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# Science & Technology

## Classroom Study Material 2021

( September 2020 to September 2021 )

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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 2013-2020 (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

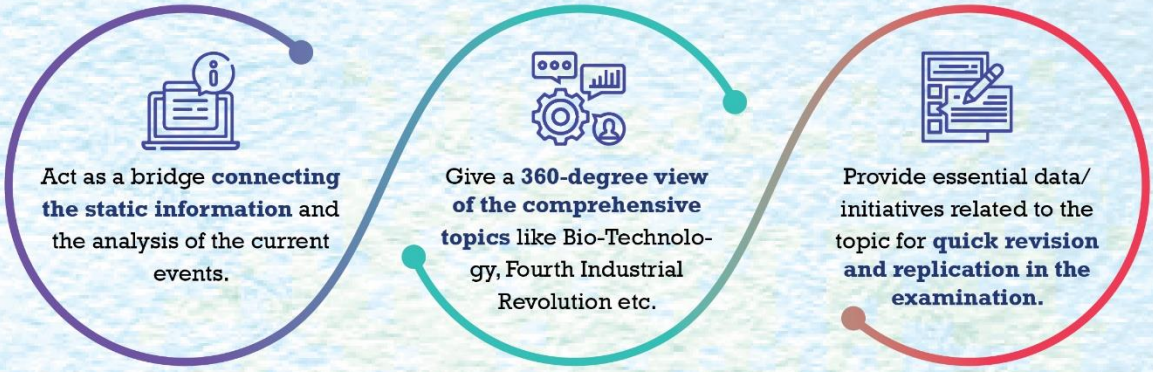

*Dear Students,*

Every year with Mains 365 documents, we aim to provide consolidated content keeping in mind the demand of the exam and the corresponding needs of the students. This necessitates keeping pace with changing pattern of the examination.

Over the course of last 3-4 years, the nature of questions in the Mains examination has changed significantly. Questions are becoming more conceptual, and more holistic in nature (i.e., having an amalgamation of both static and current parts), for e.g. the question on COVID-19 management through technology in Mains 2020 examination.

**In this context we have made following additions in the document:**

- **Topic at glance:** Topic at glance have been added to the Mains 365 Science and Technology document. These topic at glance seek to:




- **Infographics:** Infographics have been added in the document in a manner that they can readily be replicated in the examination through flowcharts, pie charts, maps etc., thereby improving the presentation of the content in the answers.

- **Previous year questions:** A QR code to the syllabus-wise segregated Previous Year Questions has been provided for student's reference. These will act as a guiding light for developing a thought process required for writing good answers.

The document seeks to not only provide a one stop solution for Science and Technology Current Affairs but it also seeks to develop a coherent thought process required for effective and well presented answer. Therefore, the articles in the document are not only to be read for content but also for understanding and adopting good practices of answer writing.

We hope that the coverage of the content in an organized manner will assist you in performing well in the examination.

Knowing is not enough; we must apply. Willing is not enough; we must do.

-Johann Wolfgang von Goethe

**All the best!**
**Team VisionIAS**

# 1. AWARENESS IN THE FIELDS OF IT, SPACE, COMPUTERS, ROBOTICS, NANO-TECHNOLOGY, BIO-TECHNOLOGY AND ISSUES RELATING TO INTELLECTUAL PROPERTY RIGHTS

## 1.1. BIOTECHNOLOGY

### BIOTECHNOLOGY AT- A- GLANCE

#### ABOUT BIOTECHNOLOGY

- Area of biology that **uses living processes, organisms or systems to manufacture products or technology** intended to improve the quality of human life.
- Includes disciplines **like molecular modeling, genomic, bio – informatics, bio – simulation etc.**
- **Branches based on application:**
  - **Blue biotechnology** (marine and aquatic application),
  - **Green biotechnology** (agriculture processes),
  - **Red biotechnology** (medical),
  - **White biotechnology** (industrial).

#### BIOTECHNOLOGY IN INDIA

- **Among top 12 destinations** with approximately 3% share in the global Biotechnology industry.
- **Estimated to increase to $100 billion (2025) from $7 billion (2015).**
- Five major segments- **Bio-pharma, Bio-services, Bio-agri, Bio-industrial, and Bioinformatics.**
- **Department of Biotechnology (DBT)** to promote large scale use, support R&D and manufacturing in Biology etc.
- **BIRAC** (Biotechnology Industry Research Assistance Council) by DBT **to help emerging biotechnology enterprises**.

#### BIOTECHNOLOGY TO ADDRESS VARIOUS ISSUES IN INDIA

- **Food security** (More productive, pest tolerant, stress tolerant crops).
- **Adapting to Climate change** (Drought resistant crops).
- **Tackling Diseases**.
- **Bioenergy** (Use of Bioethanol and Biodiesels).
- **Advancement in Drugs Manufacturing**.
- **Bio-fortification**.
- **Animal Biotechnology** to improve the productivity of livestock.
- **Bioremediation**(For Waste Management).

#### CHALLENGES FACED IN INDIA

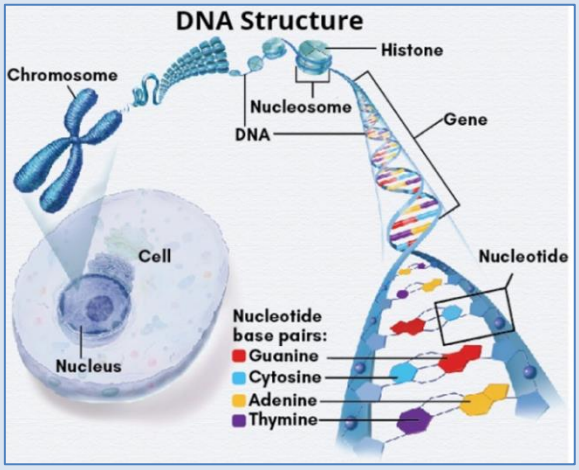
- **Low Research and development (R&D)**: Quite low (0.67 per cent of GDP) as compared to Japan and US (around 3%).
- **Intellectual Property Right regime**
  - **Section 3(d) of the Patents (Amendment) Act, 2005** (sets a higher standard than mandated by TRIPS)
  - **Compulsory licensing** (allows government power to suspend a patent in health emergencies)
- **Lack of Marketisation:** As most of the funding runs out in R&D.
- **Lack of Public Awareness:** About possible use of Biotech.
- **Less Lucrative:** As number and quality of jobs offered is less.

#### WAY FORWARD

- Increase in investment towards R&D and building human capital.
- Collaboration between government and industry to chalk out a middle ground for IPR protection.
- Funding mechanism for select innovative ideas based on their national importance.
- Ecosystem of innovation by involving scientists, innovators and future entrepreneurs.
- Extending Reach of biotechnology to other fields of study.

**Glossary**

- **Genetically modified organisms (GMOs): Organisms in which the genetic material (DNA) has been altered** in a way that does not occur naturally by mating and/or natural recombination.
- **GM foods:** Foods produced from or using GM organisms.
- **Chromosome:** DNA is tightly coiled to make a thread like structure called Chromosome. Human beings have 46 chromosomes (23 from each parent).
- **Nucleotide:** A nucleotide is an organic molecule that is the building block of DNA and RNA.
- **DNA:** DNA, or deoxyribonucleic acid, is the hereditary material in most of the living beings.
- **RNA:** RNA or Ribonucleic acid molecules are single-stranded nucleic acids. They are hereditary material in some viruses.
- **Genes:** A gene is a 'specific' section of DNA. It is involved in making RNA (transcription) or protein (translation).
- **Genome:** An **organism's complete set of DNA.** It includes all chromosomes, which houses the DNA, and genes. It contains all the data that is needed to describe the organism completely.
- **Gene pool:** A gene pool is the collection of different genes within an interbreeding population.

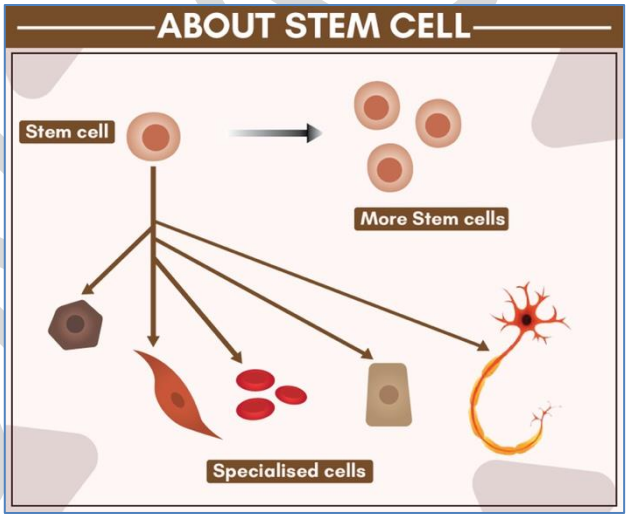



## 1.1.1. ALLOGENEIC STEM CELL

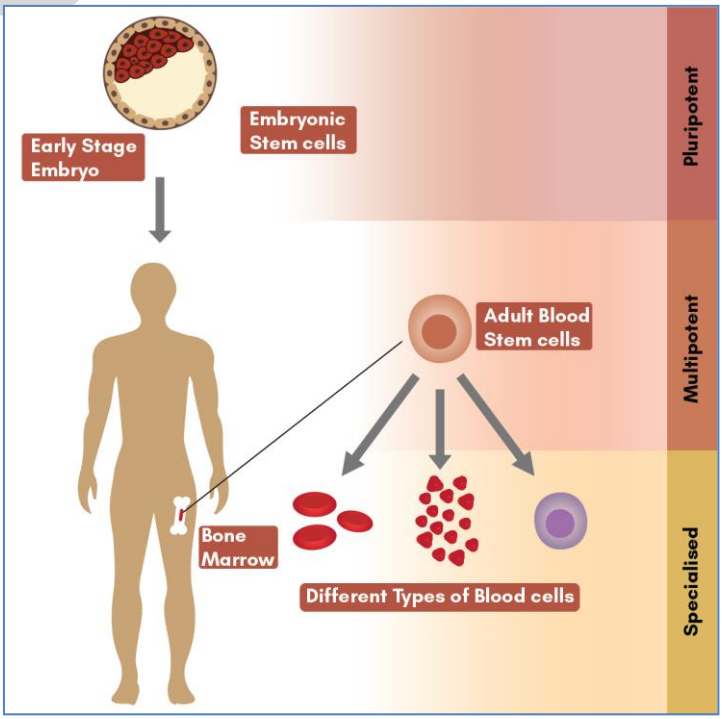
**Why in News?**

Recently, Odisha's SCB Medical College & Hospital performed the first-ever allogeneic bone marrow transplant.

**About stem cells**




- Stem cells are s**pecial human cells that are able to develop into many different cell types.**
- **Two unique properties** enable them to do this:
  - They **can divide over and over again** to produce new cells.
  - As they divide, they **can change into the other types of cell** that make up the body.
- **There are three main types of stem cell**
  - **Embryonic stem cells:** supply new cells for an embryo it grows and develops into a baby. These stem cells are said to be pluripotent, which means they can change into any cell in the body.
  - **Adult stem cells:** supply new cells as an organism grows and to replace cells that get damaged. Adult stem cells are said to be multipotent, which means they can only change into some cells in the body, not any cell, for example:
    - ✓ Skin (or 'epithelial') stem cells provide the different types of cells that make up our skin and hair.
  - **Induced pluripotent stem cells:** are stem cells that scientists make in the laboratory.
    - ✓ Just like embryonic stem cells, they are pluripotent so they can develop into any cell type.



- **Stem cells have several uses including**
  - **Research:** to help us understand the basic biology of how living things work and what happens in different types of cell during disease.
  - **Therapy:** to replace lost or damaged cells that our bodies can't replace naturally. This can help in treatment of various diseases such as Cardiovascular diseases, autoimmune diseases etc.
- **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:** Ethical dilemma involving the destruction of a human embryo was and remains a major factor that has slowed down the development of stem cell based clinical therapies.
  - **Limited technology:** To generate large quantities of stem cells.

**About Stem Cell Therapy**

- Stem cell therapy, **also known as regenerative medicine, promotes the repair response of diseased, dysfunctional or injured tissue** using stem cells or their derivatives.
  - Researchers grow stem cells in a lab. These stem cells are **manipulated to specialize into specific types of cells,** such as heart muscle cells, blood cells or nerve cells.
- **Two of the most common types of stem cell transplants** are autologous and allogeneic transplants.
  - An **autologous transplant** uses a person's own stem cells for treatment, while in **allogeneic procedure,** a donor donates stem cells.

**Way forward**

- **Better regulation:** Monitoring mechanism and regulatory pathway 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 manner and should discuss a broader range of information with potential participants.
- **Scientific considerations:** appropriate measures should be taken and proper investigations performed 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 address permissible and impermissible categories of stem cell research.

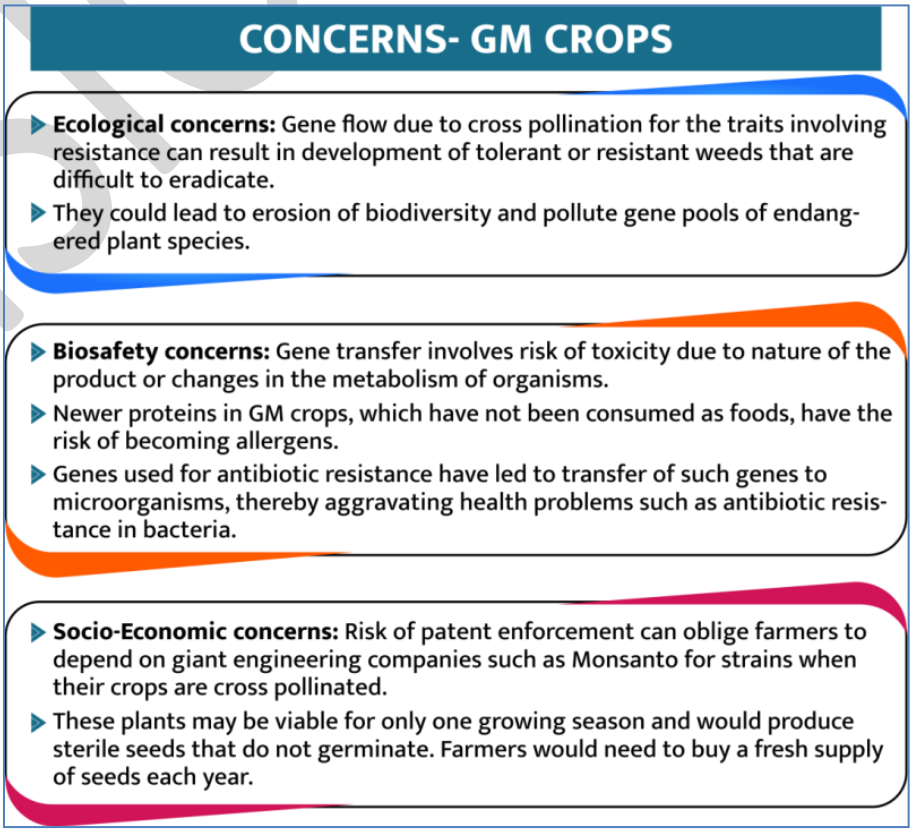
## 1.1.2. GENETICALLY MODIFIED CROPS

**Why in news?**

India will import genetically modified (GM) soyameal for the first time to be used as livestock feed.

**More on news**

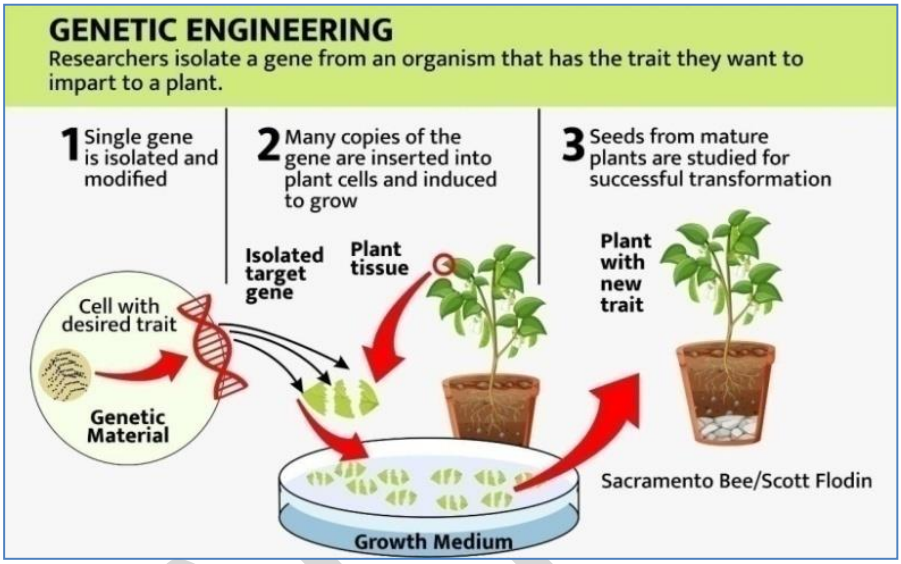
- Ministry of Environment, Forest, and Climate Change (MoEFCC) cleared the proposal for import of GM soyameal, **on the grounds that material was non-living.**
  - **Genetic Engineering Appraisal Committee (GEAC),** a special committee under the ministry entrusted to govern matters related to GM crops, **was bypassed, given the non-living nature of the material.**



- ✓ Soymeal is a protein-rich solid leftover raw material after extracting oil from soyabean seed. **It is a major ingredient of poultry feed** (makes up 65% of the cost of production).

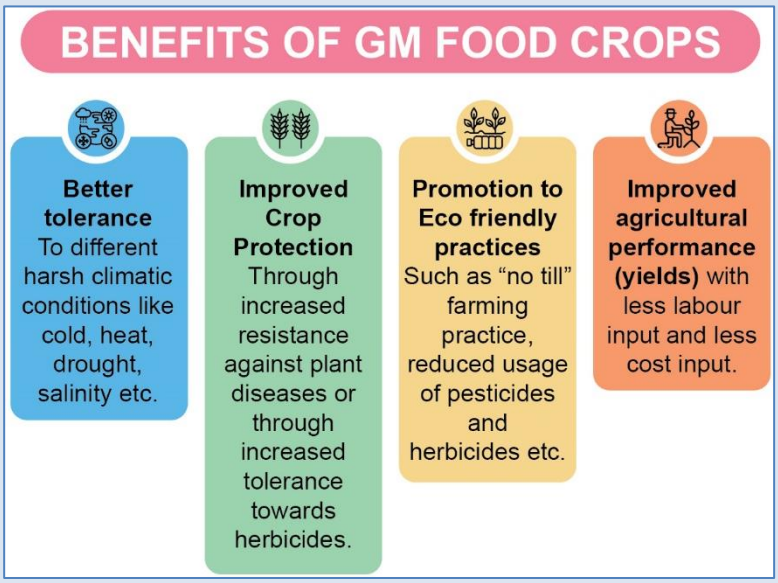
**What are Genetically Modified (GM) Food crops?**

- **GM crops carry genes of other species artificially inserted into them.**
- **USA, Brazil, Argentina, India and Canada** are top 5 GM crops growing countries, together accounting for approx. 90% area of the GM cultivation.
- **In India, Bt cotton is the only GM crop that has been approved for commercial cultivation in 2002.**
  - **GM mustard Dhara Mustard Hybrid 11** (DMH 11) developed by Delhi University is **pending for commercial release** as GEAC has advised to generate complete safety assessment data on environmental biosafety.
  - **GEAC has allowed biosafety research field trials of two new transgenic varieties of indigenously developed BtBrinjal**– namely Janak and BSS-793 – **in eight states** during 2020-23 only after taking NOC from states concerned.




**Policy framework for GM Crops**

- Rules governing the handling of GMOs and products thereof **were notified in 1989 under Environment Protection Act 1986 (EPA) and guidelines issued later.**
  - **Ministry of Environment and Forests (MoEF) and the Department of Biotechnology (DBT)** are responsible for implementation of the regulations.
- **Genetic Engineering Appraisal Committee (GEAC):** for approving commercial cultivation of GM crops as well as the manufacture, import and selling of processed foods made from GM ingredients.
  - GM food imports require approvals under two laws: **EPA and the Food Safety and Standards Act of 2006.**
- **Codex Alimentarius Commission (Codex):** It is the joint FAO/WHO intergovernmental body responsible for developing the standards, codes of practice, guidelines and recommendations that constitute the Codex Alimentarius, meaning the international food code.
  - Codex developed principles for the human health risk analysis of GM foods in 2003.




**Way Forward**

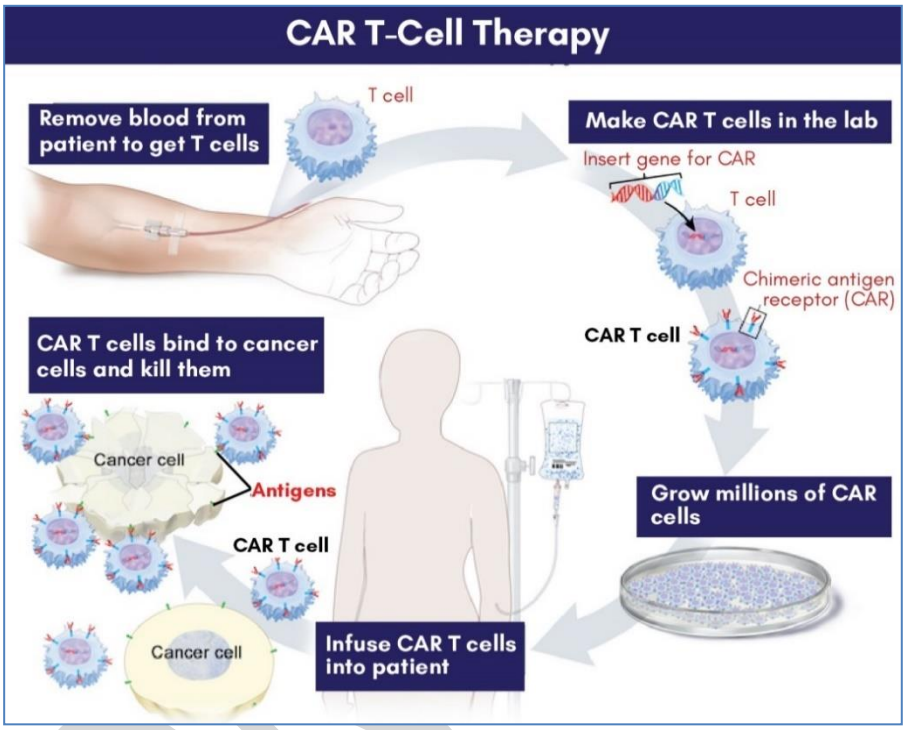
- **Focus on GM technology:** National policy on GM crops to define the exact areas where GM is required by the country and where the government will encourage public and private investment in GM technology.
- **Grievance redressal of all stakeholders:** Before allowing GM crops by putting the safety documents online and addressing the concerns in all comments received.

- **Fixing accountability:** There should be a liability clause, that is, if something goes wrong the liability should be fixed statutorily like in case of US law.
- **Stringent Regulation:** With advances in biotechnology, there is an urgent need for stringent regulation or scrutiny in the sector to ensure cultivation and sale of environmentally-safe agro products.

## 1.1.3. GENOME EDITING

**Why in News?**

Recently, Department of Biotechnology supported First Chimeric Antigen Receptor T-cell (CAR-T) therapy was conducted.




**About Chimeric Antigen Receptor T-cell (CAR-T) therapy**

- It is a way **to get immune cells called T cells** (a type of white blood cell) **to fight cancer by editing them in the lab** so they can find and destroy cancer cells.
  - T cells are **taken from the patient's blood** and are changed in the lab by adding a gene for a man-made receptor (called CAR).
  - This helps them better identify specific cancer cell antigens. The CAR T cells are then given back to the patient.
- It is also sometimes talked about as a **type of cell-based gene editing, because it involves altering the genes** inside T cells to help them attack the cancer.

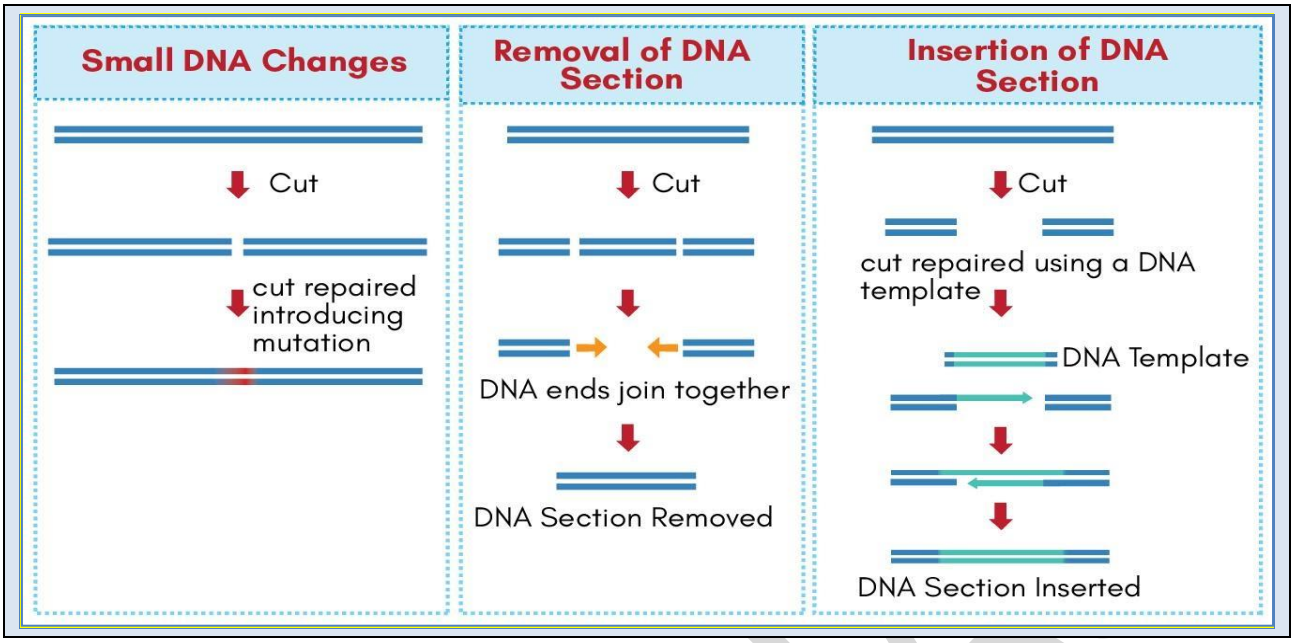
**What is gene editing?**

- Genome (or gene) editing 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 does it work?**

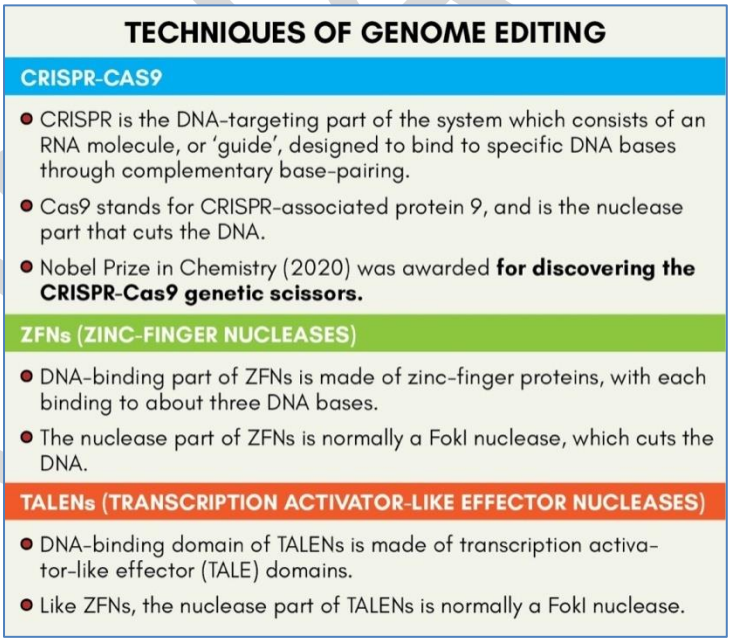
- Genome editing **uses a type of enzyme called an 'engineered nuclease' which cuts the genome** in a specific place.
  - **Engineered nucleases are made up of two parts:** A nuclease part that cuts the DNA and A DNA-targeting part that is designed to guide the nuclease to a specific sequence of DNA.
- 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.

**Types of Genome editing**



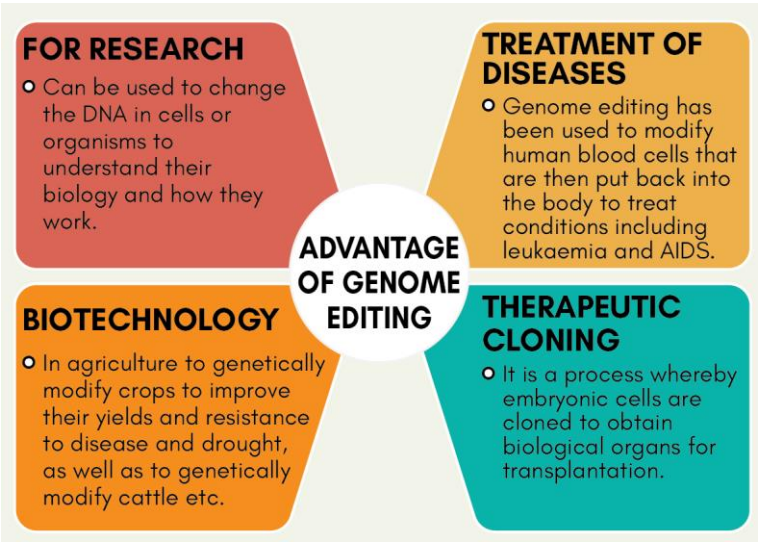

**Techniques used for Genome editing**

- They mainly **differ in how they recognise the DNA to cut.**
  - **Protein based:** contain a protein that recognises and binds to the target DNA to be cut.
  - **RNA based:** contain a short sequence of RNA that binds to the target DNA to be cut.




**Concerns regarding genome editing**

- **Ethical Dilemma:** Principal concern include the morality, the eugenics helping the fittest to survive, ongoing clinical debates about informed consent, religious debate, the possible rise of clones, designer babies, and possibly superhumans.
- **Safety concerns:** Slight changes made at the smallest cellular level may lead to unexpected results.
- **Potential loss to diversity:** Genetically engineering our species will have a detrimental effect on genetic diversity.




**Conclusion**

The approaching **biotechnological revolution seems imminent and undeniable**. The pressing need therefore demands a **harmonious and regulated translation of needed aspects of genome-editing-related technologies** for molecular medicine and other non-clinical crop and food industries.

## 1.1.4. GENOME SEQUENCING

**Why in news?**

**IndiGen programme,** the Council of Scientific and Industrial Research's (CSIR) resource, was completed in six months, and the results were recently published.

**About IndiGen programme**

- It aims to **undertake whole genome sequencing of a thousand Indian individuals** representing diverse ethnic groups from India.

**Significance of the 'Indigen Project'**

- **Understanding the Indian genome variation**: This could benefit the people of India in following manner:
  - **Understanding the epidemiology of genetic diseases** to enable cost effective genetic tests.
  - **Carrier screening** (determining chances of having a child with genetic disorders) applications for expectant couples.
  - **Pharmacogenetic** (study of how genes affect a person's response to drugs) **tests to prevent adverse drug reactions.**
  - **Understanding the genetic diversity** on a population scale.
  - Making **genetic variant frequencies** available for clinical applications.
- **Scaling up Indian genome data:**The country is very diverse with **more than 4500 anthropologically distinct populations.**
- **Understanding genomes**: Study of the entire genome sequence will help scientists understand how the genome as a whole works.

- Now, CSIR has announced the **conclusion of 'Whole Genome Sequencing"** of 1,008 Indians from different populations across the country. It was found that:
  - **32% of genetic variations in Indian genome sequences are unique** as compared to global genomes.

**About Genome sequencing**

- **Genome sequencing** means deciphering the exact order of base pairs in an individual. This data can be analysed to understand the function of various genes, identify genetic mutations and explore how the mutations impact gene functions.

**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:** Because of limited financial resources, genetics projects are not as big a priority as national security and social welfare.
- **Legal issues:** Data privacy bill is yet to be passed. Anonymity of the data and questions of its possible use and misuse would need to be addressed.
- **Cyber Security:** According to Internet Crime Report for 2019, **India stands third in the world among top 20 countries that are victims of internet crimes.**

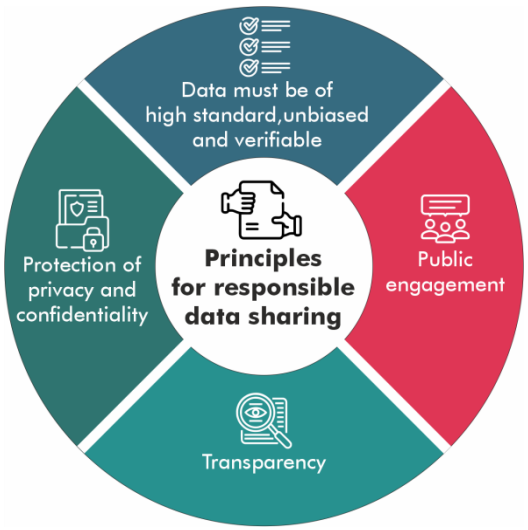
**Way ahead**

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. **Funding in the technology** has been the major obstacle for in scaling up this project. To overcome such challenges **India should also go for private funding of science projects.**

## 1.1.5. BIOTECH- PRIDE GUIDELINES

**Why in news?**

"Biotech-PRIDE (**Promotion of Research and Innovation through Data Exchange**) Guidelines" developed by Department of Biotechnology (DBT), Ministry of Science and Technology were released recently.




**About Guidelines**

- These have been formulated in conformity with the principles of **NDSAP (National Data Sharing and Accessibility Policy) 2012**, for enabling the **sharing, access and storage** of biological data.
  - At present, in India the biological data is deposited in International Repositories **and there are no guidelines** for sharing it.

- Under the guidelines, it is the **responsibility of the data-generator/ producer/submitterto deposit data** in an appropriate database in the notified Data Repository.
- **Data withdrawal may be granted** if the individual or the organization, whose data have been placed on a publicly accessible database, make a **justified request either directly or through the submitter**, with valid claims to the data.
- These Guidelines will be implemented through **Indian Biological Data Centre (IBDC)** at Regional Center for Biotechnology supported by Department of Biotechnology. Other datasets/ data centres will be bridged to the IBDC which will be called **Bio-Grid.**
    - The Bio-Grid will be a **National Repository for all biological knowledge, information and data** generated through research within the country and will be responsible for:
        - ✓ **Enabling its exchange** to facilitate the Research and Innovation,
        - ✓ Developing measures for **safety, standards and quality for datasets** and
        - ✓ Establishing **detailed modalities** for accessing data.
- The modalities for data sharing shall be managed by IBDC under **three categories** as follows:
    - **Open access**: All data, under 'open access' category, generated from public-funded research will be available to everyone (larger scientific community and public) under **FAIR (findable, accessible, interoperable and reusable) principles.**
    - **Managed access**: **shared with specific restrictions** imposed by the data producer/generator/ submitter. In case of data generated using public funds, restrictions to access and use of such data are to be **established by the funding agency** before its deposition.
    - **No access:** Access to **'sensitive data' shall not be permitted**, even if generated using public funds.

# 1.2. IT, COMPUTER & ROBOTICS

## 1.2.1. CRYPTOCURRENCY

### CRYPTOCURRENCY AT A GLANCE

#### Definition of cryptocurrency and its working methodology

A cryptocurrency is a digital or virtual currency that is secured by cryptography. As a currency, it satisfies all major functions of money i.e., acting as a unit of account, store of value and a standard for deferred payment. Its system works on following lines-

- **Generation:** They get generated through a mining process in a decentralized and distributed ledger system called Blockchain.
- **Distribution:** They can be traded on cryptocurrency exchanges or exchanged on a peer-to-peer basis.
- **Maintenance:** Blockchain serves as a distributed ledger for maintenance of records. Every transaction in this chain is immutable and is subject to approval of a large section of participants in the chain.

#### Looking ahead

- In 2021, El Salvador became the first country to adopt Bitcoin as a legal tender, but the same cannot be expected from economically stronger countries like India, US and Japan etc.

#### Cryptocurrencies as a tool of economic empowerment

- **Eliminating the middleman,** resulting in significantly lowered transaction costs and increased pace of transactions.
- **Effectively servizng the functions of money** as they can be transacted over long distances and reduce leakages by increasing transparency.
- **Enhancing security of the payment systems** by enabling cryptographic encryption to protect against cyberthreats.
- **Being an enabler of financial inclusion** by overcoming the issues related to banking infrastructure and discrimination regarding access to finance.
- **Empowering businesses by complementing the technological revolution** by creating tools like Smart Contracts among others.

#### Looking ahead

- The cryptocurrencies have been **showcasing high potential for use outside economic discourse** i.e., in social spheres like platform for artists.

#### Regulatory challenges in their adoption

- **Controlling the macroeconomic variables** like money supply, inflation etc. with advent of an alternate currency.
- **Checking the misuse of technology in criminal activities** like money laundering and terrorist financing.
- **Controlling tax evasion and avoidance** as there is no central oversight.
- **Managing cybersecurity issues** which could be susceptible to hackers and malicious users.
- **Ensuring that advent of digital currency does not create a new divide** due to limited financial inclusion and technological access.
- **Weaponization of cryptocurrency** in the context of geopolitics.

#### Looking ahead

- Cryptocurrency mining could become a **major factor in carbon dioxide emissions.**
- Cryptocurrencies could **alter the global currency-exchange mechanisms and hence the geo-economic world order.**

#### Balancing regulatory challenges and potential benefits of cryptocurrencies

- **Mastering the regulatory sandbox** by adopting a regulatory approach which evolves rapidly and fixes problems along the way.
- **Exploring the idea of Central Bank Digital Currencies (CBDCs)** to enable precise interventions in the macroeconomy and help increase the efficiency of the payment system.
- **Preparing the ecosystem for adoption of digital finance** by improving financial literacy, increasing digital penetration, and strengthening cybersecurity ecosystem.
- **Involving private sector to encourage innovation** through supportive policies and encouraging competition.
- **Evolving a monetary policy for the digital age** by redesigning traditional mechanisms and experimenting with financial elements like 'Stablecoins' among others.
- **Maintaining international collaboration for financial stability** through international forums like Financial Stability Board (FSB).

#### Looking ahead

- Given the success that the nation has seen in the past three decades vis-à-vis ITeS-based solutions, **India can become a tech powerhouse for innovation with adoption of a pro-crypto policy.**
- **Non-fungible tokens (NFTs)** are emerging as an idea which is going beyond cryptocurrencies by creating a parallel to physical ownership in the digital world.

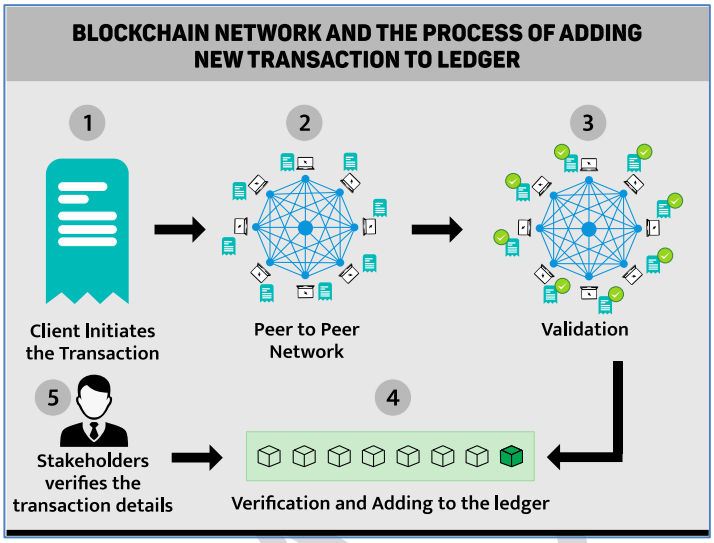
## 1.2.2. NATIONAL STRATEGY ON BLOCKCHAIN

**Why in News?**

Ministry of Electronics and Information and Technology (MeitY) has released drafted National Strategy on Blockchain

**What is blockchain?**

- A blockchain is essentially a **digital ledger of transactions (DLT) that is duplicated and distributed across the entire network of computer systems** on the blockchain.
  - Blockchain is a specific type of DLT in which **blocks are linearly connected to each other.** (This may not be the case in other types of DLT.)
  - Thus, **all blockchains are DLT; however, all DLT platforms are not blockchains.**
- Each block in the chain contains a number of transactions, and every time a new transaction occurs on the blockchain, a record of that transaction is added to every participant's ledger.
- **Copy of each transaction along with its hash is stored in the ledger** shared across all participants of the network.
- Salient properties of the Blockchain technology **are user anonymity, cryptography based security, immutability (i.e., an entry cannot be changed without recreating it), shared read & write, accountability, transparency and distributed ownership.**
- Blockchain was first introduced in the design and development of cryptocurrency, **Bitcoin in 2009 allegedly by a Japanese entrepreneur named Satoshi Nakamoto.**




**What is blockchain?**

| | |
|---|---|
| A Database | A list of records / 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 an network, syncing within minutes / seconds; |
| Adjustable Transparent | Records stored in the database may be made visible to relevant stakeholder without risk of alteration; |
| Highly Secure | Malicious actors (hackers) can no longer just attack one computer and change any records; |
| and Immutable | The mathematical algorithms make it impossible to changes / delete any data once recorded and accepted |

**Potential Blockchain Applications**

- Transfer of Land Records (Property Record Management);
- Digital Certificates Management (Education, Death, Birth, agreements, etc);
- Pharmaceutical supply chain;
- e-Notary Service (Blockchain enabled e-Sign Solution);
- Farm Insurance;
- Identity management;
- Power distribution;
- Duty payments;
- Agriculture and other supply chains;
- eVoting;
- Electronic Health Record Management;
- Digital Evidence Management System;
- Public Service Delivery;
- IoT Device Management and Security;
- Vehicle lifecycle management;
- Chit fund operations administration; Microfinance for Self-Help Groups (SHG)

**SWOT Analysis of Blockchain Technology**

| Strengths | Weaknesses |
|---|---|
| Distributed resilience and control<br>Decentralized network<br>Open source<br>Security and modern cryptography<br>Asset provenance<br>Native asset creation<br>Dynamic and fluid value exchange | Lack of ledger interoperability<br>Customer unfamiliarity and poor user experience<br>Lake of intraledger and interledger governance<br>Lake of hardened/tested technology Limitation of smart contract code programming model<br>Wallet and kay management<br>Poor tooling and poor developer user experience<br>Skills scarcity and cost<br>Immature scalability<br>Lack of trust in new technology suppliers |
| **Opportunities** | **Threats** |
| Reduced transaction costs<br>Business process acceleration and efficiency<br>Reduced fraud<br>Reduced systemic risk<br>Monetary democratization<br>New business-model enablement<br>Application rationalization and redundancy | Legal jurisdictional barriers<br>Politics and hostile nation-state actors<br>Technology failures<br>Institutional adoption barriers<br>Divergent blockchains<br>Ledger conflicts/competition<br>Poor governance |

**Importance of Blockchain Technology**

- **Blockchain can bring value addition in e-Governance**: Improves Transparency & Accountability, Building Trust with Citizens, speed up transactions, Protecting Sensitive Data and Reducing Costs & Improving Efficiency.
- **No Middlemen in Transaction.**
- **Protect businesses from fraud:** Blockchain is open-source ledger which is why it is very easy to identify if a fraud has taken place since every transaction is recorded on them.
- **Blockchain Business Value:** The World Economic Forum (WEF) anticipates that **10% of the global GDP will be stored on blockchain by 2025** and lists blockchain as one of 7 technologies that are anticipated to revolutionize various aspects of our lives.

**Challenges to the adoption of Blockchain Technology identified**

- **Technological Challenges**
  - **Performance:** Replication of data on each node as well as calculations associated with encryption-decryption and hashing at every node large computational capacity. This may lead to performance issues.
  - **Scalability:** Variable requirements for processing power, network bandwidth, block size, Consensus etc. affect their scalability.
  - **Storage:** Data stored in the Blockchain becomes perpetual. Also, such data is replicated at all the nodes in the network. This demands a heavy resource in terms of storage.
  - **Transaction details and interoperability:** In order to get the benefit of interoperability across similar applications, transaction standardization for certain classes of applications have to be evolved.
- **Legal &implementational Challenges**
  - **Privacy & Regulation:** Decentralized storage on every node creates privacy challenges. The state of regulations and compliance for Blockchain applications is still ambiguous.
    - ✓ **Right to be Forgotten** is a prevailing feature of the Draft Personal Data Protection Bill, 2019. Blockchain where data cannot be deleted, and history of data is always accessible contradicts this principle.
  - **Digital Signatures:** It is a core part of Blockchain networks and application.
    - ✓ Currently there exist no details in the Information Technology Act, 2000 on transactions involving immovable property, wills and negotiable instruments. Thus, this provision excludes the applicability of the technology for such activities**.**
  - **Localization:** Data redundancies are stored across all nodes on a blockchain network. Thus, the technology may hit a hurdle with data localization requirements.
- **Lack of Skill set and Awareness.**

**Global Efforts**

- **European Blockchain Partnership (EBP),** aims to use blockchain and distributed ledger technologies and develop a trusted, secure and resilient **European Blockchain Services Infrastructure (EBSI)** which will meet the highest standards in terms of privacy, cybersecurity, interoperability, regulation in applying policies etc.
- **Keyless Signature Infrastructure (KSI)** is a Blockchain technology designed in Estonia to prove the authenticity of the electronic data (records) mathematically.
- **United Arab Emirates has "Smart Dubai" initiative**, which aims to become the "first city fully powered by Blockchain by 2021," and enhance everything from health care, education etc.

**Efforts in India**

- **MeitY has supported a multi-institutional project titled Distributed Centre of Excellence in Blockchain Technology with** Centre for Development of Advanced Computing (c-DAC), Institute for Development and Research in Banking Technology (IDRBT) and VeermataJijabai Technological Institute (VJTI) as executing agencies.
- **Centre of Excellence (CoE) in Blockchain technology was established by NIC** in association with NICSI. Its objectives include **accelerating adoption & deployment of**Blockchain technology in Government.
- **NITI Aayog has recognized Blockchainas a promising Technology** enabling features such as decentralization, transparency and accountability.
- **Reserve Bank of India (RBI)** is exploring on applying Blockchain Technology **in banking domain**.

**Key recommendations by National Strategy on Blockchain**

- **Need for National Level Blockchain Framework (NLBF):** NLBF can aid in scaling deployments for developed applications, creating shared infrastructure and also enable cross domain application development.

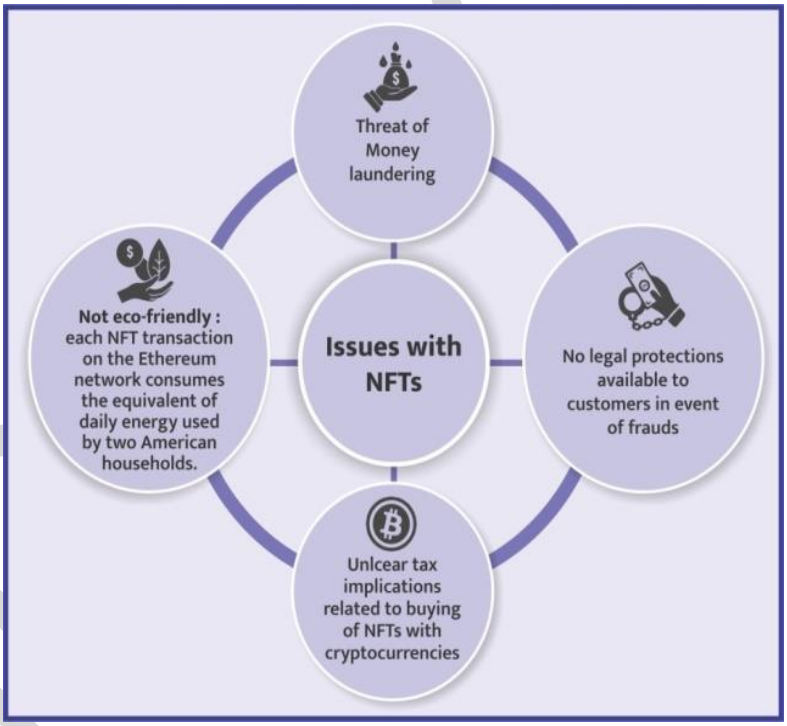
- **Government does not create any framework for the time being** and allows the ecosystem to evolve freely with the active support of the government.
- In order to plan and implement NLBF**, a multi-institutional Centre of Excellence is proposed.**

- **Integration of important National Level Services to Blockchain**such as eSign, ePramaan, DigiLocker etc.
- **Focus on research** in the domains of standards & interoperability, scalability & performance, consensus mechanisms, security & privacy, key management, secure smart contracts etc.
- **Consultancy services can be offered** in architecting the Blockchain based applications as different ministries / departments are showing interest in adopting Blockchain Technology.
- **Capacity building in Blockchain Technology** needs to be promoted by conducting short term courses or bootcamps.
- **Explore the potential of Blockchain Technology** in the proposed public digital platforms in various **sectors like Agriculture, Health, Energy etc., for more security.**

## 1.2.3. NON-FUNGIBLE TOKEN

**Why in news?**

Indian cryptocurrency exchange, WazirX has launched a non-fungible tokens (NFT) marketplace for Indian artists.




**What are NFTs?**

- An NFT, or a non-fungible token, is a **digital object** that can be a drawing, animation, piece of music, photo, or video **with a certificate of authenticity created by blockchain technology.**
  - In simple terms, NFT is a **unique proof of ownership** over something you can't usually hold in your hand — a piece of digital art, a digital coupon, maybe a video clip.
- The virtual object, which is actually a computer file, **can be exchanged or sold with its certificate.**
- "Tokenizing" these assets **allows them to be bought, sold, and traded more efficiently** while reducing the probability of fraud.
- NFTs can also be used to **represent people's identities, property rights, and more.**

**Characteristics of NFT**

- All NFTs have a **unique quality** and a **distinct value** from any other similar token.
  - The metadata of each NFT is an unalterable record that gives it the certificate of authenticity.
    - ✓ They are **digitally rare.**
    - ✓ They must **be sold or purchased as a whole** as they **cannot be divided** unlike fungible tokens.

**Importance**

**It seeks to solve the problem of** Ownership tracking, Value storage, and Decentralisation.

- **Monetisation:** Artists, musicians, influencers and sports franchises are using NFTs to monetise digital goods that have previously been cheap or free.
- **Authenticity:** Contemporary artists can now archive their collections through the blockchain and have NFTs to authenticate their works and ensure no fakes exist in the future.
  - NFTs can still be copied, of course, but only one file has a certificate of authenticity, which cannot be replicated.
- **Protecting intellectual property rights of Artisans:** who can use NFTs to verify their original work.

**Conclusion**

**NFT marketplace is exploding,** and surprisingly large amounts are being paid for NFT artwork. These prices, together with the uncertainty of a new technology, **raise potential legal liability issues for art creators, buyers, and marketplaces.**

There is **need for government to lay down framework to regulate cryptocurrency and other digital currencies** to avail its advantages which in the future would be profound.

- Fungibility refers to an **asset's ability to be exchanged with a similar asset** without sacrificing its value.
  - For example, **a Rs. 100 note is fungible,** because if one person has a Rs.100 bill and another person also has a Rs. 100 note, they could interchange the bill and the value does not change.
  - **NFTs are not fungible** as they **cannot be traded directly** with each other because they are unique.

## 1.2.4. QUANTUM COMPUTING

**Why in news?**

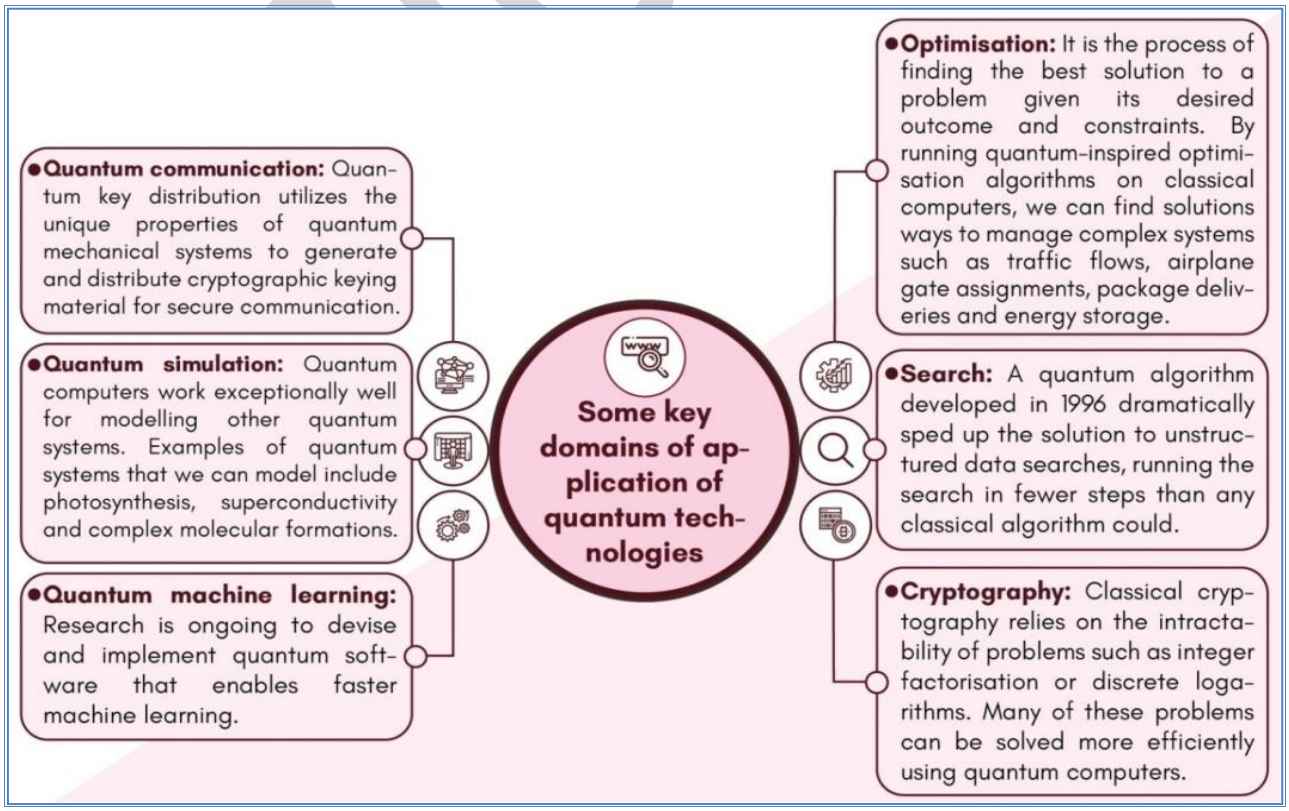
Ministry of Electronics and Information Technology (MeitY) recently launched QSim – Quantum Computer Simulator Toolkit.

**About QSim**

- QSim toolkit **allows researchers and students to write and debug Quantum Code** that is essential for developing Quantum Algorithms and **to carryout research in Quantum Computing (QC) in a cost-effective manner.**
- It is an outcome of the project **"Design and Development of Quantum Computer Toolkit (Simulator, Workbench) and Capacity Building",** an initiative for advancing QC research frontiers in India.

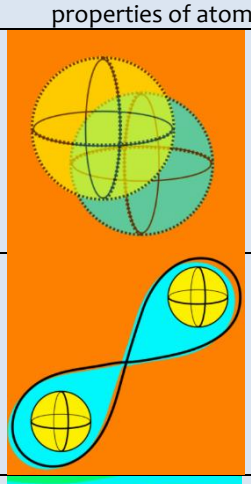
**What is Quantum Computing?**

- Quantum computers **harness the unique behaviour of quantum mechanics** and apply it to computing. This introduces new concepts to traditional programming methods.
- Quantum computing **use qubits as its basic unit of information.**
- **A quantum computer hasthree primary parts:**
  - An area that houses the qubits.
  - A method for transferring signals to the qubits.
  - A classical computer to run a program and send instructions.



**Quantum mechanics and related terms and concepts**

- Quantum mechanics explains the **nature and behaviour of matter and energy on the atomic and subatomic level.**
- In physics, a **quantum is the smallest possible discrete unit of any physical property.** It usually refers to properties of atomic or subatomic particles, such as electrons, neutrinos and photons.



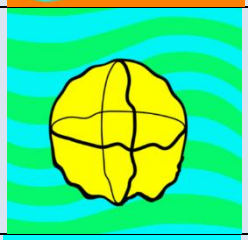
**Superposition:** In superposition, quantum particles are a combination of all possible states. They fluctuate until they are observed and measured.

- One way to picture the difference between binary position and superposition is to imagine a coin. Classical bits are measured by "flipping the coin" and getting heads or tails. However, if you were able to look at a coin and see both heads and tails at the same time, as well as every state in between, the coin would be in superposition.



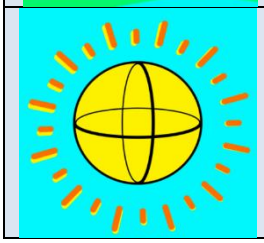
**Entanglement:** It is the ability of quantum particles to correlate their measurement results with each other. When qubits are entangled, they form a single system and influence each other. Thus, measurements from one qubit can be used to draw conclusions about the others.

- By adding and entangling more qubits in a system, quantum computers can calculate exponentially more information and solve more complicated problems.



**Decoherence:** The interaction of qubits with their environment in ways that cause their quantum behavior to decay and ultimately disappear is called decoherence. Their quantum state is extremely fragile.

- The slightest vibration or change in temperature—disturbances known as “noise” in quantum-speak—can cause them to tumble out of superposition before their job has been properly done.



**Quantum supremacy:** It’s the point at which a quantum computer can complete a mathematical calculation that is demonstrably beyond the reach of even the most powerful supercomputer.

**Steps taken by Government of India for advancement of Quantum Computing**

- **National Mission on Quantum Technologies and Applications (NM-QTA):** Budget 2020 allocated Rs 8000 Crore to the mission for a period of five years.
- **Quantum-Enabled Science & Technology (QuEST**): It is a research program to build quantum capabilities set up by the Department of Science & Technology.
- **Quantum Frontier mission:** It is an initiative of the Prime Minister's Science, Technology, and Innovation Advisory Council (PM-STIAC) which aims to initiate work in the understanding and control of quantum mechanical systems.
- **MeitY will establish a Quantum Computing Applications Lab** to accelerate quantum computing-led research and development and enable new scientific discoveries.
- **Indian Space Research Organisation (ISRO)is collaborating With Research Institute to** develop secure quantum communications in space.

# 1.3. INDIA AND FOURTH INDUSTRIAL REVOLUTION

## FOURTH INDUSTRIAL REVOLUTION (IR) AT- A- GLANCE

### ABOUT

- Refers to the increasing **integration of technology into business and production processes**.
- Aim is to **provide increasingly enhanced, customized offerings** to help meet the needs of individuals and organizations that can **adapt and evolve to changing situations and requirements** over time.

### Improve quality of life

- Potential to **raise global income levels.**
- Allowing things to be done remotely.

### Benefits to businesses

- Technological innovation **to lead supply-side miracle.**
- **Gains in efficiency** and productivity.
- **Lowering of Transportation and communication costs.**


### Better quality jobs

- Displacement of workers will **result in a net increase in safe and rewarding jobs.**

### Empowered Citizens

- Enabling them to **engage with governments, voice their opinions**, coordinate their efforts etc.

### Challenges posed by Fourth IR

#### Rising inequality

- Automation can potentially disrupt labor markets.

#### Rise in social tensions

- Increasingly segregated "low-skill/low-pay" and "high-skill/high-pay" segments.
- **Discontent fueled by digital technologies** and the dynamics of information sharing.

#### Privacy concerns

- Free flow of data leads to **concerns around protecting sensitive personal information.**

#### Surveillance state

- With **governments gaining new technological powers** and ability to control digital infrastructure.

#### Threat to National security

- With new technologies such as **autonomous or biological weapons becoming easier to use.**

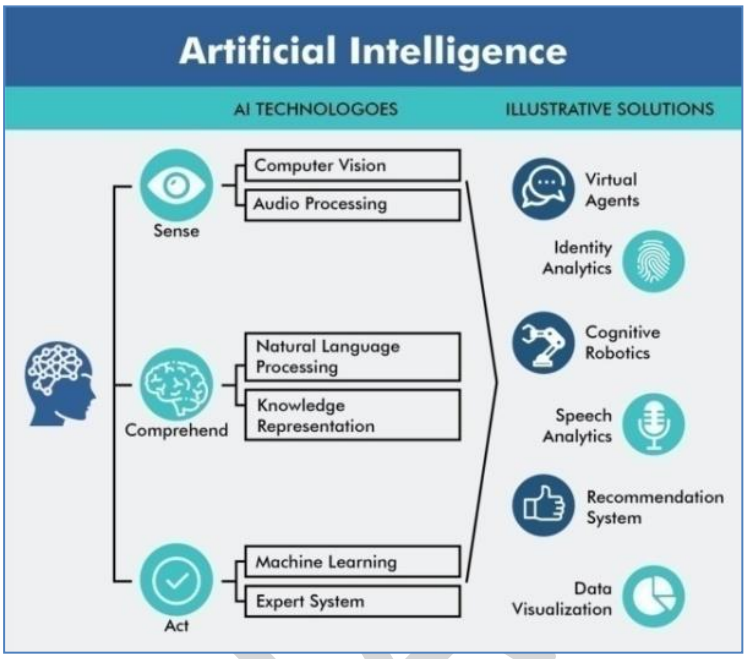
### WAY FORWARD

- Government contributing to **social security benefits of low-skilled/low-pay workers.**
- **New education programmes** to prepare the workforce of tomorrow and retrain displaced workers.
- **Agile governance** where regulators adapting to new fast-changing environment.
- Earn trust and loyalty of modern consumers by **personalizing opportunities.**

## 1.3.1. ARTIFICIAL INTELLIGENCE (AI)

**Why in news?**

Recently, U.S. India Artificial Intelligence (USIAI) has launched for working in the field of AI.

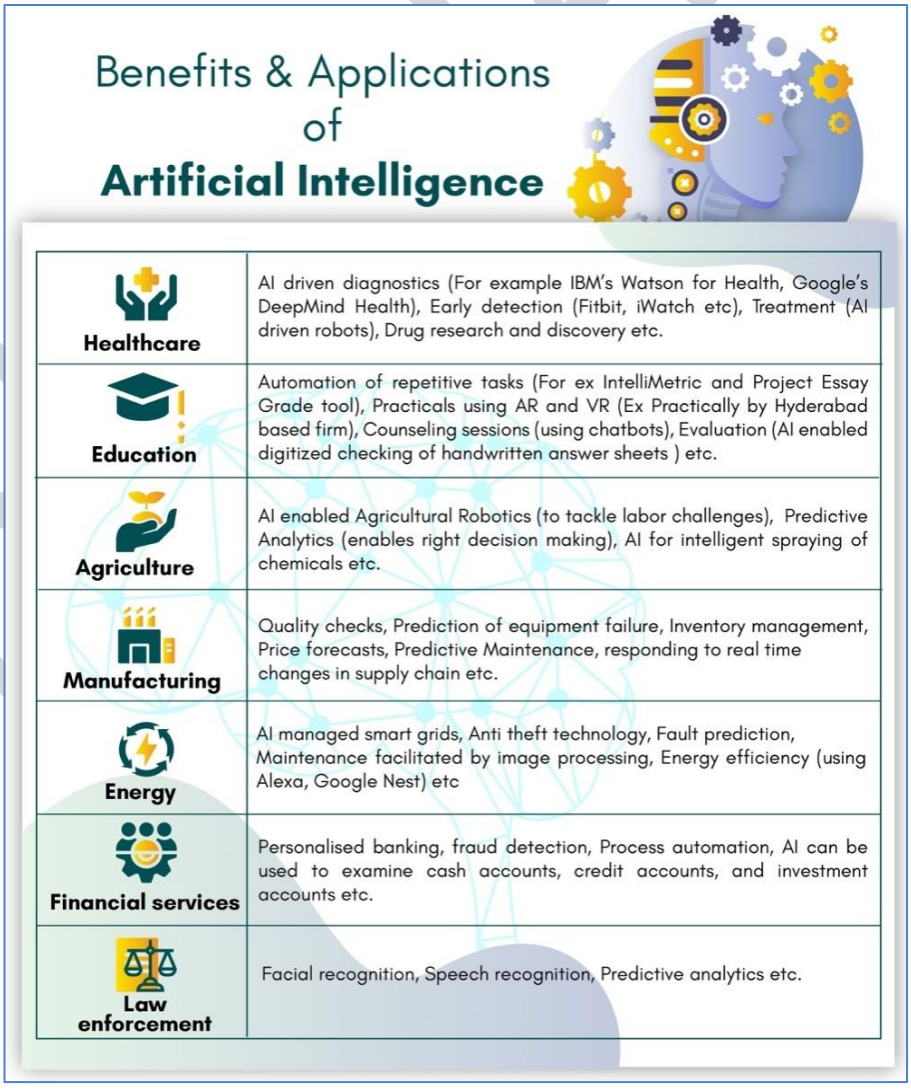



**More about News**

- USIAI, an **initiative of IUSSTF,** will serve as a **platform to discuss opportunities, challenges, and barriers for** bilateral AI R&D collaboration, enabling AI innovation, share ideas for developing an AI workforce and recommend modes and mechanisms for catalyzing partnerships.
- **It will provide breakthrough solutions in a range of sectors, like** agriculture, energy, climate change, affordable housing and smart cities etc.

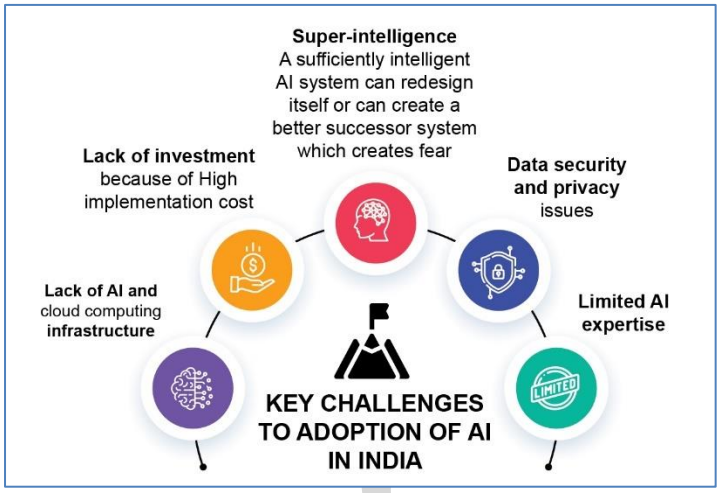
**About Artificial Intelligence (AI)**

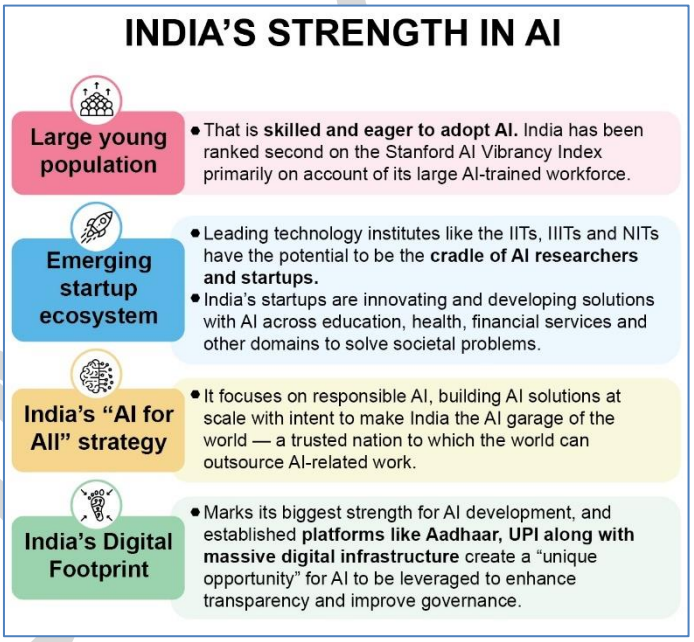
- It is the branch of computer science concerned with **making computers mimic human-like intelligence.** In contrast to normal hardware and software, AI enables a machine to perceive and respond to its changing environment.
- AI has the potential to boost the **national growth rate by 1.3% and add $957 bn by 2035 to India's economy.**
- **Human-AI Collaboration**
  - **Supportive Mode:** AI performs alongside humans by facilitating human judgements by providing resources such as predictive outputs.
  - **Reimagining the Business:** AI performs activities that go beyond the cognitive abilities of humans. For e.g., large-scale genome study in bioinformatics.
  - **AI replaces the Humans:** This is especially useful in potentially harmful situations for humans such as rapid system response in nuclear reactors.



**Need for regulating Artificial Intelligence (AI)**

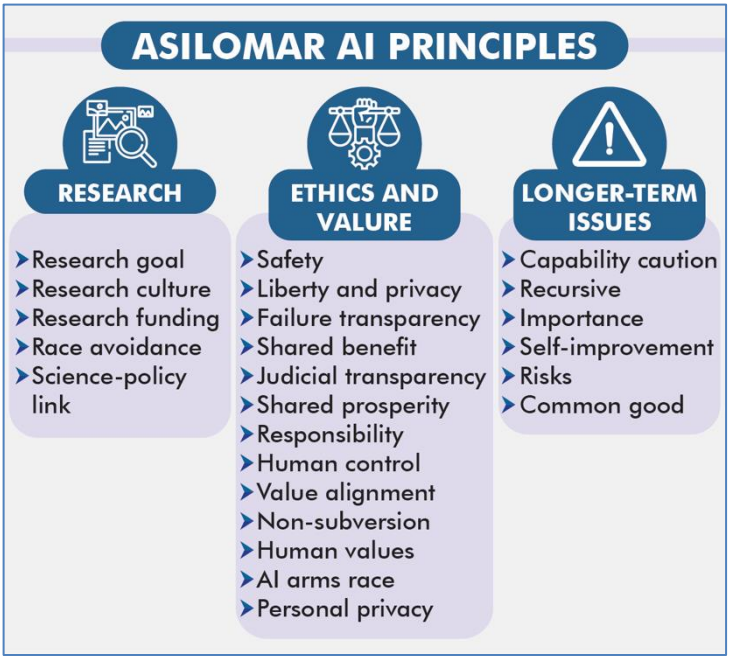
- **Ethical concerns:** There are real concerns about the potential negative consequences of AI, from deep fakes to nefarious uses of facial recognition technology.
- **Data Management:** as there is lack of clarity on data flow and data ownership which might result into data colonialism (data generated by developing countries yet not benefitting them).
- **Biasedness:** The algorithms used in AI are discrete and can be biased by making them adopt the stereotypes that exist in society or which are transferred to them by developers and make decisions based on them.
- **Accountability:** If an AI system fails at its assigned task, someone should be made responsible for it.




**Way forward**

- **Regulations and Policy:** to ensure safety of the people, protection of privacy for making people aware about this technology and create confidence in the people.
- **Asilomar AI Principles** (by Future of Life Institute, a non-profit organization) could be used as guiding principal (refer infographic).
- **Following set of ethical principles** could be adopted:
  - Minimize Biasedness and arrest inequalities and discrimination arising out of it.
  - Robots should act in the best interests of humans.
  - Human interactions with robots should be voluntary.
- **Research and Development:** Government has a major role to play in funding R&D and innovation projects with International cooperation.
  - Involvement of industry is necessary while funding R&D projects and facilitating interaction between the R&D centres/ academic institutions and industry.
- **Human Resource Development:** For this both formal and informal education systems should be reviewed to produce the manpower who can deal with the changing employment needs.



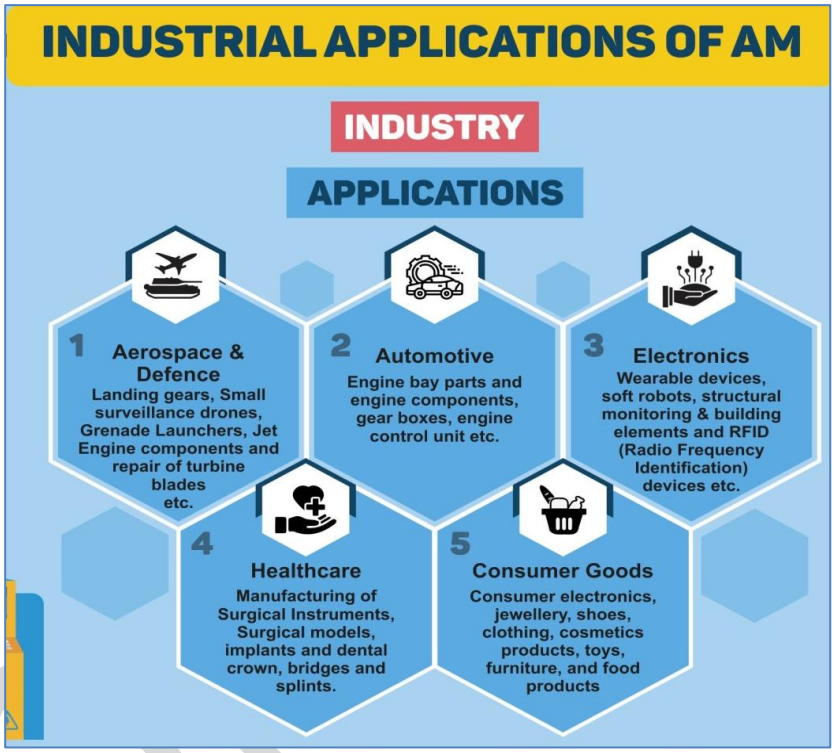
## 1.3.2. ADDITIVE MANUFACTURING/3D PRINTING

**Why in news?**

Recently, the Ministry of Electronics and Information Technology (MeitY) prepared a strategy paper titled **"National Strategy on Additive manufacturing (AM)".**

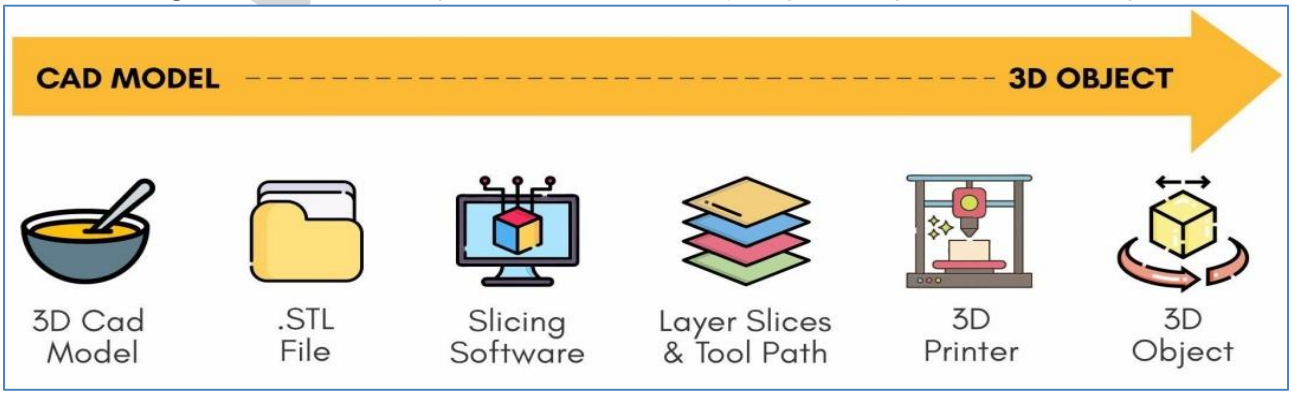
**About National Strategy on Additive manufacturing (AM)**

- Strategy aims to **promote various verticals of the AM (also known as 3D printing),** including machines, materials, software and designs to leverage the untapped business opportunities that will unfold in the near future.
- This will further accelerate **execution of recommendations as laid out in the National Electronics Policy, 2019.**
- **Its objectives include:**
  - Ensure creation of a **sustainable ecosystem for the AM industry** to compete globally.
  - Position India as a global **Innovation and Research hub for AM.**
  - **Promote creation of Indian IPR.**
- **Strategy envisages:**
  - **Creation of National AM Centre:** to position India at the forefront of development of AM technologies and address legal & ethical issues arising out of it.
  - **Engineering curriculum suitable for bachelor and master degrees** to be developed through in consultation with Industry and be introduced in ITI's /NIT's/IITs.




**About Additive Manufacturing (AM)/ 3D printing**

- It is defined as the **technology that constructs a three-dimensional object from a digital 3D model or a Computer-aided design (CAD) model** by adding material layer by layer.
- The addition of material can happen in multiple ways, namely **power deposition, resin curing, filament fusing.**
  - The deposition and solidification are **controlled by computer to create a three-dimensional object.**
- Traditional manufacturing methods, by contrast, are **subtractive in nature**.
  - Subtractive manufacturing involves **removing parts of a block of material** in order to create the desired shape.
  - Cutting wood into useful shapes, for instance, is a very simple example of a subtractive process.

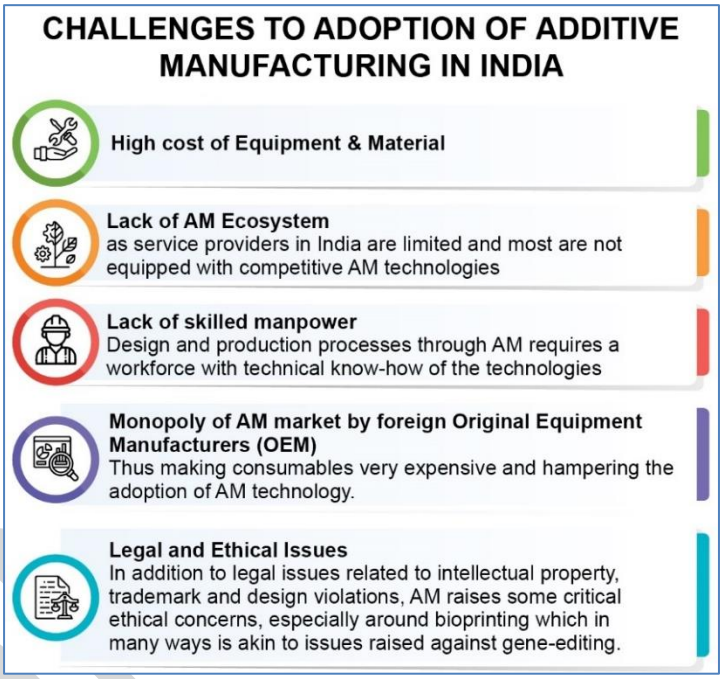



- **Thermoplastics, Metals, Ceramics as well as Biomaterials** can be used in additive manufacturing.

- USA's market share on AM is 36%, followed by EU as 26% and China 14% and **India holds a meagre 1.4%** of the AM global market share.

**Potential impact of Additive Manufacturing over different sectors**

- **Economic impact:** AM technologies will enable fast and cost-effective manufacturing. It will allow participation in the global value chain thereby developing new technology-driven industries and jobs.
- **Environmental impact:** AM facilitates development of new materials and technologies which are more energy and resource efficient to alleviate its carbon footprint and increases its energy security.
- **Innovation Diffusion:** It allows for removing design constraints without the risk of high expenditure thereby boosting innovation in the product development process. For e.g.:
  - **Production of customized implants and reduction in healthcare** costs due to minimal re-intervention enabled by accurate diagnosis.




**Ways to tackle challenges in adoption of AM technologies in India**

- **Government policies and incentives:** Preferential Market Access Policy should be adopted and incentives to be provided to support local additive manufacturers.
- **International R&D Partnership:** by attracting foreign leaders to set up their base in India and simultaneously promote Indian ancillary companies through bilateral and multilateral collaboration.
- **Skilling &Upskilling:** Effective measures must be adopted to proactively provide skilling and upskilling programmes on AM to ensure a technically competent, readily available workforce.

## 1.3.3. PRIME MINISTER WI-FI ACCESS NETWORK INTERFACE (PM-WANI)

**Why in News?**

Union Cabinet recently approved a framework for the proliferation of public Wi-Fi networks through PM Wi-Fi Access Network Interface or PM WANI scheme.

**About PM-WANI**

- The initiative **aims to elevate wireless internet connectivity** in the country.
- **PM-WANI eco-system will be operated by different players** such as Public Data Office (PDO); Public Data Office Aggregator (PDOA); App Provider; Central Registry.

**What is Wi-Fi?**

- Wi-Fi is a **wireless networking technology** that allows devices such as computers (laptops and desktops), mobile devices (smart phones and wearables), and other equipment (printers and video cameras) to interface with the Internet.
  - It is commonly called a **wireless LAN (local area network).**
- It allows **these devices--and many more--to exchange information with one another, creating a network.**
- The wireless network is operating three essential elements that are **radio signals, antenna, and router**. The radio waves are keys that make Wi-Fi networking possible.
- **Mobile data works essentially the same way as Wi-Fi.** The biggest difference is that the signal comes through your mobile service provider rather than ISP (Internet service provider).
- Also, both **Bluetooth and Wi-Fi are used for providing wireless communication** through radio signals.
  - However, **Bluetooth is actually accustomed to connect short-range devices for sharing information whereas Wifi is used for providing high-speed web access or internet.**
  - The **range** of Bluetooth is about 10 metres in comparison to wi-fi's hundred metres.
  - **Bluetooth limits the number of devices that can connect** at any one time, whereas Wi-Fi is open to more devices and more users.
  - In addition, Bluetooth, because it requires only an adapter on each connecting device, tends to be simpler to use and needs less power than Wi-Fi.

- The public network will be **set up by the PDOAs to provide Wi-Fi service through the PDOs** spread throughout the country.
  - ✓ A PDOA buys bulk bandwidth from licencedtelcos/ISPs, and re-sells it to multiple PDOs to ensure the latter can offer Wi-Fi connectivity to customers.
  - ✓ This **nationwide network of public Wi-Fi hotspots**, termed **PDOs after the public call office (PCO) concept** rolled out by the Indian government to set up a nationwide network of landline public pay-phones.
- The government will **develop an app to register users and discover the WANI-compliant Wi-Fi hotspots** in the nearby area and display them for accessing internet service.
  - ✓ The App Provider **will also be able to verify a customer's credit card details** if payment for WiFi service is done electronically instead of cash. The App provider works closely with the PDOA.
- **Central Registry** will maintain the details of App Providers, PDOAs, and PDOs. To begin with, the Central Registry will be maintained by Centre for Development of Telematics (C-DOT).
- PDOA **shall make necessary provisions for storage of user data for one year** to ensure compliance with legal provisions, as required.
- The **user data privacy will be ensured by App Providers and PDOAs**. Complete user data and usage logs will be stored within India.

- There shall be **no license fee for providing Broadband Internet through these public Wi-Fi networks.** A customer wanting to access the network from a PDO's premise can do so only after an eKYC authentication.

## SIGNIFICANCE OF PUBLIC WI-FI

| | |
|---|---|
| COST EFFECTIVE | • Wi-Fi is **easier to scale** than adding new mobile towers.<br>• It **bolsters connectivity** inside buildings, airports, etc. where mobile network penetration is limited.<br>• Also, Wi-Fi uses free unlicensed spectrum and Wi-Fi hardware is cheap and widely adopted. |
| DE-CONGEST TELECOM NETWORKS | • Enhanced usage of public Wi-Fi networks reduces load on Telecom Service Providers as limited spectrum is available for voice calling and internet. |
| CAPACITY UTILISATION | • It will **vastly improve utilisation of the large and high-capacity fibre network** created by Bharat Broadband Network (BBN), RailTel, GAIL etc. |
| BOOST GDP | • World Bank observed that a **10% increase in internet penetration leads to a 1.4% increase in GDP.**<br>• Public hotspots hold an **important place in the last-mile delivery of broadband to users.** |
| BRIDGE RURAL-URBAN DIVIDE | • As per 'The Indian Telecom Services Performance Indicators' report of TRAI **broadband penetration in rural India is limited to 29.2%** against urban India which has a broadband penetration of 93%. |
| EMPLOYMENT OPPORTUNITY | • It will **create job opportunities** for entrepreneurs, local businesses, IT engineers, app developers and cybersecurity professionals. |

**Challenges**

- **Public Wi-Fi accessibility is prone to security attacks** due to the non-encryption of such networks. In the past, there are cases where it was **misused for unauthorized access.**
- **Financial status of telecom service provider:** Huge debt of telcos do act as a deterrent for Wi-Fi deployment in the country
- **Lack of supporting infrastructure** such aselectric connection in both Rural and Semi - Urban areas, getting the space (Access Point) for the tower etc
- **Customers are facing the issue of manual action for periodic Login to Wi-Fi networks** rather than automatically connecting the network while on the move.
- **Right of Way (RoW) issues:** Complex procedures across states, non-uniformity in levies and obtaining approvals from various government agencies leads to **delay in deploymentofoptical fibre cables (underground)** and **mobile towers (overground) infrastructure.**

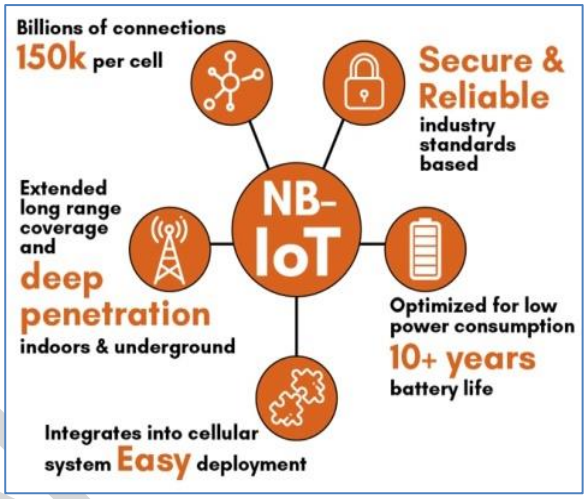
**Way forward**

- **Wi-Fi hotspots deployment as per India's population** so Indian government should strategise accordingly and focus more on villages.
- Since user data is being handled by multiple agencies – app providers, PDOAs, PDOs, DoT and TSPs/ISPs, at every stage **user data safe-handling protocol with respect to storage, sharing, encryption and grievance redressal must be well-documented and enforced.**
- **Consumer education and hand-holding has to be part of the overall deployment strategy** to build trust and acceptability.
- **Seamless Wi-Fi Roaming** is important where people can easily access Wi-Fi on the move.

## 1.3.4. NARROW BAND-INTERNET OF THINGS

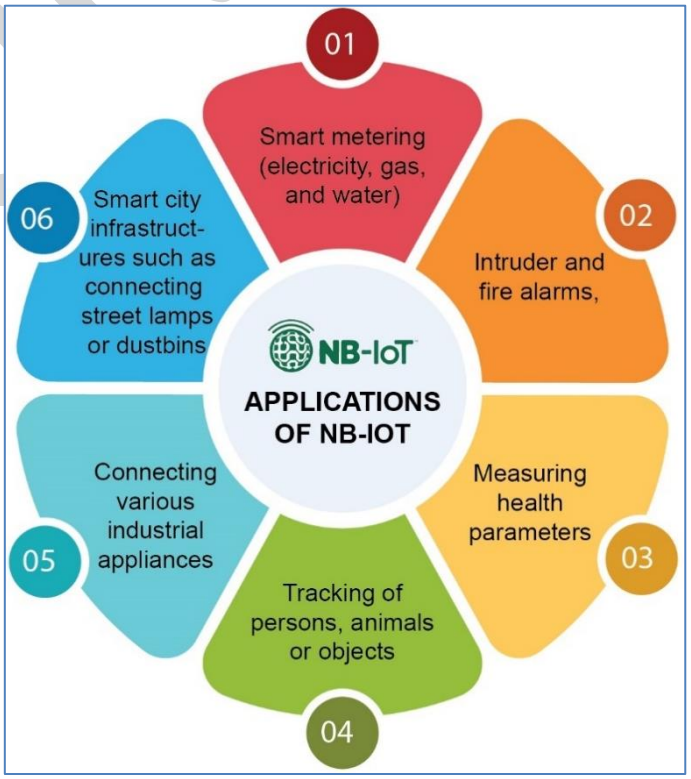
**Why in news?**

BSNL, in partnership with Skylotech India, announced worlds' first satellite-based narrowband-IoT (NB-IoT) network in India.




**More about news**

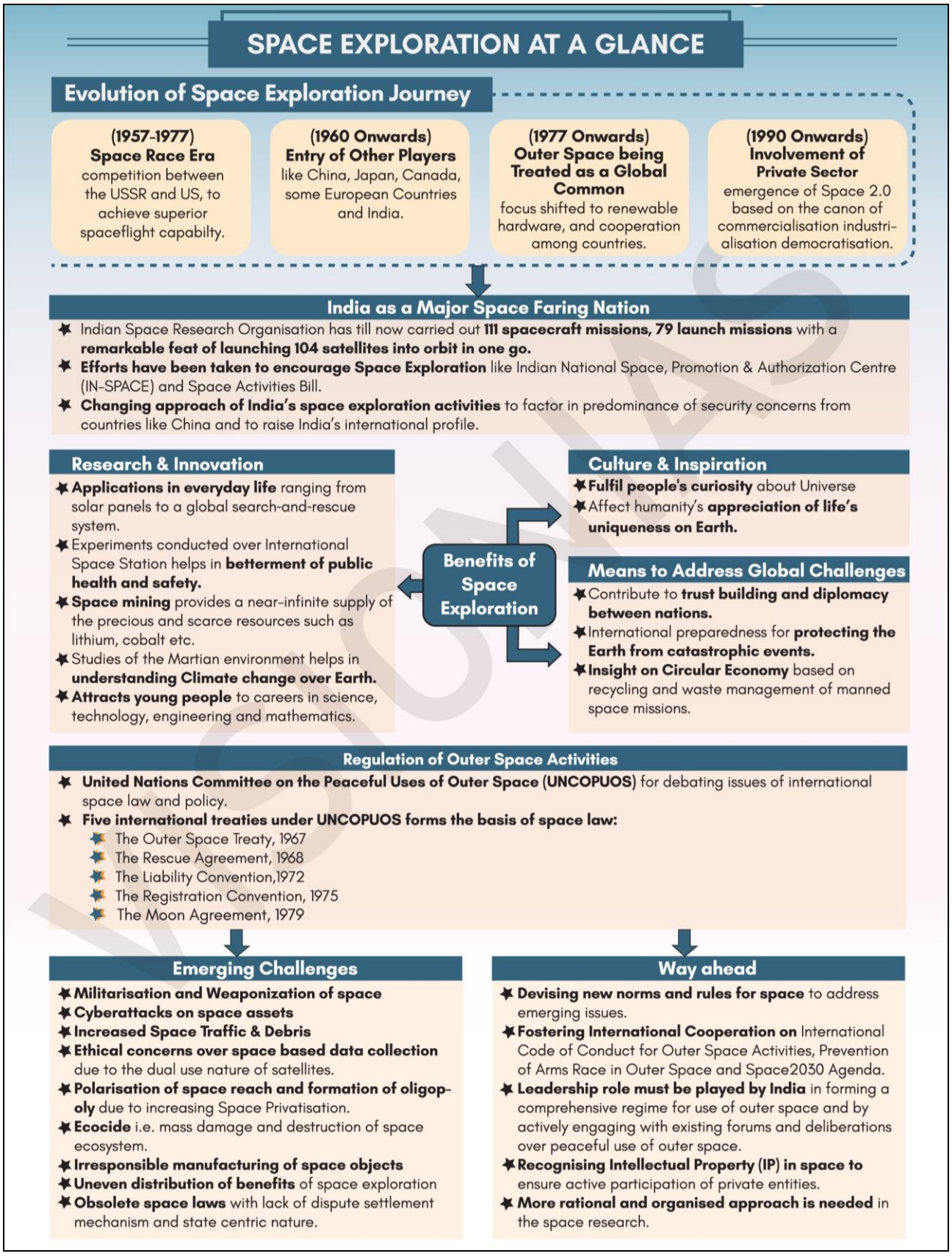
- This is in vision of Digital India and **to provide affordable, innovative telecom services and products across customers segments.**
- With this solution, **India will now have access to a ubiquitous fabric of connectivity for millions** of yet unconnected machines, sensors and industrial IoT devices.
- This new 'Made in India' solution will **connect with BSNLs satellite- ground infrastructure and provide PAN-India coverage,** without leaving any dark patch within the boundary of India and Indian seas.
- NB-IoT supports the Department of Telecom and NITI Aayog's plan of **bringing indigenous IoT connectivity to India's core sectors** and already been tested successfully in Indian Railways, fishing vessels and enabling connected vehicles across India.




**About Narrow Band-Internet of Things (NB-IoT)**

- It is a **wireless communication standard for the Internet of Things (IoT)** belonging to the category of low-power wide-area networks (LPWAN).
  - **Internet of Things, or IoT**, refers to the billions of physical devices around the world that are now connected to the internet, all collecting and sharing data.
- It **enables to connect devices that need small amounts of data,** low bandwidth, and long battery life.
- NB-IoT can **co-exist with 2G, 3G, and 4G mobile networks.**
- It **doesn't operate in the licensed LTE construct,** Instead, it works in one of three ways:
  - Independently
  - In unused 200-kHz bands that have previously been used for GSM (Global System for Mobile Communications).
  - On LTE base stations allocating a resource block to NB-IoT operations or in their guard bands.

## 1.4. SPACE


SPACE EXPLORATION AT A GLANCE
Evolution of Space Exploration Journey
(1957-1977) Space Race Era competition between the USSR and US, to achieve superior spaceflight capabilty.
(1960 Onwards) Entry of Other Players like China, Japan, Canada, some European Countries and India.
(1977 Onwards) Outer Space being Treated as a Global Common focus shifted to renewable hardware, and cooperation among countries.
(1990 Onwards) Involvement of Private Sector emergence of Space 2.0 based on the canon of commercialisation industri-alisation democratisation.
India as a Major Space Faring Nation
Indian Space Research Organisation has till now carried out 111 spacecraft missions, 79 launch missions with a remarkable feat of launching 104 satellites into orbit in one go.
Efforts have been taken to encourage Space Exploration like Indian National Space, Promotion & Authorization Centre (IN-SPACE) and Space Activities Bill.
Changing approach of India's space exploration activities to factor in predominance of security concerns from countries like China and to raise India's international profile.
Research & Innovation
Applications in everyday life ranging from solar panels to a global search-and-rescue system.
Experiments conducted over International Space Station helps in betterment of public health and safety.
Space mining provides a near-infinite supply of the precious and scarce resources such as lithium, cobalt etc.
Studies of the Martian environment helps in understanding Climate change over Earth.
Attracts young people to careers in science, technology, engineering and mathematics.
Benefits of Space Exploration
Culture & Inspiration
Fulfil people's curiosity about Universe
Affect humanity's appreciation of life's uniqueness on Earth.
Means to Address Global Challenges
Contribute to trust building and diplomacy between nations.
International preparedness for protecting the Earth from catastrophic events.
Insight on Circular Economy based on recycling and waste management of manned space missions.
Regulation of Outer Space Activities
United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) for debating issues of international space law and policy.
Five international treaties under UNCOPUOS forms the basis of space law:
The Outer Space Treaty, 1967
The Rescue Agreement, 1968
The Liability Convention,1972
The Registration Convention, 1975
The Moon Agreement, 1979
Emerging Challenges
Militarisation and Weaponization of space
Cyberattacks on space assets
Increased Space Traffic & Debris
Ethical concerns over space based data collection due to the dual use nature of satellites.
Polarisation of space reach and formation of oligop-oly due to increasing Space Privatisation.
Ecocide i.e. mass damage and destruction of space ecosystem.
Irresponsible manufacturing of space objects
Uneven distribution of benefits of space exploration
Obsolete space laws with lack of dispute settlement mechanism and state centric nature.
Way ahead
Devising new norms and rules for space to address emerging issues.
Fostering International Cooperation on International Code of Conduct for Outer Space Activities, Prevention of Arms Race in Outer Space and Space2030 Agenda.
Leadership role must be played by India in forming a comprehensive regime for use of outer space and by actively engaging with existing forums and deliberations over peaceful use of outer space.
Recognising Intellectual Property (IP) in space to ensure active participation of private entities.
More rational and organised approach is needed in the space research.

## DEVELOPMENTAL ROLE OF INDIAN SPACE RESERACH ORGANISATION

| | |
|---|---|
| **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. |
| **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. |
| **Resource management** | ISRO through Earth Observatory satellites provides for effective management of natural resources. |
| **Railway sector** | Applications of space technology are realised in guarding unmanned railway crossings, detecting obstructive objects on rail tracks to avoid train accidents etc. |
| **Education** | EDUSAT provided connectivity to schools, colleges and higher levels of education and also supported non-formal education including development communication |
| **Disaster Management** | Using geoportals like Bhuvan to address various aspects of natural disasters, using space based inputs. |
| **Navigation with Indian Constellation (NavIC)** | It 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. |
| **Urban Development** | High resolution satellite data provides accurate information on current landuse practices in a city or town. |



## 1.4.1. MANNED SPACE MISSION

**Why in news?**

Recently NASA launched its first full-fledged human mission (CREW-1) using a privately owned spacecraft.

**About CREW-1 Mission**

- It is part of **NASA's first commercial human spacecraft system** to the International Space Station (ISS), onboard SpaceX'sCrew Dragon spacecraft called Resilience.
- It is the first of 6 crewed missions that NASA and SpaceX will operate **as part of NASA's Commercial Crew Program (CCP).**

**Manned Space Mission**

- Manned Space missions includes **sending human aboard spaceflights beyond the gravity of the Earth.**
  - Until now **only US, Russia and China** have managed to send manned missions to outer space.

**What are the challenges for India to carry out Manned Space Missions?**

- **Financial:** These missions require exorbitantly huge investment as they are highly technology intensive.

- Initial cost of Gaganyaan was projected to be Rs. 12, 000 crore. However, ISRO is required to complete the project with a budget outlay of Rs. 10,000 crore only.

- **Technological challenges**
  - **Mastering of complex reentry and recovery technology**.
  - **Crew escape system** in case of a faulty launch.
  - **Developing regenerative environment in the spacecraft** for continuous supply of food water, oxygen, carbon-dioxide and to manage human wastes.
  - **Need of heavier rockets:** Such rockets enable contingencies to be mitigated without having to rely on another launch.
- **Training of astronauts.**
- **Awareness of celestial objects in the path of a rocket/satellites, and communication** is also a major challenge.

**Indian Human Spaceflight Programme (IHSP)**

- IHSP was **initiated in 2007 by ISRO to develop the technology needed to launch crewed orbital spacecraft** into Low Earth orbit.
  - Under it, first unmanned mission is planned in December 2021. Second unmanned flight is planned in 2022-23, followed by human spaceflight demonstration (Gaganyaan)
- Gaganyaan has been designed **to carry three Indian astronauts to the low earth orbit** for a period of five to seven days.
- It will **take off on a GSLV Mk III** which is capable of launching **four-tonne satellites in the Geosynchronous Transfer Orbit** (GTO).
- **Gaganyaan National Advisory Council** has been created with members from different institutions and industries to deliberate on various aspects of the mission.
- **Gaganyaan includes** a Space Capsule Recovery Experiment (SRE-2007), Crew module Atmospheric Reentry Experiment (CARE-2014), GSLV Mk-III (2014), Reusable Launch VehicleTechnology Demonstrator (RLV-TD), Crew Escape System and Pad Abort Test.

**Significance of Gaganyaan**

- The mission will add **significant value to India's space activities.**
- It re-establish India's role as a key player in the new space industry hence improving international collaboration **giving space to Space diplomacy.**
- The securitisation of outer space has an **impact on national security** as a result of which outer space is increasingly seen as a 'strategic domain'.
- **Spinoff technologies,** attraction of talent to scientific careers, scientific knowledge etc.

**Related News**

**Humans in Space Policy**

The Department of Space has put up for public consultation, the draft "Humans in Space Policy for India -- 2021" and guidelines and procedures for its implementation.

**About the policy**

- **Applicability:** The guidelines are applicable to activities presently postulated under Indian human space program (IHSP) and for those activities which shall be defined and carried out in future in conjunction with IHSP.
- **Aim:** It envisages undertaking demonstration of human spaceflight to LEO (low-earth orbit) in the short-term and lay the foundation for a sustained exploration in the long run that will enable presence in LEO and beyond.

**Significance of the policy**

- **Leveraging the existing experience**: Demonstrating human space flight capability will leverage the expertise of ISRO, national research institutions, academia, industry and other organisations in various technological elements such as development of human rated launch vehicle, environmental control and life support system, crew escape system among others.
- **Technological innovation, advancement, and scientific discovery** like Regenerative life support systems, development of Rendezvous and docking systems, Inflatable habitats, extravehicular activity suits etc.
- **Industrial competitiveness**: Policy framework will unlock the space sector by facilitating the participation of non-traditional players/private sector in undertaking space activities through a handholding approach and a transparent regulatory framework.
- **Employment generation-** According to the ISRO chief, the Gaganyaan mission would create 15,000 new employment opportunities, 13,000 of them in private industry.
- **Enhance public involvement in human space programmes**.
- **Fulfilling ISROs long term objective:** It will support ISRO to undertake capacity building measures — collaborations, infrastructure development, modernisation, technology development etc.

**Way Forward**

- **Leveraging Private Sector:** For various inputs required for developing the spacecraft.
- **Expanding International collaboration**: Other than Russia, US and France had also offered training support to Astronauts for Gaganyaan. Collaborating with more countries would provide better choices.

- **Doing away with the bureaucratic hassles:** Cryogenic engine development was delayed for decades due to bureaucratic hassles. Priority should be given to ensure that required R&D is carried out seamlessly.
- **Capacity building:** ISRO is imparting basic knowledge on Space Technology, Space Science and Space Applications to the 10th Std students (through its programs like **'Yuvika'**).
    - Similar programmes should be carried out for imparting specialized knowledge in the field to the youth.

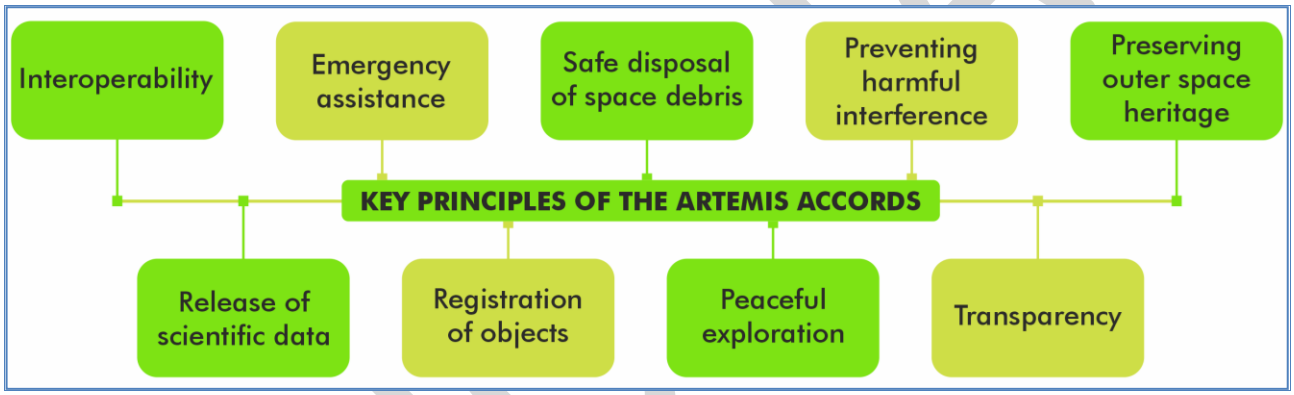
## 1.4.2. ARTEMIS ACCORDS

**Why in news**

Recently, New Zealand became the 11th Country to sign the Artemis accords.

**About the Artemis Accords**

- Announced by **NASA** in 2020, Accords is a **set of guidelines surrounding the Artemis Program** for crewed exploration of the Moon. This **agreement is for lunar exploration and beyond,** with participation of both international partners and commercial players.
- The accords describe a shared vision for principles, **grounded in the Outer Space Treaty of 1967** to create a safe and transparent environment.
- **Signatories:** US, New Zealand, Australia, Canada, Italy, Japan, Luxembourg, the Republic of Korea, the United Kingdom, the United Arab Emirates, and Ukraine.
- Major space players like **India, Russia, China, France and Germany are not a signatory** of the accord.




**Factors that may prompt India to sign the Artemis Accords**

- **Enhanced space cooperation among Quad countries:** as US, Japan and Australia are already signatories of the accords.
    - India is also collaborating with Japan on a future lunar mission, called LUPEX, to the Moon's surface.
- **Attracting more investments:** By being a part of the accords, India's space companies could become part of a global supply chain. This would also help attract investment capital towards Indian space startups.
- **Opportunities to learn about interplanetary missions and human spaceflight**.

**Challenges that India faces in signing the Artemis accords**

- **Reinforcing US Hegemony:** US promotion of the accords outside of the "normal" channels of international space law is a cause of consternation for some Countries.
- **Harbinger of change in space governance:** The accords are bilateral agreements and **not binding instruments of international law**. But, by establishing practice in the area, they could have a significant influence on any subsequent governance framework for human settlements on Mars and beyond.
- **Diplomatic challenges:** India has had a traditional partnership with Russia, which recently partnered with China in its International Lunar Research Station (ILRS) initiative. Russia might invite India to join, but on the other hand, growing assertiveness of China is likely to prevent any meaningful association of India with ILRS.
- **Focus on indigenous programmes may be compromised**.

**Way ahead:** India's decision to sign the Artemis accords, or for that matter any other bilateral space agreements, should completely be based on the merits of the proposal i.e. whether proposals meet India's expectations or not. All such decisions could be complemented with following initiatives

- **Confidence building with US:** Working together on the Chandrayaan-1 and NASA-ISRO Synthetic Aperture Radar (NISAR) missions have helped to build confidence in each other.
- **Strategic balance with Russia:** India has maintained a balanced relationship with the US as well as Russia in other strategic areas and the same could apply for space after India signs the accords as well.
- **Pursuing Indigenous programmes:** India should encourage the involvement of the private sector in communications and Earth-observation satellites construction and launch and should also outline its priorities for interplanetary and human spaceflight missions and actively pursue them.

## 1.4.3. VENUS ORBITER MISSION: SHUKRAYAAN

**Why in news?**

ISRO has short-listed 20 space-based experiment proposals, for its proposed Venus orbiter mission 'Shukrayaan'.

**More about news**

- For the mission **20 proposals were received**, including collaborative contributions from Russia, France, Sweden and Germany.
- The one already selected is **France's VIRAL instrument (Venus Infrared Atmospheric Gas Linker)** co-developed with the Russian space agency (Roscosmos) and French space agency (CNES and the **LATMOS atmospheres,** environments and space observations laboratory attached to the French national scientific research centre.
- The **possible detection of phosphine in Venus' upper atmosphere** shows prospects of life there.

**About Venus**

- **Formation:** It is believed that **Earth and Venus both planets share a common origin, out of a condensing nebulosity** (gravity pulled swirling gas and dust together) around 4.5 billion years ago.
- **Similarity with earth**
  - Venus with a **radius of 6,052 km** is roughly the similar to the Earth with radius 6378 km.
  - Venus has a **central core, a rocky mantle and a solid crust, similar to Earth's structure**. However **magnetic field is much weaker than the Earth's due to Venus' slow rotation.**
  - Venus has **mountains, valleys, and tens of thousands of volcanoes**, with highest mountain Maxwell Montes, 20,000 feet high (8.8 kilometers), similar to the highest mountain on Earth, Mount Everest.
  - Hence, Venus is often **described as the 'twin sister' of the Earth because of the similarities in size, mass, density, bulk composition and gravity.**
- **Atmosphere**
  - **Venus' atmosphere consists mainly of carbon dioxide, with clouds of sulfuric acid droplets**, that traps the Sun's heat, resulting in surface temperatures higher than 470 degrees Celsius.
  - Also, **Venus is around 30% closer to the Sun** as compared to Earth resulting in much **higher solar flux.**
  - Venus is the **brightest planet in solar system because** it is covered with clouds that reflect and scatter sunlight.
- **Orbit and rotation**
  - Venus rotates from **east to west, unlike the Earth from west to east** and **completes one rotation in 243 Earth days**, the longest day of any planet in our solar system.
  - Venus makes a **complete orbit around the Sun (a year in Venusian time) in 225 Earth days** and **orbit around the Sun is the most circular,** while other planet's orbits are more elliptical, or oval-shaped.
  - Though Venus has **no moons**, where Earth has one moon.

**About 'Shukrayaan'**

- **Shukrayaan, mission to Venus, is to study the planet for more than four years** will be launched either in 2024 or 2026 during optimal launch window (Venus is closest to the Earth), which comes about every 19 months.
- The **payload capability** of the proposed 2500-kg satellite, is likely to be **175 kg with 500W of power.**
- It is planned **to be launched onboard GSLV Mk II rocket or GSLV Mk III** rocket to carry more instruments or fuel.
- **Scientific objectives of mission:**
  - investigation of the surface processes and shallow subsurface stratigraphy
  - study solar wind interaction with Venusian Ionosphere
  - study the structure, composition and dynamics of the planet's atmosphere.
- **Instruments to be carried with mission:**

- **Synthetic aperture radar (SAR) to examine the Venusian surface.** (earlier launched on Chandrayaan-2 spacecraft)
- Swedish-Indian collaboration, **the Venusian Neutrals Analyzer to examine how charged particles from the sun** interact with the atmosphere of Venus. (earlier launched on the Indian Chandrayaan-1).
- Also, **instrument to examine the planet's atmosphere in infrared, ultraviolet and submillimetre wavelengths** and presence of phosphine, other biomarkers and locate any active volcanism could be confirmed using the **orbiter's Near Infrared Spectrometer**.

## 1.4.4. SPACE TOURISM

**Why in news?**

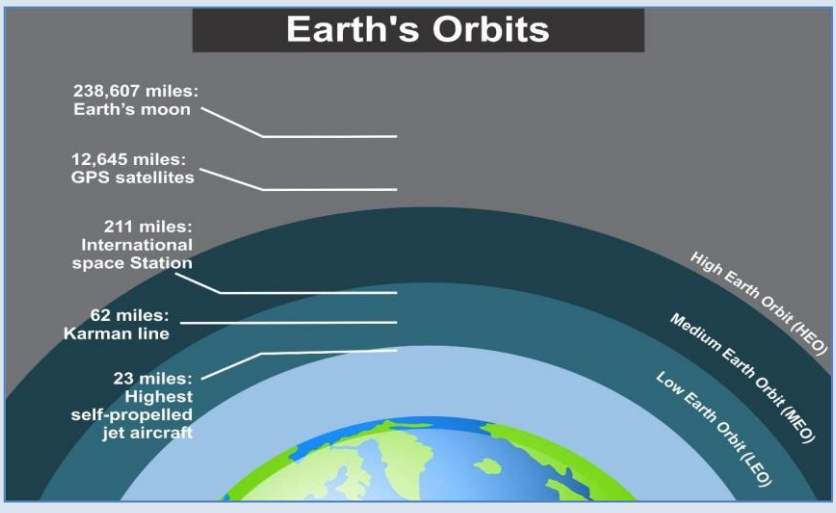
Several private companies are developing plans to take paying customers to space on a regular basis leading to a rapid growth in space tourism industry.

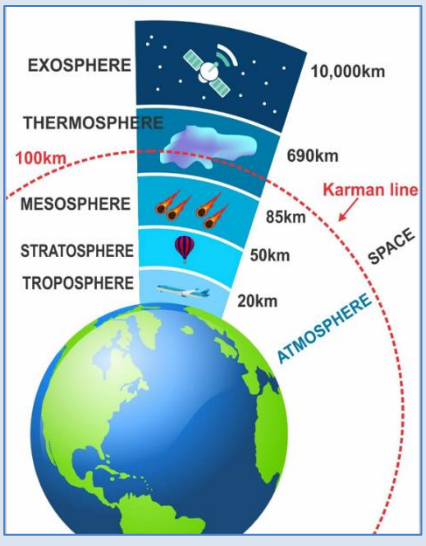
**About Space Tourism**

- Space tourism is **space travel for recreational, leisure or business purposes**. There are several different types of space tourism, **including orbital, suborbital and lunar space tourism.**
  - Several private spaceflight **companies are now working towards developing suborbital space tourism** vehicles to take paying customers to space *(Refer infographic)*.

**What do we call space and space travel?**

- According to the **FédérationAéronautiqueInternationale**(world governing body for aeronautic and astronautic records), space starts at an altitude of 100 km (62 miles) above the surface of the earth.
  - This is the **Karman line** where atmospheric lift no longer supports a flying object and the object would need to reach orbital velocity or risk falling back to Earth.
- **Space travel** is referred to as any flight operation that takes one or more passengers beyond the altitude of 100 km and thus into space.
- The main **difference between orbital and suborbital flight** is the speed at which a vehicle is traveling.
  - An **orbital spacecraft must achieve orbital velocity** i.e. the speed that an object must maintain to remain in orbit around a planet. To orbit 125 miles (200 kilometers) above Earth for instance, a spacecraft must travel at a screaming 17,400 mph (28,000 km/h).
  - **Suborbital flight, in contrast, requires much lower speeds** and doesn't have the power to achieve orbit. Instead, it will fly up to a certain height that depends on its speed, and then come back down once its engines are shut off.
  - At the top of their flight arc in a suborbital flight, when the object is falling back toward Earth, passengers achieve a few minutes of weightlessness under zero gravity.



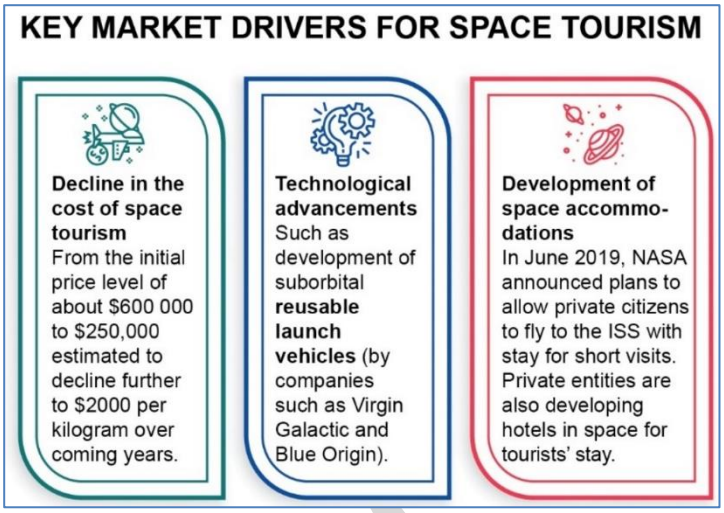




**Issues with respect to emerging space tourism industry**

- **Unclear status of Space tourist:** No international space law has defined space tourists. Existing space treaties such as Outer Space Treaty, Rescue Agreement etc. are only applicable to astronauts, envoys of mankind, or personnel of a spacecraft.
- **Authorization issues:** To send a vehicle to space, it is compulsory for the national and international space law to authorize it according to Article VI of the Outer Space Treaty. However, the national and

international legislations and regulations are reticent on the subject of authorization of space travel with tourists aboard.

- **Passenger Liability:** International treaties and conventions are aimed at regulating the signatory states and are bereft of the provisions to handle the liability of private entities in space.
    - For instance, according to Article VII of the Montreal convention, the **international liability for any damage incurred by a space object is imposed on the launching State,** regardless of the space object being a public or a private entity.




- **Space insurance:** It is an excruciatingly technical issue and requires expert knowledge of the launch vehicles, satellites, and other issues.
- **Ethical issues:** Many health risks associated with space flight are still not well understood, and very little research has been done on medical consequences of such flights on the health of participants.

**Way ahead**

With the space tourism industry inching closer to launch every day, there emerges a dire **need to formulate laws and legislations that shall regulate issues of space tourism** including the regulation of private players. The role of the government includes a **legal responsibility to authorize and supervise private activities in space,** while ensuring that it gives the private sector enough opportunities to develop technologically and commercially and enhance their growth.

## 1.4.5. SPACE COMMUNICATION

### 1.4.5.1. DRAFT SPACE BASED COMMUNICATION POLICY -2020

**Why in News?**

Indian Space Research Organisation (ISRO) has released the draft of a new Spacecom Policy 2020.

**More on news**

- Space is becoming a vital frontier for strategic applications and India needs to augment its space capabilities **to ensure its national security and sovereignty** through appropriate monitoring and control measures.
- Draft policy is in line with **announcements made under Aatmanirbhar Bharat** which called for level playing field provided to private companies in satellites, launches and space-based services, predictable policy and regulatory environment etc.

**Objectives of the policy**

- Adopt measures to **monitor and authorize use of space assets** for communication to or from Indian Territory.
- **Ensure protection of space assets** and adopt measures to bring in more space assets under the administrative control.
- **Promote increased participation of commercial Indian industry** to provide space based communications both within the country and outside.
- Concentrate on **realization of space based communication systems** for addressing the requirements that cannot be satisfied by commercial Indian industry either because of national security concerns or economic factors.
- **Provide a timely and responsive regulatory environment** for the commercial Indian industry.

**Key features of the policy**

- **Private players can provide communication services** using space based assets within and outside India.

- **Private service providers are liable for financial damages** if any damages that may occur to other space objects in the outer space.
- Any communication service within the Indian territory from space can be carried out only with an authorised space asset. **Only Indian entities are eligible for obtaining space asset authorisation.**
- The Indian companies **can establish telemetry, tracking and command (TT&C) earth stations and satellite control centre (SCC)** in or outside India.
- **Objectives of societal development** such as social empowerment, providing access to health care and education, rural/tribal development etc. for reasons of economic viability or sustainability **shall be realized by Department of Space (DOS).**
- **Indian National Space Promotion & Authorization Center (IN-SPACe),** shall accord necessary authorizations and permissions for all satcom related activities, to or from Indian territory.

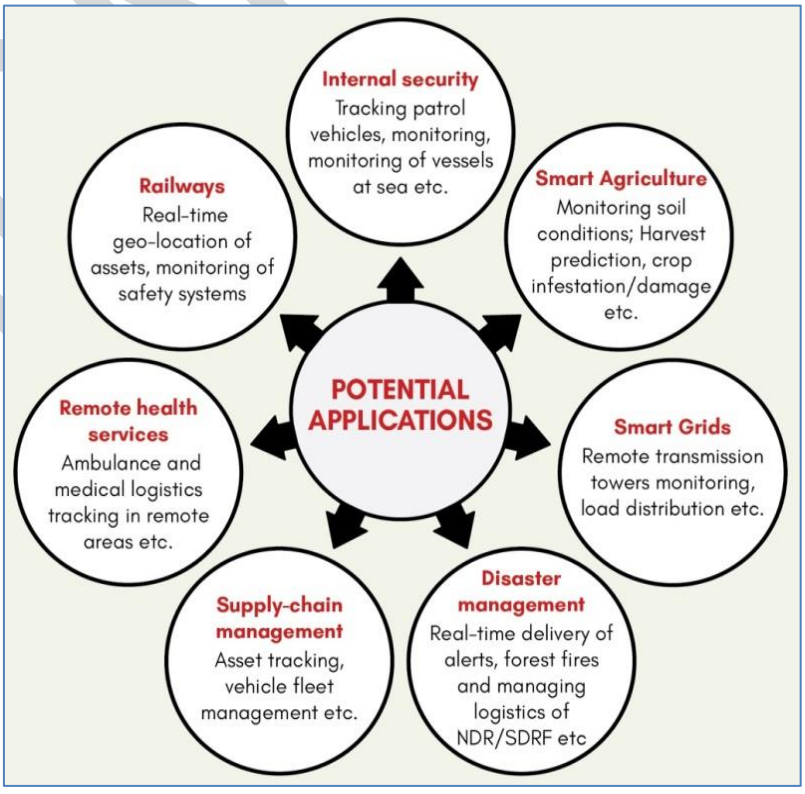
**Why role for private sector?**

- **Securing our space capabilities,** by distributing them across many different satellites and spacecraft, so that business continuity is unaffected even if an adversary manages to disable one or more satellites.
- **Meeting India-centric needs:** Private-sector help is needed to cater rapidly changing technological scenarios and to contribute to digitalization.
- **Increasing Demand:** Demand for satellites has reached a stage where ISRO has to deliver 18-20 satellites in a year. ISRO will find this difficult to meet without private sector participation.
- **Getting latest innovations and trends**.
- **Freeing up resources:** active involvement of the private sector would allow ISRO to devote more time to core research, deep-space missions etc.
- **Job creation:** Creation of new jobs in high-skilled-labour market in the private space industry.
- **Reducing dependence on taxpayer's money:** Privatising activities in space sector will allow economic contribution from private sector and will reduce dependence on funds from government.

## 1.4.5.2. SATELLITE BASED INTERNET CONNECTIVITY

**Why in news?**

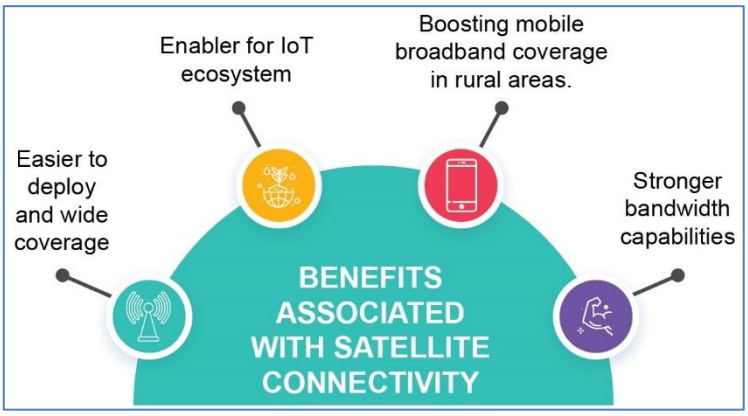
Telecom Regulatory Authority of India released a Consultation Paper on Licensing Framework for Satellite-based connectivity for low bit rate applications.




**About Satellite based connectivity**

- Rather than using an underground copper/fibre network, satellite based broadband connection **operates by sending and receiving broadband signal to a satellite in space.**
- Satellite-based low-bit-rate connectivity is possible using Geo Stationary, Medium and Low Earth orbit Satellites.
- **Factors favouring development of Satellite based connectivity**
  - **Innovation of technologies:** like AI, cloud and big data are gaining importance for exploring new prospects in the satellite Internet of Things (IoT) ecosystem.
  - **Smaller and cheaper satellites**: Smaller satellites, often weighing as little as 10 kg, are eliminating the entry barriers for the space industry.
  - **Private investment**: Investment and funding in space research is shifting from public to private organizations, allowing private companies to enter the space industry in more numbers.

**Issues related to Satellite connectivity**




- **High cost of services:** Right now, these services are priced at $15-$20 per GB, about 22-30 times higher than the $0.68 charged for mobile data.
- **Lack of enough domestic satellite capacity:** India does not have access to high-throughput satellites offering 100-500 Gbps of bandwidth.
- **Worries over the accumulation of space debris in the LEO.**
  - This also increases possibility of collisions with existing debris and catastrophic events such as **Kessler syndrome** (collisional cascading).
- **Impact on astronomy:** Due to Satellite brightness, Astronomers are concerned that constellations of space Internet satellites can make it difficult to observe other space objects, and to detect their signals.
- **Operational issues:**
  - **Poor latency or high ping rate:** Since you have to send data to space, to your ISP and back again, satellite internet has poor latency, or a high ping rate.
  - Minor obstructions or **disturbance in weather can affect signal and quality of internet.**

**Way Forward**

- **Encouraging commercial use of satellites for internet connectivity:** through steps such as
  - Allowing satcom operators to directly lease bandwidth from foreign operators and access very high-throughput satellites.
  - Encouraging private investment in the satellite industry.
- **Reducing satellite brightness:** For instance, SpaceX has been undertaking experiments to reduce brightness of its satellites such as
  - DarkSat, which is an experimental satellite with certain parts darkened to tackle on-station brightness.
  - Adding a deployable visor to the satellite to block sunlight from hitting the brightest parts of the spacecraft.

## 1.4.6. SPACE BASED REMOTE SENSING

**Why in news?**

Recently, Department of Space has published a draft 'Space based Remote Sensing Policy' of India (SpaceRS Policy 2020).

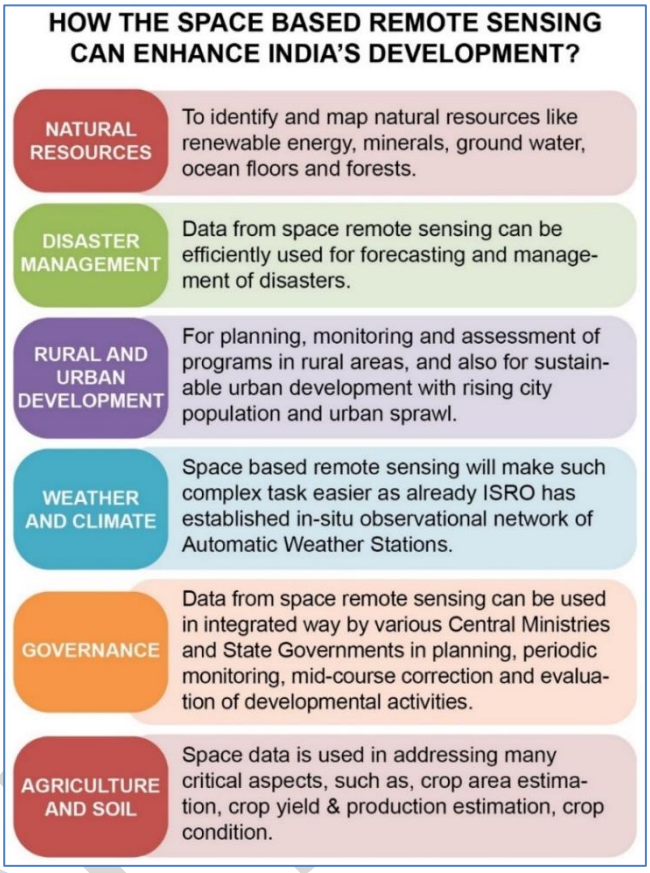
**About Remote Sensing**

- Remote sensing is the **process of detecting and monitoring the physical characteristics of an area/object** by measuring its reflected and emitted radiationat a distance (typically from satellite or aircraft).
- These help researchers to sense things about the earth.
- Remote Sensing data have **ability to detect changes, observations at different resolutions** due to characteristics like synoptic view, repetitive coverage with calibrated sensors etc.
- **Space based remote sensing** is the process of detecting and monitoring the physical characteristics of an area from satellite, aircraft and Unmanned Arial Vehicle (UAV).

**About Space Remote Sensing Policy - 2020' (SpaceRS Policy - 2020)**

- Policy aims at **encouraging various stakeholders in the country to actively participate in space based remote sensing activities** to enhance commercialization of space technology.
- Policy states that Government of India shall:
  - **Promote Indian Industries** to carry out space based remote sensing activities within and outside India.
  - **Enable easy access to space based remote sensing data**, except for "sensitive data and information".
  - **Concentrate on realisation of space based remote sensing systems.**
  - **Provide a timely and responsive regulatory environment.**
- Earlier **Remote sensing data policy (RSDP) 2011, is said to be more restrictive and provides less opportunities** to service providers.
- Hence this new policy helps to address these issues and provides opportunities through **Self- reliance (Atma-Nirbhar), Knowledge exploration, Competitiveness & Conducive environment.**

- **Spectral, spatial, temporal and polarization signatures are major characteristics** of the remote sensing, which facilitate target recognition and classification.
- An easy access of space based remote sensing data and information shall **enable unfolding of knowledge based solutions,** addressing many planning and monitoring requirements of the nation.




**What challenges are being faced in space based remote sensing?**

- **Lack of financial resources:** is an obstacle for investing in space programs in developing countries, because it is less commercialised and poorly funded by private sector.
- **Technology and skills gaps:** Lack of capability and expertise to produce satellite information with local resources and to provide user support can be a barrier to expanding the use of space-based remote sensing.
- **Data challenges:** Restrictive data access, lack of standardization, lack of analysis of ready data and demand of user needs are obstacles to the wider use of space based remote sensing.
- **Space debris:** The accumulation of space debris represents a considerable risk of collision for satellites, or in some cases, they might even fall back on Earth in an uncontrolled manner.
- **Risks and security concerns:** Images and data produced by space remote sensing can be used for military purposes and may create information asymmetries that can adversely affect different market actors.

**Other methods of remote sensing**

- **Light Detection and Ranging (LiDAR):** It is an active remote sensing technology that uses optical measurements of scattered light to find distance.
- **Radio Detection and Ranging (RADAR):** It is a detection system that uses radio waves to determine the range, angle, or velocity of objects.
- **Sound Navigation Ranging (SONAR):** The method of remote sensing uses echoes of sound waves to learn the landscape.
- **Hyperspectral Imaging (HSI):** It is a technique that analyzes a wide spectrum of light. The light striking each pixel is broken down into many different spectral bands in order to provide more information.

**Way forward**

- **Creating investment opportunities:** There is need to make space remote sensing sector more open to attract private investment and competitive.
- **Use of emerging technologies:** Use of Block chain and Artificial intelligence for processing high amount of data and enhance computing capacities to derive more benefits.
- **Regulations and guidelines:** Formulating international cooperation, guidelines and mitigation measures to address the sustainability of human space expansion and reduce space debris.

## 1.4.7. NUCLEAR TECHNOLOGY IN SPACE MISSIONS

**Why in News?**

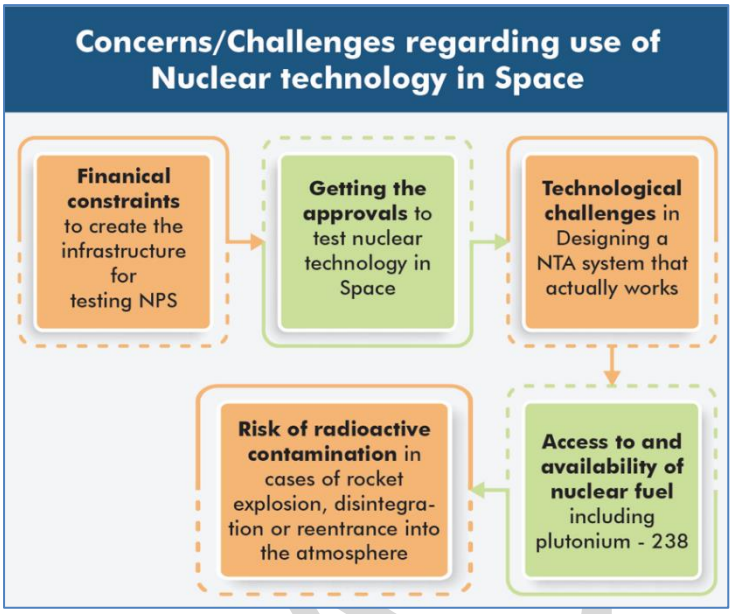
Recently, the UR Rao Satellite Centre (URSC) of ISRO invited proposals for the three-phase development of a 100-Watt **Radioisotope Thermoelectric Generator (RTG).**

**More on the News**

- The centre envisions using **Radioisotope Thermoelectric Generator (RTG)** for power generation and thermal management of ISRO's deep space missions.
- RTG is a type of Nuclear-based power system that is generally used for power generation and thermal management of space missions.

**Types of Nuclear Power Systems (NPS) with application in Space missions**

- **Radioisotope power systems (RPSs):** They are a type of nuclear energy technology that uses heat (produced by the natural radioactive decay of plutonium-238) to produce electric power for operating spacecraft systems and science instruments.
- **Nuclear Propulsion Systems:** Nuclear power can be used for a **rocket propulsion system.** NASA is currently working on development of nuclear thermal propulsion (NTP) systems, which are powered by Nuclear Fission.




**Associated Benefits with use of Nuclear Technology in Space**

- **RTGs are highly reliable and maintenance-free:** The absence of moving parts in thermocouples reduces the chances of failure and wear out.
- **Enable deep space and interplanetary travel:** Nuclear-propelled rockets are more fuel efficient and lighter than chemical rockets. Hence, they would travel further, are faster, and would shorten the trip time. This would also prove **beneficial for human space travel.**
- **RTGs as an alternative to solar power:** Solar power is not an option for space objects meant to operate on the dark sides of celestial objects where sunlight is obscured or those sent to far off missions away from the sun.
- **Flexible launch windows:** as RTGs are independent of solar proximity and planetary alignment.
- **Continuous operation over long-duration space missions.**

**Way forward**

- **Maintaining highest standards of safety**— keeping in mind both humans and the environment—can minimise contamination risks.
- **Maturing technologies** associated with fuel production, fuel element manufacturing and testing. **NASA is presently looking at systems that use low-enriched uranium** as using low-enriched uranium could be less impactful on budget and schedule due to the reduction of handling and security regulations.
- **Pursuing multiple study paths** to evaluate the cost/benefits and route to execute a NTP Flight Demonstration Project along with detailed cost analysis.
- **Establishing international cooperation and collaboration.**

**Conclusion**

**With plans of setting up a space station**, and **launching the first Indian human space flight mission, Gaganyaan;** the first Indian solar observatory, Aditya L-1; **Chandrayaan-3 as a reattempt to land on the Moon;** and the Venus orbiter mission Shukrayaan; ISRO has embarked on a monumental journey of **exploring remote and challenging environments.**

Against this backdrop, the decision to invest in **RTG and nuclear thermal propulsion (NTP) appears inevitable.**

## 1.4.8. SPACE DEBRIS

**Why in News?**

China has launched a robot prototype in April 2021 that can **scoop up debris left behind by other spacecraft** with a big net.

**More on news**

- **The robot,** NEO-01 will use a net to capture debris and then **burn it with its electric propulsion system.**

- It will also **peer into deep space** to observe small celestial bodies, paving the way for future technologies capable of **mining on asteroids.**


**About Space Debris**

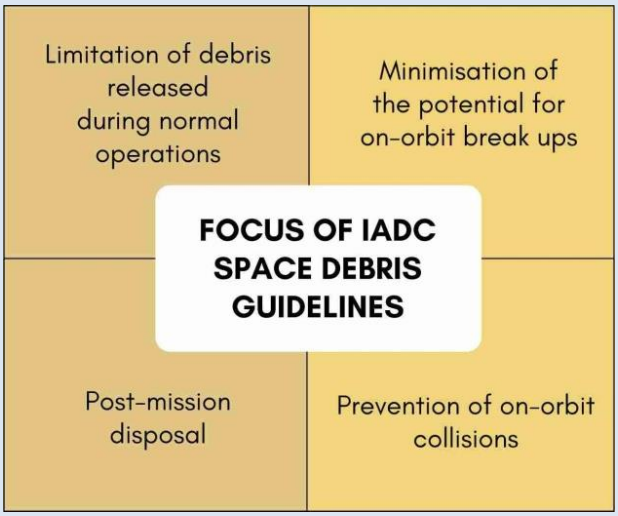
- Space debris encompasses both **natural (meteoroid) and artificial (man-made)** particles. Meteoroids are in orbit about the sun, while most **artificial debris is in orbit about the Earth** which is commonly referred to as **orbital debris.**
- Orbital debris is any man-made object in orbit about the Earth which **no longer serves a useful function.** Such debris includes **non-functional spacecraft, abandoned launch vehicle stages, mission-related debris and fragmentation debris**.
- Much of the debris is in **low Earth orbit (LEO),** though some debris can be found in **geostationary orbit**.
- There are **about 500,000 pieces of debris** the size of a marble or larger orbiting the Earth, travelling at speeds up to 17,500 mph.
- International guidelines suggest removing space crafts from LEO **within 25 years of the end of their mission**. However, **only 60 percent of missions** follow the guidelines.

**Strategies to Tackle Space Debris**

- **Mitigating Damage**: Space debris is **tracked by a number of countries**, including Germany, France, UK and USA.
  - ISRO has come up with **'Project NETRA'** - an early warning system in space to **detect debris and other hazards** to Indian satellites.
- **Avoiding future debris: by adopting better designs** of rockets and other objects. For example, making **rockets reusable** could vastly cut down waste.
  - UK's **TechDemoSat-1 (TDS-1)**, was designed in such a way that once its mission is over, a system, would drag the satellite to **re-enter the atmosphere and burn up**.
- **Removal of the debris:**
  - End-of-Life Services by Astroscale Demonstration **(Elsa-D), by Japan** was launched to **locate and retrieve used satellites** and other space junk.
  - **RemoveDebris is an EU research project** to give **in orbit demonstrations of cost-effective technologies** that can be used to observe, capture and dispose of space debris. It has performed key technology demonstrations including **Net capture, Harpoon Capture, Vision-based navigation etc.**

**International efforts to tackle Space debris**

- **Inter-Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation** Guidelines (2002) focuses on (refer infographic):
  - IADC is an **international governmental forum** for the worldwide coordination of activities related to the **issues of man-made and natural debris in space.**
  - ISRO is one among 13 member agencies of IADC.
- Committee **on the Peaceful Uses of Outer Space (COPUOS)** concluded **various international treaties** (like Outer Space Treaty, Liability Convention etc.) which **deal with issues** like **liability for damage** caused by space objects, **Prevention of harmful interference** with space activities and **registration of space activities** etc.
  - COPUOS was set up by UN General Assembly in 1959 to govern the exploration and use of space for the benefit of all humanity.



## 1.4.9. THE UNICORN–CLOSEST BLACK HOLE TO EARTH EVER DISCOVERED

**Why in news?**

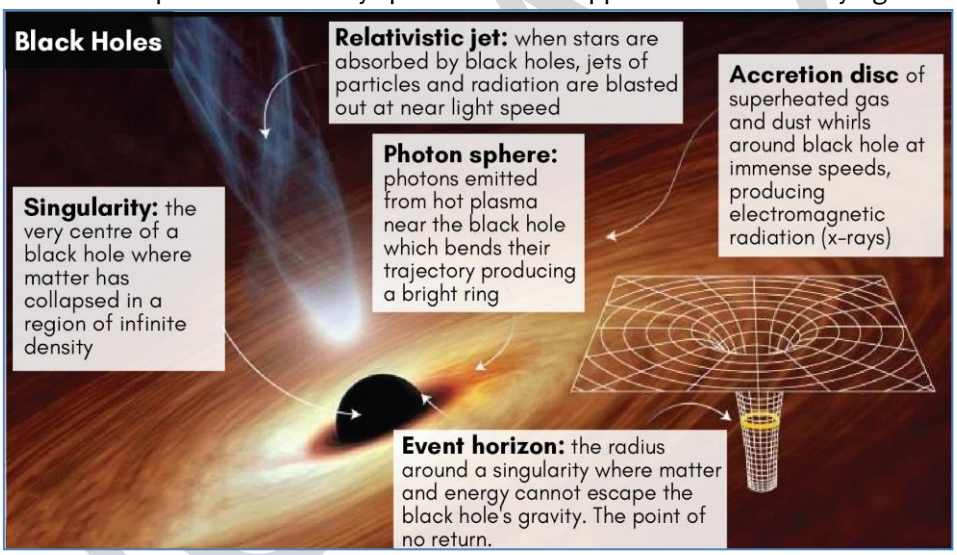
Scientists have discovered the **smallest-known black hole** which is dubbed as **'the Unicorn'** in the Milky Way galaxy and **closest to the solar system.**

**More in news**

- The **black hole 'Unicorn' is roughly three times the mass of the sun.**
- 'The Unicorn' falls into a **'mass gap' between the largest-known neutron stars** (around 2.2 times the mass of the sun) and what previously had been considered the smallest black holes (around five times the sun's mass).
- Its **strong gravity alters the shape of its companion star** in a phenomenon known as **tidal distortion,** making it **elongated** rather than spherical and causing its light to change as it moves along its orbital path.

**Black holes**

- A black hole is a **place in space where gravity pulls so much that even light cannot get out.** The gravity is so strong because matter has been squeezed into a tiny space. This can happen when a star is dying.
- They are **invisible** and electromagnetically dark. Space telescopes with **special tools can help find black holes.** The special tools can see how stars that are very close to black holes act differently than other stars.
- Black holes can be **big or small.**
- There are **different categories of black holes** namely, **Tiny black holes, stellar black holes (also called unicorn), supermassive black holes** (recently intermediate-mass black holes were also discovered).




**Significance of black hole in space research**

- **Evolution of galaxy:** Astrophysicists have gained new insights by calculating how black holes influence the **distribution of dark matter,** how heavy elements are produced and distributed throughout the cosmos, and **where magnetic fields originate.**
- **Star formation:** In particular, Supermassive black holes play an important role in star formation within galaxies.
- **Gravitational waves:** Scientists have detected that **gravitational waves are generated when two black holes collide,** and found that ringing pattern of the wave predicts the cosmic body's mass and spin.
- **General theory of relativity:** The discovery of black hole has opened the door to several new lines of **scientific investigation, enabling quantitative estimates** of black hole related parameters. It has provided another laboratory to test the predictions of the **Einstein's general theory of relativity.**
- **Bending of light:** The **bending of light** around a black hole is very significant because of its **extremely large mass.** Because of this bending, one can see light from material that is behind the black hole, which would not be seen if light were traveling in straight lines.

**Related News**

Scientists have **first time observed magnetic field around a Black Hole.**

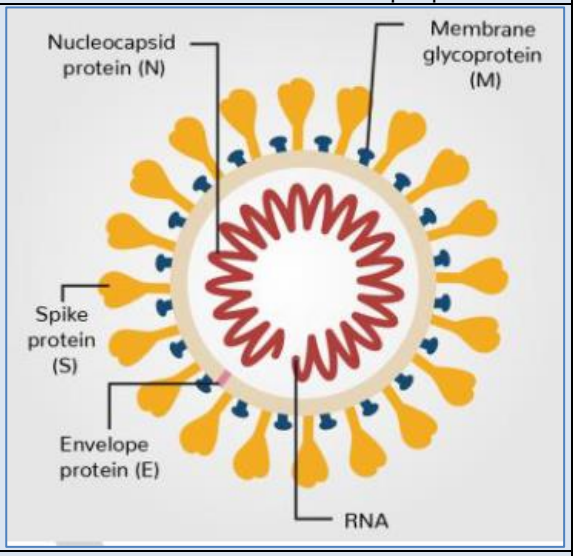
**About Black Hole's magnetic field**

- A new image from Event Horizon Telescope (EHT) shows **polarised light, waves oscillating in only one direction produced by matter at the edge of the black hole.**
  - While, **unpolarised light is made up of light waves oscillating in many different directions**.
- **Light becomes polarized when it goes through certain filters** like, for instance, the lenses of polarized sunglasses, or when it is emitted in hot regions of space that are magnetized, hence it **suggests that presence of strong magnetic fields around the black hole.**
- New polarised image also gives **compelling evidence for how strong magnetic fields around black holes can launch and sustain bright jet of matter and energy** that emerges from its core and extends at least 100,000 light years away.
- Research suggests that the **magnetic fields are strong enough to push back on the hot gas and help it resist gravity's pull.**
  - **Only the gas that slips through the field** can start flowing inwards to the event horizon.

# 2. HEALTH

## 2.1. 2019 NOVEL CORONAVIRUS (2019-NCOV)

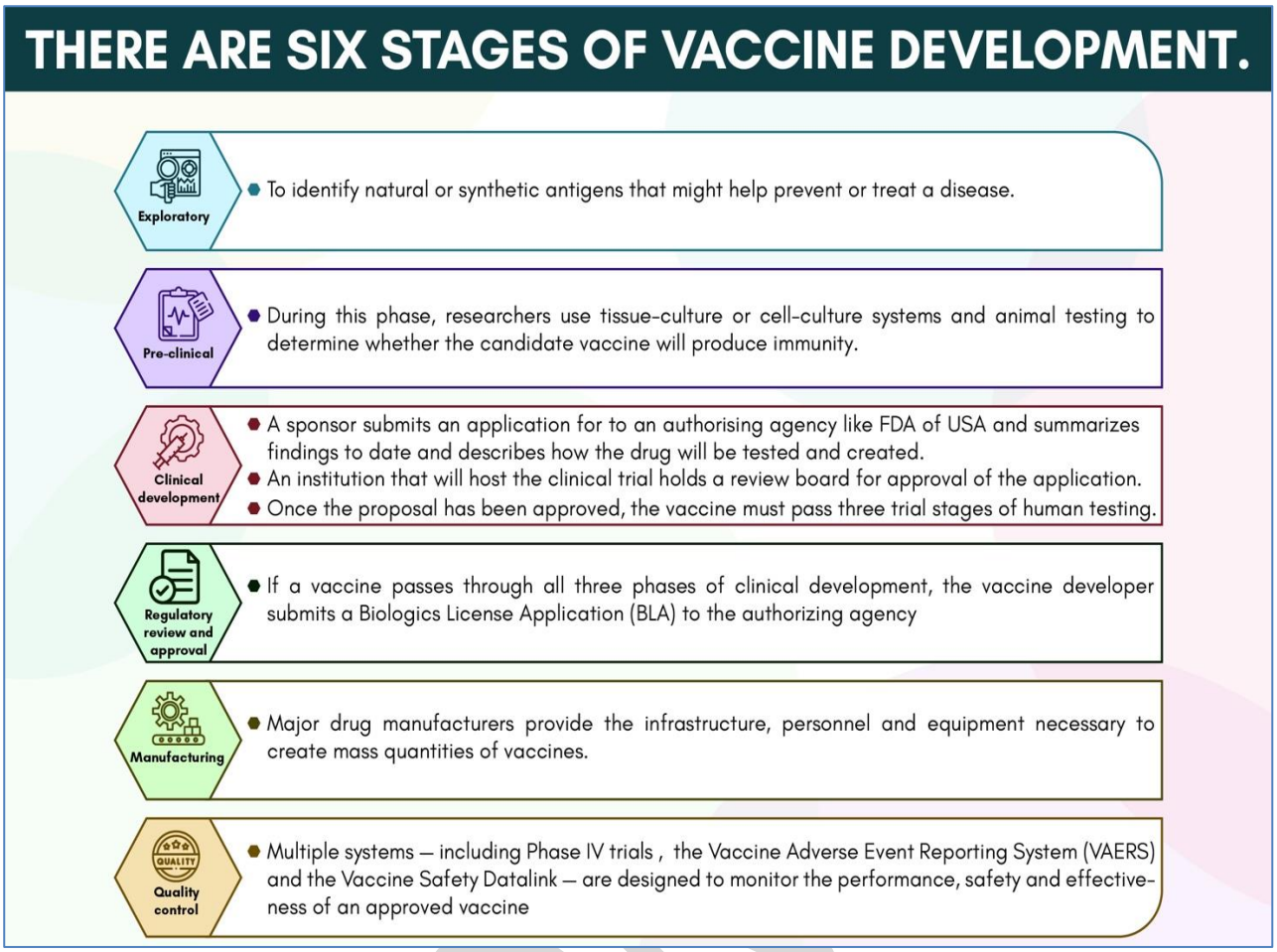
In 2020, Coronavirus was declared global health emergency by **World Health Organization (WHO). WHO declared COVID-19 an official name for coronavirus disease.**

| | |
|---|---|
| **About Novel coronavirus (nCoV)** | • Coronaviruses are large family of viruses that cause illness ranging from the common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS-CoV) and Severe Acute Respiratory Syndrome (SARS-CoV).<br>  ○ nCoV is a new strain that has not been previously identified in humans.<br>• **Coronaviruses are zoonotic,** meaning they are transmitted between animals and people. |
| **Structure** | • Coronaviruses are spherical shaped and consist of a core of genetic material **(RNA) surrounded by an envelope with mushroom shaped protein spikes.**<br>• These spikes bind and fuse to human cells allowing the virus to gain entry and replicate itself inside the body.<br>• **Protein spikes gives the appearance of a crown or a halo around the Sun.** Crown in Latin is called as "Corona" and this is how the virus also got its name.<br>  <br> |
| **Physiology** | • **COVID-19 is caused by SARS-CoV-2 also known as n-CoV,** as it is very similar to the one that caused SARS in 2002.<br>• SARS-CoV-2 has spike proteins which contain a receptor-binding domain (RBD).<br>  ○ **RBD facilitates the virus' entry into target cells by binding with the cellular receptor called angiotensin-converting enzyme-2 (ACE-2)** found in heart, lungs, kidneys and the gastrointestinal tract.<br>• Once inside, it hijacks the cell's reproductive machinery to produce more copies of itself, before breaking out of the cell again and killing it in the process.<br>• **However, unlike in the case of SARS, the spike protein of the novel coronavirus binds to the cell receptor with much higher affinity**.<br>  ○ RBD's bonding affinity is increased due to mutation within the virus.<br>• This stronger bonding affinity **partly explains the apparent high human-to-human transmissibility** and COVID-19's faster spread as compared to SARS epidemic. |
| **Epidemiology** | • **Reproduction Number [Ro (R-naught)]** (the number of additional cases that likely result from an initial case).<br>• **Route of transmission:** mainly via respiratory droplets of an infected person, through aerosols in the air.<br>• **Incubation period (**the time between catching the virus and beginning to have symptoms of the disease).<br>  ○ **14 days following exposure**, with most cases occurring approximately four to five days after exposure. |

### 2.1.1. VACCINE DEVELOPMENT

With more than a year into COVID-19, the **immunization of a critical mass of the world's population**—which is crucial for getting the pandemic under control- **has gained importance.**

**Global effort to develop and distribute an effective vaccine is unprecedented;** the process typically takes eight to fifteen years.

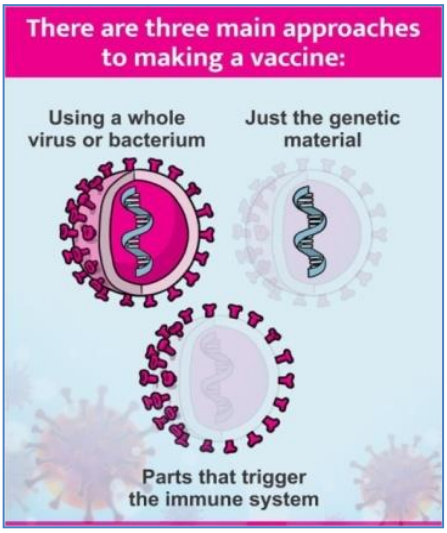



## 2.1.2. DIFFERENT TYPES OF VACCINES

### 2.1.2.1. NUCLEIC ACID VACCINES

**Why in News?**

Recently, ZydusCadilla, a pharmaceutical company, received **emergency use approval for ZyCov-D, its plasmid DNA vaccine against COVID-19.**




**More on News**

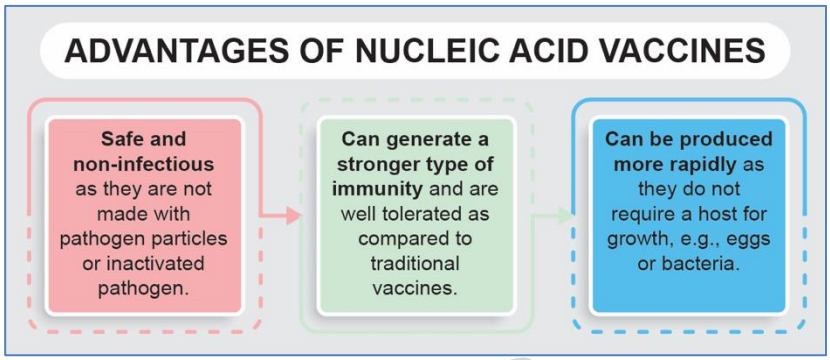
- This **would be the world's first DNA vaccine against COVID-19.**
- Both **DNA and RNA are types of Nucleic acid vaccines** (also known as gene-based vaccines).

**About Nucleic Acid vaccines**

- Instead of injecting a weakened form of a virus or bacteria into the body, Nucleic acid vaccines **use genetic material from a disease-causing virus or bacterium** (a pathogen) **to stimulate an immune response** against it.
  - That **immune response, which produces antibodies,** is what protects us from getting infected if the real virus enters our bodies.
- Depending on the vaccine, the **genetic material could be DNA or RNA.**
  - **DNA and RNA are the instructions our cells use to make proteins.** In our cells, DNA is first turned into messenger RNA (m RNA), which is then used as the blueprint to make specific proteins.
  - **mRNA teaches cells how to make a protein** that triggers an immune response inside human bodies.
- In the case of DNA vaccines, **a piece of DNA encoding the antigen is first inserted into a bacterial plasmid.**

- A plasmid is a small, **often circular DNA molecule** found in bacteria and other cells. They generally carry only a small number of genes, notably some associated with antibiotic resistance.

- DNA plasmids carrying the **antigen are usually injected into the muscle and then driven into cells** with the help of technologies like electroporation (short pulses of electric current are used to create temporary pores in patients' cell membranes).
- **RNA vaccines encode the antigen of interest in mRNA.**




- The RNA **can be injected by itself, encapsulated within nanoparticles** (as Pfizer's mRNA-based Covid vaccine is), or driven into cells using some of the same techniques being developed for DNA vaccines.
- Unlike mRNA vaccines, **DNA based vaccines donot require ultra-cold storage systems** and are said to be more cost effective.

**Challenges with vaccines development in case of Pandemics**

- **Before a vaccine is available the pandemic will probably have peaked and declined.**
- **As soon as a vaccine is approved, it's going to be needed in vast quantities.**
- **In case of a pandemic, countries also have to compete with each other for medicines. The challenge is to make sure the vaccine gets to all those who need it.**
- Because pandemics tend to hit hardest those countries that have the most fragile and underfunded healthcare systems, there is **an inherent imbalance between need and purchasing power** when it comes to vaccines. During the 2009 H1N1 flu pandemic, for example, vaccine supplies were snapped up by nations that could afford them, leaving poorer ones short.

### 2.1.2.2. OTHER TYPES OF VACCINES

- **Live Attenuated Virus (LAV):**
  - Uses a weakened (or attenuated) form of the germ that causes a disease.
  - Because these vaccines are so similar to the natural infection that they help prevent, they create a strong and long-lasting immune response.
  - **Used in case of Measles, Rubella (MMR combined vaccine), Tuberculosis, Rotavirus, Oral Polio Vaccine (OPV), Yellow fever etc.**
- **Inactivated vaccines:**
  - Uses the killed version of the germ that causes a disease.
  - These vaccines usually don't provide immunity that's as strong as live vaccines so several doses over time (booster shots) is needed to get ongoing immunity against diseases.
  - **Used in case of Polio (IPV), Pertussis, Hepatitis A etc.**
- **Subunit and Recombinant vaccines**
  - Use only part of a target pathogen like its protein, sugar, or capsid (a casing around the germ) presenting it as an antigen on its own to provoke a response from the immune system.
  - It can also be created via genetic engineering. **The end result of this approach is a recombinant vaccine:** the immune system will recognize the expressed protein and provide future protection against the target virus.
  - **Used in case of Haemophilius Influenza type B(Hib). The Hepatitis B** vaccine currently used in the United States is a recombinant vaccine.
- **Conjugate vaccines**
  - Similar to recombinant vaccines but are made using pieces from the coats of bacteria. These coats are chemically linked to a carrier protein, and the combination is used as a vaccine.
  - Conjugate vaccines are used to create a more powerful, combined immune response: typically the "piece" of bacteria being presented would not generate a strong immune response on its own, while the carrier protein would.
  - The vaccines **currently in use for children against pneumococcal bacterial infections** are made using this technique.
- **Toxoid vaccines**
  - Uses a toxin (harmful product) made by the germ that causes a disease.
  - They create immunity to the parts of the germ that cause a disease instead of the germ itself.
  - booster shots are needed to get ongoing protection against diseases.
  - **Used in case of Tetanus and Diphtheria.**

## 2.1.3. VACCINE DISTRIBUTION

**Why in News?**

Recently, WHO chief highlighted inequality in vaccine distribution while stating that for every 100 people in high-income countries, 133 doses of COVID-19 vaccine have been administered, while in low-income countries, only 4 doses per 100 people have been administered.

**Hurdles in vaccine equity**

- **Lack of access:** US and other rich countries such as UK and Israel, are doling out third shots, while in low income countries (vast majority in Africa) just 2.2% of people have received even a single dose.
- **Supply Chain issue:**vaccines of some companies require a minus 70 degree cold chain which would be tough to arrange for many poor countries.
- **Vaccine hesitancy:** Partly driven by misinformation, vaccine hesitancy, which exists in every country, is still a problem that needs to be constantly addressed.
- **Transparency and Trust:** Broader public also need information on how the vaccine is performing, and consistent messaging from scientists.
- **Affordability gap:** Considering average vaccine dose cost and distribution cost, n, low income countries have to increase their health care spending by 56.6%.

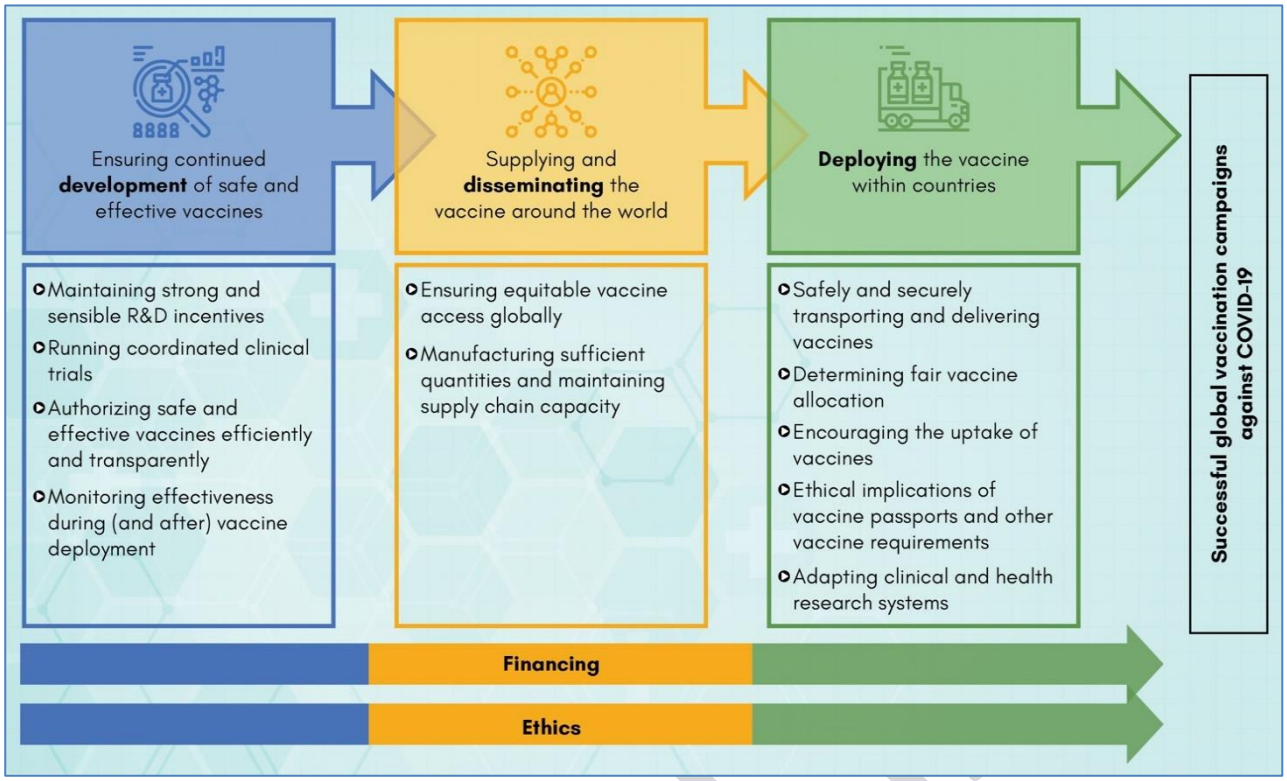
- **Need for equity in vaccine distribution**
  - **No one is safe until everyone is safe:** Unmitigated transmission means rampant viral replication and emergence of new, more transmissible variants that could escape natural or vaccine-induced immunity.
  - **To achieve herd immunity:** Vaccines not only protect the vaccinated persons, but also reduce transmission, protecting those not vaccinated by reducing the number of people who can transmit disease.
  - **To prevent deepening economic divergence:** UNDP analysis suggests that the economic recovery rate will be faster for countries with higher vaccination rates, with about US$7.93 billion increase in global GDP for every million people vaccinated.

This has **stressed upon the need for an ethical decision-making** in vaccine distribution.

**Following values could be the basis for deciding who should get priority:**

| | |
|---|---|
| **Equality** | • Each person's interest should count equally unless there are good reasons that justify the differential prioritization of resources.<br>• Race, ethnicity, creed, ability or gender, should not serve arbitrarily as the basis for the differential allocation of resources. |
| **Best outcomes (utility)** | • To justify the allocation of resources according to receiver's capacity to do the most good or minimize the most harm. |
| **Prioritize the worst of** | • To justify the allocation of resources to those in greatest medical need or those most at risk.<br>• For example, vaccines for those most at risk of infection and severe illness, or those most in need. |
| **Prioritize those tasked with helping other** | • To justify the allocation of resources to those who have certain skills or talents that can save many other people.<br>• This value could be most appropriate to guide vaccination to health care workers, first responders, etc. |

**Measures to achieve equity in vaccine distribution**




**Global initiatives for vaccine equity**

- **COVAX:** An international partnership which supports vaccine development, procurement, and distribution globally.
- **Global Dashboard for Vaccine Equity:** combines the latest data on the global roll-out of COVID-19 vaccines with the most recent socio-economic information to illustrate why accelerating vaccine equity is critical to save lives.
- **COVID-19 Technology Access Pool (C-TAP):** launched by WHO to **facilitate timely, equitable and affordable access** of COVID-19 health products by boosting their supply.
- **WHO's Strategy to Achieve Global Covid-19 Vaccination by mid-2022:** A three-step approach, with all older adults, health workers, and high-risk groups of all ages, vaccinated first, followed by the full adult age group and lastly extended vaccination of adolescents.

## 2.2. REDUCING RISK OF ZOONOSES IN FOOD PRODUCTION

**Why in news?**

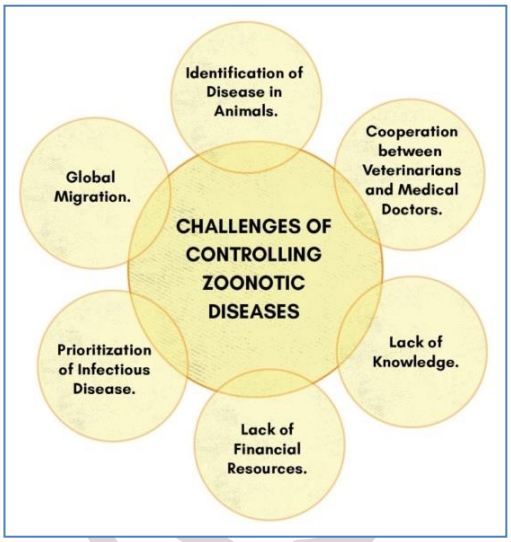
The guidelines to **reduce the risk of transmission of zoonotic pathogens to humans in food production** and marketing chains has been prepared by the **World Health Organisation (WHO), World organisation for Animal Health (OIE) and United Nations Environment Programme (UNEP).**

**What is zoonosis?**

- A zoonosis is an **infectious disease** that jumps from a **non-human animal to humans.**
- **Zoonotic pathogens** may be **bacterial, viral, parasitic or fungal**. They can spread to humans through direct contact or through food, water and the environment.
- Zoonoses can cause **disruptions in the production and trade of animal products** for food and other uses.
- As per the **National Centre for Disease Control (NCDC),** about 75% of emerging and re-emerging infections are zoonotic.
- **Causes of zoonosis:** Climatic change, deforestation, animal adaptation and migration, vectors, lack of hygiene, human- animal interface, pathogen mutation and factors leading to its adaptability, urbanisation, laboratory escapes, etc. are some of the causes of zoonoses.
- **Population at risk:** Wild animal's meat sellers, agricultural workers, and people living adjacent to wilderness areas etc. face higher risk of zoonotic disease.
- **Examples of zoonotic diseases:** Japanese encephalitis (JE), Kyasanur forest disease (KFD), Nipah virus infection, Ebola virus disease, Middle East respiratory syndrome (MERS) etc.

**WHO guidelines**

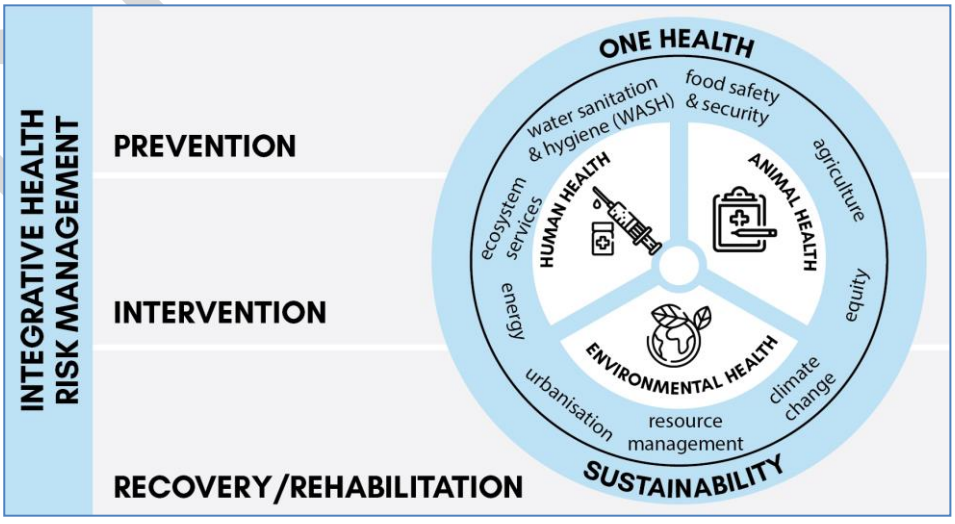
- **Suspension of trade in wild animals**.
- **Strengthening the regulatory basis:** It improves standards of **hygiene and sanitation in traditional food**. Additional measures for **crowd control and physical distancing**, hand washing and sanitizing stations should be introduced in market settings.
- **Conducting risk assessments**: It provides the evidence base for developing regulations to **control the risks of transmission of zoonotic microorganisms** from farmed wild animals and caught wild animals that are intended to be placed on the market for human consumption.
- **Capacity building:** It ensures that **food inspectors are adequately trained** to ensure that businesses comply with regulations to protect consumers' health and are held accountable.
- **Surveillance systems**: for zoonotic pathogens to include both domestic and wild animals. This will provide an **early warning for pathogen emergence** and help expedite development of control measures.




- **Awareness:** Developing and implementing **food safety information campaigns** for market traders, stall holders, consumers and the wide general public.

**Measures taken to control zoonotic diseases:**

- **One health approach:** The concept of **'One Health' recognised by WHO** as health of human beings is connected to health of animals and environment.
  - The **Ministry of Science and Technology** has constituted a **National Expert Group on One Health** to identify priority areas for better understanding of mechanism of virulence, infections and their transmissions.
- **Integrated Disease Surveillance Programme (IDSP):** It strengthens the disease surveillance in the country by establishing a **decentralized State based surveillance system for epidemic prone diseases**.
- **National Programme for Containment of Anti-Microbial Resistance:** It carries out surveillance of antimicrobial usage, strengthen infection control practices and promote rational use of antimicrobials through Antimicrobial stewardship activities.
- **Effective laboratory systems** for a successful zoonotic disease surveillance program.
- **Inter-Sectoral coordination for Prevention and Control of Zoonotic Diseases**.
- **Genome mapping of animals**: Different initiatives like **Bat1K** are present across the world to sequence the genomes of all living bat species.




**Way forward**

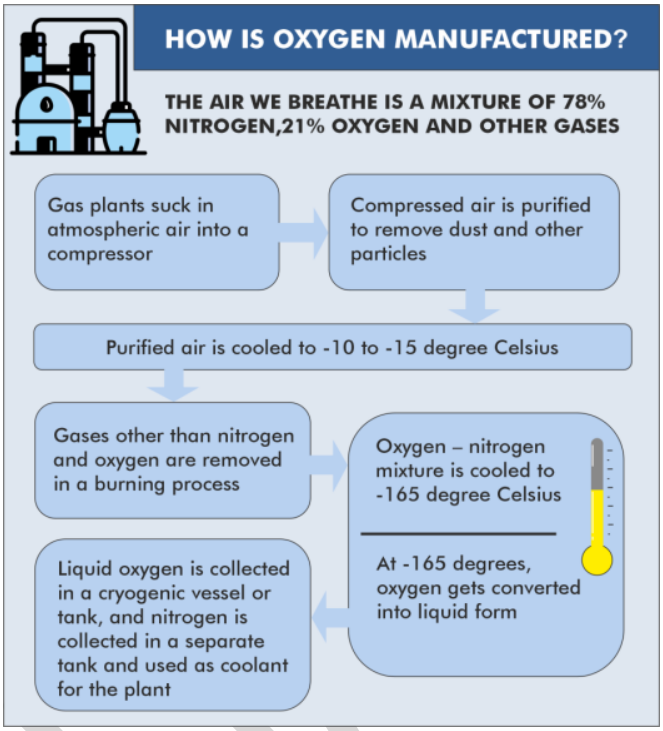
In order to work toward controlling, eradicating, and intervening one needs to work at different levels.

- **Pathogen level**: Studies should be carried out to undertake genome mapping of pathogens for research purpose.
- **Individual level:** In remote and backward areas, research should focus on whether the nutritional status of people is adequate to respond to zoonotic diseases.
- **Environment level**: Parameters such as how close animals are living with people, their educational and cultural backgrounds need to be factored in.

## 2.3. MEDICAL OXYGEN

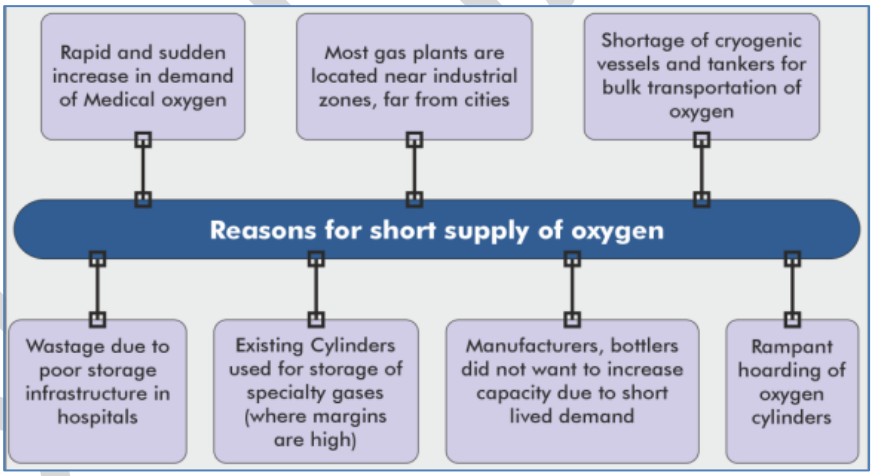
**Why in news?**

India faced a shortage of medical oxygen (MO) at several locations amidst a massive surge in COVID-19 infections.




**About medical oxygen**

- The term **'medical oxygen' means high-purity oxygen,** which is used by hospitals and clinics in the treatment of various illnesses that cause oxygen saturation levels in the body to drop.
- It generally comprises of **minimum 90% oxygen** ($O_2$) with 5% nitrogen and 5% argon.
- Medical grade oxygen is highly concentrated and **can be obtained in several ways:**
  - **Liquifying air through a process called cryogenic distillation:** In this method Liquid Medical Oxygen (LMO), with 99.5% purity, is manufactured in large plants using cryogenic distillation techniques to compress atmospheric air, feed it into distillation columns and get liquid oxygen.
  - **Oxygen concentrator:** It is an electrically powered medical device designed to concentrate oxygen from ambient air.
  - **Pressure swing absorption (PSA) plants:** A PSA oxygen plant employs a technology that absorbs nitrogen from ambient air to concentrate oxygen for supply to hospitals.




**Steps taken by Government to ensure adequate oxygen supply for treatment of COVID-19 patients**

- **Setting up of Empowered Group-II (EG-II)** to manage requisite supplies of medical equipments, drugs including medical oxygen across the country.
- **Temporarily restricting industrial usage of oxygen.**
- **Facilitating inter-state movement:** Centre invoked the Disaster Management Act making the district magistrates and senior superintendent of police personally liable to ensure unhindered **inter-State movement of vehicles carrying medical oxygen.**
  - Also, free movement of oxygen tankers inter-state was facilitated through Ministry of Road Transport and Highways (MoRTH) without registration in the other states.
- **Coordination between ministries:** A sub- group was formed under MoRTH with Ministry of Railways and transport departments of States to facilitate the movement of transport tankers for LMO.
- **Conversion of Argon and nitrogen tankers for oxygen transport:** Petroleum and Safety Organisation (PESO) has ordered for conversion of argon and nitrogen tankers for use as oxygen tankers after appropriate cleaning.
- **Setting up PSA plants:** PM CARES Fund gave in-principle approval for allocation of funds for installation of 551 dedicated PSA Medical Oxygen Generation Plants inside public health facilities in the country.
- **'Oxygen Express' trains:** by the Railways to transport liquid medical oxygen and oxygen cylinders across the country.

| Differences between Oxygen concentrators and Oxygen cylinders | | |
|---|---|---|
| | **Oxygen concentrators** | **Oxygen cylinders** |
| **Purity of $O_2$ supply** | 90-95 per cent pure | 99.5 per cent pure |
| **Operational Lifespan** | Designed for continuous operation and need just a power source to draw in ambient air | Require continuous refilling |
| **Suitability for COVID 19 patients** | Good enough for mild and moderate Covid-19 patients with oxygen saturation levels of 85% or above, but not advisable for ICU patients | Can be used for treating all types of Covid-19 patients |
| **Rate of $O_2$ supply** | Low-Moderate (5-10 litres of oxygen per minute) | High (upto 25 litres of oxygen per minutes) |
| **Portability** | Portable and lightweight | Cylinders are bulky and heavy |
| **Temperature requirements** | Need no special temperature for storing oxygen | Need cryogenic tankers for storage and transportation of LMO |
| **Cost effectiveness** | More expensive than cylinders, but lower operational cost in the long run | Less expensive but involve refilling and transportation costs |

**Conclusion**

India has **sufficient daily production capacity** and stock to fulfill the demand. There is a **need to optimise supply chains** to ensure round the clock oxygen **availability to high caseload states** such as Maharashtra, Gujarat, Madhya Pradesh, Uttar Pradesh, Delhi, Chhattisgarh, etc.

This will require **proper assessment and analysis of oxygen demand and procurement system.** Also, State authorities and hospitals need to make **rational use of medical oxygen** and ensure that there is no wastage of oxygen.

## 2.4. HEALTH DATA

**Why in news?**

Recently, the **Health Data Management Policy (HDMP)** was launched in pursuance of the earlier envisaged **National Digital Health Mission (NDHM)**.

**National Digital Health Mission (NDHM)**

- NDHM is a project of the Government of India which stems from the National Health Policy, 2017.
- It intends to digitize the entire healthcare ecosystem of India.
- This would be done by **creating digital health records** and **creating and maintaining registries for healthcare professionals and health facilities**.

This **Health Data Management Policy** is the first step in realizing the **NDHM's guiding principle of "Security and Privacy by Design"** for the protection of individuals'/data principal's personal digital health data privacy.

**What is health data and why is appropriate handling and regulation is important?**

**Health data can be broadly considered as** every type of data related to **health status, personal choice about selecting a treatment, health security or policy number**, all kind of **treatment reports, causes of death,** socio-economic **parameters regarding health and wellness, historical healthcare background** such as diseases in past years or any data which relates to the physical or mental health of an individual.

Given this definition, regulation of health data becomes important due to **following issues**:

- **Issue of privacy and sensitive nature of data:** leak of such data may lead to exploitation or discrimination against the individual.
- **Individual losing the control over data:** This could lead to a scenario where this data is misused for surveillance or for corporate interests.
- **Poor record-keeping and maintenance of health data:** In the absence of regulation, health data tends to be kept poorly with very low shareability. Loss of records and delays can even lead to misdiagnosis and other harms to patients.

The importance of health data has become even more important due to **data-based approaches forced by the outbreak of COVID-19**.

**Current status of Health Data Ecosystem in India**

Before passing of the Health Data Management Policy, the Health Ministry had proposed a **'Digital Information Security in Healthcare Act' in 2018** that would enforce privacy and security standards which has now been subsumed under Personal Data Protection (PDP) Bill. Also, some earlier efforts include-

- Creation of a **national Health Management Information System (HMIS)** to enable better use of data.
- **National Health Portal** which aims to become a single point access for authenticated health information for citizens, students, healthcare professionals and researchers.

But these efforts were stalled by the **health data challenges prevalent in India**-

- **Fragmented data:** given the interaction of citizens ranges across multiple diagnostic centers, hospitals, medical practitioners and pharmacies.
- **Multiples entities in healthcare delivery:** There are also several distinct parts in delivery chain, whether its insurance agents, third-party administrators (TPAs) or intermediaries such as ASHA workers. This increases the integration challenge in the system.
- **Data remains in Silos due to lack of interoperability:** The development of IT systems without a mode of interoperability (i.e., the-ability of a hospital system X to communicate with system Y in a different location) has led to redundancies with static silos of data repositories that have sprung up.
- **Absence of an overall policy:** There have been concerns about the lack of data policy on storage, rights of access, and privacy of individuals vis-à-vis usage in the overall system.
- **Creation of multiple data handling entities:** Several national data systems, such as the mother-child tracking system, were introduced in parallel to HMIS. This undermined the existing HMIS and increased the workload of field health staff. States themselves maintain local level data sets, resulting in multiple systems.

**Salient features of Health Data Management Policy**

- **Creating a standard for privacy protection and storage of data** to ensure compliance with relevant and applicable laws, rules and regulations.
- **Federated structure with interoperability:** Here federated structure implies that the data will not be stored in a central repository but with respective agencies and the policy will provide a platform for their exchange and interaction.
- **Voluntary Participation:** If an individual chooses to participate, he/she will be **issued a Health ID** (as defined in this Policy). Where an individual wishes to avail of any health services, the **Health ID of the individual may be verified by the use of Aadhaar** or any other method of identification as may be specified.
- **Network connecting each hospital and laboratory:** It will increase the pan-India portability of the Health Data and it may also generate aggregated data which could be used for research and clinical purposes.
- **Control of data with the individual:** The policy has created a **consent manager**, which is an electronic system for consented sharing of data.
- **Integration of data collection and usage with Ayushmaan Bharat**.

It should be noted that the document itself states that the **policy will be dynamic in nature** and will serve as an **enabling document before complete roll out of the National Digital Health Mission.**

**Potential challenges in implementation of the policy**

- **Absence of a Personal Data Protection (PDP) bill:** creates ambiguities in areas like what are definitions of key terms like Health Data or what happens if there is data privacy breach.
- **Poor reliability and inconsistencies in data:** may render the data sharing ineffective. For e.g.- Several central agencies have shown skeptism about the State level data.

**Key features of PDP Bill proposed by the BN Sri Krishna Committee**

- It **talks about various types of personal data** (data that can identify an individual), such as:
  - **Sensitive personal data** (related to finances, health, official identifiers, etc.).
  - **Critical personal data** (military or national security data and the government can define it from time to time).
  - **General personal data**- other than sensitive and critical personal data.
- **It fixes obligations of data fiduciary** (an entity or individual who collects and decides the means and purpose of processing personal data).
- **It provides rights of the data principal** (the individual whose data is being collected and processed).
- It sets up a **data protection authority** which may take steps to protect interests of individuals, prevent misuse of personal data etc.

- **Poor digital literacy:** This may create a scenario where data fiduciaries (such as hospitals and clinics) manage consent on the data subject's behalf.
- **Absence of clear accountability mechanisms for prevention from commercial usage**.
- **Right to be forgotten:** The policy doesn't speak of the "right to be forgotten" of a patient or clarity on how a health stack built with a biometric authentication (Aadhaar) layer would solve for concerns around anonymity, especially as health data is categorized as sensitive personal data.

**Way forward**

To ameliorate the potential challenges, multi-stakeholder consultations should be adopted for the next iteration of the policy (as the policy is dynamic in nature) to provide more balance to the policy. This **balance** between the protection of **personal privacy**, **providing transparency** and **accountability** for the institutions that govern this data (whether consent managers or data exchanges) whilst ensuring the **empowerment of the individual is at the heart** of setting a prudent, appropriate and federated rights-based design for healthcare data protection.

## 2.5. PUBLIC HEALTH SURVEILLANCE IN INDIA

**Why in news?**

Recently, NITI Aayog released a white paper on 'Public Health Surveillance in India by 2035', in the context of issues faced in surveillance during the COVID-19 pandemic.

**More on news**

- The document envisions a Public Health Surveillance System that is **predictive, responsive, integrated, and tiered.**
- It also aims to make India capable enough to provide regional and **global leadership in managing events that constitute a public health emergency** of international concern.

**Need for a Public Health Surveillance System**

- **Predicting/Forecasting and Preparedness for Epidemic Outbreaks**.
- **Guiding Prevention and Health Promotion Strategies:** Identify new/hidden reservoirs and sources of infection, block chains of rapid transmission and limit the resulting morbidity, disability or death.
- **Responding to Outbreaks and Guiding Future Programs of Disease control**: Surveillance can help create standard protocols to interpret actionable medical data in real time and subsequently use tools like genetic mapping to target variations or susceptible hosts.

Also, the importance of these roles in the Health setup has further increased in the recent time due to following reasons:

- **Re-emerging and new Communicable Diseases**.
- **Increasing rates of non-communicable diseases and acute and chronic conditions**: For example, data suggest that 61% of overall mortality and 55% of the disability adjusted life years were caused by NCD in 2016.
- **Anti-microbial resistance (AMR):** Increasing AMR in the recent times has decreased the efficacy of drugs and has developed into diseases like Multi-Drug Resistant TB etc.

**Current Public Health Surveillance Framework in India**

- The **Integrated Disease Surveillance Project (IDSP)** within the National Health Mission constitutes the primary Centre for surveillance in India.
- In 2019, WHO in partnership with the Government of India launched the **Integrated Health Information Platform (IHIP) within the IDSP program.**
  - The IHIP is a **digital web-based open platform that captures individualized data** in almost real-time, generates weekly and monthly reports of epidemic outbreaks and early warning signs and captures response by 'rapid response teams', for 33+ disease conditions.
- Apart from IDSP, the **Indian Council of Medical Research (ICMR)** has played a key role in strengthening surveillance and research related to surveillance with its **large network of 130+ laboratories.**
- **Early Health Warning System:** The system is being developed by **Ministry of Earth Sciences** and is expected to forecast the possibility of disease outbreaks in the country.

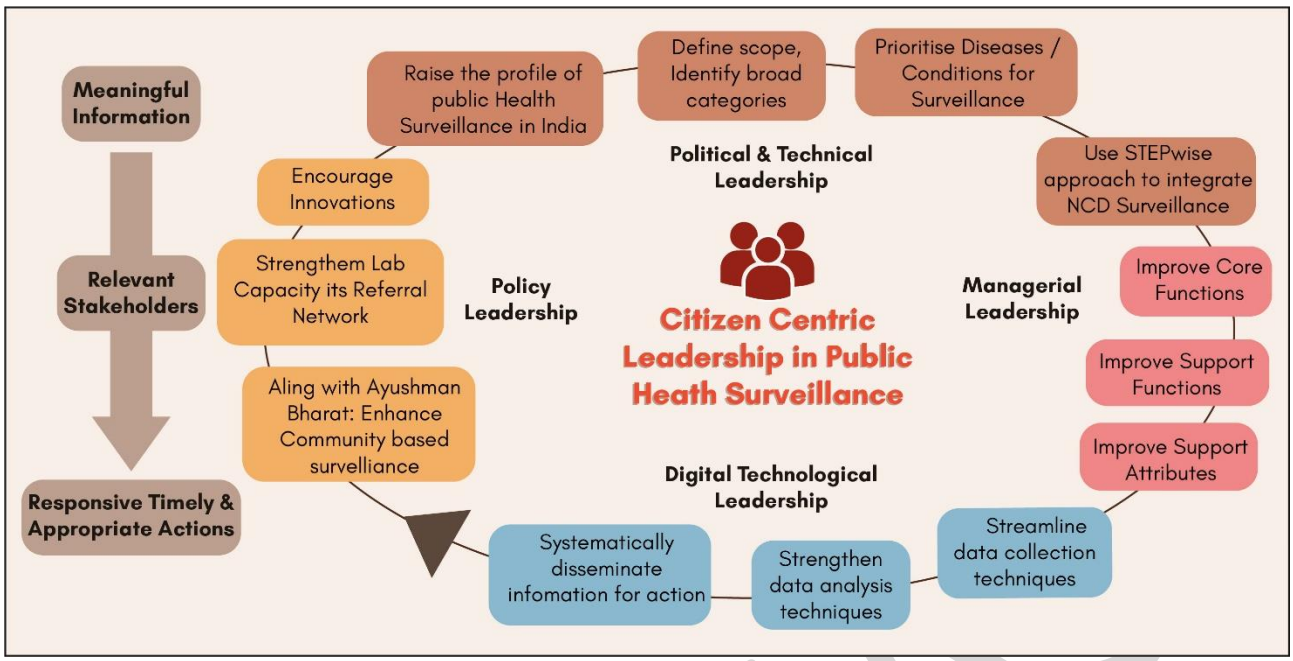
**Issues in the current surveillance system in India**

- **Surveillance is not comprehensive:** The IHIP is not yet fully operational across the country, reason being lack of uniformity in outbreak investigation and reporting and limitations in geographic coverage within states.
- **Surveillance functions in vertical silos of programs and institutions:** There is limited ability of program implementation structures to work in synchrony with research organizations and vice versa.
- **Private sector involvement in surveillance is limited** which constitutes 75% of the outpatients and 62% of inpatients of the country.
- **Inadequate linkage of morbidity with mortality data:** limiting potential solutions for better healthcare provision and prevention of future deaths.
- **Limited use of digital, social and print media in surveillance:** These media sources can be used to promote disease prevention and containment actions at community level during new infectious disease outbreaks (e.g., During COVID-19 pandemic).
- **Limited focus on non-communicable disease surveillance**.
- **Other issues** include **inconsistent recruitment** of human resources at State and district level in many States and **lack of in-house expertise for training in health surveillance.**

**Recommendations given by the aforementioned document**

In the light of these issues, the document has suggested four key pillars for health surveillance- **developing a governance ecosystem for surveillance**, **introducing data sharing mechanisms**, **using data analytics** and focusing on the idea of **'Information for action'**. To enable these pillars, following recommendations have been given by the report-

- **Streamline data sharing, analysis, dissemination and use for action:** Creating an integrated system which has its basis Unique Health Identifier (UHID) which is the primary source of data.
- **Align with Ayushman Bharat:** The Health and Wellness centres present a unique opportunity to strengthen community-based surveillance at the primary health care level, by capacitating front-line health personnel.
- An amalgamation of **plant, animal, and environmental surveillance in a One-Health approach.**
- **Raise the Profile of Public Health Surveillance** from a standalone activity to an integral part of the healthcare system.
- **Create/Strengthen an Independent Health Informatics Institute:** Public health informatics has an essential role in data collection, collation, analysis and transmission for public health surveillance and related actions.
- **Define the scope of surveillance into broad categories of diseases/ conditions**: Apart from Communicable/Infectious diseases the scope can be expanded to Non-Communicable Diseases, Occupational Health (issues like Silicosis) and Environmental Health Surveillance (issues like pollution).
- **Use a WHO STEPwise approach to include NCD Surveillance:** The STEPwise approach refers to an integration procedure that is inclusive of death, disease and risk factors.
- **Strengthen laboratory infrastructure, referral networks and community-based surveillance** to enable more efficient disease surveillance and associated prevention.




## 2.6. NON-COMMUNICABLE DISEASES

**Why in News?**

**Global Health Estimates (GHE) released by World Health Organization** estimates that all non-communicable diseases together accounted for 74% of deaths globally in 2019.

**More in News**

- WHO Global Health Estimates provide a comprehensive and comparable assessment of mortality and loss of health due to diseases and injuries for all regions of the world.
- **Key findings of GHE 2019 report**
  - Non-communicable diseases make up **7 of the world's top 10 causes of death**, an increase from 4 of the 10 leading causes in 2000.
    - ✓ The new data cover the period from 2000 to 2019.
  - Heart disease now represents 16% of total deaths from all causes.
  - **Life spans have increased over the years**, with a global average of more than 73 years (in 2019) compared to nearly 67 (in 2000).

**Non-Communicable Diseases**

- NCDs are **medical conditions or diseases that are not caused by infectious agents**. These are chronic diseases of long duration, and generally slow progression.
- **Main types of NCDs are** cardiovascular diseases (like heart attacks and stroke), cancers, chronic respiratory diseases, Chronic neurologic disorders (Alzheimer's, dementias), diabetes etc.

**Factors influencing the NCDs**

- **Genetic Factor:** in major NCDs including cancer, diabetes, cardiovascular diseases, mental health and asthma.
- **Behavioural Factors**: Physical inactivity, unhealthy diets (diets low in fruit, vegetables, and whole grains, but high in salt and fat), tobacco use (smoking, secondhand smoke, and smokeless tobacco), and the harmful use of alcohol
- **Socio-economic factors:** Poverty is closely linked with NCDs.
  - Nearly 30% of NCD-related deaths in low-income countries occur under the age of 60, whereas in high-income countries the proportion is only 13%.
- **Urbanization and urban development policy:** encouraged mechanized transport and discourages physical activity. The nature of work available in urban areas may require less energy expenditure than rural areas.

- Also, Children living in unfavourable social conditions, poor housing and no access to parks and recreation centres were likely to be overweight or obese.

- **Cultural norms:** Beliefs and norms amongst some social groups include preferences for foods high in animal fat which are socially acceptable but can result in obesity, hypertension etc.

**Global Measures to control NCDs**


- NCDs are **recognized as a major global challenge in the United Nation's 2030 Agenda for sustainable development.**
  - As part of the Agenda, Heads of State and Government committed to develop ambitious national responses, by 2030, to reduce by one-third premature mortality from NCDs through prevention and treatment (SDG target 3.4).
- WHO has developed a **Global action plan for the prevention and control of NCDs 2013-2020**, which includes nine **global targets that have the greatest impact on global NCD** mortality. These targets **address prevention and management of NCDs.**
  - **India is the first country to develop specific national targets** and indicators aimed at reducing the number of global premature deaths from NCDs by 25% by 2025.

**Measures taken by India to control NCDs**

- **National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS) was launched in 2010.**
- **Ayushman Bharat which would help to deal with NCDs** and injuries along with communicable diseases.
- **Food Safety and Standards Authority of India** (FSSAI) proposed a tax and advertisement ban on unhealthy foods.
  - **FSSAI has launched 'Eat Right India' movement** and a **mass media campaign 'Heart Attack Rewind'.**
- **PradhanMantriUjjwalaYojana** helps to reduce indoor air pollution which is also responsible for a significant number of acute respiratory illnesses.

**Way forward**

- **Monitoring progress and trends of NCDs** and their risk.
- **Investing in better management of NCDs is critical.** Management of NCDs includes detecting, screening and treating these diseases and providing access to palliative care for people in need.
- High impact essential NCD interventions can be delivered through a **primary health care approach to strengthen early detection and timely treatment.** If provided early to patients, they can reduce the need for more expensive treatment.
- Countries with adequate health insurance coverage are likely to provide **universal access to essential NCD interventions.**
- A **comprehensive approach is needed** requiring all sectors including health, finance, transport, education, agriculture, planning and others, to collaborate to reduce the risks associated with NCDs and promote interventions to prevent and control them.

## 2.7. NEGLECTED TROPICAL DISEASES

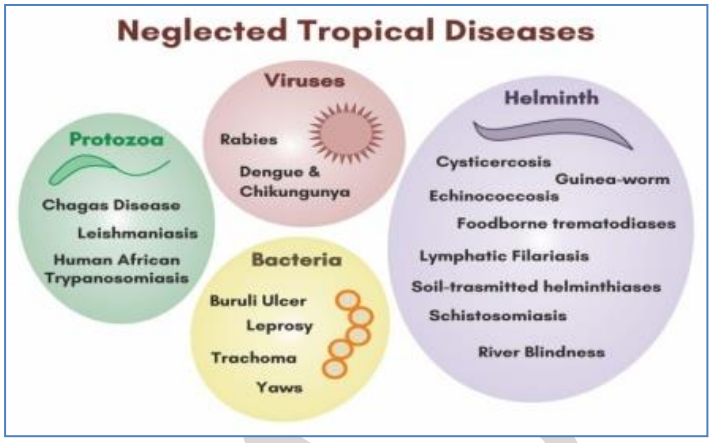
**Why in News?**

Accepting the proposal of the United Arab Emirates (UAE), 74th World Health Assembly declared January 30 as 'World Neglected Tropical Diseases (NTD) Day'

**About Neglected Tropical Diseases (NTD)**

- NTD are communicable diseases that **prevail in tropical and subtropical countries** and affect more than one billion people.

- **Populations living in poverty, without adequate sanitation** and in close contact with infectious vectors and domestic animals and livestock **are those worst affected.**
  - Worldwide, 149 countries and territories are affected by at least one NTD.
- India experiences the **world's largest absolute burden of at least 11 major NTD** (2018), though India has already **eliminated several NTDs, including guinea worm, trachoma, and yaws.**




**Impact of NTDs**

- **Affecting the world's poorest people:** NTDs overload already stretched health systems in developing countries, and some of them can lead to catastrophic expenditures and can reduce individual productivity.
- **On children's health:** Some disease impair physical and cognitive development amongst children as infection leads to malnutrition, cognitive impairment, stunted growth, and the inability to attend school.
- **On Women's Health:** Some diseases with **cutaneous manifestations are disfiguring, particularly for women,** because they delay health-seeking behaviour, diagnosis and treatment.
  - They **affect women's social health** by promoting exclusion and stigma.
  - And they **affect women's economic health**, by affecting women's ability to work.

**Challenges in tackling NTD**

- **Lack of prioritized efforts:** because NTDs are characterized by little attention from policy-makers, lack of priority within health strategies, inadequate research, limited resource allocation and few interventions.
- **Non availability of treatments:** For many NTDs, there are no vaccines or simple tests to ensure timely diagnosis and treatment, and treatments can be toxic, ineffective, and costly.
- **Prevalence of Social stigma:** along with the social displacement of people affected by NTDs.

**Way forward**

- **Resource mobilization, public–private partnerships and community mobilization** are important and must be prioritized.
- **Effective surveillance and monitoring** are urgently needed, together with an evaluation system for tracking progress on a regular basis.
- **Regular briefing of the media** can increase community involvement in elimination programmes, reduce stigma and discrimination.
- Development of **community-based programmes for the rehabilitation of disabled persons** and their reintegration into their communities.

## 2.8. RARE DISEASES

**Why in news?**

Ministry of Health & Family Welfare (MoH&FW) approved the National Policy for Rare Diseases (NPRD) 2021.

**Background**

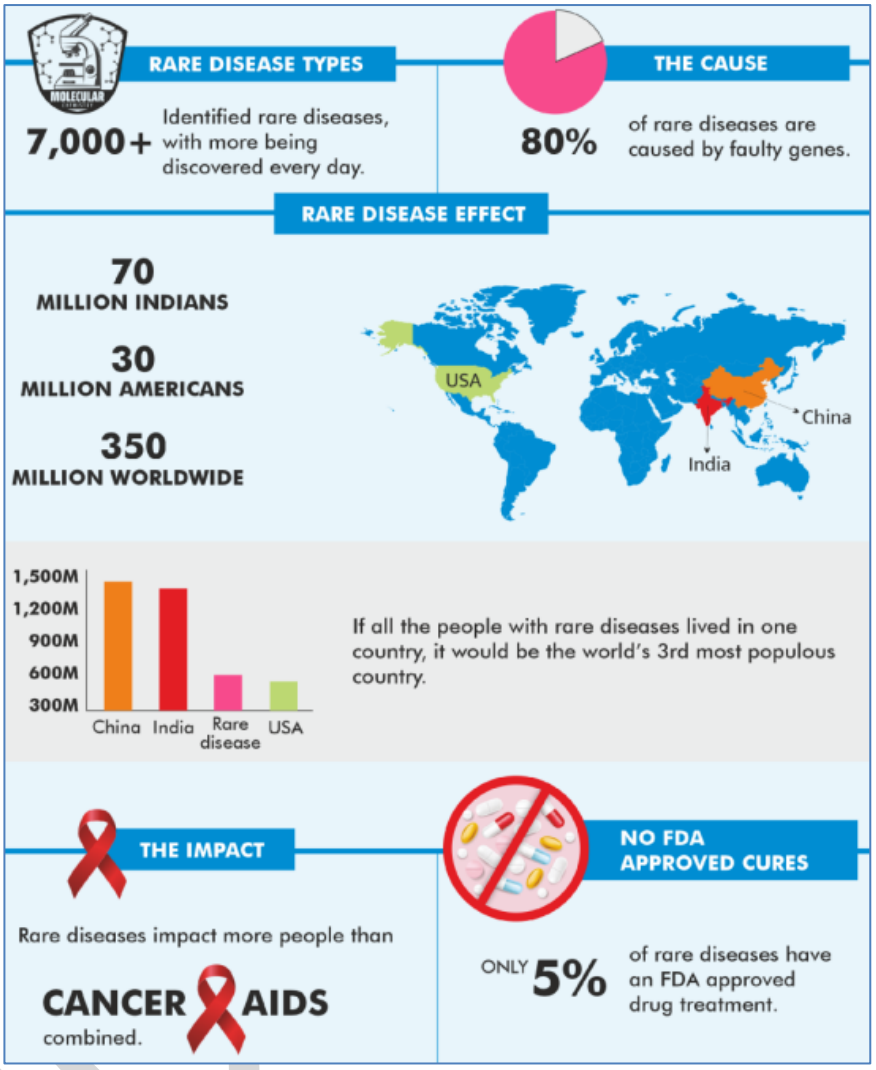
- MoH&FW formulated a **National Policy for Treatment of Rare Diseases (NPTRD) in 2017,** however, implementation of the policy faced certain challenges including the issue of cost effectiveness of supporting such health interventions.
- **An Expert Committee was constituted** by Ministry in 2018 to review the NPTRD, 2017.

**About Rare Diseases**

- There is **no universal or standard definition of rare disease** but broadly defined as diseases that infrequently occur in a population, and **three indicators are used to identify**— the total number of people with the disease, its prevalence, and the availability/non-availability of treatment options.
- **WHO defines rare disease as often debilitating lifelong disease or disorder with a prevalence of less than 10 per 10,000 people** (or 1 per 1000 population). However, different countries have their own

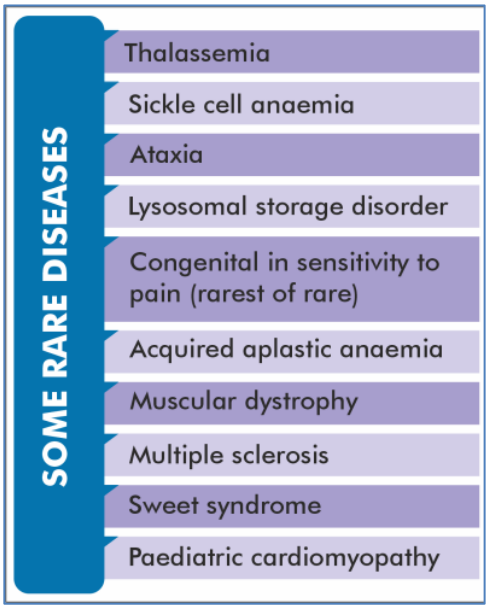
definitions to suit their specific requirements and in context of their own population, health care system and resources.

- The term **"Orphan diseases"** is often used for these and drugs to treat them are called **"Orphan drugs"**.
- New diseases are discovered each year and added to the databases such as **Orphanet database** maintained by the European Union that is freely accessible to everyone.




**Issues with rare diseases in India**

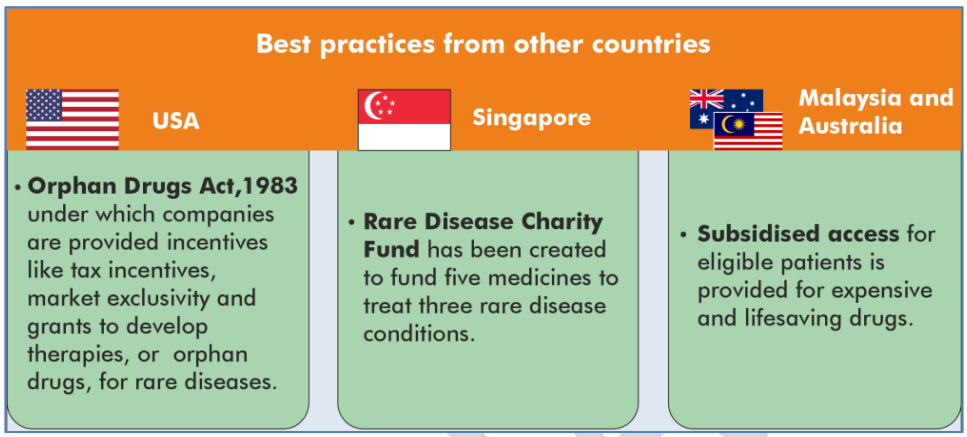
- **No standard definition in India:** The lack of epidemiological data on incidence and prevalence of rare diseases impedes understanding of the extent of the burden of rare diseases and development of a definition.
- **Early diagnosis of rare diseases is a challenge:** owing to multiple factors that include lack of awareness among public as well as primary care physicians, lack of adequate screening and diagnostic facilities.
- **Unavailability of treatment:** Very few pharmaceutical companies are manufacturing drugs for rare diseases globally.
  - In general, **government provides free supportive treatment to patients with rare diseases** where one is available in India. For instance, free blood transfusions to a Thalassaemic child.
  - **India is yet to have legislation on the development of Orphan Drugs.**
- **Prohibitive cost of treatment:** As the patient pool is small, they do not constitute a significant market for drug manufacturers to develop drugs thus increasing their cost.
- **Challenges in research and development** as the patient pool is very small.
- **Macroeconomic allocation dilemma in resource constrained settings:** Interventions that address health problems of a much larger number of persons by allocating a relatively smaller amount are prioritized over funding treatment of rare diseases.




**Key provisions of the Policy**

**Public Health and hospitals being a State subject,** the Central Government through the NPRD, would encourage & support the States in their endeavour towards screening and prevention of rare diseases. Major provisions of the policy include:

- **Aim of the policy:**
  - **To lower the incidence and prevalence of rare diseases** based on an integrated and comprehensive preventive strategy
  - **To enable access to affordable health care** to patients of rare diseases
  - **To increase focus on indigenous research** and local production of medicines**.**
- **Categorization of rare diseases in 3 groups:**
  - **Group 1:** Disorders amenable to **one-time curative treatment.**
  - **Group 2:** Those **requiring long term or lifelong treatment.**
  - **Group 3:** Diseases for which definitive treatment is available but challenges are to make optimal patient selection for benefit, very high cost and lifelong therapy.




- **Financial Support for treatment :**
  - The **assistance of Rs 20 lakh to be provided by the Central government** to patients suffering from rare diseases under Group1 under the umbrella scheme of **RashtriyaArogyaNidhi(RAN).**
  - **Beneficiaries for such financial assistance however would not be limited to BPL families**, but extended to about 40% of the population, who are eligible as per norms of PradhanMantri Jan ArogyaYojana, for their treatment in Government tertiary hospitals only.
  - **For diseases listed under Group 2**, State Governments can consider supporting patients of such rare diseases with special diets or hormonal supplements or other relatively low cost interventions.
- **Alternate Funding mechanism:** Provision for voluntary crowd-funding for treatment through setting up a digital platform for voluntary individual and corporate donors to contribute to the treatment cost of patients of rare diseases especially those under Group 3.
- **Centres of Excellence and NidanKendras:**
  - NidanKendras set up by Department of Biotechnology (DBT) under Unique Methods of Management and treatment of Inherited Disorders (UMMID) project will be performing screening, genetic testing and counseling for rare diseases.
    - ✓ Currently NidanKendras are supporting aspirational districts for screening of rare diseases.
- **Creation of Database on rare diseases:** A national hospital-based registry of rare diseases will be created by ICMR to ensure adequate data and comprehensive definitions of such diseases are available for those interested in research and development.
- **Increasing affordability of drug related to rare diseases**: PSUs would be encouraged for local manufacturing of drugs for rare diseases.
- **Research & Development:** Creation of an integrated research pipeline to start the development of new drugs, repurposing the drugs and use of biosimilars (the reference medicine).
- **Increase awareness** amongst all the levels of health care personnel as well as general public about the prevalence of such diseases and prevention measures.

## 2.9. TRANS FATS

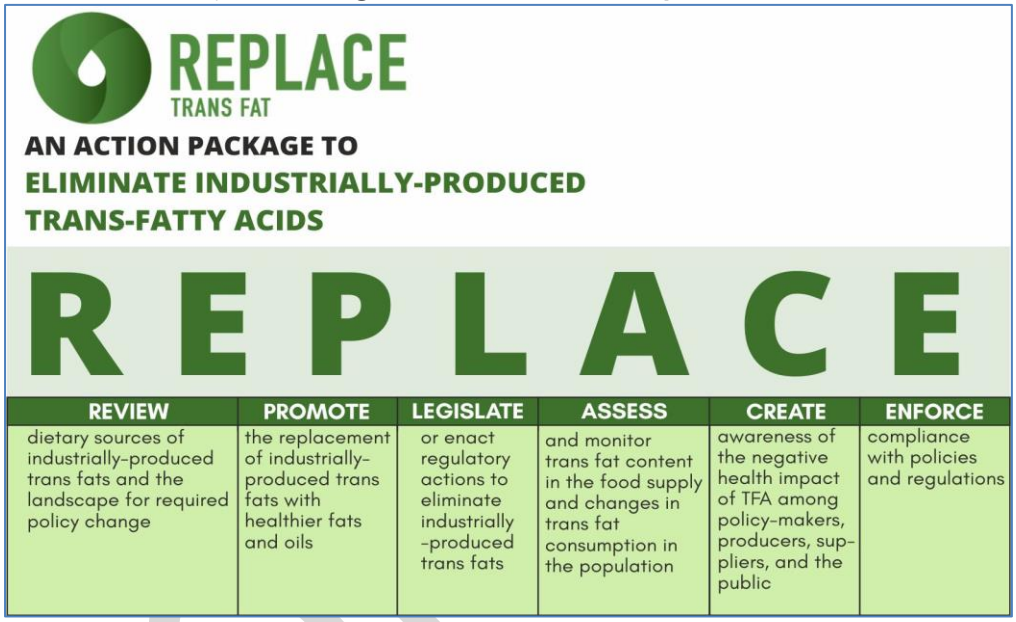
**Why in News?**

After oils, Food Safety and Standards Authority of India (FSSAI) has put the cap on trans fats in foods.

**Details**

- Recently, FSSAI issued a revised regulation according to which **"Food products" using edible oils and fats as an ingredient shall not contain industrial TFAs** more than 2% by mass of total oils/fats present in product, on and from 1st January, 2022.

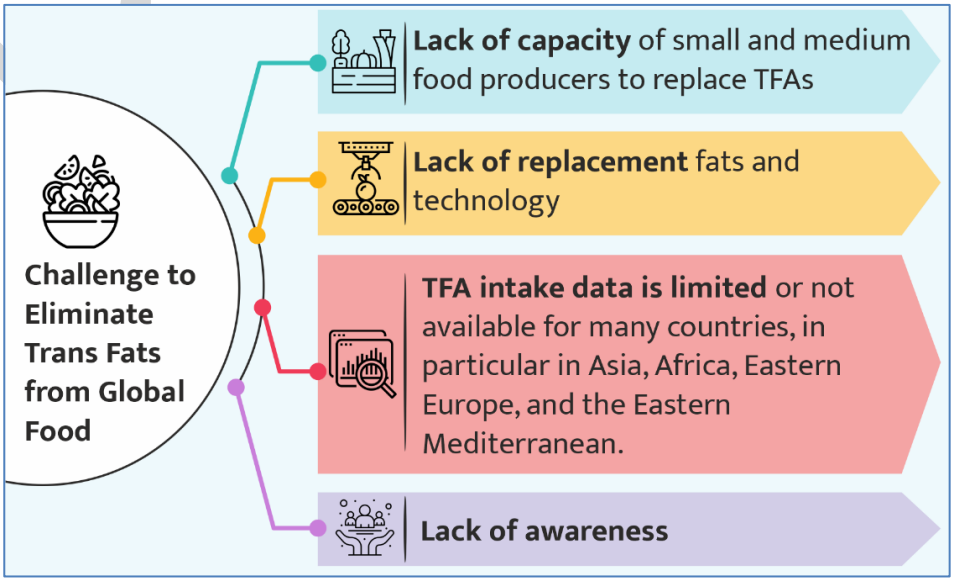
- Earlier, in December, FSSAI had capped the amount of **trans fatty acids (TFA) in 'oils and fats' to 3% for 2021 and 2% by 2022 from the current permissible limit of 5%** through an amendment to the Food Safety and Standards (Prohibition and Restriction on Sales) Regulations.
- Trans fat, or trans-fatty acids, **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).
- Industrially produced trans-fats are **found in hardened vegetable fats such as margarine and ghee** (clarified butter) and are often present in snack foods, baked goods and fried foods.
- Manufacturers often use them as they **have a longer shelf life and are cheaper than other fats**.
- They are unhealthier than saturated fats as they increase **bad cholesterol, i.e., Low Density Lipoproteins (LDL)** and **lower good cholesterol, i.e., High Density Lipoproteins (HDL).**




- **Approximately 540,000 deaths each year** can be attributed to intake of industrially produced trans fatty acids and in India the figure reaches to 60,000.
- **WHO recommends that trans-fat intake be limited to less than 1%** of total energy intake i.e., less than 2.2 g/day with a 2,000-calorie diet.

**Steps taken against Trans fats**

- WHO launched a comprehensive plan **to eliminate industrially-produced artificial trans fats from the global food supply by 2023 called REPLACE.**
- FSSAI, Ministry of Health and Family Welfare, is **working for the elimination of industrially produced trans-fat in the 'food supply' in India by the year 2022.** To achieve the target, the FSSAI launched following initiatives:
  - **Eat Right Movement** is built on two broad pillars of 'Eat Healthy' and 'Eat Safe'. It aims to cut down on salt, sugar and oil consumption by 30% in three years by educating customers.
  - **Heart Attack Rewind campaign** to warn citizens about the health hazards of consuming trans fats and offer strategies to avoid them through healthier alternatives.



- **Trans Fat Free logo:** Food establishments which use trans-fat free fats/oil and do not have industrial trans-fat more than 0.2g/100g of food, can display "Trans-fat free" logo in their outlets and on their food products.

**Way forward**

- Regulations targeting TFAs should take into account the concerns of small and medium food producers, for example **through long enough transition periods and technical support**.
  - Knowledge transfer between large and small producers could be an additional solution.
- Promote the development of **alternative supplies of more healthful alternatives of trans fats** such as natural unsaturated oils,
- **Mandatory labelling of TFA and saturated fat content** for all edible oils and food products should be implemented.
- For proper implementation in India, **FSSAI will 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.
- Civil society organisations should play an important **role in informing the public, providing support for draft legislation/ regulation and monitoring implementation.**

## 2.10. FOOD FORTIFICATION

**Why in news?**

NAFED (National Agricultural Cooperative Marketing Federation of India Ltd) recently launched fortified rice bran oil.

**More about news**

- Rice Bran oil (made from the hard outer layer of the grain i.e. bran) has multiple health benefits, including **lowering cholesterol** level due to its **low trans-fat content** and high mono unsaturated and poly unsaturated fat contents. It also **reduces the risk of cancer** due to the high amount of **Vitamin E** it contains.
- This oil is recommended by WHO as **one of the best substitutes for other edible oils.**
- According to the FSSAI, fortified oil can help a person **fulfil 25-30% of the recommended dietary intake for vitamins A and D**.

**About Fortification**

- WHO defines Fortification as the practice of **deliberately increasing the content of an essential micronutrient**, i.e. vitamins and minerals (including trace elements) in a food, so as to improve the nutritional quality of the food supply and provide a public health benefit with minimal risk to health.
- Fortification has been **particularly successful for iodized salt:** 71 percent of the world's population has access to iodized salt and the number of **Iodine-deficient countries has decreased from 54 to 32 since 2003**.
- Other common examples of fortification include **adding B Vitamins, Iron, and/or Zinc to wheat flour and adding Vitamin A to cooking oil and sugar.**
- **Food fortification can take several forms like:**

| | | |
|---|---|---|
| **Mass fortification:** Addition of one or more micronutrients to foods commonly consumed by the general public, such as cereals, condiments and milk. | **Targeted fortification:** Foods aimed at **specific subgroups of the population** are fortified, thereby increasing the intake of that particular group rather than that of the population as a whole. | **Market-driven fortification:** Situations whereby a **food manufacturer takes a business-oriented initiative** to add specific amounts of one or more micronutrients to processed foods. |

**Benefits of food fortification**

- **Addressing Hidden hunger:** WHO defines 'hidden hunger' as a **lack of vitamins and minerals.** Over 70% of the Indian population consumes **less than half the daily recommended dietary allowance** of micronutrients a day. According to the **National Family Health Survey (NFHS-4):**
  - **58.4% of children** (6-59 months) are anaemic,
  - **53.1% women** in the reproductive age group are anaemic,

- 35.7% of children under 5 are **underweight**.

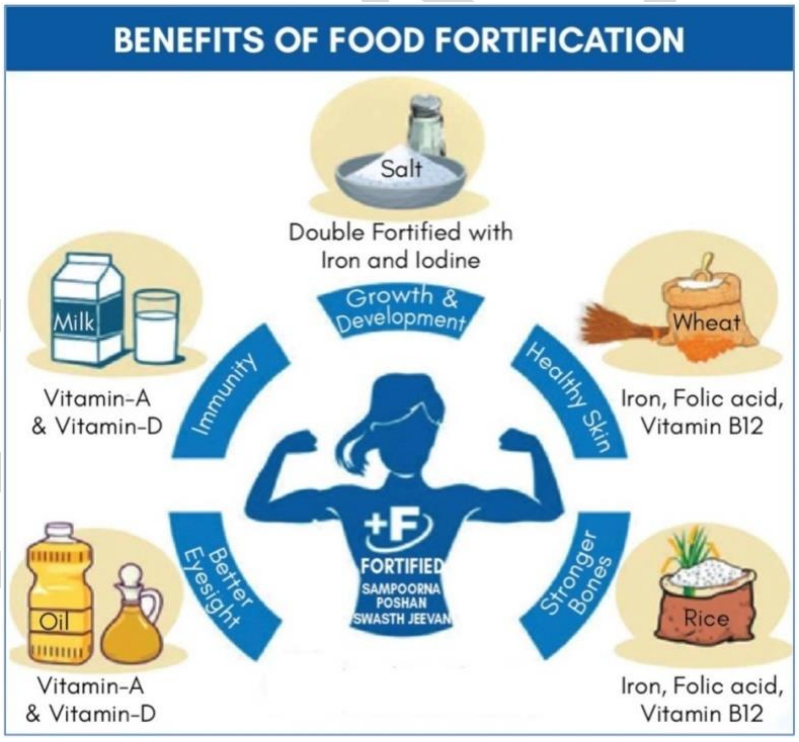
- **High Benefit-to cost ratio:** The Copenhagen Consensus (a thinktank) estimates that **every 1 Rupee spent on fortification results in 9 Rupees in benefits to the economy**.
- **Safe method:** The addition of micronutrients to food does not pose a health risk to people.
- **Other Benefits:**
  - It does not require any changes in food habits of people. It is a **socio-culturally acceptable** way to deliver nutrients to people.
  - It **does not alter the characteristics** of the food—the taste, the feel, the look.
  - It can be **implemented quickly** as well as show results in improvement of health in a relatively short period of time.

**Concerns raised over Food fortification**

- **Can do more harm:** A group of health experts have recently argued that **India's programme on fortification of rice** to address chronic anaemia and micro-nutrient **deficiency ignores the central role of balanced and diverse diet.**
  - They have cautioned **specifically against iron supplementation**. Consumption of **excess iron by pregnant women** can adversely affect foetal development and birth outcomes.
- **Difficult to withdraw**: Mandatory fortification **will create markets that will be hard to withdraw** when we have achieved the target of reduced micronutrient deficiency. These foods can contribute to **nutrient overdoses**.
- **May be misused to promote junk food:** It may be applied to junk foods, effectively **making unhealthy foods look better** than they are.

**Steps towards fortification in India**

- The journey with **food fortification in India began in the 1950s** with vegetable oil fortification and salt iodization. Other commodities such as rice and wheat flour were finally **introduced in the 2000s**.
- India's **10th, 11th ,12th Five Year Plans, POSHAN Abhiyan** (National Nutrition Mission) and **Anaemia-Mukt Bharat Mission** recommend food fortification as an important strategy to tackle micronutrient malnutrition.
- In 2016, FSSAI had come out with **regulations on fortification for staples** like wheat flour, maida, rice, double fortified salt, milk and oil.
- **Other Steps taken by FSSAI include:**
  - A dedicated unit called the **Food Fortification Resource Centre has been set up** for all **end-to-end technical and advocacy support** to both States/UTs as well as the open market.
  - Contributed towards various **capacity building trainings and developed Information Education & Communication (IEC) material** specifically for **POSHAN Maah.**
  - Further, one of the key messages in the **Eat Right India movement** is consumption of fortified foods.




**Other Steps taken by the Government to promote Indian system of medicine**

- **Centrally Sponsored Scheme of National AYUSH Mission** and the strategy of **mainstreaming of AYUSH under National Health Mission and National Health Policy-2017** are implemented for promoting and strengthening AYUSH sector. Under it, AYUSH facilities are being set up in PHCs, CHCs and District hospitals.
- **For promotion of AYUSH systems across the globe,** Ministry of AYUSH has signed Country to Country MoUs. Further, 31 AYUSH Information Cell have been set up in 28 countries to disseminate authentic information about AYUSH systems.
- **Under Ayushman Bharat,**10% of the Sub- centres are to be upgraded as Health and Wellness Centres (HWCs) which will be developed by the Ministry of AYUSH to provide comprehensive Health care to the needy community.

- In 2019, **Centrally Sponsored Pilot Scheme** on **'Fortification of Rice and its Distribution under Public Distribution System'** was approved for a period of three years with focus on 15 districts.
  - Government has also decided to scale up the scheme to cover the **Integrated Child Development Scheme (ICDS) and Mid-Day Meal (MDM) scheme** in 'aspirational districts'.
- Food Corporation of India (FCI) has made it mandatory for the rice millers in all states to **install blending infrastructure for the production of fortified rice.**

## 2.11. ALTERNATIVE MEDICINES

### 2.11.1. INTEGRATION OF TRADITIONAL MEDICINE AND MODERN MEDICINE

**Why in news?**

Recently, the Central Council of Indian Medicine (CCIM) amended Indian Medicine Central Council (Post Graduate Ayurveda Education) Regulations, 2016, to allow the Postgraduate (PG) students of Ayurveda to practise general surgery.

**More about news**

- According to CCIM's notification, **students will be trained in two streams of surgery** and would be awarded titles of MS (Ayurveda) Shalya Tantra — (General Surgery) and MS (Ayurveda) Shalakya Tantra (Disease of Eye, Ear, Nose, Throat, Head and Oro-Dentistry).
  - CCIM is the statutory body that regulates the **Indian Medical systems of Ayurveda, Siddha, Sowa-Rigpa and Unani Medicine.**
- However, the **Indian Medical Association (IMA) has been opposing the move**.

**Integration of traditional medicine/AYUSH with modern medicine**

- After the introduction of modern medicine in India, **traditional medicine/AYUSH was usually rejected by the formal medical service system.**
- Recently, however, many traditional remedies and therapies have transcended their original culture and become "complementary/ alternative" medicine in other countries.
- **Three different approaches for integration**
  - **Incorporation of traditional medicine into the general health service system.**
  - **Integration of the practice of traditional medicine with that of modern medicine** side by side.
  - **Synthesis of two branches** to form a new branch of medical science, incorporating elements of both.
- **Chopra Committee 1948** had recommended to integrate the teaching of traditional and modern systems of medicines; however, proposals were later scrapped.

**Need of integrating AYUSH with Allopathy**

- **Better disease management:** Traditional Medicine play a vital role in **preventive care**. For example, in Osmanbad, Maharashtra AYUSH doctors and nurses were trained to take care of the general wards. This management effectively reduced the COVID-19 fatality in the district.
- **Enhancing the accessibility: Rural areas have** 71% of the population but only 34% of Allopathy doctors. High proportion of AYUSH doctors in these areas could be banked upon to enhance the accessibility of rural areas to the health services system**.**
- **Necessary for universal healthcare:** In India, the ratio of the doctor-patient is 1:1456 if we consider only allopathic doctors; the ratio will come to 1:800 if the AYUSH practitioners are added.
- **Recognition and regulation of invisible AYUSH doctors:** In many hospitals (particularly at Primary Health Centre) AYUSH doctors provide the health care services but data is reported under the name of an Allopathic doctor "for legal reasons."

**Challenges in integrating AYUSH with Allopathy**

- **Lack of proof for the effectiveness of Traditional Medicine:** As traditional medicine has not been fully tested by using modern scientific means.
- **Skewed financing:** In Budget 2020-21, the Ministry of Health and Family Welfare was allocated ₹ 69, 000 crore whereas Ministry of AYUSH was allocated only ₹ 2,122.08 crore.

- **Low acceptance of AYUSH:** National Sample Survey in 2014 indicates that only 6.9% of patients seeking outpatient care opted for AYUSH.
- **State subject:** Health being a state subject adds an extra layer of complexity to any national level initiative.
- **Infrastructure related issues:** Lack of processing technique, trained personal, sophisticated instrument, utilization of modern techniques, etc.

**Way ahead**

- **Integrated policy:** To ensure a clearly defined role for the AYUSH doctors and Allopathy doctors with respect to the treatment of patients.
- **Bridging the financing gap:** Equal emphasis should be given to both AYUSH as well as Allopathy system. Public Private Partnership (PPP) could also be utilised for funding.
- **Mutual respect and trust:** Unless allopathic and AYUSH practitioners respect each other's system of practice and work as a team, there is a likelihood of the system becoming competitive and counterproductive.
- **Facilitate cross-learning and collaboration:** To address the subservient status of AYUSH and to foster its legitimate inclusion into mainstream health care. The **Chinese experience of integrating Traditional Chinese Medicine** with Western medicine makes for a good example.

**Conclusion**

An integrated framework should create a middle path fusing the two systems, while still permitting some autonomy for each. Accordingly, a medium- and long-term plan for seamless integration should be developed expeditiously in view of the massive drive for achieving universal health care already under way in the country.

## 2.11.2. NEW BILLS RELATED TO ALTERNATIVE MEDICINES

**Why in news?**

Recently, **Parliament passed three Bills related to alternative medicine** viz. The National Commission for Indian System of Medicine (NCISM) Act, 2020, The National Commission for Homoeopathy (NCH) Act, 2020 and The Institute of Teaching and Research in Ayurveda (ITRA) Act, 2020.

**Alternative Medicine System in India**

- Alternative medicine is **any practice that aims to achieve the healing effects of medicine, but which lacks biological plausibility and is untested, untestable or proven ineffective.** It is also known by different names such as Traditional Medicine, Complementary medicine (CM), integrated medicine or integrative medicine (IM). **In India, it is known by the name Indian System of Medicine (ISM).**
- ISM is the system of medicines which are considered to be **Indian in origin or which have come to India from outside and got assimilated into Indian culture.** ISM **mainly comprises the AYUSH streams** (Ayurveda, Unani, Yoga, Naturopathy, Siddha, and Homeopathy), and are fast gaining traction and popularity in India.
- There is **great curiosity to understand the principles and practice** of Ayurveda, Homeopathy, Siddha and Unani especially **due to growing challenges in medicine** in Non Communicable Diseases (NCDs), Life style disorders, long term diseases, multi drug resistant diseases, emergence of new diseases etc.
- The **Ministry of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH)** was formed in November 2014 **to ensure the optimal development and propagation of AYUSH** systems of healthcare.
- Currently there are eight lakh registered AYUSH doctors in India. Of these, 56% of doctors belong to Ayurveda, 6.4% to Unani, and 1.4% to Siddha and Naturopathy. But there are several challenges which have prevented successful integration of AYUSH in India's mainstream healthcare.

**Issues related to it**

- **Lack of scientific reliability and trust amongst end-users** that these practices do provide proper cure for a range of conditions by helping in maintaining overall fitness.
- **Issues with the quality of medicines:** Ayurvedic preparations have been found to contain lead, mercury, and arsenic, substances known to be harmful to humans.

- **Quality of research has been substandard,** and drugs have been launched without any rigorous pharmacological studies and meaningful clinical trial.
- **Ethical concerns** have been raised about various schemes that increasingly compel rural populace into accepting AYUSH based healthcare; which often leads to disbursal of incompetent healthcare services by unqualified practitioners.
    - Ayushman Bharat has been noted to increase privatization of state healthcare facilities and compel rural populace into preferentially choosing alternative medicine, raising concerns about ethics.

## 2.11.3. THE NATIONAL COMMISSION FOR INDIAN SYSTEM OF MEDICINE ACT (NCISM), 2020

**Key provisions of the act**

- The Act **seeks to repeal the Indian Medicine Central Council Act, 1970** and to provide for a medical education system which ensures:
    - Availability of adequate and high-quality medical professionals of Indian System of Medicine
    - Adoption of the latest medical research by medical professionals
    - Periodic assessment of medical institutions and an effective grievance redressal mechanism.
- **Constitution of National Commission for Indian System of Medicine (NCISM)** and **State Medical Councils.** NCISM would have the following responsibilities:
    - **To frame policies for the regulation of medical professionals and institutions** for ISM.
    - To **assess the human resources and infrastructure** required in relation to healthcare.
- **Autonomous boards:** It sets up certain autonomous boards under the supervision of the NCISM. These boards are:
    - The Board of Ayurveda and the Board of Unani, Siddha, and Sowa-Rigpa
    - The Medical Assessment and Rating Board for Indian System of Medicine
    - The Ethics and Medical Registration Board
- **Advisory Council for Indian System of Medicine:** will be constituted by the central government and will be the **primary platform through which the states/union territories can put forth their views and concerns** before the NCISM.
- **Entrance examinations**: **uniform National Eligibility-cum-Entrance Test** for admission to under-graduate education, **common final year National Exit Test** for the students graduating and a **uniform post-graduate National Entrance Test** for admission into post-graduate courses in all medical institutions will be regulated by the Act.
- **National Teachers' Eligibility Test** for postgraduates of each discipline of Indian System of Medicine who wish to take up teaching that particular discipline as a profession.

## 2.11.4. THE NATIONAL COMMISSION FOR HOMOEOPATHY (NCH) ACT, 2020

**Key Provisions**

- The Act **seeks to repeal the Homoeopathy Central Council Act, 1973** and provide for a medical education system which ensures availability of adequate and high quality homoeopathic medical professionals, etc.
- **Constitution of the National Commission for Homoeopathy (NCH) and State Medical Councils for Homoeopathy**
- **Functions of** (NCH): same as of NCISM but with regards to homeopathy
- **Autonomous boards:** The Act sets up certain autonomous boards under the supervision of the NCH. These are:
    - Homoeopathy Education Board:
    - Medical Assessment and Rating Board for Homoeopathy
    - Board of Ethics and Medical Registration for
- **Advisory Council for Homoeopathy**
- **Entrance examinations for UG, PG and license for practice.**
- **National Teachers' Eligibility Test**
- **Appeal on matters related to professional and ethical misconduct:** The State Medical Councils and the Board of Ethics and Medical Registration for Homoeopathy have the power to take disciplinary action against the medical practitioner including imposing a monetary penalty.

**Conclusion**

True integration would require a concerted strategy for facilitating meaningful cross learning and collaboration between the modern and traditional systems on equal terms. This will help address the subservient status of AYUSH and to foster its legitimate inclusion into mainstream health care.

**Related News**
**The Institute of Teaching and Research in Ayurveda (ITRA) Act, 2020**
**Key Provisions**

- It **seeks to merge three Ayurveda institutes into one institution** by the name of Institute of Teaching and Research in Ayurveda (ITRA). The proposed Institute will be situated in the campus of Gujarat Ayurveda University, Jamnagar and **will be an institution of National Importance.**
- **Objectives of the Institute:**
  - **Develop patterns of teaching** in medical education in Ayurveda and pharmacy,
  - **Bring together educational facilities for training of personnel** in all branches of Ayurveda,
  - **Attain self-sufficiency** in postgraduate education to meet the need for specialists and medical teachers in Ayurveda, and
  - Make an **in-depth study and research in the field of Ayurveda.**
- **Functions of Institute:**
  - **Provide for undergraduate and postgraduate teaching** in Ayurveda (including pharmacy),
  - **Prescribe courses and curricula** and **hold examinations and grant degrees**, diplomas and other distinctions and titles in education in Ayurveda and pharmacy
  - **Provide facilities for research** in the various branches of Ayurveda,
  - **Maintain well-equipped colleges and hospitals for Ayurveda** supporting staffs such as nurses and pharmacists.

## 2.12. ASSISTED REPRODUCTIVE TECHNOLOGY

**Why in news?**

Recently, Assisted Reproductive Technology (ART) (Regulation) Bill, 2020, was introduced in the LokSabha.

**More on news**

- **Objective** of the bill is **to standardise protocols of the growing fertility industry** and **to provide for the regulation of ART services** in the country.
- This is the **third proposed legislation to protect the reproductive rights of women** after the Surrogacy Regulation Bill, 2019, and the Medical Termination of Pregnancy Amendment Bill, 2020.

**Key provisions of the bill**

- **Assisted Reproductive Technology (ART)**: The Bill defines ART to include all techniques that seek to obtain a pregnancy by handling the sperm or the oocyte (immature egg cell) outside the human body and transferring the gamete or the embryo into the reproductive system of a woman.
  - Examples of ART services include **gamete (sperm or oocyte) donation**, **in-vitro-fertilisation** (fertilising an egg in the lab), and **gestational surrogacy** (the child is not biologically related to surrogate mother). ART services will be provided through:
    - ✓ **ART clinics**, which offer ART related treatments and procedures, and
    - ✓ **ART banks**, which store and supply gametes.
- **Regulation of ART clinics and banks**: Every ART clinic and bank must be registered under the **National Registry of Banks and Clinics of India.**
- **Conditions for gamete donation and supply, offering ART services** have also been prescribed**.**
- **Rights of a child born through ART:** A child born through ART will be deemed to be a **biological child of the commissioning couple** and will be entitled to the rights and privileges available to a natural child of the commissioning couple. **A donor will not have any parental rights over the child.**
- **National and State Boards** for Surrogacy constituted under the Bill, will regulate ART services. The State Boards will coordinate enforcement of the policies and guidelines for ART as per the recommendations, policies, and regulations of the National Board.
- **Offences and penalties:** Bill includes various offences under its purview such as(i) abandoning, or exploiting children born through ART, (ii) selling, purchasing, trading, or importing human embryos or gametes, (iii) using intermediates to obtain donors, (iv) exploiting commissioning couple, woman, or the gamete donor in any form, and (v) transferring the human embryo into a male or an animal.

**Need for the bill**

- **High demand and growth of ART:** According to a 2015 Ernst and Young study, around 27.5 million couples in the reproductive age group are infertile and about 1% seek infertility evaluation.
  - Of the people seeking remedy for infertility, 20-25% undergo IVF treatment and of that small group, one percent may require surrogacy.
- **India has become one of the major centres of the global fertility industry**, with reproductive medical tourism becoming a significant activity. This has also introduced a plethora of legal, ethical and social issues; yet, there is **no standardisation of protocols** and reporting is still very inadequate.
- **Facilitating effective implementation of other laws:** Without registration and a proper database of medical institutions and clinics providing such services, it is impossible to regulate services like surrogacy and abortion under **the Surrogacy Regulation Bill, 2019** and Medical Termination of Pregnancy (Amendment) Bill, 2020.

**Types of ARTs**

- **In Vitro Fertilization:** It is the most common form of ART that is used by maximum patients. In this, woman's eggs are combined with man's sperm in a laboratory. The fertilised egg is then placed inside the woman's uterus in a procedure called embryo transfer.
- **Gamete intrafallopian transfer (GIFT):** The man's sperm and a woman's egg are made to combine in a lab. Then the eggs are implanted into the fallopian tubes and the fertilization occurs inside a woman's body.
- **Intrauterine insemination (IUI):** Also known as artificial insemination, it involves insertion of the male partner's (or a donor's) sperm into a woman's uterus at or just before the time of ovulation by long narrow tube.
- **Gestational Surrogacy:** In this, the embryo is created via IVF, using the eggs and sperm of the intended parents or donors, and is then transferred to the surrogate. The child is thus not biologically related to the surrogate mother, who is often referred to as a gestational carrier.

## 2.13. FOOD ADULTERATION

**Why in news?**

Recently, Honey sold by several major brands in India was found adulterated with sugar syrup.

**More about news**

- It was found that **golden syrup, invert sugar syrup and rice syrup are used for adulteration in honey**, which are being procured from China and also manufactured in India.
- Such adulteration in honey is traced by tests like **Nuclear Magnetic Resonance Spectroscopy (NMR), Trace Marker for Rice (TMR), Specific Marker for Rice syrup test (SMR), C3-C4 and oligosaccharides sugar tests.**
- Still such sugar syrups used for adulteration of honey **pass all the adulteration tests** listed in the 2020 standards by FSSAI.

**About food adulteration**

- Food adulteration is an act of **adding or mixing of poor quality, inferior, harmful, substandard, useless** or unnecessary substances to food.
- Food adulteration can be **intentional to increase profit and to meet excess demands**, incidental due to negligence or lack of proper facilities.

**What are the impacts of food adulteration?**

- **Production and cost:** Adulteration can directly reduce production of raw food items, which also increases the production cost and fewer market prices for raw food.
- **Livelihood:** Eg. Adulteration in honey affects the beekeepers due to less demand of raw honey.
- **Nutritional value:** Adulterated food is of low quality and has no or very fewer nutritional values, which can create problem of malnutrition. Eg. Milk with water has less calcium and protein content.
- **Human health:** Impurity in the food items can cause various chronic diseases like Liver Disorder, Diarrhea, Stomach Disorder, Cancer, Heart Diseases and Food Poisoning etc.
- **Ecology:** Reduced production of food crops hampers the interdependence among such flora and fauna. E.g. Honeybees are important pollinators and if raw honey production is reduced then certain plant species gets affected in their pollination.

**Regulations and steps taken to check food adulteration in India**

- **Food Safety and Standards Authority of India (FSSAI)**
  - **It imposes a penalty** for the import, manufacture, storage, sale or distribution of any injurious and non-injurious adulterants **under Food Safety and Standards Act, 2006**.
  - FSSAI has released a **manual 'Detect Adulteration with Rapid Test (DART)' for quick detection of adulterants** in everyday food items.
  - FSSAI released **directives on import of golden syrup, invert sugar syrup and rice syrup** used for adulteration in honey.
- **Consumer Protection Act, 2019**: It provides for athree tier quasi-judicial machinery at national, state and district level to provide simple and speedy redressal to consumer disputes.
- **Codex Alimentarius commission**: It adopts international food standards, guidelines and codes of practice which contribute to the safety, quality and fairness of this international food trade.
- **Harmonised system (HS) code**: It describes the type of good that is shipped, so certain items that are used for adulteration can be scrutinized well during custom clearance.

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

## 3.1. ACHIEVEMENTS OF INDIANS IN SCIENCE & TECHNOLOGY

### 3.1.1. C. V. RAMAN

**Why in news?**

Recently Chandrasekhara Venkata Raman was remembered on his 50th death anniversary (21st November 2020).

**More about C. V Raman**

- He was born at Tiruchirappalli in Tamil Nadu and worked as a **civil servant** in the Indian Finance Department in Calcutta.
- He founded the **Indian Journal of Physics in 1926, Indian Academy of Sciences in 1933** and established **Raman Institute of Research at Bangalore in 1948.**
- He was awarded with the **Nobel Prize for Physics in 1930** for the discovery of the Raman effect and **Bharat Ratna in 1954**.
- India celebrates **National Science Day on 28 February** of every year to commemorate the discovery of the Raman effect in 1928.

**Contributions to physics by C. V. Raman**

- **Raman effect/ Raman scattering:** In 1922 he published his work on the '**Molecular Diffraction of Light'**, which ultimately led to his discovery of 'Raman Effect' in 1928.
  - **Light consists of particles called photons;** whose energy is directly proportional to the frequency with which they travel.
  - When they strike molecules in a medium at high speeds, **they bounce back and scatter in different directions depending on the angle with which they hit the molecules, this is known asRaman effect**.
  - Daylight interacts with the gases in Earth's atmosphere and scatters, instead of coming back straight to our eyes from the sun.
    - ✓ Blue light is scattered most, which means that it involves our eyes from all over within the sky, thus the sky appearance blue.
    - ✓ Yellow and red light are scattered least, thus we tend to typically see a yellow sun, and generally a red sun.
- **Raman spectroscopy:** It is used to better understand the composition of the structures, crystallographic orientation of the sample and the change in vibrational frequency for chemical bond in Raman effect.
  - It is used in many varied fields where **non-destructive, microscopic, chemical analysis and imaging is required.**
  - It can provide **key information easily and quickly.**
  - It can be used to **rapidly characterise the chemical composition and structure of a sample**, whether solid, liquid, gas, gel, slurry or powder.
  - Raman spectroscopy has been used to **monitor manufacturing processes in the petrochemical and pharmaceutical industries.**
  - It is additionally utilized in medication to research living cells, tissues and even in detection of cancers - while not inflicting damage.
- **Scattering by ocean:** He used a prism, miniature optical instrument and optical device to review the sky and therefore the ocean and found that the ocean was scattering light.
  - This, led to oppose the view of Lord Rayleigh, who said sea's colour is solely a mirrored image of the sky's colour.

## 3.1.2. SRINIVASA RAMANUJAN

**Why in News?**

2020 **marks 100th death anniversary** of Srinivasa Ramanujan.

**About Ramanujan**

- SrinivasaRamanujan was born on **December 22, 1887** in the town of **Erode, Tamil Nadu.**
  - His **birth anniversary on 22 December is celebrated as National Mathematics Day** to honour the achievements of the legendary mathematician.
- He received his degree from Cambridge in 1916 and went on to **publish several brilliant papers on his subject with the help of his professor GH Hardy of Trinity College, Cambridge University**.
- Ramanujan was elected to the **London Mathematical Society in 1917** and was elected a **Fellow of the Royal Society for his excellent work on Elliptic Functions and the theory of numbers**.
- He was also **the first Indian to be elected a Fellow of the Trinity College.**
- Ramanujan **died at the young age of 32** owing to deteriorating health on April 26, 1920.
- In 1976 George E. Andrews found Ramanujan's notes written during his last few years in England. Prof. Andrews, along with Bruce C. Berndt went on to compile the contents of this lost notebook into a **five-volume book entitled Ramanujan's Lost Notebook.**
- Robert Kanigel also wrote a book about him called **'The Man Who Knew Infinity'** and a **movie of the same name** premiered in **2015.**

**Ramanujan's Work**

- Ramanujan made priceless contributions to several mathematical concepts like **infinite series, continued fractions, number theory and mathematical analysis**. He also made notable contributions like the **hypergeometric series, the Riemann series, the elliptic integrals, the theory of divergent series, and the functional equations of the zeta function.**
- He introduced a summation in **1918**, now known as the **Ramanujan sum** which is currently used in **signal processing, i.e., analysing, modifying and synthesising periodically repetitive signals such as speech, music, DNA sequences etc.**
- In his famous **letter to Hardy in 1919**, he introduced the **"mock theta functions"** which are **used today in 'String Theory' in theoretical physics.**
- He is also credited for his work in **'Modular functions'** which are used to **reveal properties of Black Holes by astrophysicists**.
- He discovered **Hardy Ramanujan number i.e. 1729** which is the smallest number which can be expressed as the sum of two cubes in two different ways- $1729 = 1^3 + 12^3 = 9^3 + 10^3$.

## 3.2. OPTICAL FIBER TECHNOLOGY

**Why in News?**

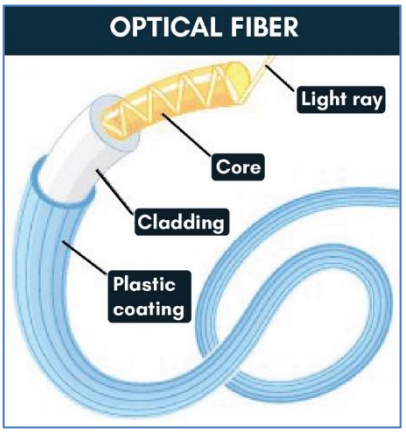
Recently, President has posthumously conferred Padma Vibhushan to Dr. Narinder Singh Kapany who is considered as the **"father of fibre optics".**

**About Dr. Narinder Singh Kapany**

- He was the **first to transmit images through fiber optics back in 1954** and laid the foundation for high speed internet technology.
- He worked in **fields of lasers, biomedical instrumentation, solar energy** and pollution monitoring.
- He received **'The Excellence 2000 Award'** from the USA Pan-Asian American Chamber of Commerce in 1998.
- He was a fellow of **British Royal Academy of Engineering, the Optical Society of America, and the American Association for the Advancement of Science**.

**More on news**

- Submarine optical fiber network is a **cable laid on the sea bed between land-based stations to carry telecommunication signals** across stretches of ocean.
- The cables are **laid using ships that are modified specifically for this** purpose. Modern submarine cables **use fiber-optic technology.**




**About fiber optic technology**

- Fiber optics is the technology used **to transmit information as pulses of light through strands of fiber** made of glass or plastic over long distances.
- Usually, a fiber optic communication system consists of three main components: **optical transmitter, fiber optic cable and an optical receiver.**
  - The optical transmitter converts the electrical signal to the optical signal; the fiber optic cable carries the optical signal from the optical transmitter to the optical receiver, and the optical receiver reconverts the optical signal to electrical signal.

- **Optical fibers are** used as a medium for telecommunication and networking because it is **flexible and can be bundled as cables.**

**Advantages of Optical Fiber Cable**

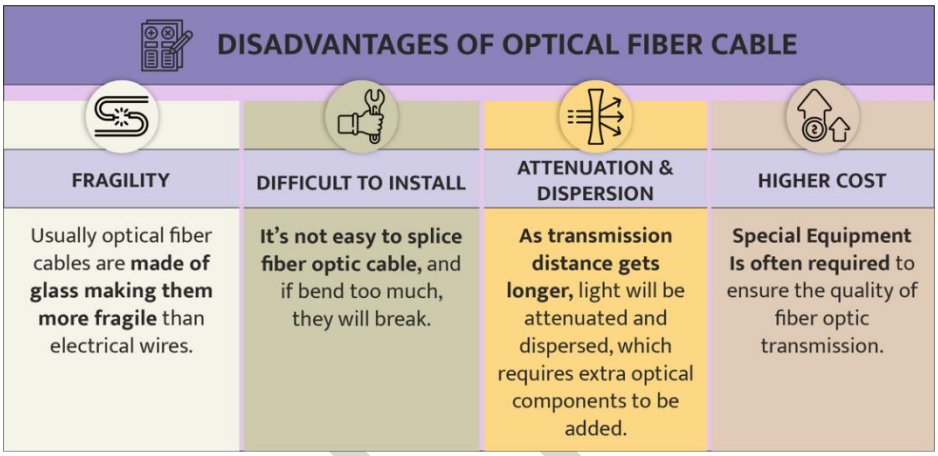
- **Greater Bandwidth:** allows advantage of amount of information that can be transmitted per unit time of fiber over other transmission media.
- **Low Power loss and less interference** allows for longer transmission distances.
- **Small size and light weight** makes them lighter and easy to install.
- **Flexibility:** An optical fiber has greater tensile strength than copper or steel fibers of the same diameter. It is flexible, bends easily and resists most corrosive elements.

**Related News**

Recently, Prime Minister launched **a submarine optical fiber cable connecting Andaman & Nicobar Islands** with the mainland.

**Importance of Submarine cables**

- **As little as 3% of global communications are carried via satellite,** while the remainder is carried by undersea cable. In other words **telephone conversations, the Internet, emails and television are all reliant on cables.**
- The **reliability of submarine cables is high**, especially when multiple paths are available in the event of a cable




- **Secure:** Optical fibers are difficult to tap. As they do not radiate electromagnetic energy, emissions cannot be intercepted.

## 3.2.1. OTHER PERSONALITIES IN NEWS

| | |
|---|---|
| **DrVikram Sarabhai** | • ISRO Names Moon Crater **Captured by Chandrayaan-2 After Vikram Sarabhai called "Sarabhai" Crate**<br>• **About DrVikram Sarabhai**<br>  ○ He founded the **Physical Research Laboratory (PRL) in Ahmedabad in 1947.**<br>  ○ He was also Chairman of the Atomic Energy Commission.<br>  ○ Played Key role in **establishing ISRO** and referred to as **father of the Indian space programmes.**<br>• **Awards conferred on him**<br>  ○ Shanti SwarupBhatnagar Award (1962)<br>  ○ Padma Bhushan (1966)<br>  ○ Padma Vibhushan, posthumous (after-death) (1972) |

# 3.3. INDIGENIZATION OF TECHNOLOGY AND DEVELOPING NEW TECHNOLOGY

## 3.3.1. HYPERSONIC TECHNOLOGY DEMONSTRATION VEHICLE (HSTDV)

**Why in news?**

Recently, **Defence Research and Development Organisation** successfully tested the hypersonic technology demonstration vehicle.

**About HSTDV**

- HSTDV is an **unmanned demonstration aircraft** used for hypersonic flight test.
  - Apart from India, **only three countries** have flown a vehicle at hypersonic speeds in the atmosphere- **Russia, USA and China.**

**Mach Number**

- Mach number expresses the **speed of an object in air relative to the speed of sound.** For example, Mach number 6 here implies that the vehicle was moving at **six times the speed of sound.**
- Velocity zones according to Mach numbers:

| Velocity Zone | Mach number |
|---|---|
| Subsonic | Mach < 1.0 |
| Transonic | Mach ~ 1.0 |
| Supersonic | Mach > 1.0 |
| Hypersonic | Mach > 5.0 |

- The primary aim of the demonstration vehicle was to test the indigenously developed propulsion system- **air-breathing Scramjet engine.**
- The **Hypersonic flight posed two major challenges:**
  - Air being rammed into the engine at high speeds makes it **difficult to simultaneously inject fuel and burn the mixture** without the flame being extinguished by the air blast.
    - ✓ This was overcome by developing technologies like **hypersonic air intake system** and **supersonic combustor.**
  - To ensure that the **skin of the vehicle remains cool** during the hypersonic phase of the flight.
    - ✓ This was overcome by developing **materials which can withstand high temperatures** and creating **computational tools to simulate the hypersonic flow** and temperature profile.

**Air-breathing engines: How they work?**

- The basic difference between air-breathing systems and others is the **material that plays the role of oxidiser.**
- Generally, launch vehicles use combustion of propellants consisting of oxidiser and fuel for deriving the energy. **Air breathing propulsion systems use atmospheric oxygen**, which is available up to about 50 km of earth's surface to burn the fuel stored on-board thereby making the system much lighter, more efficient and cost effective.

**Types of air-breathing systems: Ramjet, Scramjet and Dual Mode Ramjet (DMRJ)**

- **Ramjet Engine:** A ramjet is a form of air-breathing jet engine that uses the vehicle's forward motion to compress incoming air for combustion **without a rotating compressor**. Fuel is injected in the combustion chamber where it mixes with the hot compressed air and ignites.
  - A ramjet-powered vehicle **requires an assisted take-off** like a rocket assist to accelerate it to a speed where it begins to produce thrust.
  - Ramjets work most efficiently at **supersonic speeds around Mach 3**. However, the ramjet efficiency starts to drop when the vehicle reaches hypersonic speeds.
- **Scramjet Engine:** A scramjet engine is an improvement over the ramjet engine as it efficiently operates at hypersonic speeds and allows supersonic combustion. Thus it is known as Supersonic Combustion Ramjet, or Scramjet.
  - The Scramjet engine designed by ISRO uses Hydrogen as fuel and the Oxygen from the atmospheric air as the oxidiser.
- **Dual mode ramjet (DMRJ)**: It is a type of jet engine where a ramjet transforms into scramjet over Mach 4-8 range, which means it can efficiently operate both in subsonic and supersonic combustor modes.

**What is the technological significance of a successful hypersonic flight demonstration?**

- **Reduces the overall fuel need for satellite missions**.
- **Potential for reusing launch vehicles:** Air breathing propulsion systems enable a **powered return cruise flight** for launch vehicles, thus making them reusable and cheaper.
- **Testing of ancillary technologies:** such as aerodynamic configuration of hypersonic manoeuvres and separation mechanism at hypersonic velocities.
- **Faster civilian air transportation:** Further development of Scramjet and Dual Mode Ramjet technology could improve the fuel efficiency and peak speeds for civilian transportation.
- **Faster and long range cruise missiles:** Most cruise missiles fly today at sub-sonic speeds. A hypersonic cruise missile, flying faster than any fighter jet, would strike its target well before it can be intercepted.

## 3.3.2. NATIONAL HYDROGEN ENERGY MISSION

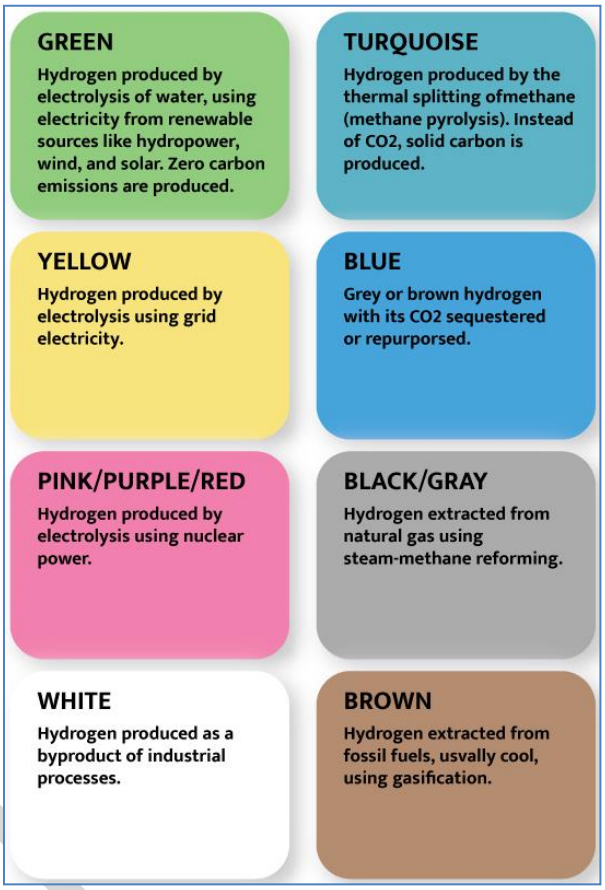
**Why in news?**

Recently, the National Hydrogen Energy Mission was formally announced in the Union budget for 2020-21.

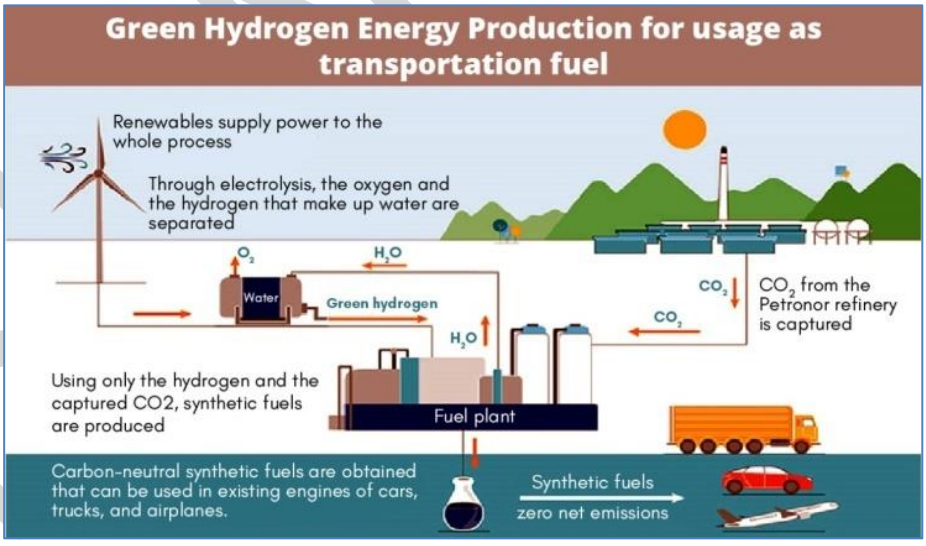
**About the mission**

- The mission emphasizes on **generating hydrogen from green power resources [known as green hydrogen, (***refer infographic***)]** and enabling its commercial use.
- **Major activities envisaged under the mission include:**
  - Creating volumes and infrastructure;
  - Demonstrations in niche applications (including for transport, industry);
  - Goal-oriented Research & Development;
  - Facilitative policy support; and
  - Putting in place a robust framework for standards and regulations for hydrogen technologies.

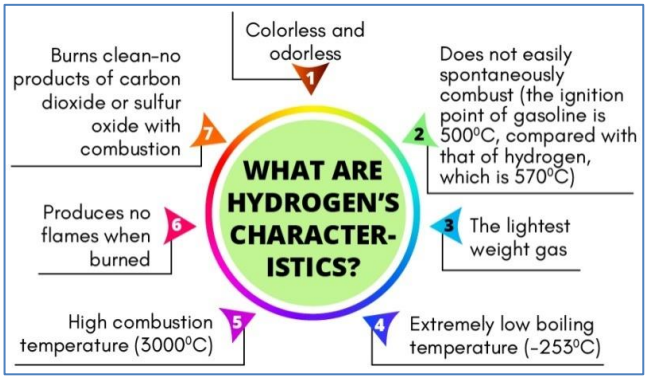
**Benefits of using Green Hydrogen Energy**




- **Clean source of energy**: It can decarbonize a range of sectors including iron and steel, chemicals, and transportation and help India in achieving its emission goals under the Paris Agreement.
- **Potential to transform transportation:** Hydrogen can be used for both fuel cell and internal combustion engines and is being seen as a direct replacement of fossil fuels.
- **Channelizing renewable energy**: Renewable energy that cannot be stored or used by the grid can be channelled to produce hydrogen. Hydrogen can act as an energy storage option, which would be essential to meet intermittencies (of renewable energy) in the future.
- **Hydrogen FCEV (Fuel cell electric vehicles) are better in comparison to Battery electric vehicles:** Hydrogen FCEV enables a refueling time of just five minutes, compared to 30-45 minutes charging for a BEV (Battery electric vehicles).
    - This also has the **potential to reduce India's demand for rare earth minerals** that are used in the manufacturing of batteries for electric vehicles.
- **Effective for sectors that cannot be electrified:** Hydrogen vehicles can be especially effective in long-haul trucking and other hard-to-electrify sectors such as shipping and long-haul air travel.



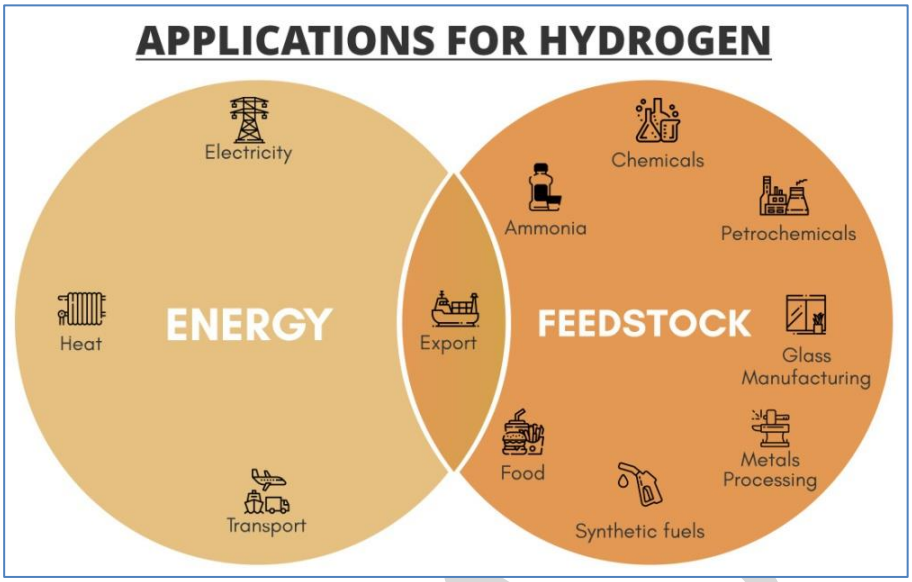

- **Investment opportunities:** Several leading organizations are exploring technologies which can convert bio and plastic waste into hydrogen, thereby providing a huge scope for investment in this technology which can combat India's twin problems of waste management and energy security.
- **Reducing India's Current Account Deficit (CAD):** India imports 85% of its oil and 53% of its gas demand. Green hydrogen has the potential reduce import dependency on fossil fuels and thus CAD.
- **Addressing uncertainty:** Hydrogen finds special resonance in India, given the uncertainty in global energy markets.




**Challenges**

- **Process of extracting green hydrogen is energy-intensive:** Hydrogen is not found freely as it exists only combined with other elements and has to be extracted from naturally occurring compounds like water.

- **High Cost**- The technology used in production and use of hydrogen like carbon capture and storage (CCS) and hydrogen fuel cell **technology are at nascent stage** and are expensive which in turn increases the cost of production of hydrogen. Furthermore, **the maintenance costs for fuel cells post-completion** of a plant can be costly.




- **High R&D requirement:** The commercial usage of hydrogen as a fuel and in industries requires mammoth investment in R&D of such technology and infrastructure for production, storage, transportation and demand creation for hydrogen.
- **Multiple regulatory authorities:** Ministry of Road Transport and Highways regulates vehicle's fuel carrier specification, MNRE regulates renewable energy sources and Petroleum and Explosives Safety Organisation regulates explosive substances, storage and fuel station's specifications.
- **Issues in transporting hydrogen:** Hydrogen in gaseous form is highly inflammable. Also, hydrogen lacks smell, which makes any leak detection almost impossible.

**Other Initiatives taken**

- **National Hydrogen Energy roadmap (2006)** for the long-term public and private efforts for hydrogenenergy development.
- **Hydrogen and Fuel cell program** by Department of Science and Technology.
- Indian Institute of Science has developed **biomass gasification-based hydrogen generation technology.**
- Delhi became the first Indian city to operate buses running on **hydrogen spiked compressed natural gas (H-CNG).**
- **NTPC Ltd is operating a pilot to run 10 hydrogen fuel cell-based electric buses** and fuel cell electric cars in Leh and Delhi.
- As a supporting regulatory framework, the **Ministry of Road Transport and Highways** issued a notification **proposing amendments to the Central Motor Vehicles Rules**, 1989, to include safety evaluation standards for hydrogen fuel cell-based vehicles.

**Way forward**

India has a huge edge in green hydrogen production owing to its favorable geographic conditions and presence of abundant natural elements.

With appropriate capacity addition to renewable power generation, storage and transmission, producing green hydrogen in India can become cost effective which will not only guarantee energy security, but also ensure gradually self-sufficiency.

**Related News: Coal Based Hydrogen**

**Why In News?**

Recently, the **Ministry of Coal** constituted a **Task Force and Expert Committee to prepare the roadmap for Coal based Hydrogen production.**

**Global status of Hydrogen**

- At present, the current global demand for hydrogen is **70 million metric tons**, most of which is being produced from fossil fuels– **76% from natural gas** and **23% from coal** and **remaining from the electrolysis of water**.
- Coal is one of the important sources of **hydrogen making (Brown Hydrogen)** apart from **Natural Gas (Grey hydrogen)** and **renewable energy (Green Hydrogen) through electrolysis**.
- The **global emphasis is on substituting liquid fuels with hydrogen** (as fuel in vehicles), storage of surplus renewable power as hydrogen (as power cannot be stored at a cost effective price), and cutting down emission.

**How is Coal based Oxygen produced?**

The **partial oxidation process** is used to **produce hydrogen from coal**, which means some air is added to the coal, which generates carbon dioxide gas through traditional combustion.

**How does the picture look for India in this sector?**

- In India, Hydrogen demand could **increase 5-fold by 2050**, with use in industry being the major driver.
- In industry, **steel and ammonia will drive growth in hydrogen demand**, followed by refineries and methanol.
- By 2030, costs of hydrogen from renewables will fall more than 50% and will start to compete with hydrogen produced from fossil fuels.
- **Almost 100% of Hydrogen produced in India is through Natural Gas** (Grey Hydrogen).

In this context, pursuing Coal based hydrogen could enable following for India-

| Benefits of Coal Based Hydrogen | Challenges of Coal Based Hydrogen |
|---|---|
| • Since India has the world's fourth-largest coal reserves, **Cost of Hydrogen produced from coal can be cheaper and less sensitive to production** through electrolysis and Natural Gas respectively.<br>• Effective way to **develop clean energy**. | • As current technology hydrogen is made primarily from fossil fuel reformation, this would lead to a **higher rate of carbon dioxide emissions**.<br>• Coal has not been encouraged elsewhere because of the fear that while extracting hydrogen via coal there may be carbon emission.<br>• Safety and storage problem.<br>• **Issue of building much-needed infrastructure** and developing consumer markets (that is, hydrogen fuel cell vehicles) for a truly clean future fuel. |

**Road Ahead**

The clean hydrogen has the potential to be traded as a new commodity. A lot of work will be required to lay down standards for large-scale use of hydrogen besides framing safety regulations. **India should be proactive in developing and deploying hydrogen technologies,** to indigenize manufacturing and maximize domestic benefits, and introduce penalty on carbon dioxide emission.

## 3.3.3. NEUTRINO OBSERVATORY

**Why in News?**

Recently, Government proposed to set up Neutrino Observatory in the country.

**About India based Neutrino observatory (INO)**

- **INO will observe neutrinos produced in the atmosphere of the Earth.** The site identified is in Bodi West Hills, in Theni district, Tamil Nadu.
- Project is a multi-institutional effort aimed at building a world-class **underground laboratory for non-accelerator based high energy and nuclear physics research in India.**

**Why neutrino observatories are located underground?**

- **It is impossible to detect neutrinos on the surface of the Earth.** This is the reason most neutrino observatories are located deep inside the Earth's surface.
  - **One of the earliest laboratories in the world** to detect neutrinos was located **at Kolar Gold Field mines in India.**
- There are two types of underground laboratories: **either located in a mine or in a road tunnel.**
- **There are now four major laboratories around the world:** in Sudbury in Canada, Kamioka in Japan, under the Gran Sasso Mountains in Italy and in Soudan mines in the USA.

- It is **jointly funded** by Dept. of Atomic Energy and the Dept. of Science and Technology.
- **Project includes:**
  - **Construction of an underground laboratory** and associated surface facilities at Pottipuram in Bodi West hills. The underground laboratory will consist of a large cavern and several smaller caverns.
  - **Construction of an Iron Calorimeter (ICAL) detector** for studying neutrinos. It will be a magnetized ICAL, which will be the heaviest one made by any country.
  - **Setting up of an Inter Institutional Centre for High Energy Physics** (IICHEP) at Madurai, for the operation and maintenance of the underground laboratory, human resource development etc.
- INO has **no strategic or defence applications**. Its operation **involves no radioactivity release** or toxic emissions.
- However, there is controversy surrounding the project as **activists say the observatory will have devastating impacts on the local biosphere and people's health.**

**Significance of INO Project**

- Primary goal is the **study of neutrinos from various natural and laboratory sources** using an ICAL detector.
- It will **tell more about the properties of neutrino particles.** The aim is to make precision measurements of the parameters related to neutrino oscillations.
- INO will have an **impact on the emerging high energy physics scenario** in the country. It will host other experiments such as the neutrino-less double beta decay and the search for dark matter.
- Over the long term INO is expected to develop into **a world class underground science laboratory straddling many fields** like physics, biology, geology and allied engineering fields.

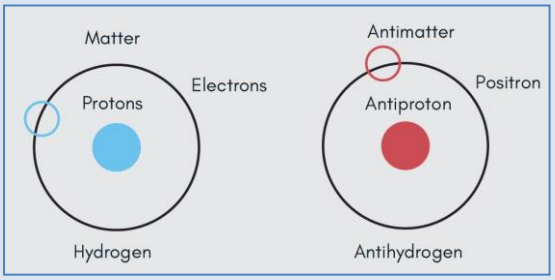
- **Students of science and technology** within the country will have the **opportunity to involve themselves in research involving cutting science and technology.**

**About Neutrinos**

- Neutrinos are **fundamental particles belonging to the lepton family.** They come in three flavours, one associated with electrons and the others with their heavier cousins the muon and the Tau.
- Neutrinos are **tiny, neutral, elementary particles which interact with matter via the weak force.** The weakness of this force gives neutrinos the property that **matter is almost transparent to them.**
- The **Sun, and all other stars, produce neutrinos** copiously due to nuclear fusion and decay processes within their core.
- Since they rarely interact, these **neutrinos pass through the Sun, and even the Earth, unhindered.**
- Neutrinos hold the key to several important and fundamental **questions on the origin of the Universe and the energy production in stars.**
- Another possible application of neutrinos is **its role in detailed investigation of the structure of the Earth** from core on wards.

**Related information**

**Matter Antimatter asymmetry**




- For each basic particle of matter, there exists **an anti-particle with the same mass but the opposite electric** charge.
  - For example, the negatively charged electron has a positively charged anti-particle called the positron.
- But when a **particle and its anti-particle collide**, they are **"annihilated"** in a flash of energy**,** yielding new particles and anti-particles.
- Physicists think that the **Big Bang** should have created **equal amounts of matter and antimatter.**
- Yet, paradoxically, today we live in a **Universe made up overwhelmingly of matter**.
- **Anti-matter is rare today**. It can be produced in "atom smashers", in nuclear reactions or by cosmic rays.
- What happened to all the anti-matter is regarded by many researchers as **one of the biggest mysteries in cosmology**
- Physicists believe that the dominance of matter in the Universe is possible only if there are differences in the behaviour of particles and anti-particles.
- **At CERN** (a European research organization) near Geneva**, physicists make antimatter to study in experiments.**
  - **India** is also an **associate member to CERN**

# 4. MISCELLANEOUS

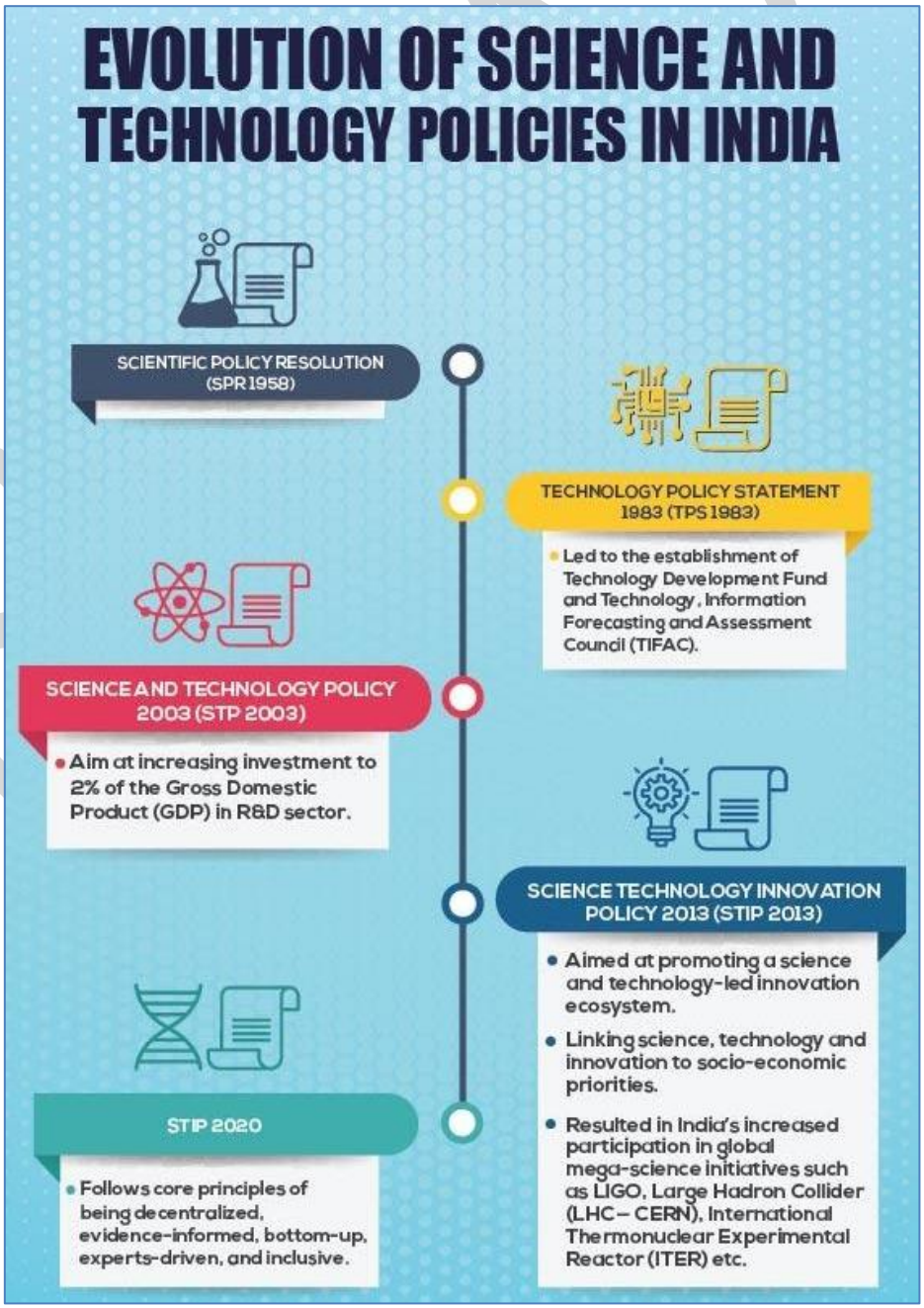
## 4.1. DRAFT NATIONAL SCIENCE TECHNOLOGY AND INNOVATION POLICY

**Why in News?**

Recently, the draft of **5th National Science Technology and Innovation Policy (STIP)** was released by the **Department of Science and Technology (DST)**.

**Need for a new policy**

- **Lack of access to scientific knowledge:** R&D institutions in India spend nearly Rs 1,500 crore per annum for subscribing to journals. But still, only a third of the country's total of 3.5 lakh-odd researchers get access to these journals.
  - **Researchers in remote areas, poor students who cannot pay for such articles**, or those who are not part of government institutions, do not have access to this scholarly knowledge.
- **Bridging the gender divide:** There is a persistent gap at the doctoral level between male and female graduates due to which overall participation of women in R&D continues to be only about 16%.
- **Learnings from COVID-19 presents opportunity to develop scientific temper in the country.**
- **Expansion of STI funding landscape:** India's Gross Domestic Expenditure on R&D (GERD) is just 0.6% of GDP which is quite low compared to other major economies (1.5% to 3%).
  - This can be **attributed to inadequate private sector investment** (less than 40%) in R&D activities in India; in comparison to other technologically advanced countries (70% of GERD).
- **Greater Thrust on Innovation:** India has improved its rank from 81 in 2015 to 48 in 2020 in the Global Innovation Index. But it is still much lower than expected for India's level of access to equity capital.



**Key provisions of the draft policy:**

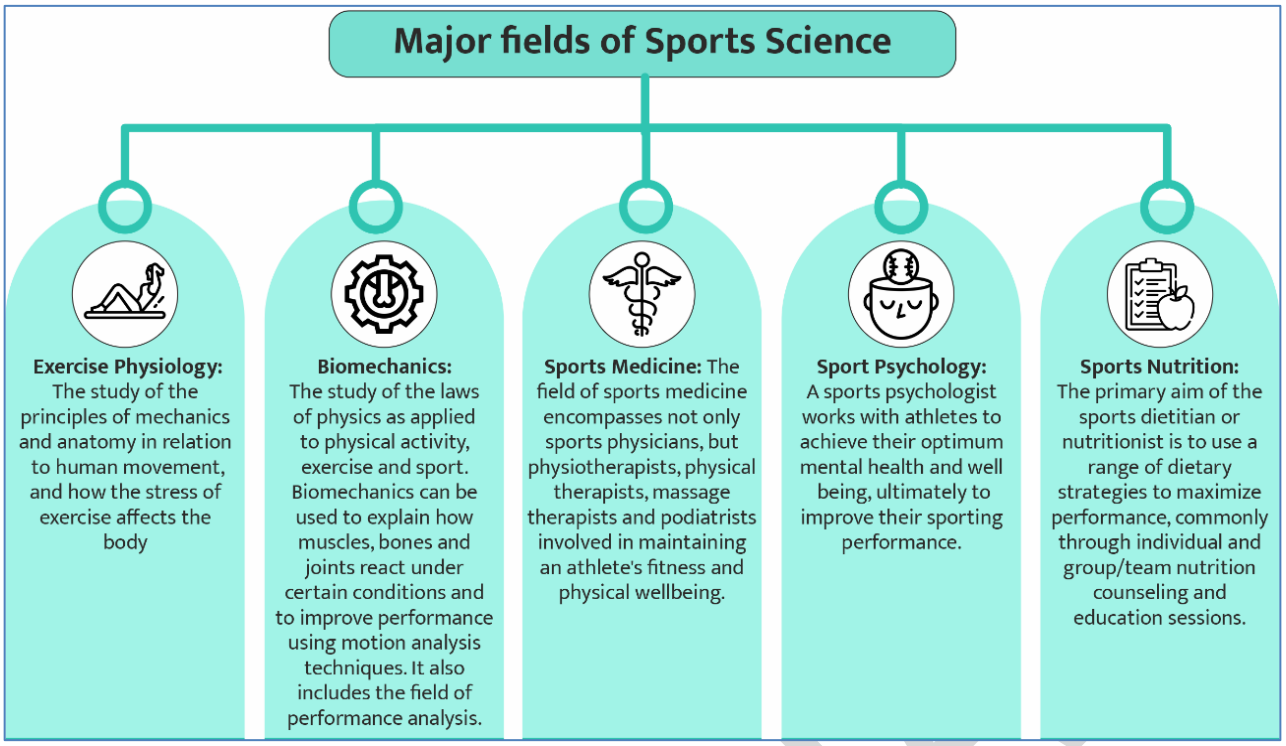
This Policy **will replace the Science Technology and Innovation Policy, 2013** and have following major provisions:

- **Open Science Framework:** It will encompass an open centralised database platform **National STI Observatory** to provide access to scientific data, information, knowledge, and resources to everyone in the country (**One Nation, One Subscription**).
  - A **dedicated portal** to provide access to the outputs of such publicly-funded research will be created through the **Indian Science and Technology Archive of Research (INDSTA).**
- **Capacity Development:** For this:
  - **Higher Education Research Centres (HERC) and Collaborative Research Centres (CRC)** will be established to provide research inputs to policymakers and bring together stakeholders.
  - **Innovation and Entrepreneurship Centres** will be established starting from the undergraduate level of university education.
  - **Research in innovation practices** will be made a mandatory component of university/college teachers' professional development programmes.
- **Financing of STI:**
  - **STI unit** will be set up in each department/ ministry in the central, the state and the local governments, public sector enterprises, private sector companies and startups with a minimum earmarked budget to pursue STI activities.
  - **Advanced Missions in Innovative Research Ecosystem (ADMIRE)** initiative for creating hybrid funding models to support distributed and localised collaborative mission-oriented projects.
  - **STI Development Bank** will be set up to facilitate a corpus fund for investing in direct long term investments in select strategic areas.
- **Research and Innovation Excellence Frameworks (RIEF)** will be developed to reorient research culture to recognize social impacts along with academic achievements.
- **Integrating Traditional Knowledge System:** An **institutional architecture** will be established to integrate Traditional Knowledge and grassroots innovation into the overall education, research and innovation system.
- **Technology Development and Indigenisation:** The policy will promote technology self-reliance and indigenization in alignment with national priorities, like sustainability and social benefit, and resources and to achieve the larger goal of "Atmanirbhar Bharat". Under this:
  - **Technology Support Framework** will be created **for facilitating International engagements**.
  - **Strategic Technology Board (STB)** and **Strategic Technology Development Fund (STDF)** will be constituted for collaboration and funding.
- **Equity and Inclusion:** An **India-centric Equity & Inclusion (E&I) charter** will be developed for tackling all forms of discrimination, exclusions and inequalities in STI leading to the development of an institutional mechanism.
- **Mainstreaming Science Communication and Public Engagement** through creative and cross-disciplinary platforms, research initiatives, and outreach platforms.
  - **Science Media Centres** will be established at national and regional levels to connect scientists with media persons and science communicators.
- **International STI Engagement (Complementing 'S&T for Diplomacy' with Diplomacy for S&T):**
  - **Engagement with the Diaspora will be intensified.**
  - **International Knowledge Centres** will be established to promote global knowledge and talent exchange.
- **STI Policy and Governance:**
  - **STI Policy Institute** will be established to build and maintain a robust interoperable STI metadata architecture.
  - **Research and Innovation (R&I) governance framework** will be set up to facilitate, stimulate and coordinate R&D activities across the sectors.

## 4.2. SCIENCE AND TECHNOLOGY IN SPORTS

**Why in News?**

The Tokyo Olympics highlighted the importance of 'sports science' in today's world of sports.






**About Sports science**

- Sport Science includes the knowledge, methods and applications of sub-disciplines of human movement studies (i.e., exercise physiology, biomechanics, motor control and motor development, exercise and sport psychology), as well as how they interact.

**Emerging Applications of Science and Technology in Sports**

- **Data enabled training:** Three-dimensional modelling, motion capture technology and biometric feedback on heart, muscle movement and respiratory rate etc., can help experts spot errors and problems in athlete's form.
- **Virtual reality and augmented reality:** Coaches and players can train better by watching and experiencing plays again and again in virtual reality.
- **Tech-powered refereeing:** Examples-
  - **Hawk-Eye**: A computer vision system used in numerous sports such as **cricket, tennis, badminton etc**, to visually track the trajectory of the ball and display a profile of its statistically most likely path as a moving image.
  - **Goal-line technology** is the use of electronic aid to determine if a goal has been scored or not.
- **Wearable Technology:** It can be used understand how an athlete is performing and also to prevent injuries. E.g.-
  - **Catapult OptimEye S5 used in football** to track a player's acceleration, positioning, collision impact, etc.
  - **QLIPP for Tennis** is attached to racket strings and offers real time data from within a tennis racket.

**Science and technology in Sports**

- **Artificial intelligence voice analysis (AIVA):** International Amateur Boxing Association (AIBA) employed military-approved AIVA and cyber technology systems to analyse judges and referees.
- **Mondo's racing track:** Three-dimensional rubber granules specifically designed with a selected polymeric system were integrated in the top layer of the track to maximize the speed of athletes and improve their performance.
- **Clothing Technology**:
  - **"RL COOLING,"** developed specifically for Team USA athletes. The product senses body temperature and disperses heat from the wearer's skin though a sophisticated device.
  - USA's Speedo's new **tech race swimsuits** drew inspiration from sharkskin in an attempt to minimise swimmers' drag in the water.
  - **3D printed shoes by Chinese boxing team** and **anti-grab technology of fabric for wrestling** to reduce the likelihood of being grasped by the opponent.
- **Climate training**: At the US Olympic Committee's flagship training center in Colorado Springs, Colorado, athletes used a high tech training room that simulated the climate of Tokyo to prepare their bodies for the environment they would be competing in.

- **Injury Recovery Systems:** Examples include-
  - **Cryotherapy:** It exposes parts of the body to freezing or near-freezing temperature.
  - **Hyperbaric therapies, such as hyperbaric oxygen therapy (HOT):** It is said to repair and regenerate tissue, limit swelling, stop infections, and aid in muscle soreness after intense training sessions.
- **Sweat Analysis:** useful for monitoring health signs, gathering data to boost recovery, and eventually improving athletic performance.
- **Intelligent clothing and sports gear**: They are explicitly designed to reduce hassles and maximise performance with clothing that can regulate temperature, endurance and so on.
- **Talent Identification System:** These are Research models in which physical appearance and specific genetic characteristics can be used to determine the suitability of a player for a specific sport.
- **Other uses:** Fan engagement technologies, including live streaming and e-sports, Identification of genes to code for different traits and behaviours to optimise training etc.

**Issues pertaining to use of Science and tech in Sports**

- **Fairness**: The advancement and rampant use of tech in the sporting world raises questions over how much technology should be acceptable for athlete training and to what extent can it be considered fair play.
- **Inequality:** Inequalities in terms of revenue and technological accessibility can widen the barrier for emerging athletes in developing nations.
- **Technological doping**: Performance-enhancing tech and gear can be used to gain a 'competitive advantage' in sports.
  - For instance, specific shoes have been banned from use in the Tokyo Olympics by World Athletics as their design was considered an unfair form of performance enhancement.

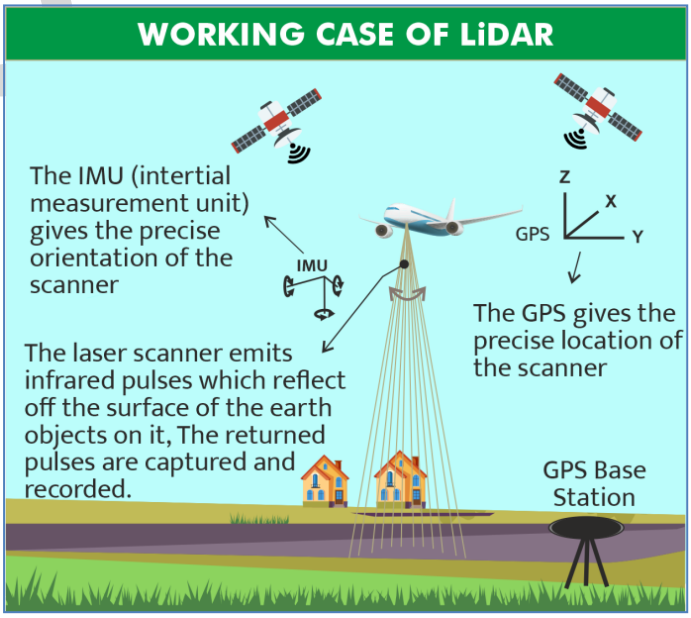
**Conclusion**

Technological developments in sports offer endless benefits and lead to more exciting events, fairer referees, and fewer injuries. Use of technology to improve sports performance is inevitable. It is therefore important to develop stringent and comprehensive technical rules for clarifying extent and type of technologically enabled enhancements that can be allowed in any sport.

## 4.3. LIDAR SURVEY REPORTS

**Why in News?**

Recently, Ministry of Environment, Forest and Climate Change released LiDAR (light detection and ranging) based reports mapping out the water requirement within forest areas in 10 states.




**More on News**

- **Project was awarded to WAPCOS,** a public sector unit under the Ministry of Jal Shakti.
- WAPCOS **followed the Ridge to Valley approach of watershed management** for this survey.
- **LiDAR technology was used to create 3-D images** of the project areas to recommend soil and water conservation structures.
- State forest departments **will use Compensatory Afforestation Fund Management and Planning Authority (CAMPA) funds** towards implementation of these projects.
- The **survey would help in:**
  - **Identifying areas** which need groundwater recharge.
  - **Reducing human-animal conflict** by reducing water scarcity.

**About LiDAR technology**

- LiDAR is a **remote sensing technology** that uses light in the form of a pulsed laser to measure ranges (distances) to a target.
  - These light pulses—combined with other data recorded by the airborne system— **generate precise, three-dimensional information about the shape of the Earth** and its surface characteristics.
  - It is similar to **radar and sonar** (that use radio and sound waves, respectively).
- A LiDAR instrument principally consists of a **laser, a scanner, and a specialized GPS receiver**.
  - Airplanes and helicopters are the most commonly used platforms for acquiring lidar data over broad areas.
- **There are following two types of LiDAR:**
  - **Topographic:** typically uses a near-infrared laser to map the land.
  - **Bathymetric:** uses water-penetrating green light to also measure seafloor and riverbed elevations.
- **Applications**: Land management and planning efforts, including hazard assessment, forestry, agriculture, geologic mapping, and watershed and river surveys etc.

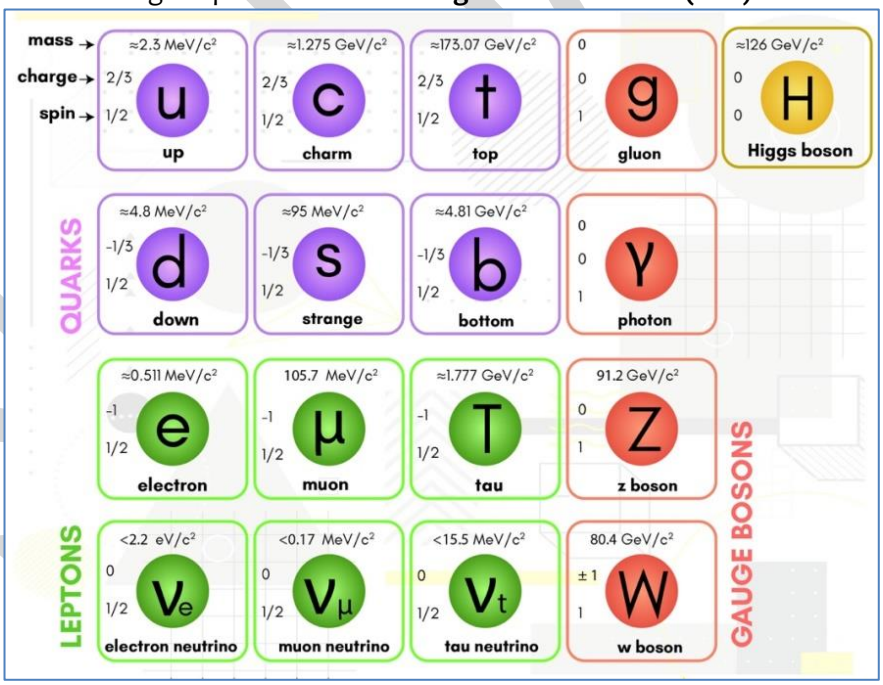
## 4.4. LARGE HADRON COLLIDER BEAUTY EXPERIMENT (LHCB)

**Why in news?**

Researchers at University of Zurich and European Organization for Nuclear Research (CERN) have found new results at Large Hadron Collider beauty (LHCb) experiment.

**About Large Hadron Collider beauty experiment (LHCb)**

- The LHCb experiment is one of the four large experiments at the **Large Hadron Collider (LHC) at CERN in Geneva.**
- It is **designed to study decays of particles containing a beauty quark,** the quark with the highest mass forming bound states.
  - Beauty quarks are **produced during the collision of high-energy proton beams** in LHC at CERN.
    - ✓ **Quarks are elementary subatomic particles** that interact by means of the strong force and are believed to be among the **fundamental constituents of matter.**
    - ✓ **There are six types of quarks** that differ from one another in their mass and charge characteristics that are grouped in three pairs: **up and down, charm and strange, and top and bottom.**
    - ✓ Beauty quarks (bottom quark) are much **heavier than the up and down quarks and particles containing b quarks are also unusually long-lived,** which make them very useful to physicists looking for physics beyond the standard mode.




- As per **Standard Model the decay process** involves the conversion of a beauty quark into a strange quark with the production of an electron and antielectron or a muon and antimuon.
  - **Electrons are the subatomic particles that orbit the nucleus** of an atom and generally negative in charge. While antielectron is positively charged also called as positron.
  - **Muon is elementary subatomic particle similar to the electron** but 207 times heavier. It has two forms, the negatively charged muon and its positively charged antimuon.

- But **results at LHCb shows anomalies** in decaying process than standard model with new **fundamental force in addition to four fundamental ones**.
  - Four fundamental forces of standard model are **Gravity, electromagnetism, weak nuclear interactions responsible for radioactivity and strong nuclear forces that hold matter together.**
- This anomaly in result gives **hint of the possible existence of a hypothetical particle called a leptoquark** has appeared as an unexpected difference in how beauty quarks decay to create electrons or muons.

**Large Hadron Collider (LHC)**

- It is the **world's largest and most powerful particle accelerator** at CERN's accelerator complex.
- The LHC consists of a 27-kilometre ring of **superconducting magnets with a number of accelerating structures to boost the energy** of the particles along the way.
- The **beams inside the LHC are made to collide at four locations** around the accelerator ring, corresponding to the positions of **four particle detectors ATLAS, CMS, ALICE and LHCb**.
- The project was officially approved in 1997, and is capable of **accelerating particles up to 99.99 percent the speed of light and smashing them together.**
- In 2012, the researchers at the LHC announced the **discovery of the Higgs boson**, particle named after physicist Peter Higgs.
  - Higgs boson, an **elementary particle, gains their mass from a fundamental field (Higgs field) through its interactions.**

## 4.5. INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR (ITER)

**Why in news?**

India has recently competed 50 per cent of the work assigned to it under the ITER project.

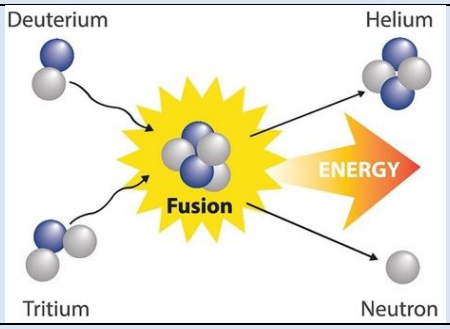
**About ITER Project**

- Launched in 1985, ITER is an **experimental fusion reactor facility** currently under construction in Cadarache, south of France.
- It aims to prove the feasibility of **nuclear fusion as a future source of energy** and build the world's largest **tokamak** through an international collaboration.
- **ITER Members:** Signatories to the ITER Agreement include **China**, the **European Union**, **India**, **Japan**, **Korea**, **Russia** and **US** (35 nations).
  - These countries share the **cost of project construction, operation and decommissioning**, and will also share in the **experimental results and any intellectual property** generated by the project.
  - **Each Member has created a Domestic Agency** to fulfill its procurement responsibilities to ITER.
- **India's contribution:** India is responsible for delivery of cryostat, in-wall shielding, cooling water system, cryogenic system, heating systems, Diagnostic Neutral Beam System, power supplies and some diagnostics.
  - India is contributing resources worth about $2.2 billion to this effort.
  - **ITER-India is the Indian domestic agency,** a specially empowered project of the Institute for Plasma Research, an aided organization under Dept. of Atomic Energy.

**Tokamak**

- The **tokamak** is an experimental **magnetic fusion device** designed to harness the energy of fusion.
- Inside a tokamak, the energy produced through the fusion is **absorbed as heat in the walls of the vessel**, which will be used by a fusion power plant to produce steam and then electricity by way of turbines and generators.
- The device uses **magnetic fields** to contain and control the hot plasma, which enables the fusion between **deuterium and tritium nuclei** to produce great amounts of energy.
  - **Plasma** is an ionized state of matter similar to a gas. A gas becomes plasma at extreme temperatures.
- The **machine has been designed** specifically to:
  - **Produce 500 MW of fusion power**
  - **Demonstrate the integrated operation of technologies for a fusion power plant** such as heating, control, diagnostics, cryogenics and remote maintenance.
  - **Achieve a deuterium-tritium plasma** in which the **reaction is sustained for a long duration** through internal heating
  - **Test tritium breeding**: Since the world supply of tritium is not sufficient to cover the needs of future power plants
  - **Demonstrate the safety characteristics of a fusion device.**

**Differences between Nuclear Fission and Fusion**

| Nuclear Fission | Nuclear Fusion |
|---|---|
| Fission is the **splitting of a heavy, unstable nucleus into two lighter nuclei**, which releases a tremendous amount of energy. | Fusion is the process where **two light nuclei combine together** releasing vast amounts of energy. |
|  |  |
| **Uranium and plutonium** are most commonly used for fission reactors. | **Atoms of Tritium and Deuterium** (isotopes of hydrogen) are used in fusion reactors. |
| Energy produced is **lesser** than that in nuclear fusion. | Energy released is **several times greater** than fission. |
| Fission reactors produce **highly radioactive fission products**. | Fusion reactors produce **no high activity/long-lived radioactive waste**. The burnt fuel in a fusion reactor is helium, an inert gas. |
| Additional neutrons released in the fission reaction can initiate a **chain reaction** which **sustains fission reactions for longer durations**. | Due to the tremendous amount of pressure and temperature needed to join the nuclei together, fusion reactions are **difficult to sustain for long periods** of time. |

**Advantages of fusion energy**

- **Abundant energy:** Fusing atoms together in a controlled way 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.
- **Sustainability:** Fusion fuels are widely available and nearly inexhaustible.
- **Zero carbon emissions:** Fusion doesn't emit harmful toxins like carbon dioxide or other greenhouse gases into the atmosphere. Its major by-product is helium: an inert, non-toxic gas.
- **No high activity long-lived radioactive waste.**
- **Limited risk of proliferation:** Fusion doesn't employ fissile materials like uranium and plutonium. There are no enriched materials in a fusion reactor like ITER that could be exploited to make nuclear weapons.
- **No risk of meltdown:** It is difficult to reach and maintain the precise conditions necessary for fusion. Thus if any disturbance occurs, the plasma cools within seconds and the reaction stops.

**Issues related to India's participation in ITER**

- **Delays in in-cash contribution:** Since 2017, India has not fulfilled its in-cash contribution.
- **Low allocation of human resources at the ITER site:** Only 25 Indians are currently working there, as against 100 engineers/ scientists allowed as per the agreement. This gives opportunity to countries like China to have excess staffing.
- India deputed a rather **junior person to represent the country** in comparison to heads of states by other nations at the recent high profile global virtual event.

**Conclusion**

By the end of the century, demand for energy will have tripled under the combined pressure of population growth, increased urbanization and expanding access to electricity in developing countries.

Relying on fossil fuels alone to increase the energy production is both impractical and impossible, because of lack of access to required resources and irreparable damage to the environment through global warming. Thus fusion provides a great opportunity to India to meet its energy needs in the future.

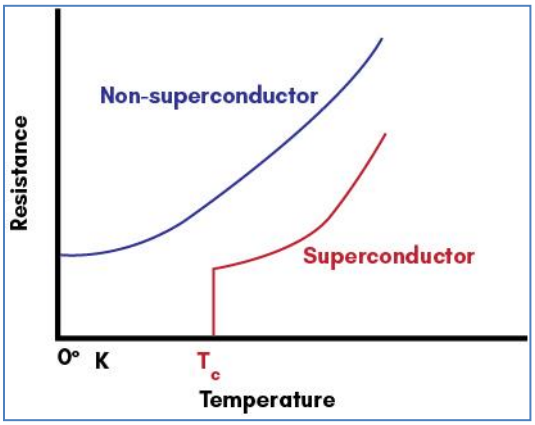
## 4.6. SUPERCONDUCTIVITY AT ROOM TEMPERATURE

**Why in news?**

For the First Time, Physicists Have Achieved Superconductivity at Room Temperature.

**More on news**

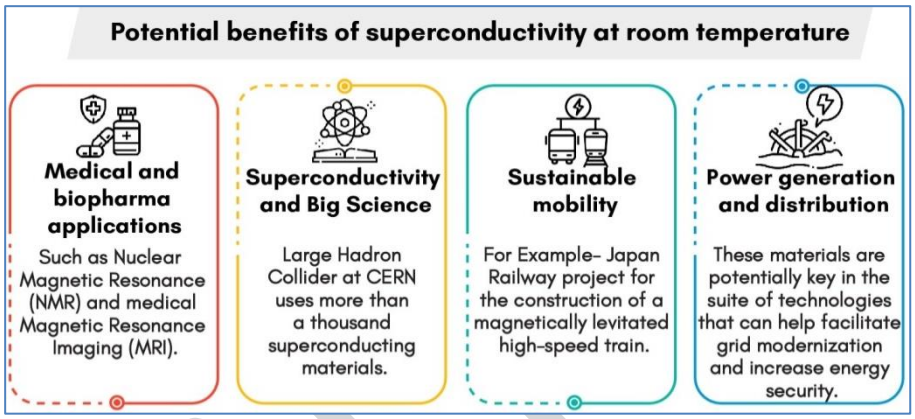
- For the first time, physicists have achieved the resistance-free flow of an electrical current in a material at room temperature - **15 degrees Celsius (59 degrees Fahrenheit).**
- Although, the **sample sizes used were microscopic and the pressure** at which superconductivity emerged are **still rather impractical.** This achievement will pave the way forward for generation of superconductivity in atmospheric conditions.




**About Superconductivity**

Superconductivity is a phenomenon in which the **electrical resistivity suddenly drops to zero at its transition temperature (Tc).** It consists of two key elements:

- **Zero electrical resistance:** Usually, the flow of an electrical current encounters some degree of resistance. The higher the conductivity of a material, the less electrical resistance it has, and the current can flow more freely.
- **Meissner effect:** It is the expulsion of a magnetic field from a superconductor during its transition to the superconducting state when it is cooled below the critical temperature.



# WEEKLY FOCUS:
# SCIENCE & TECHNOLOGY

| ISSUE | DESCRIPTION | LEARN MORE |
|---|---|---|
|  5G Technology Challenges and Opportunities | 5G Technology is one of the lynchpins in the emerging parlance of 4th Industrial Revolution as it drastically alters economy and the life around us. The omnipresence of this technology also brings in a geopolitical dimension to this debate. The multi-dimensional impact of this technology necessitates adoption of a progressive, open but cautious approach for a country like India given the developments in relation to China and United States. | |
|  Clean Coal Technologies | Coal is regarded as the dirtiest energy resource with the highest carbon emission coefficient, but it plays a vital role in electricity generation worldwide. Given the importance of coal in the global energy framework, and the difficulty in phasing out its use, at least in the foreseeable future, the development of clean coal technologies (CCTs) has been pressed as an appropriate way to achieve both coal-driven energy production and environmental protection. | |
|  AI and National Security | Artificial intelligence (AI) is a rapidly growing field of technology that is capturing the attention of commercial investors, defense intellectuals, policymakers, and international competitors alike. Recently, developments like increased use of AI in cyberattacks and growth of hybrid warfare techniques have showcased how AI can potentially affect National Security. AI presents many opportunities vis-à-vis National Security along the challenges. In this context, it becomes important for India to keep pace with the integration of technological growth and defence. | |
|  Data-Driven Innovations and Privacy | Data is the new oil and data-driven innovations are the new sources of growth. However, the story is incomplete without talking about the privacy of data generators. This document explains various types of data, their usage and the inter-relationships that exist between innovation and privacy. Further, it also provides an insight into how a middle path can be identified that can protect data privacy while promoting the culture of data-driven innovations. | |

| | | |
|---|---|---|
|  Space Exploration: Changing dynamics & pathway to the future | Space exploration has played an important role for countries with regard to their economies and security. With the sector experiencing substantial growth, the need for collaboration in the sector has also increased. India being an emerging power in the sector can play a vital role in creating and enabling space collaboration. | |
|  Cryptocurrency: A tool of Economic Empowerment or a Regulatory Nightmare? | Cryptocurrency is having its best year yet in 2021; becoming more popular, mainstream, and accessible. But, is there a future for cryptocurrency in India? In what form cryptocurrency would be acceptable to Indian lawmakers and regulators remains to be seen. Discussing the basics of cryptocurrency, the document puts light on their role in economic empowerment of the masses and the path ahead to overcome the emerging regulatory challenges due to their increased usage. | |
|  Universal Immunisation Towards A Healthier And A Safer World | The recently launched global immunisation agenda aims for a world where everyone, everywhere, at every age, fully benefits from vaccines for good health and well-being. The document provides an insight into the science of how a vaccine activates immune system of our body and protects us against deadly diseases. Going ahead, it discusses why universal immunisation across the globe is the need of hour and assesses India's progress in this direction. | |
|  India's Vaccination Drives: Strategy, Obstacles and Opportunities | Launching the most awaited COVID vaccine, India started its journey on the road to recovery from a pandemic that has unprecedently disrupted and taken lives. India is now also the fastest country in the world to achieve the 100 million vaccination mark. This document takes us through the story of India becoming the global leader in vaccine manufacturing and analyses the success stories, existing bottlenecks in the system and the potential opportunities. It also delves into the ongoing debate over the efficacy of vaccine diplomacy as pursued by India. | |

# 10 IN TOP 10 SELECTIONS IN CSE 2020

*from various programs of* **Vision Ias**

**1 AIR**

**SHUBHAM KUMAR**
(GS FOUNDATION BATCH CLASSROOM STUDENT)

**2 AIR**

**JAGRATI AWASTHI**
(ALL INDIA TEST SERIES)

**3 AIR**

**ANKITA JAIN**
(ALL INDIA TEST SERIES)

**4 AIR**

**YASH JALUKA**
(ABHYAAS TEST SERIES)

**5 AIR**

**MAMTA YADAV**
(ALL INDIA TEST SERIES)

**6 AIR**

**MEERA K**
(ALL INDIA TEST SERIES)

**7 AIR**

**PRAVEEN KUMAR**
(ALL INDIA TEST SERIES)
ESSAY TEST, ABHYAAS, PDP)

**8 AIR**

**JIVANI KARTIK NAGJIBHAI**
(GS FOUNDATION BATCH CLASSROOM STUDENT)

**9 AIR**

**APALA MISHRA**
(ABHYAAS TEST SERIES)

**10 AIR**

**SATYAM GANDHI**
(ALL INDIA TEST SERIES, EASSY TEST)

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