular plant) were in a state of **pulsatory motion** (similar to rhythmic beating of the heart).
    - ✓ This pulsation caused **the pumping of water from cell to cell in an upward direction.**
  - In this field, his two major works include **'Response in the Living and Non-Living'** and **'The Nervous Mechanism of Plants.'**



- **Literature:** J.C. Bose is also regarded as **the first science fiction writer in Bengali.**
  - He authored **'Niruddesher Kahani', The Story of the Missing One (1896),** which was **one of first works in Bengali Science fiction.**
  - **Polatok Tufan:** This science fiction was published in a collection of mostly non-fictional writings Abyakto (1921).
    - ✓ In this short story, J.C. Bose, used the literary instrument called **Magic Realism** to challenge western knowledge that was the root to colonial powers and its institutions.

J.C. Bose: A Satyagrahi Scientist—

- He used **satyagraha** as a tool **against salary discrimination** by British administration.
- Bose revolted **against the strict compartmentalisation in discipline** and asserted that the **Eastern aim is to investigate the multiplicity of the phenomena.**

J C Bose's legacy and relevance of his work for the present times

- He taught great minds like **Satyendra Nath Bose** (Boson was named after him), **Meghnad Saha, P C Mahalanobis,** etc. who went to become famous scientists of India.
- **Pioneering work in Millimetre wave**: In telecommunications, **millimeter wave is used for a variety of services on mobile and wireless networks**, as it enables higher data rates.
- **Biophysics and cybernetics:** His measurements of the effect of **electromagnetic radiation on plant growth** is becoming an **important area of plant biophysics and cybernetics**.
  - **Biophysics**: This field applies the theories and methods of physics to understand how biological systems work.
  - **Cybernetics**: The science of control and communications between animals and machines.
- Alongside the scientific contributions of J C Bose**, Rabindranath Tagore** found in his works an essence **of Indian scientific spirit, a reflection of Indian national culture, its national pride and heritage.**

6. MISCELLANEOUS

6.1. OTHER NOBEL PRIZE

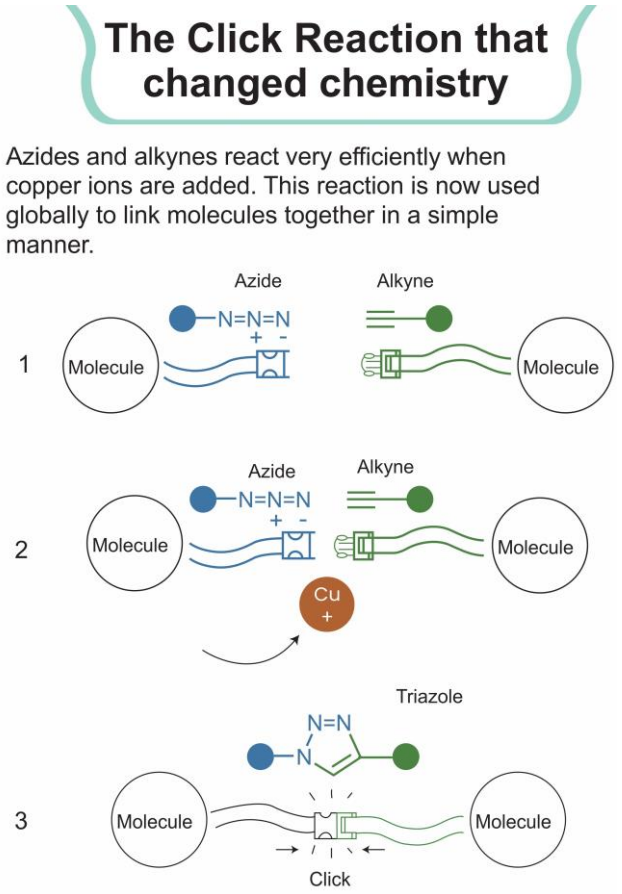
6.1.1. NOBEL PRIZE IN CHEMISTRY 2022

Prize awarded for: the development of click chemistry and bioorthogonal chemistry.

Awardees: The prize was given to **Carolyn R. Bertozzi (USA), Morten Meldal (Denmark)** and **K. Barry Sharpless (USA)**.

About Click Chemistry and Bioorthogonal Chemistry

- **K. Barry Sharpless** (his second Nobel prize) and **Morten Meldal** have laid the **foundation of click chemistry**- a branch of science in which molecular building blocks snap together quickly and efficiently.
  - **Click Chemistry** is defined as a set of powerful, selective, and modular blocks that work reliably in both small- and large-scale applications.
  - Instead of trying to make carbon atoms react with each other, **click chemistry focuses on using smaller molecules that already have a complete carbon frame.**
  - One such reaction is **copper-catalysed azide-alkyne cycloaddition (CuAAC)** that is now widely used medicinal chemistry (refer **image**).
- **Carolyn Bertozzi** developed **click reactions that work inside living organisms to map important but elusive biomolecules** on the surface of cells **called glycans.**
  - Also known as **Bioorthogonal reactions,** these reactions take place without disrupting the normal chemistry of the cell.



Significance of the Work

- **Development of enzyme inhibitors and receptor ligands, pharmaceuticals (anticancer agents, antimicrobials etc.), herbicides, photostabilizers, etc.**
- **Mapping of complex biological processes** like DNA and **creating unique materials.**
- Bioorthogonal Reactions are used **to explore how cells function** and **track biological processes.**
  - This has helped in **improved targeting of cancer pharmaceuticals.**

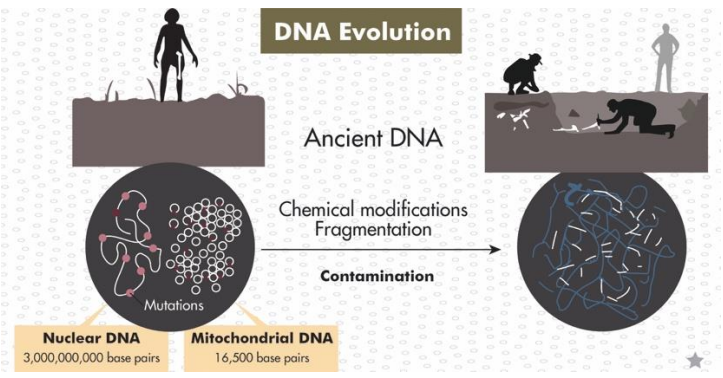
6.1.2. NOBEL PRIZE IN PHYSIOLOGY OR MEDICINE 2022

Prize awarded for: discoveries concerning the genomes of extinct hominins and human evolution.

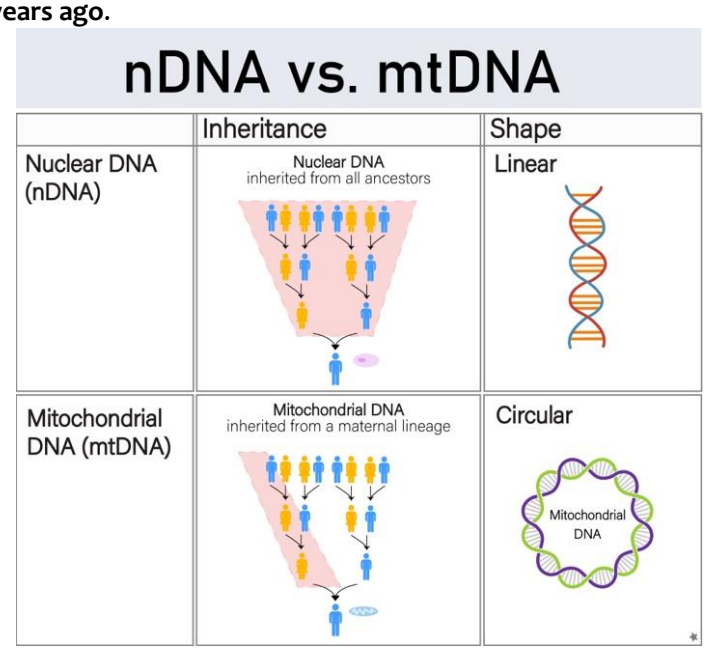
Awardee: Prize was given to Swedish geneticist **Svante Pääbo**.

About his discoveries on human evolution

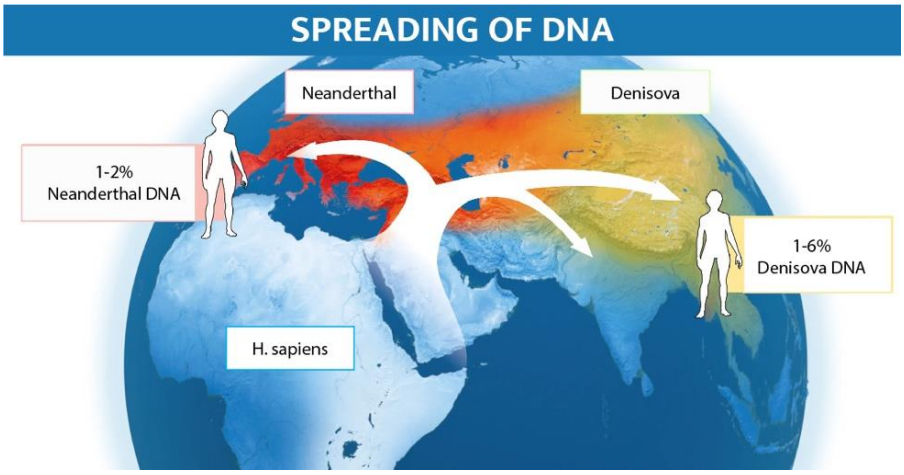
- He sequenced the genome of the **Neanderthal,** an extinct relative of present-day humans.



- Neanderthals developed **outside Africa** and populated **Europe** and **Western Asia** from around **400,000 years**. They went extinct around **30,000 years ago**.
- He analyzed and sequenced the **mitochondrial DNA** (mtDNA) of Neanderthals – demonstrating that Neanderthals were **genetically distinct**.
- Though the **mtDNA** is small and contains only a fraction of genetic information, it is present in thousands of copies for sequencing.
- In comparison, the **Nuclear DNA (nDNA)** tends to degrade and modify chemically over time, making it difficult to sequence them.



- He made the discovery of a previously unknown hominin, **Denisova**.
  - **Denisova** was discovered in **2008** from a cave in the southern part of **Siberia**.
- He also found that **gene transfer** had occurred from these now extinct hominins to Homo sapiens following the migration out of Africa around 70,000 years ago.
  - **Homo sapiens**, or anatomically modern human, first appeared in Africa approximately **300,000 years ago**.
  - About **70,000 years ago**, groups of Homo sapiens **migrated from Africa to the Middle East** and, from there they spread to the rest of the world (refer **image**).



Significance of his work

- His research gave rise to a new scientific discipline called **paleogenomics**, i.e. the study and analysis of genes of ancient or extinct organisms.
- His work on differences between living humans from extinct hominins is useful for:
  - **Better understanding** of human evolution and migration.
  - **Understanding** how the ancient flow of genes influences humans today. E.g.
    - ✓ **Neanderthal genes** affect our **immune response** to different infections, and
    - ✓ Denisovan version of the gene EPAS1 confers an **advantage for survival at high altitude** (commonly found among **Tibetans**).

Path of Human Evolution

	Adaptation
Primates (An order of Mammals)	Forward facing eyes, Larger Brain, Menstrual Cycle, Claws became nails
Hominidae (Great Apes)	Turned bipedal in later parts, flat and widened rib cage, flexible wrists
Genus Homo (Contemporary Humans)	
Homo Erectus	Introduced clothing, fire and constructed the wheel
Homo Neanderthalensis	Brain size stabilizes, trunk and extremities elongate, Reduction in body hair.
Homo Sapiens	Protruding Nose, decrease size in jaws and teeth.

6.2. ATOMIC/NUCLEAR FIELD ADVANCEMENTS

6.2.1. NUCLEAR ENERGY IN INDIA

NUCLEAR ENERGY IN INDIA AT A GLANCE

- **Present installed** nuclear power capacity is **6780 MW comprising of 22 operational nuclear power reactors.**
- Of the total installed capacity of 4,16,91 MW (April 2023), **Nuclear contributed 1.6%.**
- India is **currently on second stage** of the **3-stage nuclear energy program,** envisioned by Homi Bhabha, which is based on a closed nuclear fuel cycle.

Significance of Nuclear energy for India

- It is a **clean and environment friendly source** of electricity generation, which is **available 24X7.**
- Nuclear power grid **helps India to provide low-cost power** and assist in Grid balancing.
- Will **help in the country's energy transition** for meeting the **goal of net zero economy.**
- **A strong civilian nuclear sector** is essential in global arena to **influence the peaceful use** of nuclear technologies.
- With operational upgradations, nuclear plants **can produce hydrogen and help decarbonising other sectors** of the economy.

Challenges for India's Nuclear energy program

- **Safety concern:** Accidents in nuclear power plants may lead to radiation harm in absence of adequate precautionary measures and redressal mechanisms.
- **Land requirements:** There has been opposition and local protests to the government plans of land acquisition to develop nuclear energy plants.
- **Import dependency on fuel requirements:** In terms of uranium required for operational reactors as well as reactors planned for the near future, India looks set to continue importing uranium.
- **Manufacturing and manpower needs:** India's current manufacturing capability lacks heavy engineering components and delicate and precision-engineered equipment requirement for nuclear power plants.
  - Also, India currently faces a shortfall in nuclear scientists and engineers.

Measures taken to enhance generation from nuclear power plants

- **Conclusion of fuel supply contracts** with several countries under IAEA Safeguards and augmentation of fuel supplies from domestic sources.
- **Resolution of issues related to Civil Liability for Nuclear Damage** (CLND) Act & Creation of Indian Nuclear Insurance Pool.
- **Amendment of the Atomic Energy Act** to enable Joint Ventures of Public Sector Companies to set up nuclear power projects.
- **Enhanced project monitoring** through Pro-Active Governance And Timely Implementation "PRAGATI" platform.
- **Global Centre for Nuclear Energy Partnership** for training in the field of nuclear technology.

Way Forward

- **Structured plan for effective management of radioactive wastes** should involve characterisation, segregation, handling, treatment, conditioning and monitoring.
- **Ensure Safety, cost and efficiency** while drafting action plans for nuclear energy promotion, with the local community and environment occupying a central position in the process.
- **Building societal awareness** and decoding the negative connotations around nuclear power generation with scientific know-how.
- **Optimal regulatory regime** to assess the safety requirements and compliances.
- **Public-private partnership** with necessary policy support, free flow of authentic information and careful impact assessment on diverse stakeholders.

6.2.2. NUCLEAR FUSION

Why in news?

In a fusion experiment using lasers, the scientists at Lawrence Livermore National Laboratory in California achieved a net energy gain for the first time.

More about news

- Scientists for the first time ever, were able to achieve ignition in **nuclear fusion i.e., creating a nuclear reaction that generates more energy than it consumes.**
- Powerful lasers were used to heat and compress hydrogen nuclei. **When the nuclei fuse, they release heat.** When this heat is equal to or greater than the heat delivered to the container, the event is called ignition.
- The experiment reportedly achieved ignition with a **gain of 1.53** with a **yield (net energy from the reaction) of about 3 megajoules.**

Why India should Invest in Nuclear fusion?

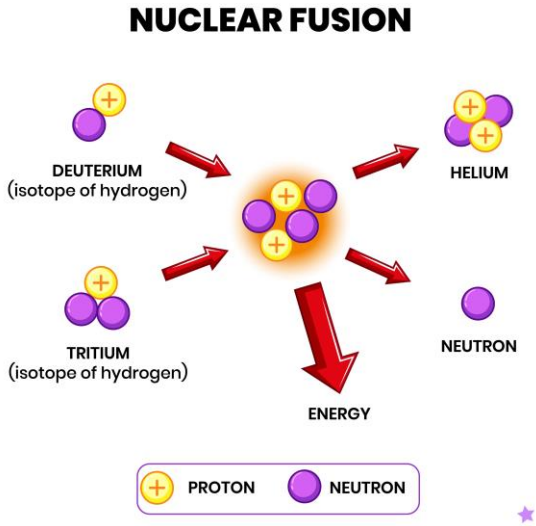
Lack of fossil fuels: India is not endowed with the required resources either for hydrocarbon energy or nuclear fission-based energy.

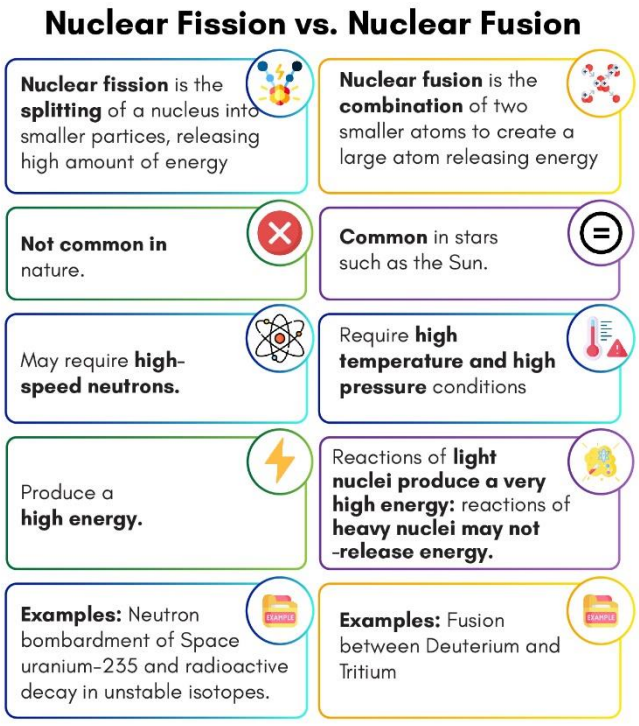
Long-term plan: India's declared net-zero goal in 2070 allows us enough time for fusion to become a practical and preferred complement to renewables.

Rising Energy Demand: Fusion with a high density of energy can help in meeting the increasing demand.

What is Nuclear Fusion?

- Nuclear fusion is the process by **which two light atomic nuclei (for example tritium and deuterium)** combine to form a single heavier (**Helium)** one while releasing massive amounts of energy.
- Fusion reactions **take place in a state of matter called plasma** a hot, charged gas made of positive ions and free-moving electrons with unique properties distinct from solids, liquids, or gases.
- **Conditions required to achieve fusion**
  - **Temperature** of **more than 100 million degrees Celsius.**
  - **Maintaining a high enough density for a long enough time** so that the rate of fusion reactions will be large enough to generate the desired power.





Types of Nuclear Fusion: Inertial and Magnetic

- **In an inertial fusion (used in the present experiment),** laser or ion beams are focused very precisely onto the surface of a target, which is a pellet of fuel, a few millimetres in diameter. This results in very high temperatures.
- **Another method is Magnetic fusion,** in which, hundreds of cubic meters of plasma at a density of less than a milligram per cubic meter are confined by a magnetic field at high pressure and heated to fusion temperature.
- It is relatively easier to attain **break-even energy levels through inertial fusion** compared to magnetic fusion.

Advantages of Nuclear fusion power generation

- **Abundant energy:** Fusion releases nearly four million times more energy than a chemical reaction such as the burning of coal, oil, or gas and four times as much as nuclear fission reactions (at equal mass).

- **Sustainability:** Fusion requires two elements i.e. deuterium and tritium, both available much easier.
- **Zero CO_2:** Its major by-product is helium: an inert, non-toxic gas.
- **Limited risk of proliferation:** Fusion doesn't employ fissile materials like uranium and plutonium.
- **No risk of meltdown:** as quantity of fuel present in the reactor at any one time is enough for a few seconds.
- **No long-lived radioactive waste.**

Major challenges

- **Time-taking process:** energy released by the reactions needs to be greater than the energy going into the lasers.
- **Difficult to sustain such extremely high temperatures** for prolonged periods.
- Developing much **powerful and devastating fusion-based nuclear weapons.**
- **Huge energy requirements** for creating conditions for fusion reactions.

Initiatives in the world

International Thermonuclear Experimental Reactor (ITER) Assembly: In southern France, 35 nations including India are collaborating to build the world's largest tokamak, a magnetic fusion device that has been designed to prove the feasibility of fusion.

China's Artificial Sun: The Experimental Advanced Superconducting Tokamak (EAST) device replicates the nuclear fusion process carried out by the sun.

Steady State Tokamak-2 (SST-2): India's attempt at an **experimental fusion reactor** at the Institute of Plasma Research in Gujarat.

The Joint European Torus (JET): It is a joint European project to future nuclear fusion grid energy.

Way forward

The way forward for India's nuclear fusion policy will involve continued investment in research and development, as well as collaboration with international partners. India's participation in the ITER project is a major step towards this goal, as the project aims to demonstrate the feasibility of nuclear fusion as a source of energy.

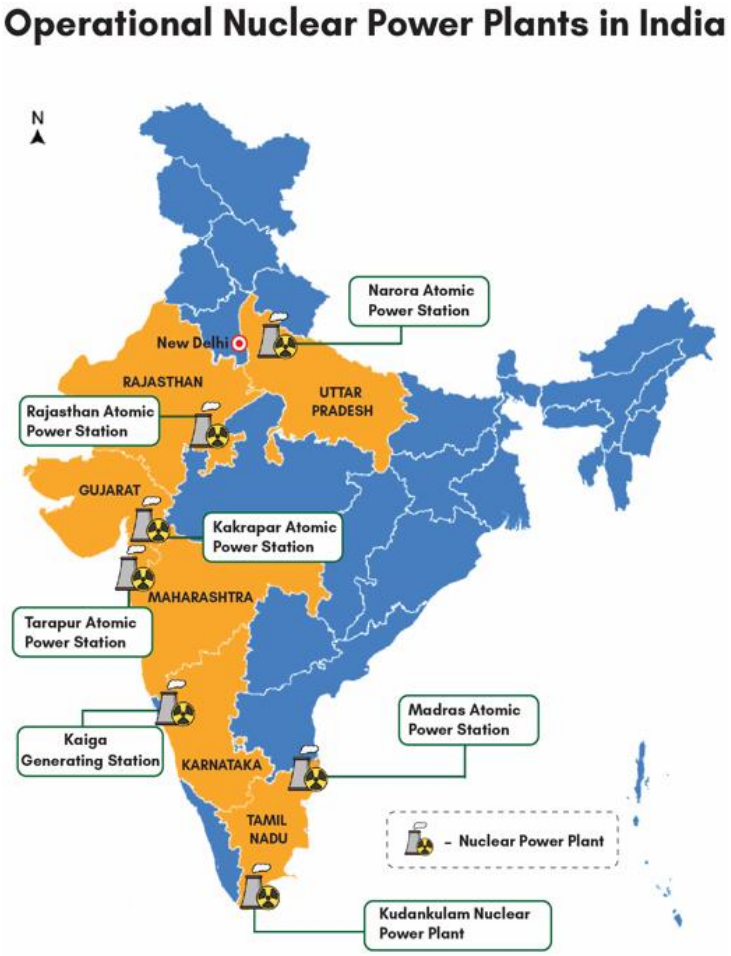
6.2.2.1. INDIA'S THREE-STAGE NUCLEAR ENERGY PROGRAM

Why in News?

Haryana's first nuclear power plant- Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP) will have **two units of 700 MWe capacity each of Pressurised Heavy Water Reactor (PHWR).**

About India's Nuclear Program

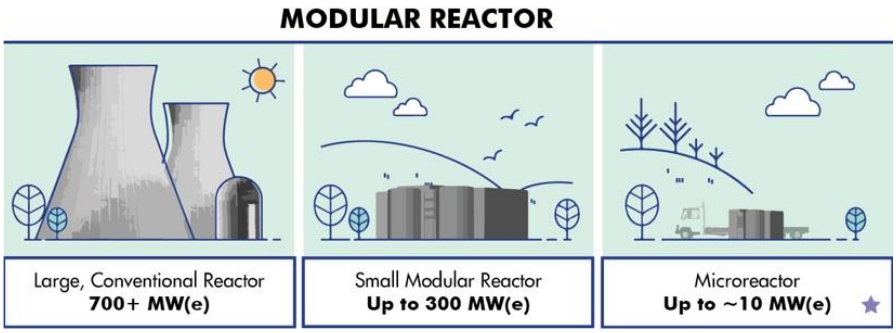
- India's **3-stage nuclear energy program,** envisioned by Homi Bhabha, is based on a closed nuclear fuel cycle.
  - **Stage-I: PHWRs fuelled by Natural uranium would produce plutonium-239. Heavy water (D2O)** is used as **moderator and coolant in PHWR.**
  - **Stage-II:** Fast Breeder Reactors utilising **plutonium- 239 fuel from first stage** and formed **uranium-238.**
  - **Stage-III:** Advanced nuclear power systems for **utilisation of thorium.**
- India successfully **reached the first stage in 2013** with over 22 nuclear reactors (18 PHWRs, and 4 Light Water Reactors) in 7 nuclear power plants (refer map).
- **India is currently on second stage of program.**
  - Nuclear energy is **fifth-largest source of electricity for India.**



6.2.2.2. SMALL MODULAR REACTORS (SMR)

Why in news?

A report on the 'Role of Small Modular Reactors in the energy transition' was recently released by the NITI Aayog.



About SMRs

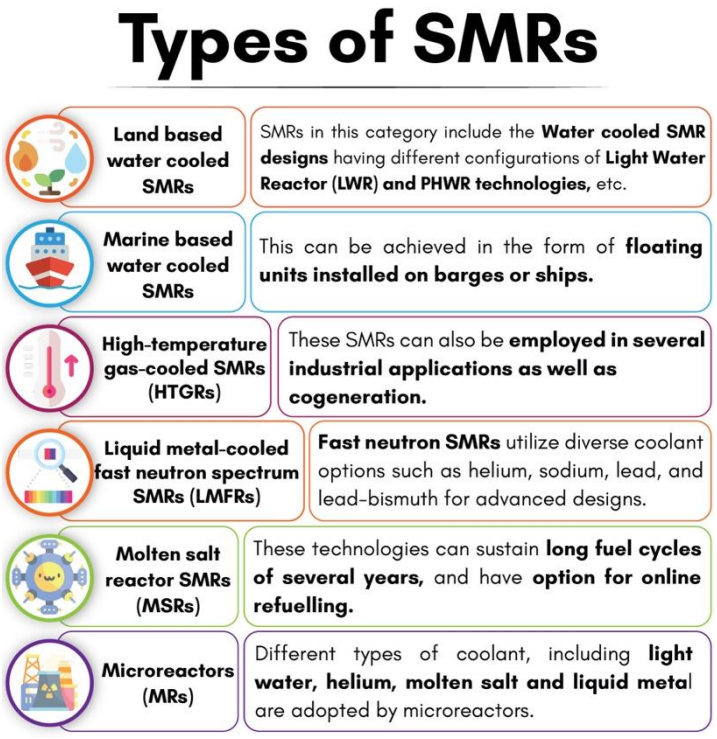
- As per the International Atomic Energy Agency (IAEA), the **SMRs are advanced nuclear reactors with a power generation capacity ranging from less than 30 MWe to 300+ MWe.**
- The global market for SMRs is expected to be **$300 billion a year by 2040.**
- As of now, two SMR projects, one each in Russia and China, have reached at operational stage globally.

Advantages of SMRs

Specification	Description
Adaptable and scalable	• SMRs **can be scaled up or down to supply more or less power.**
Longer refuelling interval	• SMR-based power plants might only need to refuel **every three to seven years,** as opposed to every one to two years for traditional plants.
Compact design	• **Land requirement in the case of SMRs are less** as compared to land requirements for large reactors and renewable energy sources.
Passive safety features	• Its reliance on the **laws of physics to shut down and cool the reactor** under abnormal circumstances, provide inherent safety. o In **most cases**, these technologies **don't need a power supply** and can handle accidents without the **assistance of a person or a computer**. o **A molten salt reactor with a freeze stopper** is an example of a passive safety mechanism.
Economical	• Low capital outlay and/ or a phased capital expenditure is needed. o Also, they have the adaptability to allow **co-generation, supply heat for desalination and manufacturing etc.** o When coupled with variable energy sources SMRs **can mitigate fluctuations on a daily and seasonal basis.**

Challenges of SMRs

- **Nuclear waste generation:** SMRs are inferior to conventional reactors with respect to radioactive waste generation, management requirements, and disposal options.
- **Economies of scale:** SMRs produce relatively small amounts of electricity in comparison to large nuclear power plants. SMRs will, therefore, cost more than large reactors for each unit (megawatt) of generation capacity.
- **Lack of regulations:** Regulatory and other barriers preventing their construction are substantial making process of getting safety approvals for SMRs longer and more expensive.
- **Supply chain issues:** Supply chains for the SMR industry **may need consolidation** in order to capitalise on economies of scale, as witnessed in the aviation industry.



- **Financing:** According to the IEA, annual global investment required for nuclear power expansion is around **USD 100 billion by 2030**.

Way ahead for adoption of SMRs

- **Updating regulatory frameworks:** to allow various kinds of SMR technologies and designs.
- **Updated safety assessment methodology:** Define emergency planning zone for SMRs, follow Standard Operating Procedures (SOPs) for safe handling of spent-fuel and reprocessing.
- **Standardisation of design**: It will open the possibility of **repetitive manufacturing** in a better quality-controlled environment of a factory including Industry 4.0 paradigm.
- **Catalyse private investment:** This could be done through inclusion in green taxonomy and utilization of innovative financing instruments such as blended finance, green bonds, etc.
- **Human resource**: Ensure availability of required skilled personnel across the value chain of engineering, design, testing, inspection, construction, etc.

Microreactors

- **Microreactors** are small modular nuclear power plants that have a capacity of **fewer than 10 megawatts (MW).**
- They are expected to operate for years without refueling including the need to generate power on a **small scale in remote locations, at deployed military installations, and in locations recovering from natural disasters**.

Conclusion

SMR may complement large-size reactors in many countries to increase the nuclear share in their energy mix and achieve Net Zero Emissions goals. The respective governments and local authorities have to play a major role in consensus building towards nuclear energy by engaging relevant stakeholders**.**

6.3. TECHNOLOGY IN GOVERNANCE

Why in news?

Recently, Prime Minister stated that India has embraced technology to revolutionise governance and uplift service delivery.

Need for technology in governance

- **Driving optimization and efficiency and transparency** across all sectors today, including the public and private sectors.
- **Providing of high-quality government services** to citizens and businesses, with equal access and equal treatment to the rich and the poor.
- Can add **value towards areas such as online transactions, government subsidy transfers**, and procurement to enhance efficiency and productivity.
- **Improving government effectiveness**, that includes, among other things, control of corruption and efficient delivery of public goods such as education, health, social security, and transport.
- **Shaping Public policy** by bringing technologists and policymakers together.

With the launch of the 'Digital India' program, Government of India has bolstered transparency and governance in the country.

Some prominent examples include:

- **National ID systems:** Aadhaar digital ID program used to deliver government subsidies, benefits, and services, to improve governance etc.
- **In healthcare:** For example, National Digital Health Mission to create a national digital health ecosystem.
- **In policing:** Many state governments have begun to use face recognition technologies, AI, and Machine learning to control crime, monitor traffic, etc.
- **In the Financial domain:** India stack is the largest open Application Programming Interface (API) in the world.
- **In Education:** Diksha is a national-level educational platform that helps students and teachers to participate, contribute and leverage a common platform to achieve learning goals.
- **SVAMITVA** uses drone technology for mapping land parcels, providing a 'Record of Rights' to village household owners.
- **Disaster relief agencies** have used drones as part of their operations.

Challenges in adopting technology in governance

- **Adverse effect of technology through misuse:** in ways that can be detrimental to society.
- **Limited or lack of regulation:** towards consequences that could arise due to the use of transformative technologies.

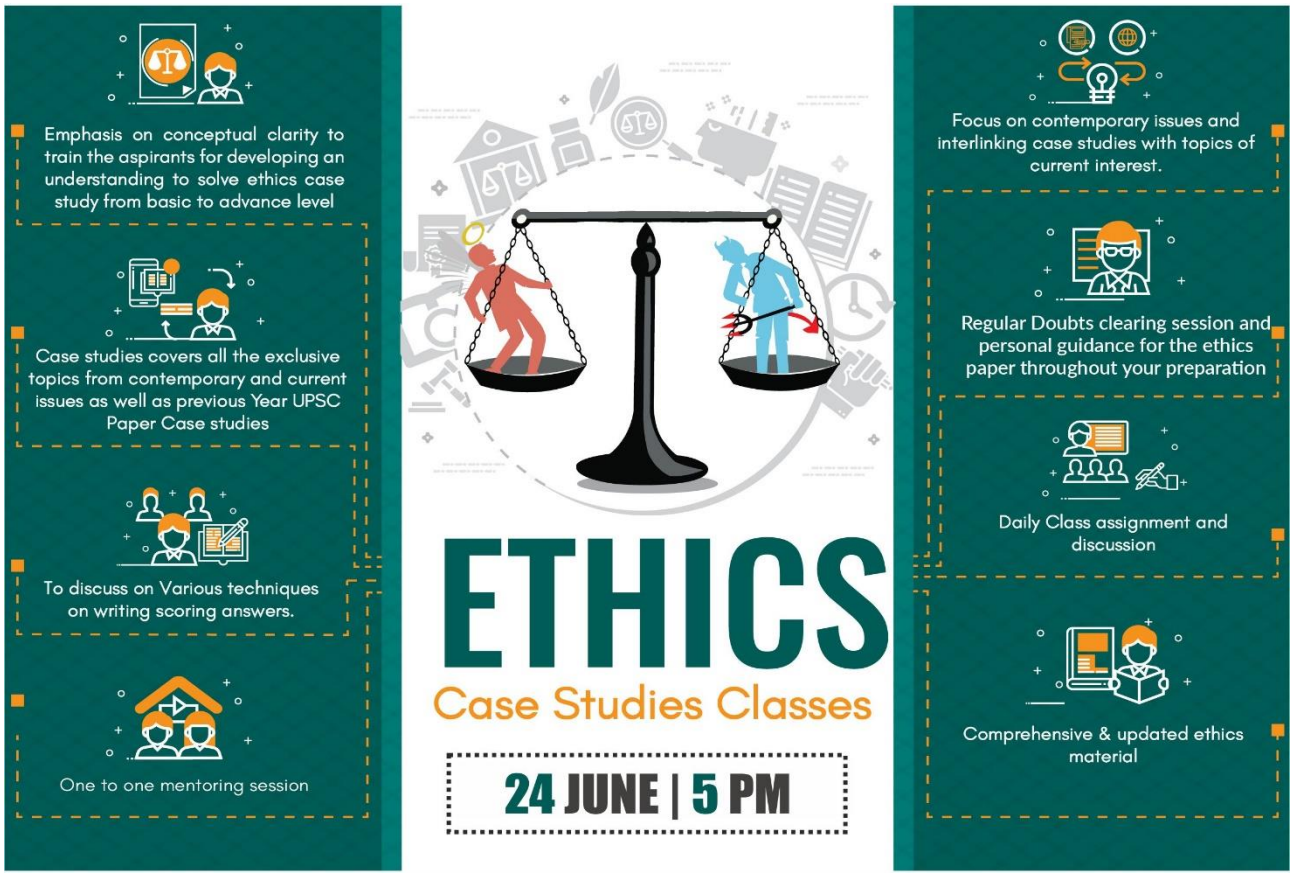
- **Privacy and Data Sharing:** as at present there is little in the way of shared technical standards or governance frameworks to regulate how such information can be dispensed.
- **Dominance of Private sector:** Private sector entities, particularly Big data companies like Amazon, may have significant influence over the development and governance of technology, potentially undermining the interests of other stakeholders.
- **Lack of rules** in the cases of misuse of technologies by government agencies.
- **Vulnerabilities and exposure** of fast-expanding digital networks to cyberattacks.

Way Forward

- **Developing impetus in** three key thrust areas: **Advanced education** focused on innovative research and development, **Government-funded research**, **Industry-academia collaboration** to commercialize the innovation.
- **Tweaking of the fundamental governance machinery and processes** is imperative to ensure the effectiveness of technology.
- **A better oversight mechanism in governmental processes** will bring about transparency, build trust with citizens and spur further digital innovation to make any administration more robust.
- There is a need for **government, public bodies and regulators to raise awareness** further to enable wider and well-informed technological adoption.
- **Anticipatory governance approach** to predict innovation and disruption outcomes.

Some technologies that can further improve governance

- **Artificial Intelligence and Analytics:** Governments can harness citizen's data and behavior based on interactions with agencies and digital websites. The intelligence collected can offer personalized public services to citizens, derive actionable insights, and help them predict future trends.
- **Blockchain:** A NITI Aayog paper identified use-cases where the technology can potentially improve governance ranging from tracing of drugs in the pharmaceutical supply chain to verification of education certificates.
- **IoT:** IoT solutions involve a broad deployment of IoT sensors across the city, providing real-time data about city events; a centralized system analyses data and improve decision-making in cities' governance.
- **Cloud computing:** It has immensely transformed the way IT is consumed and managed, resulting in higher and improved cost efficiencies, a faster time-to-market, and enhanced scalability of applications-on-demand.
- **Digital twins:** are poised to innovate and transform the sectors involving capital-intensive assets and processes such as energy, utilities, and manufacturing are pioneering digital twin use cases globally.



6.4. USE OF TECHNOLOGY IN AGRICULTURE

AGRICULTURE AND TECHNOLOGY AT A GLANCE

Drivers of Agricultural technology growth in India

- **Increasing population, increasing average income and globalization effects** increase demand for quantity, quality and nutritious food, and variety of food.
- **To build an agriculture and food system that is efficient, environmentally sustainable, equitable,** and able to link farms with consumers.
- **India is the third-largest nation in terms of funding received and start-ups in the agritech space.** Agritech is projected to grow to a $30-$35 billion market by 2025.

Applications of technology in Agriculture

- **Crop and soil monitoring** (where companies are leveraging sensors and internet of things, or IoT-based technologies.
- **Predictive and agricultural analysis** (where artificial intelligence and machine learning, tools are used to predict the optimal time to sow seeds or to raise alert about possible pest attacks)
- **Real-time data analytics** to build an efficient and smart supply chain

Schemes/Initiatives

- **National e-Governance Plan in Agriculture (NeGPA)** for timely access to agriculture related information through ICT use.
- **AI-Sowing App** developed in collaboration with International Crops Research Institute for the Semi-arid Tropics (ICRISAT).
- **ISRO's Geo-platform, Bhuvan**, provides valuable data on the plantation, pest surveillance and weather.
- Krishi Vigyan Kendras (KVKs) mandated with **Technology Assessment and Demonstration for its Application and Capacity Development (TADA-CD).**
- **Agristack**, a unified platform for provision for end-to-end services.
- Promotion of **Kisan Drones** for crop assessment, digitization of land records, spraying of insecticides and nutrients.

Constraints

- **High transaction cost** because of small farm holdings, shortage of power and infrastructure, insufficient human capital investments.
- **Surplus Agricultural labour and farmer's reluctance** to invest in tech solutions **due to lack the skills and knowledge**
- Public as well as private sector **investment in agri R&D is low.**
- **Regional imbalances** in credit disbursement.
- **Hilly and rolling topography** with mixed cropping and integrated farming.

Way Ahead

- Review regulations constraining the adoption of technologies.
- Innovative financial arrangements and micro-loans might be required to increase adoption.
- Support digital entrepreneurship ecosystems for innovative agri focused solutions.
- Bring awareness on digital and hi-tech services to farmers.
- Indigenous Research and Development to roll out farmer-friendly and location specific agricultural machinery.
- Encouraging farm mechanization through Agriculture Machine Banks at district level for leasing of farm equipment.

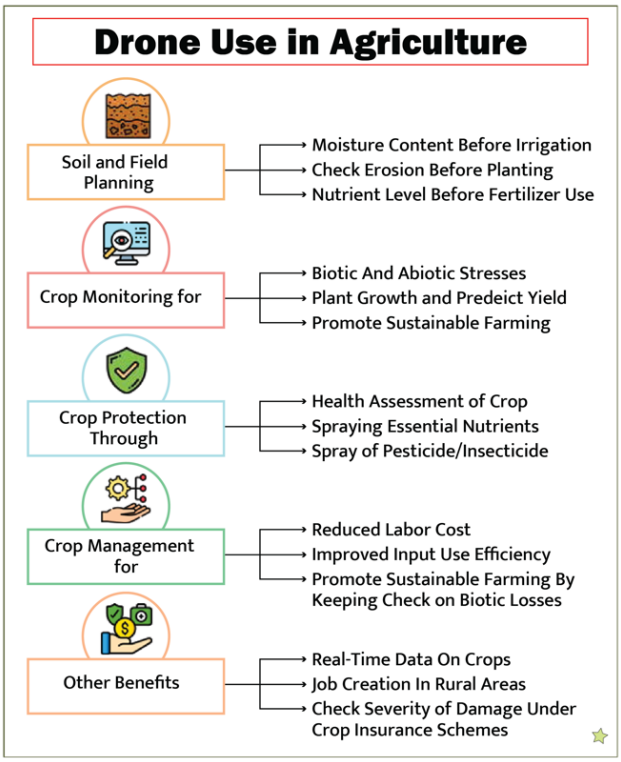
6.4.1. DRONE TECHNOLOGY IN AGRICULTURE

Why in News?

Ministry of Agriculture and Farmers Welfare released Crop Specific Standard Operating Procedures (SOP) for the Application of Pesticides with Drones.

Potential of Drone Technology use in Agriculture

- Finding use in many fields, it holds potential to **modernize the routine manual agriculture** activities as well by **linking with AI, machine learning (ML)** etc.
- It will also help in **finding solutions to:**
  - **Addressing Increasing food demand** with world population predicted to reach 9 billion by 2050;
  - **React faster to pest invasions**. E.g., in 2020, drones were used in fight against the attack on crops by swarms of locusts in India.
  - **Help in Smart Agriculture** through direct communication between drones and other agricultural equipment.

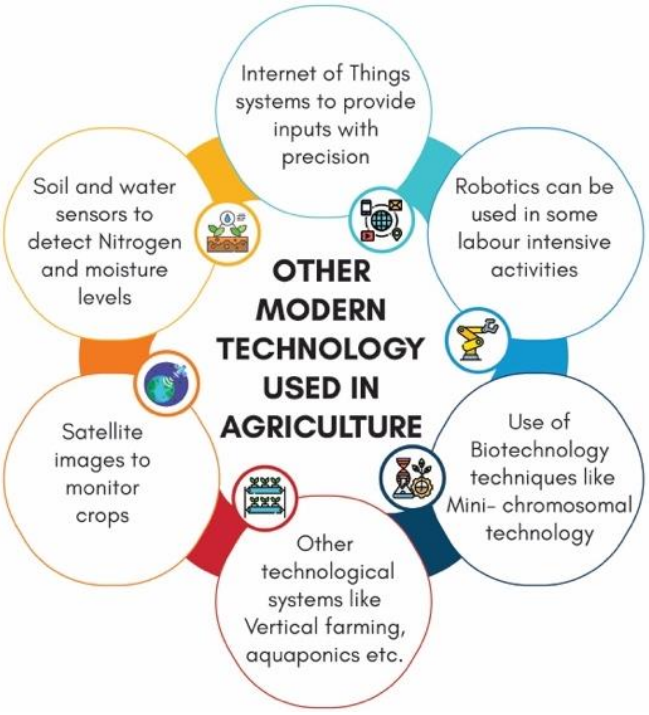


Challenges

- **Unviable Commercial Operation** due to small and scattered landholding. E.g. According to the Agriculture Census (2015-16), around 86% farmers in India hold land less than 5 acres.
- **Limited Flight time and range** of Drones due to relatively high payloads (20-60 minutes).
- **High Initial costs** of drones with maintenance issues.
- **Connectivity issues** in rural areas for online coverage.
- **Knowledge and skill issues** as it needs specialized skills and knowledge from farmer to utilize drone inputs,
- **Concerns over misuse of drones** as use of drones might infringe privacy and security (especially in border areas).
- **Weather dependence** with difficulties to operate in windy or rainy weather.

Why use drones for spraying pesticides?

- Being toxic in nature (Biocides), the Conventional pesticide use methods carry issues like:
  - **High Labor Cost, Lower spray uniformity** and **excessive application.**
  - **Health and environment risks** on **Oral, respiratory or dermal** (by skin) contact; pollution of soil and water.
- Drones use can **help address most of these issues.**



Way Forward

Drone Rules, 2021, SOPs and **PLI scheme for drones** would benefit all sectors including agriculture.

The **Indian Council of Agricultural Research** (ICAR) is already working on **SENSAGRI, SENsor based Smart AGRIculture** to develop indigenous prototype for drone-based crop and soil health monitoring system.

We should further expand the **scope of research** to study the quality of its operations and **fine-tune telecom, skill,** and **other policies/initiatives** to address the challenges of connectivity and skills among others.

WEEKLY FOCUS: SCIENCE AND TECHNOLOGY

S.No.	Topic	Learn More
1.	5G Technology Challenges and Opportunities	
2.	Clean Coal Technologies	
3.	AI and National Security	
4.	Data-Driven Innovations and Privacy	
5.	Space Exploration: Changing dynamics & pathway to the future	
6.	Cryptocurrency: A tool of Economic Empowerment or a Regulatory Nightmare?	

S.No.	Topic	Learn More
7.	Universal Immunisation Towards A Healthier And A Safer World	
8.	India's Vaccination Drives: Strategy, Obstacles and Opportunities	
9.	Quantum Technology in India: Exploring the possibilities ahead	
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11.	Research and Development Ecosystem in India: Harnessing Innovation for Growth	
12.	Ethics of Emerging Technology	

Lakshya Mains Mentoring Program 2023

Lakshya Mains Mentoring Program 2023 is a targeted revision, practice, and enrichment Program that aids students in achieving excellence in the UPSC Mains Examination 2023. The Program adopts a strategic approach by providing smart preparation strategies, developing critical thinking and analytical skills, and advanced answer-writing abilities.

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Features of the Program

Dedicated Senior Mentor

A Senior Mentor is assigned to each student to provide personalized guidance in each aspect of the Mains examination preparation and assist students in consolidating their strengths maximizing their performance by identifying and improving upon student weaknesses.

Emphasis on High-Scoring Potential Subjects

The Program lays special emphasis on subjects like Ethics and Essay and provides ample opportunity for students to inculcate the learnings and effect their implementation in the answer writing.

Regular Group Sessions

Aspirants engage in interactive sessions conducted by experienced mentors which provide subject-specific strategies, insights from toppers, advanced-level answer-writing skills, etc.

Answer Enrichment

Aspirants gain insights from institutional experience and the answer scripts of previous toppers to enhance the content and presentation of their answers, making them impactful and effective.

Live Practice Sessions

Through these practice sessions, aspirants can implement session learnings and receive immediate feedback from their mentors to refine their approach and boost their confidence.

Lakshya Mains Practice Test (LMPT)

Aspirants can undertake the scheduled LMPTs in online/Offline modes to put their knowledge and skills to the test and validate their preparation strategies.

Expert Evaluation

The LMPT is evaluated by the expert team at VisionIAS through an Innovative Assessment System to provide detailed feedback for further improvement.

Feedback Session with Assigned Mentor

In this session, students can discuss the feedback received on their LMPT performance and their Answer Scripts to address any doubts or concerns in a personalized setting with their Mentor.

Peer Interaction and Motivation

Aspirants participate in constructive discussions, share their experiences, insights, and motivation with fellow aspirants facilitating co-learning and development.

Multi-platform Support

Aspirants can benefit from a comprehensive support system in the form of online/offline Groups and One-to-One sessions, telephonic support, and a dedicated Telegram platform for immediate assistance whenever needed.

With its intelligent design, effective implementation, dedication from Senior Mentors, and active participation of Students, the Program has achieved tremendous success in a short period of time with **Waseem Ahmad Bhat** securing an impressive All India Rank (AIR) of 7, **Siddharth Shukla AIR 18,** and **Anoushka Sharma** securing AIR 20.

Heartiest Congratulations
to all Successful Candidates

39 in Top 50 Selection in CSE 2022


1 AIR
ISHITA KISHORE


2 AIR
GARIMA LOHIA


3 AIR
UMA HARATHI N

हिंदी माध्यम में 40+ चयन CSE 2022 में

हिंदी माध्यम टॉपर


66 AIR
KRITIKA MISHRA


85 AIR
BHARAT JAI PRAKASH MEENA


105 AIR
DIVYA


120 AIR
GAGAN SINGH MEENA


173 AIR
ANKIT KUMAR JAIN

8 in Top 10 Selection in CSE 2021


2 AIR
ANKITA AGARWAL


3 AIR
GAMINI SINGLA


4 AIR
AISHWARYA VERMA


5 AIR
UTKARSH DWIVEDI


6 AIR
YAKSH CHAUDHARY


7 AIR
SAMYAK S JAIN


8 AIR
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