SIVARAJAVEL IAS ACADEMY
AN IDEAL INSTITUTE FOR **CIVIL SERVICE EXAMS**

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Mentoring and Enabling Through Intelligent Support system

SCIENCE & TECHNOLOGY

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SCIENCE AND TECHNOLOGY

COMMUNICATION AND IT TECHNOLOGY

Digital Signature Certificate:

About:

- Digital Signature Certificates (DSC) are the digital equivalent (that is electronic format) of physical or paper certificates. Few Examples of physical certificates are drivers' licenses, passports or membership cards.
- Certificates serve as proof of identity of an individual for a certain purpose; for example, a driver's license identifies someone who can legally drive in a particular country. Likewise, a digital certificate can be presented electronically to prove one's identity, to access information or services on the Internet or to sign certain documents digitally.
- A licensed Certifying Authority (CA) issues the digital signature. Certifying Authority (CA) means a person who has been granted a license to issue a digital signature certificate under Section 24 of the Indian IT-Act 2000.

Digital Signature:

- A digital signature is a mathematical technique used to validate the authenticity and integrity of a message, software or digital document.
- It's the digital equivalent of a handwritten signature or stamped seal, but it offers far more inherent security.
- A digital signature is intended to solve the problem of tampering and impersonation in digital communications.
- Digital signatures can provide evidence of origin, identity and status of electronic documents, transactions or digital messages.
- Signers can also use them to acknowledge informed consent.

Digital Signature Working:

- Digital signatures, like handwritten signatures, are unique to each signer.
- Digital signature solution providers, such as DocuSign, follow a specific protocol, called PKI.
- PKI requires the provider to use a mathematical algorithm to generate two long numbers, called keys. One key is public, and one key is private.
- When a signer electronically signs a document, the signature is created using the signer's private key, which is always securely kept by the signer.
- The mathematical algorithm acts like a cipher, creating data matching the signed document, called a hash, and encrypting that data.
- The resulting encrypted data is the digital signature. The signature is also marked with the time that the document was signed.
- If the document changes after signing, the digital signature is invalidated.

Uses for Digital Signatures:

1.Industries– use digital signature technology to streamline processes and improve document integrity.

2.Government – Digital signatures are used by governments worldwide for a variety of reasons, including processing tax returns,

verifying business-to-government (B2G) transactions, ratifying laws and managing contracts.

3.Healthcare-Digital signatures are used in the healthcare industry to improve the efficiency of treatment and administrative processes, to strengthen data security, for e-prescribing and hospital admissions.

4.Manufacturing- Manufacturing companies use digital signatures to speed up processes, including product design, quality assurance (QA), manufacturing enhancements, marketing and sales.

5**.Financial services** –The U.S. financial sector uses digital signatures for contracts, paperless banking, loan processing, insurance documentation, mortgages and more.

6. Cryptocurrencies – Digital signatures are also used in bitcoin and other cryptocurrencies to authenticate the blockchain.

They are also used to manage transaction data associated with cryptocurrency and as a way for users to show ownership of currency or their participation in a transaction.

SUPER COMPUTER

Supercomputers are the physical embodiment of high-performance computing (HPC), allowing organizations to solve problems that would be impossible with regular computers and to better assess associated revenue streams

Features:

- Supercomputers have certain distinguishing features.
- Unlike conventional computers, they usually have more than one CPU (central processing unit), which contains circuits for interpreting program instructions and executing arithmetic and logic operations in proper sequence.
- The use of several CPUs to achieve high computational rates is necessitated by the physical limits of circuit technology.
- Electronic signals cannot travel faster than the speed of light, which thus constitutes a fundamental speed limit for signal transmission and circuit switching.
- This limit has almost been reached, owing to miniaturization of circuit components, dramatic reduction in the length of wires connecting circuit boards, and innovation in cooling techniques (e.g., in various supercomputer systems, processor and memory circuits are immersed in a cryogenic fluid to achieve the low temperatures at which they operate fastest).
- Rapid retrieval of stored data and instructions is required to support the extremely high computational speed of CPUs.
- Therefore, most supercomputers have a very large storage capacity, as well as a very fast input/output capability.
- Globally, China has the maximum number of supercomputers and maintains the top position in the world, followed by the US, Japan, France, Germany, Netherlands, Ireland and the United Kingdom.
- India's first supercomputer was **PARAM 8000.**
- **PARAM Shivay,** the first supercomputer assembled indigenously, was installed in IIT (BHU), followed by PARAM Shakti, PARAM Brahma, PARAM Yukti, PARAM Sanganak at IIT-Kharagpur, IISER, Pune, JNCASR, Bengaluru and IIT Kanpur respectively.
- In 2020, PARAM Siddhi, the High-Performance Computing-Artificial Intelligence (HPC-AI) supercomputer, achieved global ranking of 62nd in Top 500 most powerful supercomputer systems in the world.

National Supercomputing Mission:

- In 2015, the National Supercomputing Mission was launched to enhance the research capacities and capabilities in the country by connecting them to form a Supercomputing grid, with National Knowledge Network (NKN) as the backbone.
- The NKN project is aimed at establishing a strong and robust Indian network which will be capable of providing secure and reliable connectivity.
- It supports the government's vision of 'Digital India' and 'Make in India' initiatives.
- The Mission is being jointly steered by the **Department of Science and Technology (DST) and the Ministry of Electronics and Information Technology** (MeitY).
- It is implemented by the **Centre for Development of Advanced Computing**

(C-DAC), Pune, and the IISc, Bengaluru.

- The mission was planned in three phases:
- Phase I looking at assembling supercomputers,
- Phase II looking at manufacturing certain components within the country.
- Phase III where a supercomputer is designed by India.

Objectives:

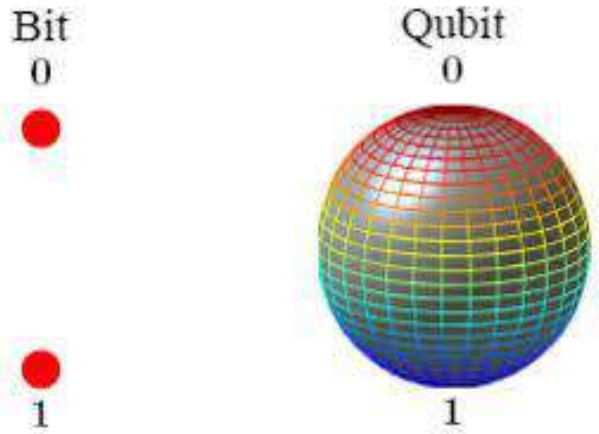
- To make India one of the world leaders in Supercomputing and to enhance India's capability in solving grand challenge problems of national and global relevance
- To empower our scientists and researchers with state-of-the-art supercomputing facilities and enable them to carry out cutting-edge research in their respective domains
- To minimize redundancies and duplication of efforts, and optimize investments in supercomputing
- To attain global competitiveness and ensure self-reliance in the strategic area of supercomputing technology.

QUANTUM COMPUTING

- Quantum computing is a rapidly-emerging technology that harnesses the laws of quantum mechanics to solve problems too complex for classical computers.
- Quantum mechanics is a subfield of physics that describes the behaviour of particles — atoms, electrons, photons, and almost everything in the molecular and sub molecular realm.
- It is an exciting new technology that will shape our world tomorrow by providing us with an edge and a myriad of possibilities.
- It is a fundamentally different way of processing information compared to today's classical computing systems.

Difference Between Conventional and Quantum Computing:

- Conventional computers process information in 'bits' or 1s and 0s, following classical physics under which our computers can process a '1' or a '0' at a time.
- Quantum computers compute in 'qubits' (or quantum bits). They exploit the properties of quantum mechanics, the science that governs how matter behaves on the atomic scale.



Key Initiatives taken by the Indian Government:

- **National Mission on quantum technologies and applications:** The Government in its 2021 budget allocated INR 8000 Crore towards the National Mission on quantum technologies and applications to spur developments in quantum computing, cryptography, communications, and material science.
- **Quantum Computing Laboratory:** In December 2021, the Indian Army set up a quantum computing laboratory and an AI centre at a military engineering institute at Mhow, Madhya Pradesh. It is also backed by the National Security Council Secretariat (NSCS).
- **Quantum Communication Lab:** The Centre for Development of Telematics (C-DOT) launched a quantum communication lab in October 2021. It can support more than 100 km of standard optical fibre.
- **Collaborations:** The Defence Institute of Advanced Technology (DIAT) and the Centre for Development of Advanced Computing (C-DAC) agreed to collaborate and develop quantum computers.
- **I-HUB Quantum Technology Foundation:** The Department of Science and Technology and about 13 research groups from IISER Pune launched I-HUB Quantum Technology Foundation (I-HUB QTF) to further enhance the development of quantum tech.
- **Startups:** A number of Start-Ups such as Qunu Labs, Bangalore; BosonQ, Bhilai have also emerged and as a result, they are making inroads in this area.

Applications:

Secure Communication: China recently demonstrated secure quantum communication links between terrestrial

stations and satellites. This area is significant to satellites, military and cyber security among others as it promises unimaginably fast computing and safe, unhackable satellite communication to its users.

Research: It can help in solving some of the fundamental questions in physics related to gravity, black hole etc. Similarly, the quantum initiative could give a big boost to the Genome India project, a collaborative effort of 20 institutions to enable new efficiencies in life sciences, agriculture and medicine.

Disaster Management: Tsunamis, drought, earthquakes and floods may become more predictable with quantum applications. The collection of data regarding climate change can be streamlined in a better way through quantum technology.

Pharmaceutical: Quantum computing could reduce the time frame of the discovery of new molecules and related processes to a few days from the present 10-year slog that scientists put in.

Augmenting Industrial revolution 4.0: Quantum computing is an integral part of Industrial revolution 4.0. Success in it will help in Strategic initiatives aimed at leveraging other Industrial revolution 4.0 technologies like the Internet-of-Things, machine learning, robotics, and artificial intelligence across sectors will further help in laying the foundation of the Knowledge economy.

Significance:

- Quantum computers can tap into the quantum mechanical phenomenon to manipulate information and are expected to shed light on processes of molecular and chemical interactions, address difficult optimization problems, and boost the power of artificial intelligence.
- These could open the door to new scientific discoveries, life-saving drugs, and improvements in supply chains, logistics and the modelling of financial data.

Quantum Supremacy:

- It means only that researchers have been able to use a quantum computer to perform a single calculation that no conventional computer, even the biggest supercomputer, can perform in a reasonable amount of time.

Disadvantages:

- The main disadvantage of computing is the **technology required to implement a quantum computer is not available at present**.
- The reason for this is the consistent electron is damaged as soon as it is affected by its environment and that electron is very much essential for the functioning of quantum computers.
- This is due to the fact that the coherent state, fundamental to a quantum computer's operation, is destroyed as soon as it is measurably affected by its environment. Attempts at combating this problem have had little success,
- The research for this problem is still continuing and the effort applied to identify a solution for this problem has no positive progress.

BLOCKCHAIN TECHNOLOGY

About Blockchain:

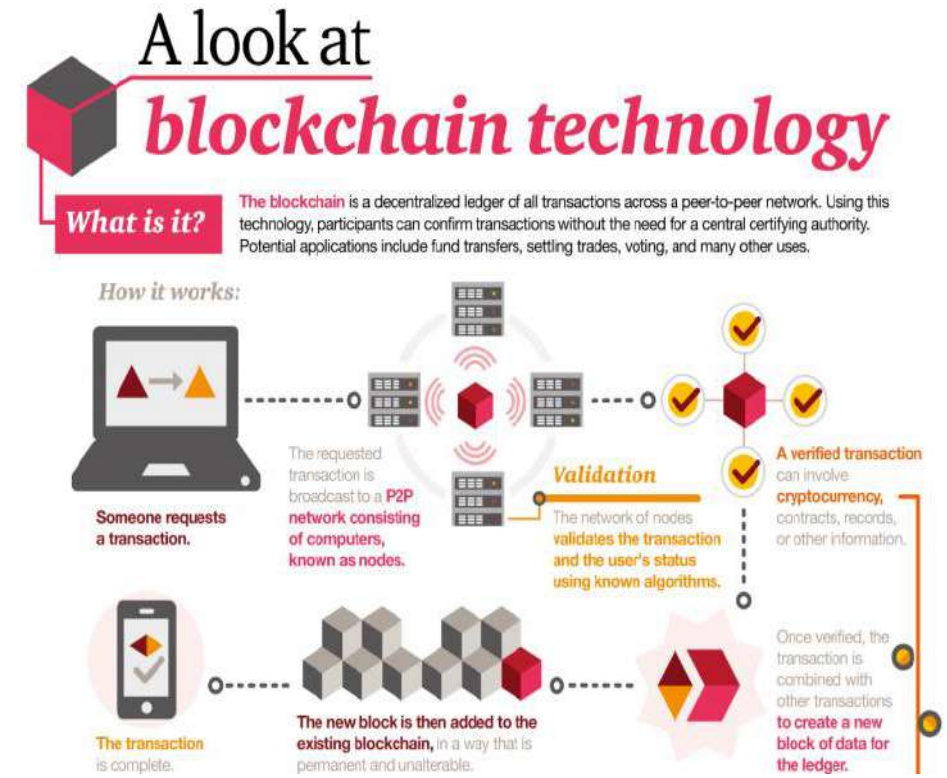
- They are a new data structure that is secure, cryptography-based, and distributed across a network. The technology supports cryptocurrencies such as Bitcoin, and the transfer of any data or digital asset.
- Spearheaded by Bitcoin, blockchains achieve consensus among distributed nodes, allowing the transfer of digital goods without the need for centralized authorization of transactions.

Operation:

1. The technology allows transactions to be simultaneously anonymous and secure, peer-to-peer, instant and frictionless.
2. It does this by distributing trust from powerful intermediaries to a large global network, which through mass collaboration, clever code and cryptography, enables a tamper-proof public ledger of every transaction that's ever happened on the network.
3. A block is the "current" part of a blockchain which records some or all of the recent transactions, and once completed, goes into the blockchain as permanent database.
4. Each time a block gets completed, a new block is generated. Blocks are linked to each other (like a chain) in proper linear, chronological order with every block containing a hash of the previous block.

Prospects:

- Bitcoin is just one of the applications for the technology, whose use is being tested across industries.
- Healthcare, banking, education, agriculture, electricity distribution and land records are sectors that could benefit.
- Blockchain-powered smart contracts, where every piece of information is recorded can enhance ease of doing business.
- It will augment the credibility, accuracy and efficiency of a contract while reducing the risk of frauds, substantially.
- Blockchain could play a crucial part in health insurance claims management by reducing the risk of insurance claim frauds.
- The technology can also be used to prevent the sale of spurious drugs in the country by tracking every step of the supply chain network.



- Artificial Intelligence and Internet of Things (IoT) can gain immensely from blockchain applications.
- In an IoT world, thousands of devices would need to rapidly and seamlessly transact with each other in real time.
- The adoption of blockchain by India's banks could help avert frauds such as the one at Punjab National Bank as the technology updates information across all users simultaneously.
- It could be used to further strengthen our national institutions, including the judiciary and the Election Commission.
- Critical citizen information like land records, census data, birth and death records, business licenses, criminal records, intellectual property registry, electoral rolls could all be maintained as blockchain-powered, tamper-proof public ledgers.

Challenges:

- Blockchain technology is expensive to initially put it in place.
- The massive usage of energy for the functioning of blockchain.
- Safeguarding the privacy of individuals and companies as blockchains are usually open ledgers for everyone to see.
- Knowledge of the benefits of distributed ledger technology is still limited.
- If automated risk management, smart contracts, and similar tools are deployed across a network, cascades of rapid and hard-to-control obligations and liquidity flows could propagate across a network.
- This interdependence will likely call for creative organizational thinking to address the need for governance and strong risk management.

Advantages of block chain technology:

- **Immutability:** In Blockchain, there is no possibility of changing the data or altering the data; the data present inside the Blockchain is permanent; one cannot delete or undo it.
- **Transparency:** By utilizing blockchain technology, organizations and enterprises can go for a complete decentralized network where there is no need for any centralized authority, thus improving the transparency of the entire system.
- **High Availability:** Unlike centralized systems, Blockchain is a decentralized system of P2P network which is highly available due to its decentralized nature. Since in the Blockchain network, everyone is on a P2P network, and everyone has a computer running, therefore, even if one peer goes down, the other peers still work.
- **High Security:** This is another major benefit that Blockchain offers. Technology is assumed to offer high security as all the transactions of Blockchain are cryptographically secure and provide integrity. Instead of relying on third-party, you need to put your trust in cryptographic algorithms.

Blockchain in Social sectors:

- **Personal Identification:** Governments manage vast amounts of personal data from birth and death records to marriage certificates, passports and census data. Blockchain technology offers a streamlined solution for managing all of it securely.
- **Fight corruption:** Registering government transactions in the blockchain helps create a trusted history for any transaction and significantly eases the auditing process. This would contribute to making public procurement more transparent
- **Cut red tapism:** As government agencies currently store data in autonomous centralized databases, they

tend not to interoperate in an optimal way.

- This results in duplication, overlap and contradiction in the information held. Blockchain eliminates this lack of interoperability which generates unnecessary red tape in obtaining relevant information from a user, and makes the process for sharing data between agencies clear and inexpensive.
- **Identity and Land rights:** The World Identity Network and Humanized Internet project can store identifiers such as birth certificates and university degrees on a blockchain, in the form of distributed digital lockboxes.
- Users can keep their information private and secure, but also give permission for anyone to access it anywhere in the world.
- Several governments, including those in Dubai, Estonia, Georgia, and Sweden are making early forays into blockchain-based approaches to securing property rights.
- **Agriculture:** First of all, it can reduce contamination and food fraud. This can happen with the help of blockchain efficiency and transparency.
- Blockchain's role is to improve the third-party involvement by ensuring that they are tracking, collecting and managing data in the best possible way.
- With blockchain, farmers and distributors are going to get their payments faster than ever-improving their ability to work on their next set of projects faster.
- **Health:** The health sector is one of those sectors that have tons of initiatives by both for-profit and nonprofit organizations.
- With blockchain, healthcare can improve digital healthcare records. It also improves pharmaceutical supply chain management. As usual, blockchain offers a decentralized, efficient and secure solution.
- **Governance and democracy:** Government and civil society can also leverage blockchain technology to strengthen democratic processes and participation. Blockchain systems such as Ballot Chain can manage online elections with secure and anonymous voting that participants can verify at any time.
- **Environmental protection:** In the environmental arena, new blockchain-supported supply chain management systems, which are transparent but cannot be tampered with, can track products from the farm to the table, and show whether or not a food product is organic or Fair Trade.
- **Philanthropy and Aid:** Billions of dollars are invested in helping the needy. However, these aids are mostly misused due to a lack of transparency. In fact, most of the aid never reaches the intended people.
- This has also led people to not contribute to these non-profit organizations. Blockchain can solve all of these problems and help elevate the confidence in non-profit in utilizing the funds.
- **Crowdfunding:** As with traditional crowdfunding, a blockchain powered crowdfunding campaign seeks to secure investment for a new project from an interested community.
- But in this instance, funding is most likely to come in the form of bitcoin or other cryptocurrencies.

Li-Fi

- Li-Fi, or light fidelity, invented by German physicist and professor Harald Haas, is a wireless technology that makes use of visible light in place of radio waves to transmit data at terabits per second speeds—more than 100 times the speed of Wi-Fi.
- Though it was discovered in the last decade, proofs of concept to test commercial utilization started emerging only in 2015.

Working:

Li-Fi is a Visible Light Communications (VLC) system. This means that it accommodates a photo-detector to receive light signals and a signal processing element to convert the data into 'stream-able' content. Unlike Wi-Fi, which uses radio waves, Li-Fi runs on visible light.

- Here, data is fed into an LED light bulb (with signal processing technology), it then sends data (embedded in its beam) at rapid speeds to the photo-detector (photodiode).
- The tiny changes in the rapid dimming of LED bulbs is then converted by the 'receiver' into electrical signal.
- The signal is then converted back into a binary data stream that the user would recognise as web, video and audio applications that run on internet enables devices.

An LED light bulb is a semiconductor light source meaning that the constant current of electricity supplied to an LED light bulb can be dipped and dimmed, up and down at extremely high speeds, without being visible to the human eye.

Advantages:

- Li-Fi could make a huge impact on the internet of things too, with data transferred at much higher levels with even more devices able to connect to one another.
- Li-Fi offers great promise to overcome the existing limitations of Wi-Fi by providing for data-heavy communication in short ranges.
- Due to its shorter range, Li-Fi is more secure than Wi-Fi.
- Since it does not pollute, it can be called a green technology for device-to-device communication in the Internet of Things (IoT).
- Li-Fi systems consume less power.

Limitations of Li-Fi:

- As visual light can't pass through opaque objects and needs line of sight for communication, its range will remain very restricted to start with. In order to enjoy full connectivity, more capable LED bulbs will need to be placed at various places.
- Li-Fi requires the lightbulb is on at all times to provide connectivity, meaning that the lights will need to be on during the day.
- Li-Fi is likely to face interference from external light sources, such as sunlight and bulbs, and obstructions in the path of transmission, and hence may cause interruptions in communication.
- Also, initially, there will be high installation costs of visual light communication systems as an add-on to lighting systems.

Challenges:

The main challenge is to create a Li-Fi ecosystem, which will need the conversion of existing smartphones into Li-Fi enabled ones by the use of a converter/adapter.

Also, an integrated chip that has both light-to-electrical conversion and data-processing capability (Wi-Fi/Bluetooth)

combined into one needs to be developed and manufactured in the millions.

Potential applications:

- Li-Fi can be used in street and traffic lights. Traffic lights can communicate to the vehicles and with each other. Through the use of Li-Fi, traffic control can be made intelligent and real-time adaptable. And each traffic and street light post can be converted into access points to convert roadsides into wireless hot spots.
- Vehicles having LED-based headlights and tail lamps can communicate with each other and prevent accidents by exchanging information.
- Visible light being safer, they can also be used in places where radio waves can't be used such as petrochemical and nuclear plants and hospitals.
- They can also be used in aircraft, where most of the control communication is performed through radio waves.
- Li-Fi can also easily work underwater, where Wi-Fi fails completely, thereby throwing open endless opportunities for military and navigational operations.
- Also, it presents another unique possibility: transmitting power wirelessly, wherein the smartphone will not only receive data through Li-Fi, but will also receive power to charge itself.

GENERATIONS OF WIRELESS COMMUNICATION

Mobile Generations is a system used by cellular telephone manufacturers and service providers to classify wireless communication into several generations; each generation is characterized by new frequency bands, higher data rates and non–backwards-compatible transmission technology.

In the recent past, mobile wireless technologies have undergone technology evolution from 0G TO 5G.

0G:

- It is also known as **Mobile Radio Telephone** or **Pre-Cellular.**
- It was usually **mounted in cars & trucks** although briefcase models were also available.
- **Motorola** in conjugation with Mobile Telephone System (**MTS**) introduced it in the US in 1946.

1G:

- 1G technology was Analog Telecommunication standard.
- It was introduced in the 1980s.
- Main Use: Voice Calls.
- Limitations: Limited capacity, not secure and background interference.
- **Speed**: 2 Kbps

2G:

- It was commercially launched as GSM standard in Finland in 1991.
- It uses **Digital** Technology (Main difference between 1G & 2G is 1G was analog and 2G was digital).
- 2G has two technologies i.e. TDMA (GSM) & CDMA.
- **Main Uses**: Voice calls, short messages and browsing.
- **Limitations**: Low network range and slow data rates due to which it can't handle complex data such as videos.
- **Speed**: 64 Kbps

2.5G:

- **2G cellular technology with GPRS (General Packet Data Service)** is called 2.5G.
- It provides the usage of e-mails, MMS, web browsing and camera facilities.
- **Speed**: 144 Kbps

EDGE or 2.75G:

- **EDGE = Enhanced Data Rule for GSM Evolution**
- It has the same network design, but the **data speed was increased noticeably** (3 times that of GPRS) .
- It had the added advantage that there was no need to install additional hardware by the telecom companies.

3G:

- **3G was introduced in 2000.**
- **Improvements over 2G**: Clarity in Voice calls, **digital broadband and increment in speed.**
- **Main Uses**: Text and high speed internet.
- **Limitations**: High power consumption, Low network coverage and High cost of spectrum licence.
- **Speed**: 2 Mbps
- Introduction of 3G technology gave rise to applications not previously available like
    1. Mobile TV
    2. Telemedicine
    3. Video on Demand
    4. Videoconferencing
    5. Location based services

4G:

- **Benefits over 3G**: Very high speeds at lower price than 3G.
- **Main Uses**: High speed applications, IP Telephony, Video Calling, gaming services, HD Tv, 3D TV and Wearable devices.

- **Limitations**: LTE supported mobiles and complicated hardware required to use 4G mobile technologies.
- **Speed**: 1 Gbps

LTE (Long Term Evolution):

- 4th Generation Network is called LTE (Long Term Evolution).
- LTE was **designed only as data network.**
- LTE has **brought very high bandwidth to mobile devices** and data transfer has become very fast.

VoLTE (Voice Over LTE):

- VoLTE is a **voice technology that works over the LTE** data connection.
- It has **extremely high voice quality.** It also includes the ability to **make video calls.**

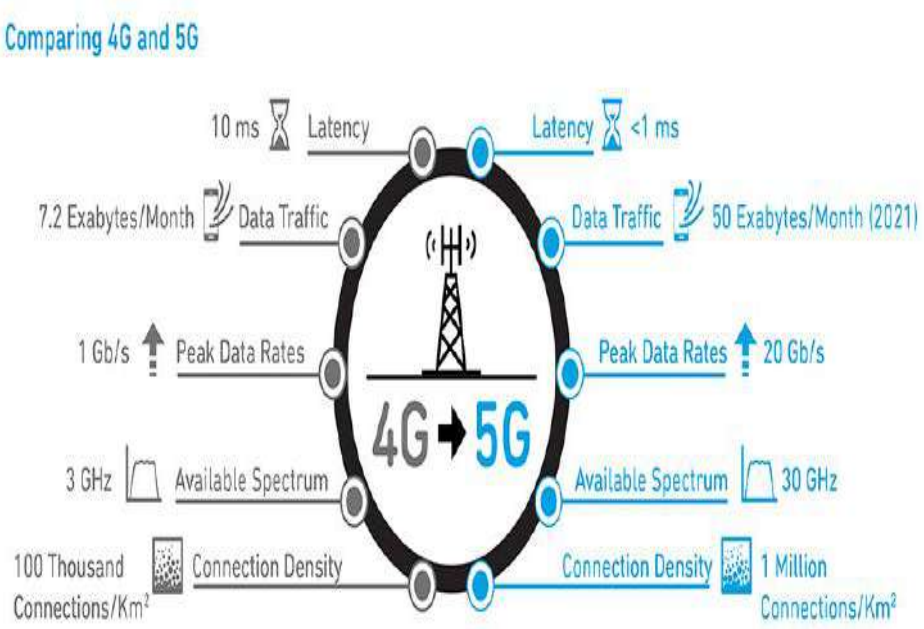
5G:

- 5G technology has **ultra High Speeds** and presents a big leap forward from the present 4G technology.
- Main Use:
  1. Internet of Things (5G System will be intelligent enough to allocate resources. Eg: Driverless car which needs to take a decision in a fraction of seconds will be given greater bandwidth than ordinary user).
  2. Hologram TV
  3. Augmented reality
- Limitations: It is not Net Neutral and involves high costs.

- It will use drones and balloons to provide internet everywhere.
- **Speed**: more than **20 Gbps.**

Advantages of 5G Technology:

- **Faster** data speed of more than 20 Gbps.
- Ultra-low latency: Latency refers to the time it takes for one device to send a packet of data to another device. In 4G the latency rate is around 50 milliseconds but 5G will reduce that to about 1 millisecond. Hence, it can be used in driverless cars where such things are required.



- 5G has 30 GHz of available spectrum in comparison to lesser 3 GHz for 4G.
- 5G antennae consume very little power compared to existing technology. Hence, it will make 5G handsets energy efficient.
- With higher speed, 5G will improve the quality of remote learning by allowing real-time interactivity and transporting students to virtual classrooms.
- As per the OECD Committee on Digital Economic Policy, 5G technologies rollout will help in increasing GDP, creating employment and digitizing the economy.
- It will help to incorporate technologies such as the Internet of Things (IoT) & Artificial Intelligence in our lives. It is said that 5G is the foundation for realising the full potential of IoT.
- Agriculture: 5G can enable improvement in the entire value chain, from **precision farming, smart irrigation**, improved soil and crop monitoring, to livestock management.

BHARATNET

BharatNet is a project of national importance to establish, by 2017, a highly scalable network infrastructure accessible on a non-discriminatory basis, to provide on demand, affordable broadband connectivity of 2 Mbps to 20 Mbps for all households and on demand capacity to all institutions, to realise the vision of Digital India, in partnership with States and the private sector.

The objective is to facilitate the delivery of e-governance, e-health, e-education, e-banking, Internet and other services to the rural India.

BharatNet Project:

- National Optical Fibre Network (NoFN) which is now renamed as BharatNet project was launched in 2012.
- The project aims to provide affordable broadband services to citizens and institutions in rural and remote areas, in partnership with States and the private sector.
- It involves connecting all the 2,50,000 Gram Panchayats in the country to the block headquarters for provision of both bandwidth and dark fibre on a universal and non-discriminatory basis.
- The network is capable of providing scalable bandwidth of up to 1 GBPS.
- The entire project is being funded by **Universal Service Obligation Fund (USOF),** which was set up for improving telecom services in rural and remote areas of the country.
- Bharat Broadband Nigam Ltd(BBNL) was created as the special purpose vehicle created to execute the project.
- BharatNet will now extend up to all inhabited villages beyond the gram panchayats (GPs) in the said states.
- Over 3.6 lakh villages over 16 states of the country will be covered under the expanded BharatNet programme.
- The revised strategy includes creation, upgradation, operation, maintenance and utilisation of BharatNet by the concessionaire who will be selected by a competitive international bidding process.
- The states to be covered under the revised plan are Kerala, Karnataka, Rajasthan, Himachal Pradesh, Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, West Bengal, Assam, Meghalaya, Manipur, Mizoram, Tripura, Nagaland and Arunachal Pradesh.

Challenges:

BharatNet is a mega project, widely dispersed to the remotest corners of the country. Among the various challenges faced in its execution are:

- The scheme has failed to deliver on its objective of triggering a broadband revolution across the country.
- The project has been marred with delays and multiple extensions.
- The quality of connectivity and the range of services provided at the last mile remains the key.
- Till date, 1.56 lakh out of the 2.5 lakh village panchayats have been connected with broadband. BharatNet has achieved little in terms of actual connectivity and utilisation.
- Maintaining coordination among multiple stakeholders including CPSUs, state governments, state implementation agencies, project implementation agencies and suppliers;
- Working in remote and difficult terrain, especially hilly areas, rocky terrain and left-wing extremism-affected regions;
- Limited availability of experienced executing agencies/resources to take up

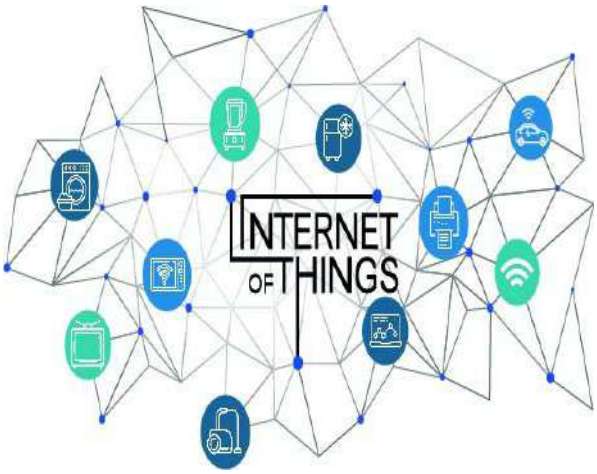
simultaneous work throughout the country;
- Delays in right-of-way permissions, especially for defence, forest areas and highways;
- Unavailability of suitable government buildings or custodians for equipment installation in GPs;
- Change of government/bureaucracy in states, affecting continuity;
- BSNL's stressed financials, affecting progress;
- Delay in the finalisation of tenders by the state and implementing agencies;
- Frequent lockdowns amidst the Covid-19 crisis.

Benefits:
- It would reduce the **cost of broadband services in India.**
- It would have **advantages like easy maintenance, faster implementation,** and utilisation of the present power line infrastructure.
- It would provide **internet connectivity** to **citizens especially in rural areas via Wi-Fi Hotspots.**
- It would provide a **boost to the economy** and would generate around 10 crore man-days of employment during the rollout of the project.
- It will help in th**e expedition of government's initiatives** such as Make In India, Start-up India, Stand-up India etc
- It is considered to be the backbone of **'Digital India'** aiming to reduce the digital divide between urban and rural India.

INTERNET OF THINGS (IoT)

About IoT:

- The internet of things, or IoT, is a **system of interrelated computing devices, mechanical and digital machines, objects, animals or people**.
- **All these are provided with unique identifiers (UIDs)** and the ability to transfer data over a network without



requiring human-to-human or human-to-computer interaction.

- A thing in the internet of things can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an Internet Protocol (IP) address and is able to transfer data over a network.

Evolution and Development of Internet of Things:

- In India, the first Internet of things India Congress 2016 was organized in Bengaluru.
- The second Internet of things India expo 2018 will be organized between 07-09 March 2018 in New Delhi.
- The Centre of Excellence for IoT will be developed in Vishakhapatnam to promote excellence in the field of IoT.

Importance of IoT:

- The internet of things helps people live and work smarter, as well as gain complete control over their lives.
- In addition to offering smart devices to automate homes, IoT is essential to business.
- IoT provides businesses with real-time insights into everything from the performance of machines to supply chain and logistics operations.
- IoT enables companies to automate processes and reduce labor costs.
- It also cuts down on waste and improves service delivery, making it less expensive to manufacture and deliver goods, as well as offering transparency into customer transactions.

Internet of Things Applications:

- **Daily life**: IoT can be used to do small tasks in daily life such as coffee-making as soon as the owner of the house

Advantages	Disadvantages
Minimizes the human work and effort	Increased privacy concerns
Saves time and effort	Increased unemployment rates
Good for personal safety and security	Highly dependent on the internet
Useful in traffic and other tracking or monitoring systems	Lack of mental and physical activity by humans leading to health issues.
Beneficial for the healthcare industry	Complex system for maintenance
Improved security in homes and offices	Lack of security
Reduced use of many electronic devices as one device does the job of a lot of other devices	Absence of international standards for better communication

returns home, refrigerator indicating that vegetables need to be bought and/or ordering them automatically from the e-store, etc. It can also be used in offices.

- **Industry**: IoT can be used to reduce human error, increase efficiency, and improve productivity, etc.
- **Agriculture**: IoT can be used to improve overall productivity by having enhanced weather forecasting, soil nutrient content, pest infestation, etc.
- **Healthcare**: there are several benefits to the medical industry. Better diagnosis of diseases, wearable monitors of vitals, sophisticated connected equipment, etc.
- **Transportation**: IoT can be used on toll booths, traffic management, driverless cars, etc. It can also be used in fleet management, safety assistance, improved logistics, etc.
- **Media/Advertising**: Companies can use IoT to analyze and predict consumer behavior and apply target marketing for better ROI in advertising/marketing campaigns, etc. Big data and data mining concepts can be used in this regard.
- **Smart Cities**: IoT can be used to make cities better places to live. It can be applied in solid waste management, smart power grids, smart energy management systems, etc.
- **Government policies and services**: the government can use IoT to offer better citizen services.

LIBRA

About Libra:

- Libra is a virtual currency, which users buy and store in a digital wallet.
- It can be used for transactions on a decentralized network that is not controlled by one bank or a government.
- It is powered by a technology called 'Blockchain', which functions like an open ledger that gets updated in real time.
- For Libra, Facebook announced a dedicated wallet app called "Calibra."
- "Calibra" will be built into WhatsApp and Messenger as well, to let users store and use "Libra" coins.

Working:

- Once launched, users will be able to buy Libra and add it to their digital wallet.
- Libra will be built into Facebook Messenger and WhatsApp, allowing users to send and receive money via messages.
- People will be able to send money at "low to no cost"
- Libra will also be used for offline payments, such as paying bills, buying coffee, or paying for public transport.

Is Libra different from other Cryptocurrencies?

- The values of most cryptocurrencies, such as Bitcoin, tend to fluctuate against real currencies.
- The plan is to ensure Libra is stable and give users confidence.
- Libra will be backed by a reserve of assets designed to "give it intrinsic value" and ensure stability.
- These assets include securities and fiat currencies (like the dollar, pound).
- The Libra reserve will include bank deposits and government bonds in several international currencies.
- However, the value of the one Libra in any local currency may fluctuate.
- Libra is planned as a "global currency" for use anywhere in the world without transaction fees.
- It will target those who are left out in the formal banking sector.

Who is involved?

- Facebook is also launching its Subsidiary Company, called **"Calibra"** which will handle its crypto dealings.
- **"Calibra"** is a digital wallet, which will store Libras.
- Libra will be controlled by the '**Libra Association'**, a non-profit based in Geneva.
- The currency has been backed by Visa and Mastercard, as well as tech firms like Uber, Lyft, Spotify, Ebay, Paypal and PayU from India.

Is 'Libra' a privacy concern?

- Libra will be built on its own blockchain, a decentralised database that records the history of transactions over time.
- Facebook has said that account details will not be shared with Facebook or third parties for advertising purposes, except for cases of data sharing "to keep people safe, comply with the law.
- Also, Facebook stated that, If someone loses their Libra coins from Calibra wallet, they will get a refund.
- For Libra, a new programming language called '**Move'** is being built, which the organization claims is more secure and private.

What about Indian Crypto law?

- Current regulations do not permit use of the banking network for blockchain currency transactions.
- The Ministry of Corporate Affairs Investor Education and Protection Fund (IEPF) Authority favours a ban on cryptocurrencies,
- Any such ban would hugely restrict the reach of Libra.

CLOUD COMPUTING

About:

Cloud computing means delivering hosted services over the internet.

It is the pool of shared resources such as networks, servers, storage, applications, and services that can be provided to the consumer rather than the consumer managing them on her own which is costly and time-consuming.

The Internet is at the core of evolution of this technology.

Salient features of Cloud Computing:

Attributes:

On-demand – It is sold on demand generally by the minute or the hour.

Elastic – a user can have as much or as little of a service as they want at any given time.

Fully managed by the provider – The consumer requires nothing but a personal computer and internet connection.

Data-intensive – The focus is on data rather than computation.

Scalability – Cloud computing has the ability to continue to function well when it is changed in size or volume in order to meet a user need.

Types of cloud:

- **Public clouds** are owned and operated by a third-party cloud service provider, which deliver their computing resources like servers and storage over the Internet. Ex- Microsoft Azure.
- **Private cloud** refers to cloud computing resources used exclusively by a single business or organisation. A private cloud can be physically located on the company's on-site data centre.
- **Hybrid cloud**s combine public and private clouds, bound together by technology that allows data and applications to be shared between them giving business greater flexibility, more deployment options and helps optimise your existing infrastructure, security and compliance.

Types of cloud services:

- **Infrastructure as a service (IaaS)**: Renting of IT infrastructure like servers and virtual machines (VMs), storage, networks, operating systems from a cloud provider on a pay-as-you-go basis
- **Platform as a service (PaaS):** Platform as a service refers to cloud computing services that supply an on-demand environment for developing, testing, delivering and managing software applications.
- **Software as a service (SaaS):** Software as a service is a method for delivering software applications over the Internet, on demand and typically on a subscription basis. Cloud providers host and manage the software application and underlying infrastructure and handle any maintenance
- **Serverless computing**: building app functionality without spending time continually managing the servers and infrastructure required to do so. The cloud provider handles the setup, capacity planning and server management.

Advantages of cloud computing:

Less capital expenditure:

- Cloud computing services minimize IT requirements and physical storage, which helps small businesses, cut significant business costs.
- Most cloud services are paid on a subscription basis, so capital expenditure is reduced.
- Cloud computing is also much faster and easier to deploy, so there are fewer start-up costs.

Improved disaster recovery:

- Moving the business data to the cloud can make disaster recovery possible i.e., retrieving data in case of a hardware compromise.

Increased Collaboration and flexibility:

- For many businesses, moving to the cloud enhances opportunities for collaboration between employees.
- Colleagues can sync and work on documents with ease, often simultaneously, receiving updates in real time.
- It allows team members to work from anywhere.

Environmentally friendly:

- Cloud computing reduces a company's carbon footprint by minimizing energy consumption and carbon emissions by more than 30%.

Disadvantages of Cloud Computing:

Internet connectivity:

- For cloud-based services, consistent internet connection is important because if any one of the cloud-based service providers loses connectivity, then the company will be out of business until that internet connection returns.

Maintenance costs:

- While the upfront or capital cost for the cloud-based server is very low compared to traditional hosting, the cloud server requires the same amount to be paid each month to maintain both servers as well as data.

Security

- Companies with highly sensitive data may need their own IT department to keep data secure because when the data is stored in the cloud, the company is trusting a third party to keep it safe.

Initiatives Taken by The Government:

E-governance:

- The government has been exploring a cloud-based model to revolutionize its e-governance initiative.
- All e-governance platforms including State Wide Area Networks (SWANs, Data Centres etc) across the country could be transferred into cloud services in the near future.
- RTI: Government adopted cloud services in the domain of Right to Information (RTI) for efficient performances.
- **Meghraj/GI Cloud:** is the Government of India's cloud computing platform used by government departments and agencies at the centre and states. It is an initiative of the Ministry of Electronics and Information Technology (MeitY).
- **eGov App Store:** The eGov App store is a common platform to host and run applications (developed by govt agencies or private players) at Meghraj which are easily customizable and configurable for reuse by different government agencies or departments at the centre and state levels without investing time or effort in the development of such applications.

Infrastructure sector:

- Smart cities mission facilitates local development by utilising technology such as cloud computing.
- Moreover, the government has also recognized the importance of cloud-based service delivery for Digital India since it integrates smart devices and infrastructure and processes a large amount of data from different sources in real time.

Banking sector:

- Reserve Bank of India (RBI) has been working towards achieving 100% financial inclusion with the help of technology.

- The RBI has been utilising cloud-based solutions, especially for cooperative banks to extend the banking services across India via core banking solutions.
- Use of cloud computing in the Banking sector will result in reduced timelines, moving the cost from capital expenditure to operational expenditure = banks could concentrate on core banking business.
- Indian Banking Community Cloud (IBCC) is the first community cloud initiative for banking sector in India.

Manufacturing sector:

- With Make in India initiative in full motion, adoption of cloud computing became even more relevant for the Indian manufacturing sector.
- Some common applications of Cloud Computing in the manufacturing sector are CRM (Customer Relationships Management), supply chain applications, data warehousing, information security, green IT, Human Machine Interface (HMI), and so on.

Telecom sector:

- Deploying operations and business support systems over cloud platforms is a highly effective method for resolving different business and technical challenges faced by the telecom sector.

Railways:

- **RailCloud** – The Indian railways has launched RailCloud, a cloud-based service that will enable faster connectivity at a minimal cost.
- **Nivaran-Grievance portal** – It is the first IT application on the Rail Cloud. It is a platform for resolution of service related grievances of both serving and former railway employees.

Health sector:

- E-health vision of the government aims at incorporating the Health Information Exchange (HIE) mechanism through a cloud platform. An electronic HIE enables stakeholders to correctly assess and securely share a patient's medical information electronically.

NANO TECHNOLOGY

- Nanotechnology or nanotech is the technology that involves the manipulation of matter on atomic, molecular, and supramolecular scales.
- This includes particles of a scale of 1 to 100 nano-meters.
- It involves a multidisciplinary approach involving fields such as applied physics, materials science, chemistry, biology, surface science, robotics, engineering, electrical engineering and biomedical engineering.

Generations of nanotechnology:

Types of Nanotechnology:

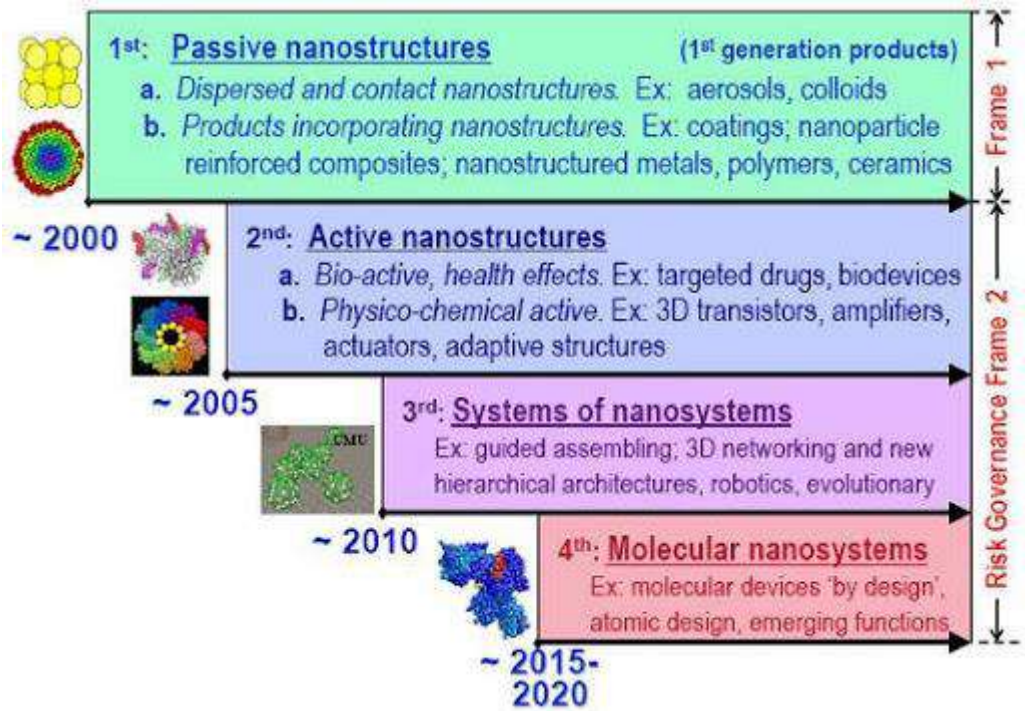
- **Descending (top-down):**Mechanisms and structures are miniaturised at the nanometric scale — from one to 100 nanometres in size —. It is the most frequent to date, especially in electronics.
- **Ascending (bottom-up):**You start with a nanometric structure — a molecule, for example — and through a mounting or self-assembly process you create a larger mechanism than the one you started with.
- **Dry nanotechnolgy :**It is used to manufacture structures in coal, silicon, inorganic materials, metals and semiconductors that do not work with humidity.
- **Wet nanotechnology:**It is based on biological systems present in an aqueous environment — including genetic material, membranes, enzymes and other cellular components.

Applications of Nanotechnology:

- Nanotechnology is a new and emerging field that has an impact on almost all sectors of the economy. The research on nanotechnology has spread across many fields like health, food, computing, textile, energy, transport, space, agriculture, etc.

Health sector:

- The application of nanotechnology in the health sector is wide-ranging.
- Nanomaterials can be used inside and outside the body.
- Thus, the integration of nanomaterials with biology has led to the development of **diagnostic devices, analytical tools, drug delivery vehicles, and physical therapy applications.**
- This technology has led to the possibility of delivering drugs to precise cells, ensuring greater efficiency and lesser side effects.
- Nanomaterials have also given the scope for repairing damaged tissues since the cells can be artificially



produced using this technology.

- This technology has currently become an important diagnostic tool since it can sense and label specific molecules, structures, or microorganisms.
- Below are some examples of recent advances in this area:
    - **Cancer detection and treatment: Gold nanoparticles** as probes for the detection of targeted sequences of nucleic acids, and they are also being clinically investigated as potential treatments for cancer and other diseases.
    - **Drug Delivery:** Nanotechnology researchers are working on a number of different therapeutics where a nanoparticle can encapsulate or otherwise help to **deliver medication directly to cancer cells** and minimize the risk of damage to healthy tissue. This has the potential to change the way doctors treat cancer and dramatically reduce the toxic effects of chemotherapy.
    - **Imaging and diagnostic tools**: Tools enabled by nanotechnology are paving the way for earlier diagnosis, more individualized treatment options, and better therapeutic success rates.
    - **Diagnosis and treatment:** Nanotechnology is being studied for both the diagnosis and treatment of **atherosclerosis, or the buildup of plaque in arteries**. In one technique, researchers created a nanoparticle that mimics the body's "good" cholesterol, known as HDL (high-density lipoprotein), which helps to shrink plaque.
    - **Genetics:** The design and engineering of advanced solid-state nanopore materials could allow for the development of novel **gene sequencing technologies** that enable single-molecule detection at low cost and high speed with minimal sample preparation and instrumentation.
    - **Regenerative medicine:** Research in the use of nanotechnology for regenerative medicine spans several application areas, including **bone and neural tissue engineering.** Novel materials can be engineered to mimic the crystal mineral structure of human bone or used as a restorative resin for dental applications. Researchers are looking for ways to grow complex tissues with the goal of one-day **growing human organs for transplant**. Researchers are also studying ways to use **graphene nanoribbons** to help repair spinal cord injuries; preliminary research shows that neurons grow well on the conductive graphene surface.
    - **Vaccine development:** Nanomedicine researchers are looking at ways that nanotechnology can improve vaccines, including vaccine delivery without the use of needles. Researchers also are working to create a universal vaccine scaffold for the annual flu vaccine that would cover more

strains and require fewer resources to develop each year.

- **Smart pills:** The term 'smart pills' refers to nano-level electronic devices that are shaped and designed like pharmaceutical pills but perform more advanced functions such as sensing, imaging, and drug delivery. Nanotechnology has previously helped in developing various kinds of smart pills, such as the PillCam, a capsule with a miniature video camera, and dose-tracking pills.
- **Nanobots:** Nanobots are micro-scale robots, which essentially serve as miniature surgeons. They can be inserted into the body to repair and replace intracellular structures. They can also replicate themselves to correct a deficiency in genetics or even eradicate diseases by replacing DNA molecules. This property is still under development.
- **Nanofibres**: Nanofibers are being used in wound dressings and surgical textiles, as well as in implants, tissue engineering, and artificial organ components. Scientists are working on developing 'smart bandages', which when left on the site, will absorb itself into the tissue once the wound heals. Embedded nanofibres in these smart bandages can contain clotting agents, antibiotics, and even sensors to detect signs of infection.
- **COVID–19:** For image-based and clinical diagnostic of COVID-19, nanomaterials are emerging as promising substrates because of their unique optical, electronic, magnetic, and mechanical properties. Nanomaterials that have been proposed for viral detection include metal, silica, and polymeric nanoparticles, quantum dots, and carbon nanotubes.

Food Industry:

- Nanotechnology provides the potential for safe and better quality food and improved texture and taste of the food.
- A contamination sensor, using a flash of light can reveal the presence of E-coli.
- Antimicrobial packaging made out of cinnamon or oregano oil or nanoparticles of zinc, calcium, etc., can kill bacteria.
- The nano-enhanced barrier can keep oxygen-sensitive food fresh.
- Nano-encapsulating can improve the solubility of vitamins, antioxidants, healthy omega, etc.
- Nano-fibres made of lobster shells or organic corn can allow for antimicrobial packaging while being biodegradable.
- Nanobarcodes are used to tag individual products and trace outbreaks.

E**lectronic components:**

- Computers are already working on a nanoscale.
- Nanotechnology has greatly improved the capacity of electronic components by:
- Reducing the size of the integrated circuits' transistors
- Improving the display screens of the electronic devices
- Reducing power consumption, weight, and thickness of the electronic devices.

Energy-efficient:

- This technology can improve the efficiency of the existing solar panels. It can also make the manufacturing process of solar panels cheaper and efficient.
- It can improve the efficiency of fuel production and consumption of petroleum materials.
- It is already being made use of in many batteries that are less-flammable, efficient, quicker-charging and are lightweight and higher power density.
- Broadly, it has the potential to improve the existing technologies to be more efficient with less consumption of energy.

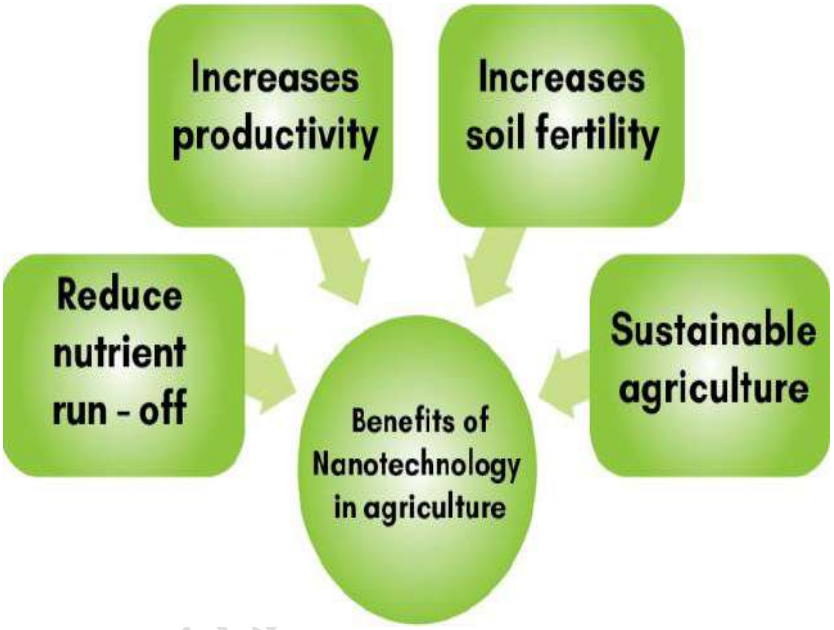
Textile industry:

- Nanotechnology has already made revolutionary changes in the textile industry and is estimated to make a market impact worth hundreds of billions of dollars.
- Nanoscience has now produced stain and wrinkle resistant cloths and may further improve upon the existing innovations.

Environment:

- The nanotechnology has numerous eco-friendly applications.
- It has the potential to address the current problem of pollution.
- It can provide for affordable, clean drinking water through swift detection of impurities and purification of water.
- The nanotechnology can be used to remove industrial water pollutants in the groundwater through chemical reactions at a cheaper rate than the current methods that need pumping of the groundwater for treatment.
- Nanotechnology sensors and solutions also have the potential to detect, identify, filter and neutralise harmful chemical or biological agents in the air and soil.

Transport:



- Nanotechnology contributes to manufacturing lighter, smarter, efficient and greener automobiles, aircraft and ships.
- It also allows various means to improve transportation infrastructures like providing resilience and longevity of the highway and other infrastructure components.
- The nanoscale sensors and devices can also provide for cheap and effective structural monitoring of the condition and performance of the bridges, rails, tunnels, etc. They can also enhance transportation infrastructure that makes the drivers avoid collisions and congestions, maintain lane position, etc.

Space:

- Materials made of carbon nanotubes can reduce the weight of the spaceships while retaining or increasing the structural strength.
- They can also be used to make cables that are needed for the space elevator.

Space elevators can significantly reduce the cost of sending materials to the orbit.

- The nanosensors can be used to monitor the chemicals in the spacecraft to look into the performance of the life support system.

Agriculture:

- The nanocapsule can enable effective penetration of herbicides, chemical fertilizers, and genes into the targeted part of the plant. This ensures a slow and constant release of the necessary substance to the plants with minimised environmental pollution.
- The nanosensors and delivery systems can allow for precision farming through the efficient use of natural resources like water, nutrients, chemicals etc.
- The nanosensors can also detect the plant viruses and soil nutrient levels.
- Nano-barcodes and nano-processing could also be used to monitor the quality of agriculture produce.

Tissue Nano-transfection:

- Tissue nanotransfection (TNT) is an electroporation-based technique capable of gene and drug cargo delivery or transfection at the nanoscale.
- Furthermore, TNT is a scaffold-less tissue engineering (TE) technique that can be considered cell-only or tissue inducing depending on cellular or tissue level applications.
- The transfection method makes use of nanochannels to deliver cargo to tissues topically.
- The new technique, called tissue nano-transfection, is based on a tiny device that sits on the surface of the skin of a living body.
    - **An intense, focused electric field** is then applied across the device, allowing it to deliver genes to the skin cells beneath it – turning them into different types of cells.
    - It offers an exciting development when it comes to repairing damaged tissue, offering the possibility of **turning a patient's own tissue into a "bioreactor" to produce cells** to either repair nearby tissues, or for use at another site.
    - It avoids an intermediary step where cells are turned into what are known as **pluripotent stem cells**, instead of turning skin cells directly into functional cells of different types. It is a single-step process in the body.
    - The new approach does not rely on applying an electric field across a large area of the cell, or the use of viruses to deliver the genes.

Nano Composite:

- Nanocomposite is a **multiphase solid material where one of the phases has one, two or three dimensions of less than 100 nanometres or structures having nano-scale repeat distances between the different phases that make up the material.**
- The idea behind Nanocomposite is to use **building blocks** with dimensions in the nanometre range to design and create new materials with unprecedented flexibility and improvement in their physical properties.
- **Nanocomposites are found in nature**, for example in the structure of the abalone shell and bone.
- The use of nanoparticle-rich materials long predates the understanding of the physical and chemical nature of these materials.
- In mechanical terms, nanocomposites differ from conventional composite materials due to the exceptionally high

surface to volume ratio of the reinforcing phase and/or its exceptionally high aspect ratio.

- The reinforcing material can be made up of particles (e.g., minerals), sheets (e.g. exfoliated clay stacks), or fibres (e.g. carbon nanotubes or electro spun fibres).
- The area of the interface between the matrix and reinforcement phase(s) is typically an order of magnitude greater than for conventional composite materials.
- The matrix material properties are significantly affected in the vicinity of the reinforcement.
- This large amount of reinforcement surface area means that a relatively small amount of nanoscale reinforcement can have an observable effect on the macro scale properties of the composite. For example, adding carbon nanotubes improves the electrical and thermal conductivity.

Nano sensors:

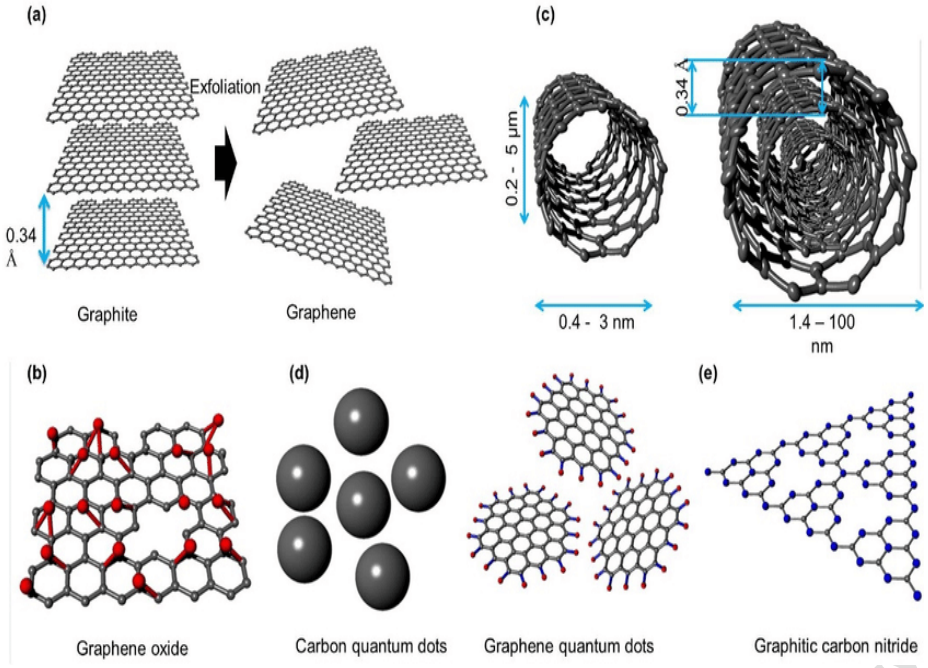
- Nano sensors are nanoscale devices that measure physical quantities and convert these to signals that can be detected and analysed.
- Nano sensors are chemical or mechanical sensors that can be used to detect the presence of chemical species and nanoparticles, or monitor physical parameters such as temperature, on the nanoscale
- There are several ways proposed today to make nano sensors; these include top-down lithography, bottom-up assembly, and molecular self-assembly.
- Some of the uses of nano sensors are:
    - in medical diagnostics and understanding neurophysiology;
    - in pollution monitoring to detect various chemicals;
    - to monitor temperature, humidity, displacement, etc.;
    - to monitor plant signalling and metabolism to understand plant biology.

Graphene:

- Graphene has been touted in the global electronics industry as a "miracle material" given its strength, electrical conductivity, and elasticity, and has been seen as an alternative to lithium-ion batteries since its discovery in 2004.
- It is a form of carbon that can be used to develop smaller, slimmer batteries but with higher capacity.
- Graphene is an allotrope (form) of carbon consisting of a single layer of carbon atoms arranged in a hexagonal lattice.
- It is nearly transparent.
- It is the basic structural element of many other allotropes of carbon, such as graphite, charcoal, carbon nanotubes, and fullerenes.
- Its thin composition and high conductivity means it is used in applications ranging from miniaturized electronics to biomedical devices.
- These properties also enable thinner wire connections; providing extensive benefits for computers, solar panels, batteries, sensors, and other devices.
- The one-atom-thick sheets of carbon conduct electrons better than silicon and have been made into fast, low-power transistors.
- Researchers have measured the intrinsic strength of graphene, and they've confirmed it to be the strongest material ever tested.

Applications:

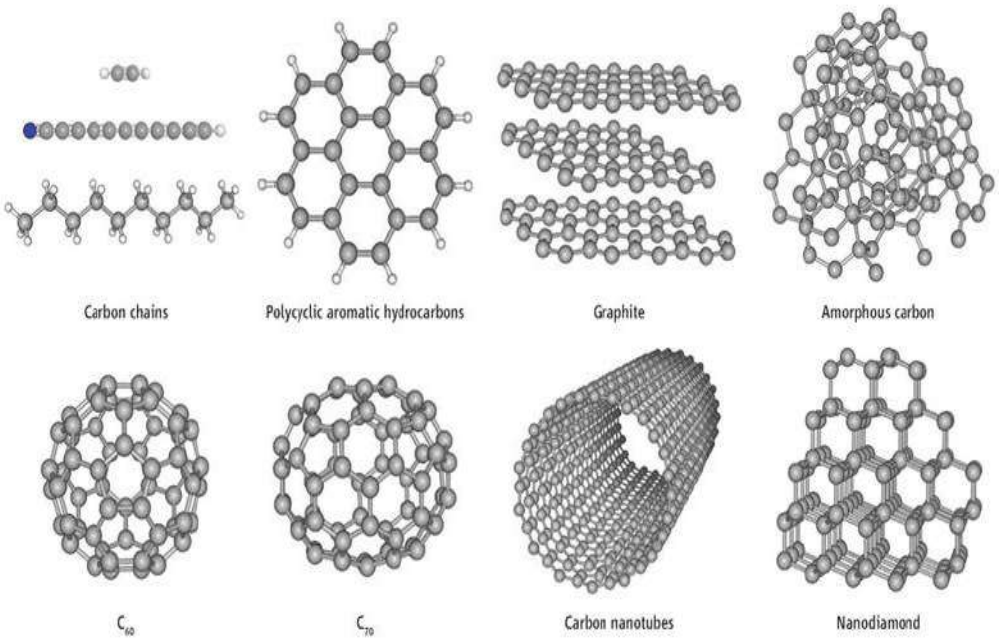
- Graphene is widely used in making solar cells, light-emitting diodes, touch panels, and smart windows.



- Graphene supercapacitors serve as energy storage devices with a capacity for faster charging and a longer life span than traditional electrolytic batteries.
- Other potential applications of graphene include water filtration and purification, renewable energy, sensors, personalized healthcare, and medicine, to name a few.

Carbon Nanotubes:

- Carbon nanotubes (CNTs) are an allotrope (Not isotope) of carbon.
- They take the form of cylindrical carbon molecules and have novel properties that make them potentially useful in a wide variety of applications in nanotechnology, electronics, optics, and other fields of materials science.
- They exhibit extraordinary strength and unique electrical properties and are efficient conductors of heat.
- Inorganic nanotubes have also been synthesized.
- Nanotubes are members of the fullerene structural family, which also includes buckyballs.
- Whereas buckyballs are spherical in shape, a nanotube is cylindrical, with at least one end typically capped with a hemisphere of the buckyball structure.
- Their name is derived from their size, since the diameter of a nanotube is on the order of a few nanometres (approximately 50,000 times smaller than the width of a human hair), while they can be up to several millimetres in length.
- There are two main types of nanotubes: single-walled



nanotubes (SWNTs) and multiwalled nanotubes (MWNTs).

- Carbon nanotubes (CNTs) are cylindrical molecules that consist of rolled-up sheets of single-layer carbon atoms (graphene).
- They can be single-walled (SWCNT) with a diameter of less than 1 nanometre (nm) or multi-walled (MWCNT), consisting of several concentrically interlinked nanotubes, with diameters reaching more than 100 nm.
- Their length can reach several micrometres or even millimetres.

Applications:

- Used in electric wires to reduce losses
- It can replace silicon made transistors as they are small and emit less heat and it can revolutionise electronics
- Can be used in solar cell

Issues in Nanotechnology:

- **Environment:** Being very small these particles can create environment pollution
- **Security:** nan o particles can be used in devices to capture videos or use as drones to launch offensive attack
- **Equity:** developing countries have less access to funds to create nanotechnology products
- **Ethical:** Using nano technology and devices in human beings can create a more powerful human being with enhanced human capabilities.

Issues in India:

- No single regulatory body in INDIA
- Insufficient studies on toxicological studies of nanoparticles
- Facilities required for research are less and outdates

Government Measures:

Nano Science and Technology Initiative (NSTI):

- It was set up by the Department of Science and Technology (DST) in 2001 to focus on issues related to infrastructure development, research and application programmes related to nanomaterials including drugs, drug delivery, gene targeting and DNA chips.

Nano Science and Technology Mission (NSTM):

- NSTM, launched in 2007, is an umbrella programme that aims to promote research and development in nanotechnology.
- The objectives include the promotion of research, infrastructure development to support the research, develop nanotechnology, human resources, and international collaborations.

REMOTE SENSING

Remote sensing is the process of acquiring information, detecting, analysing, monitoring the physical characteristics of an area by recording it is reflected and emitted radiation energy without having any physical contact with the object under study.

Types of Remote Sensing:

- **Active remote sensing**– In this mode of remote sensing, aerial sensors are used. Here the object or the phenomenon is first located regarding which one needs to collect data. Then the sensor is used to produce radiation and transmit it to that place or object.
- When the object or the phenomenon reflects the radiation, the data is collected from it. Some examples of active sensors are Radar and Lidar. They help in finding out the delay in time between emission and return.
- **Passive remote sensing**– In this mode of remote sensing, the source of radiation is natural, like the sun, and aerial sensors are not used in this case. Here the object reflects the radiation that it receives from the sun naturally.
- Satellites, aeroplanes, and various other orbital platforms are used to transmit the data received in the terrestrial stations. The data and the images collected are then analysed thoroughly to get information.
- Passive sensors are more popular than active sensors as they produce good-quality satellite images, which makes it easier to analyse and archive the data.

Advantages:

- Remote sensing helps in providing the latest information as well as helps in planning and management.
- Most applications of remote sensing are used for sustainable development, disaster management, environmental degradation, and natural resource management.
- It is also used in the development processes like soil, forestry, geology, and agriculture.
- Remote sensing is one of the most advanced technologies that can be used to find out information about an object which is at a great distance from the observer.
- Mostly information on those objects is studied that is not at all accessible by the observer.
- It helps in accurate and detailed studying of the dimensions and readings of a particular area.

Applications:

1.Agriculture:

- When farming is to be done in precision, satellite data is extensively used. Remote sensing is one of the best possible methods with the help of which agricultural viability could be studied.
- It can also be used to determine the condition of the crops.
- Farmers can also easily identify to which extent crops are damaged if a calamity occurs or there are storms.
- The data on the crops could be collected, and then further steps can be decided.

2.Monitoring drought and weather patterns:

- The weather patterns, as well as the drought patterns of a particular area that is to be studied, could be easily determined with the help of the images that are obtained from the satellites.
- The amount of rainfall that has occurred in the place and the duration of the rainfall that has occurred can also be determined.

- The extensive data collected with remote sensing also allows for calculating and estimating the time duration of the next rainfall**.**

3.Forest mapping:

- Usually, for forest mapping, traditional ground surveys were used. But they were only a suitable option sometimes.
- Instead, remote sensing technology could be used quite easily to obtain images of large tracts of forests.
- It allows us to obtain the most minute details, such as the density and textures of a leaf, accurately.
- The forests could be easily mapped, identified, and delineated with the help of remote sensing techniques.
- The picture of areas where deforestation has been done could be easily studied with the help of the pictures that are obtained.

4.Assessing the weather:

- Interesting patterns and pictures of the atmosphere could be easily obtained with the help of remote sensing techniques.
- This data is quite valuable and accurate for the meteorological and climatological study that is done throughout the world.
- It can also be used to make predictions related to natural calamities that might occur anytime soon.
- The rise of global warming in recent decades is a matter of concern, and all information regarding the same could be easily obtained with the help of remote sensing.
- The change in climatic conditions over the years can be easily studied to plan for the future.

5.Land use and land cover analysis:

- Most of the time, these terms are used quite simultaneously, but they have different meanings altogether.
- They play a significant role in planning, managing, and monitoring programs at local, regional, and national levels.
- The amount of a region that is covered by forests, wetlands, impermeable surfaces, farmland, and other land and water types is recorded by land cover data.
- On the other hand, land use data shows how people use the landscape-whether for development, conservation, or mixed uses.
- It involves modifying the natural environment into a built environment such as a settlement and semi-natural environment.
- With the help of remote sensing, the properties or information about land cover could be easily estimated.
- Based on this information, land use could be decided. The satellite images give a clear view of the land cover, and they help you to know which land is suitable for what purpose.

ROBOTICS

Robotics is the branch of technology that deals with the design, construction, operation, structural depositions, manufacture and application of robots.

Robotics in Agriculture:

The most popular applications of Robots in agriculture appear to fall into four major categories:

- **Crop and Soil Monitoring:** Companies are leveraging sensors and various IoT-based technologies to monitor crop and soil health.
- **Predictive Agricultural Analytics:** Various AI and machine learning tools are being used to predict the optimal time to sow seeds, get alerts on risks from pest attacks, and more.
- **Supply Chain Efficiencies:** Companies are using real-time data analytics on data-streams coming from multiple sources to build an efficient and smart supply chain.
- **Agricultural Robots:** Companies are developing and programming autonomous robots to handle essential agricultural tasks such as harvesting crops at a higher volume and faster pace than human labourers.

Some examples of Agricultural Robots:

- **Green seeker sensor:** This smart machine reads a plant's needs and then applies precisely the amount of fertilizer of herbicides needed. Green Seeker is a machine which uses the sensors to let the plant tell us that what it needs.
- **Flying Robots To Spread Fertilizer:** A flying robot monitors the growing condition of the crops over farmlands in Ili, a Kazak autonomous prefectur e in Northwest China's Xinjiang Uygur autonomous With camera equipment and an automatic fertilizing system in the front, the robot can fly autonomously and apply fertilizer independently.

Artificial Intelligence and Robotics:

- Artificial intelligence is the branch of computer science concerned with making computers behave like humans.
- AI refers to the ability of machines to perform cognitive tasks like thinking, perceiving, learning, problem solving and decision making.
- Artificial intelligence (AI) refers to the ability of machines to perform cognitive tasks like thinking, perceiving, learning, problem solving and decision making. Initially conceived as a technology that could mimic human intelligence.
- AI has evolved in ways that far exceed its original conception.
- With incredible advances made in data collection, processing and computation power, intelligent systems can now be deployed to take over a variety of tasks, enable connectivity and enhance productivity.

Challenges of Artificial Intelligence (AI):

1. Artificial intelligence is poised to be one of the biggest things to hit the technology industry (and many other industries) in the coming years.
2. But just because it holds enormous potential does not mean it does not also have its challenges.
3. And artificial intelligence challenges and possibilities are not small, which is why recognizing and working towards resolutions to problems can help further propel artificial intelligence's rapid growth.
4. According to studies, around 40 % of the total energy that data centres consume goes to cooling IT equipment. Now, to reduce energy consumption, companies

are moving their data centres into cooler climates such as Siberia.

5. The environmental impact caused by data centres doesn't stop at electrical consumption.
6. Coolants are often made of hazardous chemicals, and battery backups at data centres – needed for when there are power shortages – cause an environmental impact both due to mining for battery components and the disposal of the toxic batteries afterward.
7. Countries are passing stricter legislations on data security that require citizen data to be stored on servers located domestically, picking colder climates beyond their borders is becoming a difficult option.
8. Robotics and AI companies are building intelligent machines that perform tasks typically carried out by low-income workers: self-service kiosks to replace cashiers, fruit-picking robots to replace field workers, etc.

Measures to avoid misusing of Artificial Intelligence:

- Without ethical guard rails, AI will widen social and economic schisms, amplifying any innate biases at an irreversible scale and rate and lead to discriminatory outcomes.
- It is neither enough nor is it fair to expect AI tech companies to solve all these challenges through self-regulation.
- First, they are not alone in developing and deploying AI; governments also do so.
- Second, only a "whole of society" approach to AI governance will enable us to develop broad-based ethical principles, cultures and codes of conduct, to ensure the needed harm-mitigating measures, reviews and audits during design, development and deployment phases.
- To inculcate the transparency, accountability, inclusion and societal trust for AI to flourish and bring about the extraordinary breakthroughs it promises.
- Given the global reach of AI, such a "whole of society" approach must rest on a "whole of world" approach.
- Many countries, including India, are cognisant of the opportunities and the risks, and are striving to strike the right balance between AI promotion and AI governance both for the greater public good.
- NITI Aayog's Responsible AI for All strategy, the culmination of a year-long consultative process, is a case in point.
- It recognises that our digital future cannot be optimised for good without multi-stakeholder governance structures that ensure the dividends are fair, inclusive, and just.

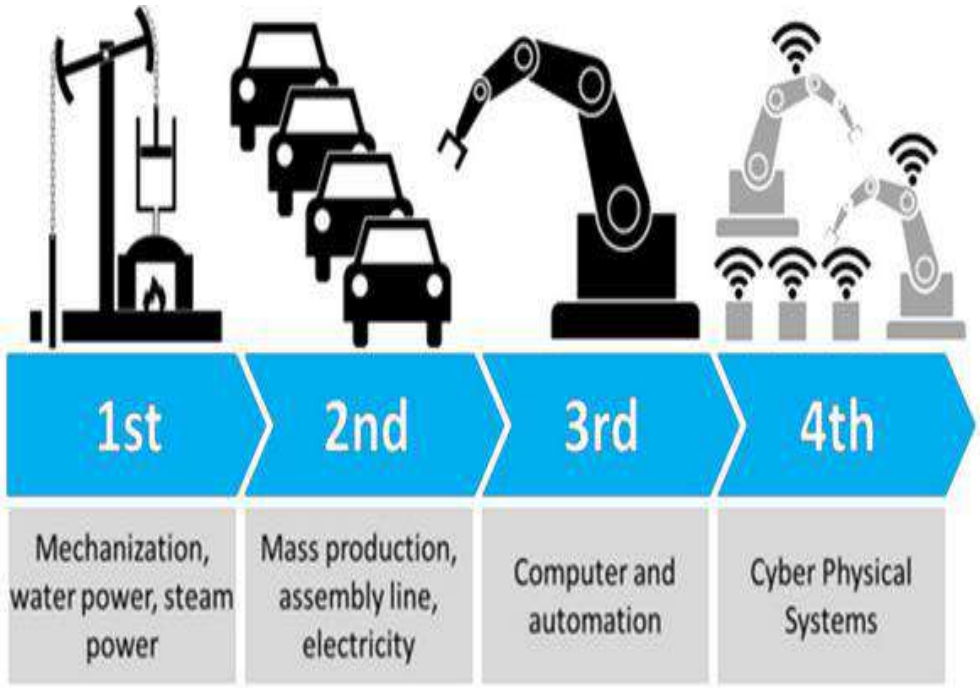
Robotics in Pandemics:

- **Disinfecting surfaces:** Large and small autonomous or remote-controlled robots could be developed to locate and constantly sterilize frequently touched surfaces with ultraviolet light.
- **Contract Tracing:** The roboticists say combining existing security systems with facial recognition software could allow authorities to retrace the steps of patients who tested positive for COVID-19 and contact others who might be at risk, which is known as contact tracing.
- **Nasal swabs:** Testing for coronavirus involves inserting a swab fairly deep into a patient's nasal cavity.
- There are parts of the process that puts humans at risk of contracting the virus, including collecting the sample, handling the sample, transferring the

sample to the test location and the test itself.

- Automated or robot-assisted nasopharyngeal and oropharyngeal swabbing may speed up the process, reduce the risk of infection, and free up staff for other tasks.
- **Medicine Delivery:** Autonomous drones and ground robots can be used to deliver medicine to patients who have the coronavirus.
- In the field hospital in Wuhan, China, Cloud Minds robots were used to deliver food, drink and medicine to patients.

Social Robots: In the time of isolation and quarantine, social robots can help people provide social stimulation and interactions, in addition to providing reminders to follow treatment regimens (to the elderly).



4th Industrial revolution and Robotics:

The Fourth Industrial Revolution (IR 4.0) is a term that describes present technological age.

It is the fourth industrial era since the inception of the initial Industrial Revolution of the 18th century.

The key elements of the fourth revolution are the fusion of technologies ranging from the physical, digital to biological spheres.

Characteristics of IR 4.0:

- It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres.
- It brings together digital technology and the physical world to create a new range of products and services.
- The possibilities of billions of people connected by mobile devices, with unprecedented processing power, storage capacity, and access to knowledge, are unlimited.
- And these possibilities will be multiplied by emerging technology breakthroughs in fields such as artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing.
- The revolution is evolving at an exponential rather than a linear pace and it is disrupting almost every industry in every country.

Agriculture Sector:

- AI can be used to predict advisories for sowing, pest control, input control can help in ensuring increased income and providing stability for the agricultural community.
- Precision agriculture uses AI technology to aid in detecting diseases in plants, pests, and poor plant nutrition on farms.

- AI sensors can detect and target weeds and then decide which herbicides to apply within the right buffer zone.
- Climate pattern and effects on different crops can be analysed using AI software which will help in prediction of the best crop for the season and the possible outcomes.
- Image classification tools combined with remote and local sensed data can bring a revolutionary change in utilization and efficiency of farm machinery, in areas of weed removal, early disease identification, produce harvesting and grading.

Manufacturing sector:

- Robots are being used for manufacturing since a long time now; however, more advanced exponential technologies have emerged such as additive manufacturing (3D Printing) which with the help of AI can revolutionize the entire manufacturing supply chain ecosystem.
- The predictive maintenance of machineries would lead to reduced operational cost
- IR technologies would be helpful in minimizing deterioration in the quality of the machinery
- By having a repository of data regarding machines and equipment's will aid in managing them well.
- Robots can perform the tasks given by a human because of sensors to detect physical data from the real world such as light, heat, temperature, movement, sound, bump, and pressure.
- Moreover, they have efficient processors, multiple sensors and huge memory, to exhibit intelligence.
- Further, they are capable of learning from their errors and therefore can adapt to the new environment.

Health and Hygiene

Health is described as the state of complete physical, mental, and social wellbeing. Being healthy is far more than just being free from diseases.

The disease is a condition of disturbed functioning of the body caused by infection, defective diet, heredity, environment, or deprived condition of the brain. Health is a state of complete physical, mental, and social wellbeing.

The disease may be a response to –

- Environmental factors (as malnutrition, industrial hazards, or climate)
- Specific infective agents (as worms, protozoans, fungi, etc)
- Inherent defects of the organism (as genetic anomalies.)
- Combination of these factors

Causes of Diseases/Disease Agents:

A disease agent is an organism, substance, or force which causes disease due to its excessive presence, deficiency, or absence.

- **Pathogens/Biological Agents:** They are biological entities which cause infectious diseases, e.g., viruses (mumps, chickenpox, smallpox), mycoplasma (e.g., bronchitis, acute leukemia), chlamydia (e.g, trachoma), bacteria (e.g. cholera, tetanus), fungi (ringworm, thrush, moniliasis, pulmonary aspergillosis), protozoa (e.g. giardiasis, sleeping sickness), helminths (e.g., filariasis, ascariasis, taeniasis), other organisms (e.g., scabies).
- **Nutrient Agents:** Deficiency of vitamins (e.g., beriberi, scurvy, night blindness), minerals (e.g., anaemia, rickets), carbohydrates, fat, and proteins (e.g., kwarshiorkar, marasmus), or excess of food (e.g., obesity).
- **Chemical Agents: Endogenous Agents–** Excess presence of uric acid, reduced secretion of ADH (diabetes

Disease	*Deficiency*	*Symptoms*
Anaemia	Haemoglobin (iron)	General weakness and pale complexion
Goitre	Iodine	Painful joints
Beri-beri	Vitamin B_1 (Thiamine)	Weakness, swelling and pain in legs, loss of appetite, enlarged heart
Scurvy	Vitamin C (Ascorbic acid)	Swollen gums, delayed wound healing
Rickets	Vitamin D	Sleeplessness, pale face, diarrhoea, deformed skull, pelvis and limbs in children
Hypokalemia	Potassium	Rise in heartbeat, kidney damage, weakness
Night blindness	Vitamin A	–
Xerophthalmia	Vitamin A	Dryness
Dermatosis	Vitamin A	Skin diseases
Ariboflavinosis	Vitamin B_2 (Riboflavin)	Blurred vision, soreness of eyes and tongue
Pellagra	Nicotinic Acid (Vitamin B complex)	Diarrhoea, mental lethargy, red skin, itchy hands, feet, elbows and knees

insipidus) or insulin (diabetes mellitus). Exogenous Agents- Pollutants (e.g., pneumoconiosis), allergens (allergy).

- **Physical Agents:** Heat (e.g., stroke), cold (frostbite), radiations, sound (impaired hearing), humidity, etc.
- **Mechanical Agents:** Fractures, sprains, dislocation, injury, chronic friction.
- **Genetic Agents:** Excess or deficiency of chromosomes, mutations, harmful alleles, e.g., colou r blindness, albinism, haemophilia, Turner's syndrome.

Classification of disease:

1.Congenital diseases:

- Congenital disorders can be due to fault in the chromosome structure or damage inflicted on the developing embryo.
- These could be caused by radiation, diseases contracted by the mother (German measles), use of certain drugs, excessive smoking and alcohol intake by the pregnant mother; for example, Hare-lip, club foot, and Mongolism.

2.Hereditary Diseases:

- Diseases that are transmitted from parent to offspring from generation to generation are termed hereditary diseases. E.g., Haemophilia and colour blindness.

3.Acquired diseases:

Acquired diseases develop in an individual after birth. These are of two kinds:

(I) Communicable diseases:

- These are caused due to the entry of disease-causing germs called pathogens into the body and are easily transmitted from person to person by direct or indirect contact or through a carrier which is called a vector, e.g., mosquito (Anopheles) is a vector of malaria. Indirect contact may be through clothes, beddings, utensils, etc.
- Communicable diseases are further classified into several types depending on the types of causative agents:

(i) Viral (ii) Bacterial, (iii) Protozoan (iv) Helminthic (v) Fungal.

(II) Non-Communicable diseases:

These are restricted to the persons suffering and they are of the following types:

(a) Degenerative Diseases:

- These diseases are due to the degeneration of tissues in old age, that is, diseases caused due to a decline in the ability of the body to repair its tissues.
- It leads to malfunctioning of the heart, lungs and central nervous system E.g., Parkinson's disease, cataract, and arteriosclerosis.

(b) Cancer:

- It is caused due to uncontrolled growth of tissues in any part of the body.
- This disease has become a challenge to medical science as it is incurable in later stages.

(c) Allergies:

- These are caused due to hypersensitivity of the body to certain foreign substances called Allergens. E.g., Hay fever, asthma, nettle rash.

Bacteria:

- Bacteria are prokaryotes, a minuscule single-celled organism that grows well in varied environments.
- They can live inside the soil, in the ocean, and inside the human bowel.
- They can be differentiated, by their shape, the nature of their cell walls and genetic differences.

The bacteria multiply by a process called **binary fission.**

Diseases	Bacteria
Cholera	Vibrio cholerae
Leprosy	Mycobacterium Leprae
Plague	Yersinia pestis
Pneumonia	Streptococcus pneumoniae
Tetanus	Clostridium tetani
Tuberculosis	Mycobacterium tuberculosis.
Typhoid	Salmonella typhi
Whooping Cough	Bordetella pertussis.

Virus:

- The virus is a tiny infectious agent that duplicates only inside the living cells of other creatures.
- These are diverse in nature and can infect animals, plants, and microorganisms and transmitted by biological vectors only.
- It is made up of a DNA or RNA genome inside a protein shell known as the capsid. Some viruses have an internal or external membrane covering.
- It lacks enzymes essential for energy production.

Diseases	Virus
AIDS	Human Immunodeficiency Virus (HIV)
Chickenpox	Varicella-zoster virus.
Common Cold	Rhinovirus
Chikungunya	Chikungunya Virus
Dengue fever	Dengue virus
Ebola	Ebola virus

Zoonotic Diseases:

- Zoonosis refers to the transmission of diseases between animals and humans. Such diseases are termed as Zoonotic Diseases.
- Zoonotic diseases range from mild to severe, while in extreme cases can even be fatal.
- Zoonoses may be bacterial, viral, or parasitic, or may even involve unconventional agents for the transmission of the disease.
- WHO in 1959 defined Zoonoses as "those diseases and infections which are naturally transmitted between vertebrate animals and man."
- The World Zoonoses Day is observed every year on July 6 to create awareness on zoonotic diseases, how to prevent them and what actions to take when exposed.

1. Rotavirus:

About:

- Rotavirus is the most common virus that contaminates the bowels.
- It causes diarrhoea among infants and children throughout the world and causes over 450,000 deaths worldwide

annually inclusive of 110,000 deaths in India which are accounts for 22 % of the estimated global deaths from diarrhoea-causing rotavirus.

Symptoms:

- Rotavirus affects the body in many ways and multiple infections can be noticed.
- Vomiting
- Low-grade Fever
- Watery diarrhoea
- Nausea

About Rotavirus vaccine:

- Rotavirus vaccine prevents diarrhoea virus to enter the body which causes death
- Rota Shield is a Rotavirus vaccine by Wyeth was licensed in 1998 in the United States
- In 1999, however, the manufacturer withdrew it from the market risking bowel obstruction in one of every 12,000 vaccinated infants
- The vaccine was under trial for 8 years since the withdrawal.
- After efficient research, Rotarix by GlaxoSmithKline and RotaTeq by Merck were manufactured which is effective and safe.

2.Ebola Virus:

About:

- Ebola virus disease (EVD), formerly known as Ebola haemorrhagic fever, is a severe, often fatal illness in humans.
- The virus is transmitted to people from wild animals and spreads in the human population through human-to-human transmission.
- Fruit bats of the Pteripodidae family are considered to be the natural host of the Ebola virus.
- Ebola is introduced into the human population through close contact with the blood, secretions, organs or other bodily fluids of infected animals.

Signs and symptoms:

- EVD is a severe acute viral illness often characterized by the sudden onset of fever, intense weakness, muscle pain, headache, and sore throat.
- This is followed by vomiting, diarrhoea, rash, impaired kidney and liver function, and in some cases, both internal and external bleeding.
- The incubation period, that is, the time interval from infection with the virus to onset of symptoms is 2 to 21 days.
- In the absence of effective treatment and a human vaccine, raising awareness of the risk factors for Ebola infection and the protective measures individuals can take is the only way to reduce human infection and death.

3. **Swine Flu:**

About:

- Swine flu (swine influenza) is a respiratory disease caused by viruses (influenza viruses) that infect the respiratory tract of pigs and result in nasal secretions, a barking cough, decreased appetite, and listless behaviour.
- The virus spreads by tiny droplets that are released when a person coughs or sneezes. The droplets reach a distance of about one meter (3ft).
- Common objects such as door handles, remote control, handrails, and computer keyboards can get contaminated with the virus when the droplet settles on these surfaces.

Signs and symptoms:

- Fever (100 0F or greater), cough, nasal secretions, fatigue, and headache, with fatigue being reported in most infected individuals. Some patients also get nausea, vomiting, and diarrhoea.
- Some patients develop severe respiratory symptoms and need respiratory support (such as a ventilator to breathe for the patient).
- In 2015 the states of Gujarat and Rajasthan are the worst affected by Swine Flu.

Neglected tropical diseases:

- Neglected tropical diseases (NTDs) are a diverse group of tropical infections that are especially common in low-income populations in developing regions of Africa, Asia, and the Americas.
- Populations living in poverty, without adequate sanitation and in close contact with infectious vectors and domestic animals and livestock are the worst affected.
- The World Health Organization (WHO) is a specialized agency of the United Nations that looks into matters regarding public health.
- They are caused by a variety of pathogens such as viruses, bacteria, protozoa and helminths.

Tuberculosis (TB):

- TB is caused by a bacterium called Mycobacterium tuberculosis, belonging to the Mycobacteriaceae family consisting of about 200 members.
- In humans, TB most commonly affects the lungs (pulmonary TB), but it can also affect other organs (extra-pulmonary TB).
- TB is a very ancient disease and has been documented to have existed in Egypt as early as 3000 BC.
- TB is a treatable and curable disease.
- TB is spread from person to person through the air. When people with lung TB cough, sneeze or spit, they propel the TB germs into the air.

Symptoms: Common symptoms of active lung TB are cough with sputum and blood at times, chest pains, weakness, weight loss, fever and night sweats.

Global Impact of TB:

- In 2019, 87% of new TB cases occurred in the 30 high TB burden countries.
- Eight countries accounted for two thirds of the new TB cases:
- India, Indonesia, China, Philippines, Pakistan, Nigeria, Bangladesh and South Africa.
- India reported 1.8 million TB cases between January and December 2020 as compared to 2.4 million the year before.
- In 2019, MDR-TB remained a public health crisis and a health security threat.
- Multi-Drug Resistant Tuberculosis (MDR-TB) is a strain of TB that cannot be treated with the two most powerful first-line treatment anti-TB drugs.
- Extensively Drug Resistant Tuberculosis (XDR-TB) is a form of TB caused by bacteria that are resistant to several of the most effective anti-TB drugs.

Leprosy:

- Leprosy, also known as Hansen's disease, is a **chronic infectious disease caused by Mycobacterium leprae.**

- The **disease mainly affects the skin, the peripheral nerves, mucosal surfaces of the upper respiratory tract, and the eyes.**
- Leprosy is known to occur at all ages ranging from early infancy to very old age. Leprosy is curable and early treatment averts most disabilities.
- Leprosy is curable with a combination of drugs known as multidrug therapy (MDT), as the treatment of leprosy with only one anti leprosy drug (monotherapy) will result in the development of drug resistance to that drug.
- The combination of drugs used in the MDT depends on the classification of the disease. Rifampicin, the most important anti leprosy medicine, is included in the treatment of both types of leprosy.
- For the treatment of patients with multibacillary leprosy, WHO recommends a combination of rifampicin, clofazimine, and dapsone; for patients with paucibacillary leprosy, MDT uses a combination of rifampicin and dapsone.

Alzheimer's Disease:

- It is a progressive brain disorder that typically affects people older than 65. It destroys brain cells and nerves and disrupts the message-carrying neurotransmitters.
- When it affects younger individuals, it is considered early onset.
- Eventually, a person with Alzheimer's loses the ability to perform day-to-day activities.
- Symptoms include memory loss, difficulty in completing familiar tasks, confusion with time or place, problems in speaking and writing, decreased or poor judgment, and changes in mood and personality.
- There is no cure for Alzheimer's because its exact causes are not known.
- Most drugs being developed try to slow down or stop the progression of the disease.

GENETIC ENGINEERING

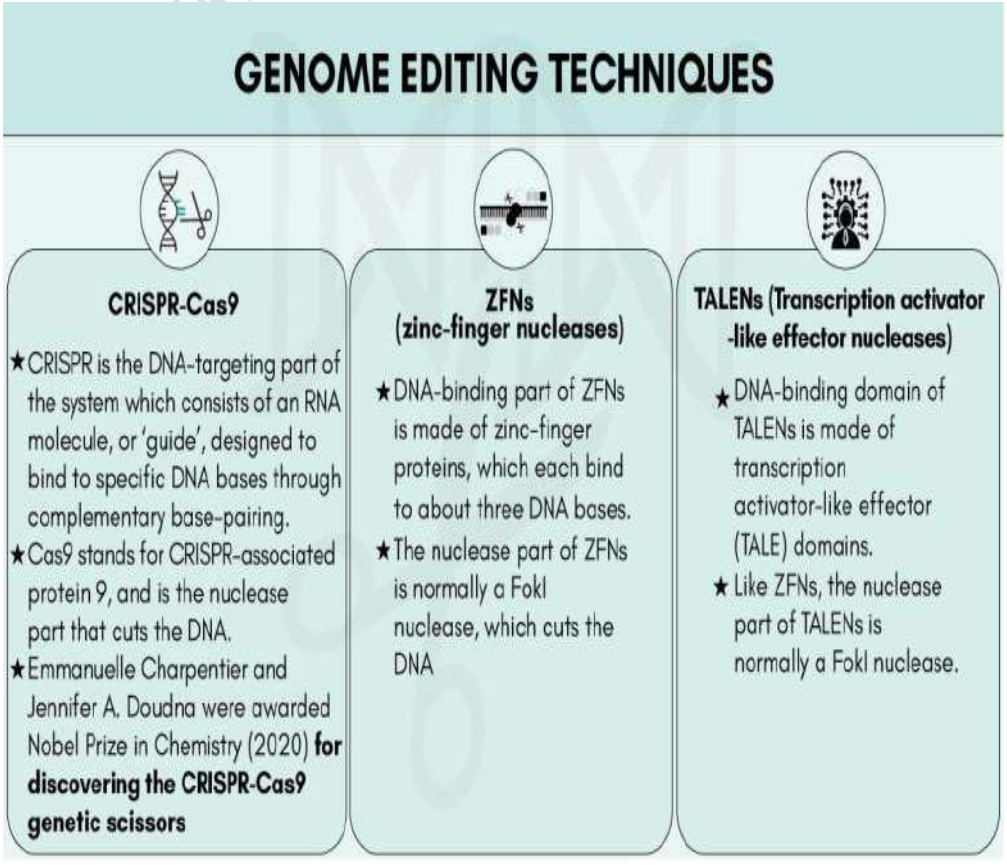
- Genetic engineering (also called genetic modification) is a process that uses laboratory-based technologies to alter the DNA makeup of an organism.
- This may involve changing a single base pair (A-T or C-G), deleting a region of DNA, or adding a new segment of DNA.
- Gene Editing is a type of genetic engineering in which DNA is inserted, deleted, modified or replaced in the genome of a living organism.
- Unlike early genetic engineering techniques that randomly insert genetic material into a host genome, genome editing targets the insertions to site-specific locations.
- CRISPR is widely considered the most precise, most cost-effective, and quickest way to edit genes.
- The techniques of genetic engineering which include creation of recombinant DNA, use of gene cloning and gene transfer, overcome this limitation and allows us to isolate and introduce only one or a set of desirable genes without introducing undesirable genes into the target organism.

There are three basic steps in genetically modifying an organism —

- identification of DNA with desirable genes;
- introduction of the identified DNA into the host;
- maintenance of introduced DNA in the host and transfer of the DNA to its progeny.

Techniques of Genetic Engineering:

1. **DNA/RNA extraction**: The DNA/RNA is isolated and extraction from cells, this can be done by breaking open the cells using enzymes to destroy macromolecules that are not needed.
2. **PCR (Polymerase Chain Reaction):** The techniques that amplify a single segment of DNA into a thousand copies within a short period. Desired DNA amplified through recurrent replication process.
3. **Enzymes**: Restriction Endonucleases, DNA Ligase, DNA Polymerase.
4. **Gel Electrophoresis:** Gel electrophoresis is the technique that separates molecules according to their size using charge in the electric field.



5. Hybridization, Southern and Northern Blotting
6. Molecular Cloning
7. **Three T's**: Transduction, Transfection, Transformation

Benefits of genetic engineering:

- Genetic modification is a faster and more efficient way of getting the same results as selective breeding.
- Improve crop yields or crop quality, which is important in developing countries. This may help reduce hunger around the world.
- Introduc e herbicide resistance, which results in less herbicides being used, as weeds are quickly and selectively killed.
- Insect and pest resistance can be developed and inserted into the plants. The plant produces toxins, which would discourage insects from eating the crop.
- Sterile insects could be created such as a mosquito. They would breed, which would lead to infertile offspring. This may help with spread of diseases, such as malaria, dengue fever and the Zika virus.

Risks of genetic engineering:

- Transfer of the selected gene into other species. What benefits one plant may harm another.
- Some people believe it is not ethical to interfere with nature in this way. Also, GM crop seeds are often more expensive and so people in developing countries cannot afford them.
- GM crops could be harmful, for example toxins from the crops have been detected in some people's blood.
- GM crops could cause allergic reactions in people.
- Pollen produced by the plants could be toxic and harm insects that transfer it between plants.

Difference between Gene therapy and Gene editing:

- All concepts of Gene therapy, Gene editing, and CRISPR CAS9 are interlinked.
- We use Gene editing for multiple reasons like designer babies, treatment of genetic disorders, for invention of medicines, etc, if we are editing Gene for health-related then it is called Gene therapy. Besides, there is also a difference of degree, in Gene therapy we don't replace the Gene.
- In gene editing, a mutated gene is revised, removed, or replaced at the DNA level.
- In gene therapy, the effect of a mutation is offset by inserting a "healthy" version of the gene, and the disease-related genes remain in the genome.
- Both approaches may provide a durable benefit to patients, and both gene therapy and gene editing, alone or in combination, may lend themselves to the development of transformative genomic medicines.
- **Gene therapy** is a technique that modifies a person's genes to treat or cure a disease. Gene therapies can work by several mechanisms:
    - Replacing a disease-causing gene with a healthy copy of the gene
    - Inactivating a disease-causing gene that is not functioning properly
    - Introducing a new or modified gene into the body to help treat a disease
- Gene therapy products are being studied to treat diseases including cancer, genetic diseases, and infectious diseases.

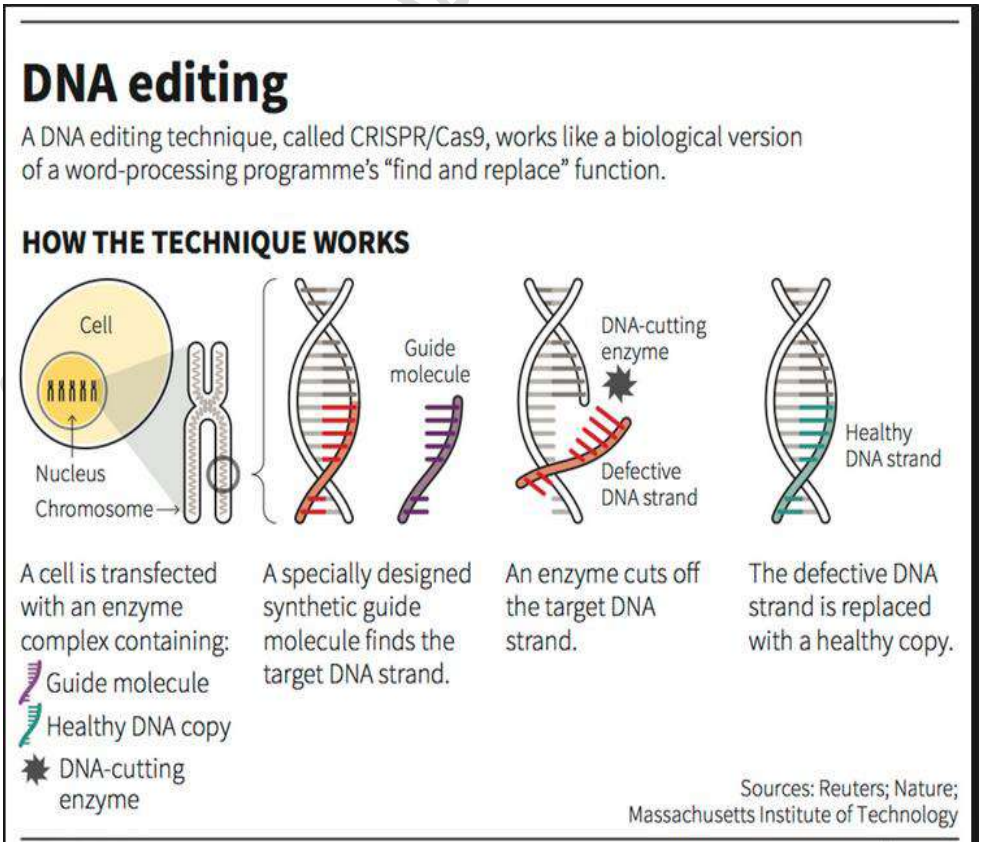
- **Types**
  - **Somatic Gene Therapy:** Effects will not be transferred to next generation
  - **Germline Gene Therapy:** Effects transferred to next generation

Mitochondrial Gene Therapy (MGT):

- Mitochondria are tiny rod-like structures in cells that act as powerhouses, generating the energy that allows our bodies to function.
- Unusually, they have their own DNA, distinct from the genetic material within the cell nucleus.
- Mitochondrial DNA (mtDNA) makes up about 0.1% of a cell's total DNA and does not affect individual characteristics such as appearance and personality.
- MGT techniques essentially swap a woman's defective mitochondrial DNA with that of a donor. The resulting embryo's DNA will mostly come from the two parents who supplied the egg and sperm, but a tiny proportion – a fraction of a percentage – will come from the donor.
- All cells have mitochondria, which are like power packs for the cells and create the energy that keeps cells alive. While a child's DNA is a mixture from both the mother and father, mitochondria are separate "packages of genetics" that come solely from the mother.
- Some people have a mitochondrial disease — a problem with the genetics in their mitochondria — which can lead to severe, life-threatening conditions, although this is rare.
- One treatment for a woman who might have one of these diseases is to replace the mitochondria in her eggs via IVF.
- This can be done via a process like the one used in Greece where the DNA is taken out of the woman's egg and put into a donor woman's egg once the DNA has been stripped from it, which is then fertilized with sperm to create an embryo.

CRISPR-Cas9:

- CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) – Cas9 (CRISPR-associated protein 9) is a unique technology that enables geneticists and medical researchers to edit parts of the genome by removing, adding, or altering sections of the DNA.



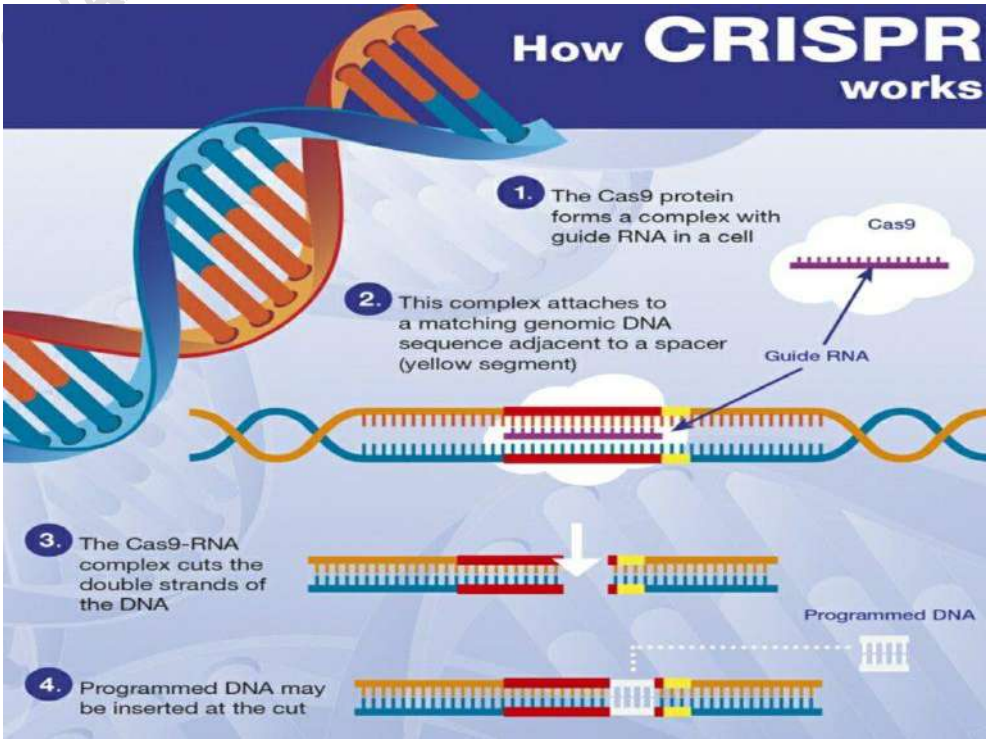
- It is currently the simplest, most versatile, and precise method of genetic manipulation and is therefore causing a buzz in the science world.

How does it work?

- The CRISPR-Cas9 system consists of two key molecules that introduce a change into the DNA. These are:
  - an enzyme called Cas9. This acts as a pair of 'molecular scissors' that can cut the two strands of DNA at a specific location in the genome so that bits of DNA can then be added or removed.
  - a piece of RNA called guide RNA (gRNA). This consists of a small piece of pre-designed RNA sequence (about 20 bases long) located within a longer RNA scaffold. The scaffold part binds to DNA and the pre-designed sequence 'guides' Cas9 to the right part of the genome. This makes sure that the Cas9 enzyme cuts at the right point in the genome.
- The guide RNA is designed to find and bind to a specific sequence in the DNA. The guide RNA has RNA bases that are complementary to those of the target DNA sequence in the genome. This means that, at least in theory, the guide RNA will only bind to the target sequence and no other regions of the genome.
- The Cas9 follows the guide RNA to the same location in the DNA sequence and makes a cut across both strands of the DNA.
- At this stage, the cell recognizes that the DNA is damaged and tries to repair it.
- Scientists can use DNA repair machinery to introduce changes to one or more genes in the genome of a cell of interest.

Advantages of Genetic Engineering:

- Genetically Modified (GM) Crops: Genetic engineering made it possible to create crop varieties regarded as "more beneficial" terms of coming up with crops with the desired traits.
  - Examples of genetically-engineered plants (Bt Cotton) with more desirable traits are drought-resistant plants, disease-resistant crops, plants that grow faster, and plants fortified with more nutrients.
- Treatment of Genetic Disorders and Other Diseases: Through genetic engineering, genetic disorders may also



be fixed by replacing the faulty gene with a functional gene.
    - Disease-carrying insects, such as mosquitoes, may be engineered into becoming sterile insects.
    - This will help in curbing the spread of certain diseases, e.g. malaria and dengue fever.
- Therapeutic Cloning: It is a process whereby embryonic cells are cloned to obtain biological organs for transplantation.

Challenges of Genetic Engineering:

While genetic engineering is beneficial in many ways, it is also implicated in certain eventualities deemed as "unpleasant" or disadvantageous.

- Irreversible Changes: Nature is an extremely co mplex interrelated chain. Some scientists believe that introducing genetically-modified genes may have an irreversible effect with consequences yet unknown.
    - GMO that can cause harmful genetic effects, and genes moving from one species to another that is not genetically engineered.
    - It has been shown that GMO crop plants can pass the beneficial gene along to a wild population which may affect the biodiversity in the region. An example is the sunflowers genetically-engineered to fend off certain insects.
- Health Issues Related with GMO Crops: There are concerns over the inadvertent effects, such as the creation of food that can cause an allergic reaction.
- Bioethics: Genetic engineering borderlines on many moral and ethical issues. One of the major questions raised is if humans have the right to manipulate the laws and course of nature.

ORGAN TRANSPLANTATION

Organ transplant: Scenario in India:

- The number of organ transplants has increased by over three times from 4,990 in 2013 to 15,561 in 2022.
- The most common organ transplant is for the kidney, followed by liver, heart, lung, pancreas, and small bowel transplants.
- In 2022 alone, nearly 12,791 living donor transplants and 2,765 deceased donor transplants were conducted.
- Only 1,743 (14%) of the organs were from deceased donors, while the majority of organs harvested were from living donors, specifically kidney and liver donations.
- Nearly all deceased organ donations in 2021 were in 15 states, with the top five accounting for over 85% of the total.

Need for Increased Organ Donations in India:

- India conducts the third highest number of transplants in the world, but the number of organs needed is still much higher than the number of transplants.
- Lifestyle diseases are increasing the demand for organs as heart and lungs can only be retrieved from deceased donors.
- Nearly 1.5 lakh persons die in road traffic accidents every year in India, many of whom can ideally donate organs.
- Organ transplantation also helps to reduce the burden on the healthcare system by reducing the need for

Government Steps to facilitate Organ Transplant in India:

- **Transplantation of Human Organs and Tissues Act (THOTA): It was enacted in 1994 and governs organ transplantation in India. The act also establishes the National Organ and Tissue Transplant Organization (NOTTO) and State Organ and Tissue Transplant Organizations (SOTTO) to oversee organ donation and transplantation activities.**
- **National Organ Transplant Programme (NOTP): It was launched in 2014 to create a national registry of organ donors and recipients, establish more organ transplant centres, and raise awareness about organ donation.**
- **Deceased Organ Donation Program: It was launched by Ministry of Health and Family Welfare to encourage organ donation from deceased individuals.**
- **National Organ Donation Day: The government of India has designated November 27 as National Organ Donation Day to raise awareness about the importance of organ donation and encourage people to pledge to donate their organs.**
- **Swasth Bharat Yatra: It is a government-led campaign to promote healthy living, prevent lifestyle diseases, raise awareness about organ donation and encourages people to pledge to donate their organs.**
- **National Organ and Tissue Transplant Registry: It has established a National Organ and Tissue Transplant Registry to maintain records of organ donations and transplantation in the country to help in the development of policies and strategies to promote organ donation and transplantation.**
- **Organ Retrieval Banking Organization: It is a part of the All-India Institute of Medical Sciences (AIIMS) in New Delhi and is responsible for the retrieval, preservation, and distribution of organs for transplantation in the Delhi-NCR region.**

hospitalization, repeat surgeries, and long-term treatment.

- India has an organ donation rate of 0.52 per million population, much lower than the rate in Spain (49.6 per million).
- Organ donation can help save the lives of multiple people, as one donor can donate several organs and tissues.

STEM CELL

- Stem cells are special cells that can make copies of themselves and change into the many different kinds of cells that the body needs. They have two unique properties that 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 several kinds of stem cells and they are found in different parts of the body at different times.
- Cancer and cancer treatment can damage the hematopoietic stem cells. Hematopoietic stem cells are stem cells that turn into blood cells.

Types of Stem Cell:

- **Embryonic Stem Cells:**
    - They supply new cells for an embryo as 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:**
    - They 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:
    - Blood (or 'haematopoietic') stem cells can only replace the various types of cells in the blood.
- **Induced Pluripotent Stem Cells:**
    - 'Induced' means that they are made in the lab by taking normal adult cells, like skin or blood cells, and reprogramming them to become stem cells.
    - Just like embryonic stem cells, they are pluripotent so they can develop into any cell type.

About Stem Cells Transplant:

- A bone marrow transplant is a medical treatment that replaces one's bone marrow with healthy cells. The replacement cells can either come from the person's own body or from a donor.
- A bone marrow transplant is also called a stem cell transplant or, more specifically, a hematopoietic stem cell transplant.
- Transplantation can be used to treat certain types of cancer, such as leukemia, myeloma, and lymphoma, and other blood and immune system diseases that affect the bone marrow.

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.
- Stem cells can then be implanted into a person. For example, Mumbai baby boy was injected with 40 million stem cells and gradually the lungs began to repair. In this case, doctors used mesenchymal stem-cell therapy (these are adult stem cells and are different from Embryonic stem cells) on an experimental basis.

Regulation of Stem Cell usage:

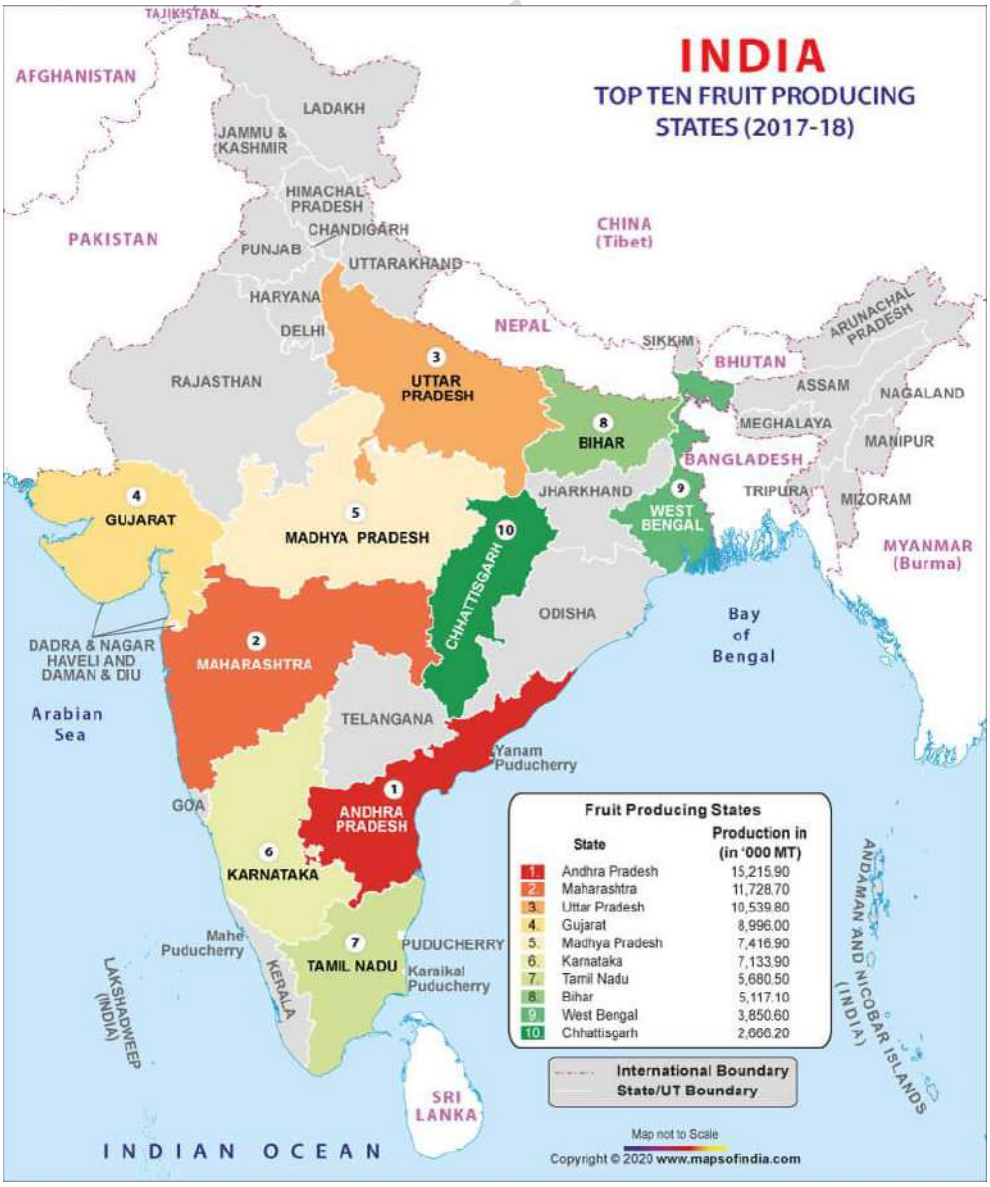
- In 2016, the International Society of Stem Cell Research (ISSCR) released model voluntary guidelines for stem cell research.

- In 2017, the National Guidelines for Stem Cell Research was given by the Department of Biotechnology and the Indian Council of Medical Research.
- The guidelines banned the commercial use of stem cells as 'elements of therapy'.
- The permission of the CDSCO (Central Drugs Standard Control Organization) is required for conducting clinical trials using stem cell therapy.
- The 2017 guidelines recognized all stem cell therapies, apart from the hematopoietic stem cell therapy (HSCT), as only investigational at present. It also gave a list of indications for which HSCT can be used.
- The guidelines also prohibited clinical trials involving 'xenogeneic cells. breeding of animals in which human stem cells have been introduced is prohibited.
- The guidelines permit only umbilical cord blood banking.
- Import of stem cells and also international research collaborations in the field require CDSCO's approval.
- In 2018, the ministry of health and family welfare proposed the exclusion of 'minimally manipulated stem cells' from the purview of the Drugs and Cosmetics Rules of 1945.
- This would classify these products as 'therapy' as opposed to 'drugs' and hence protect it from the screening and regulation by CDSCO.
- This would demarcate 'stem cell-based drugs' from 'stem cell therapy'.
- The use of stem cells for therapy in India requires permission from the government.
- This is because stem cell-derived products are considered as 'drugs' under the New Drugs and Clinical Trial Rules, 2019, as of March, 2019.

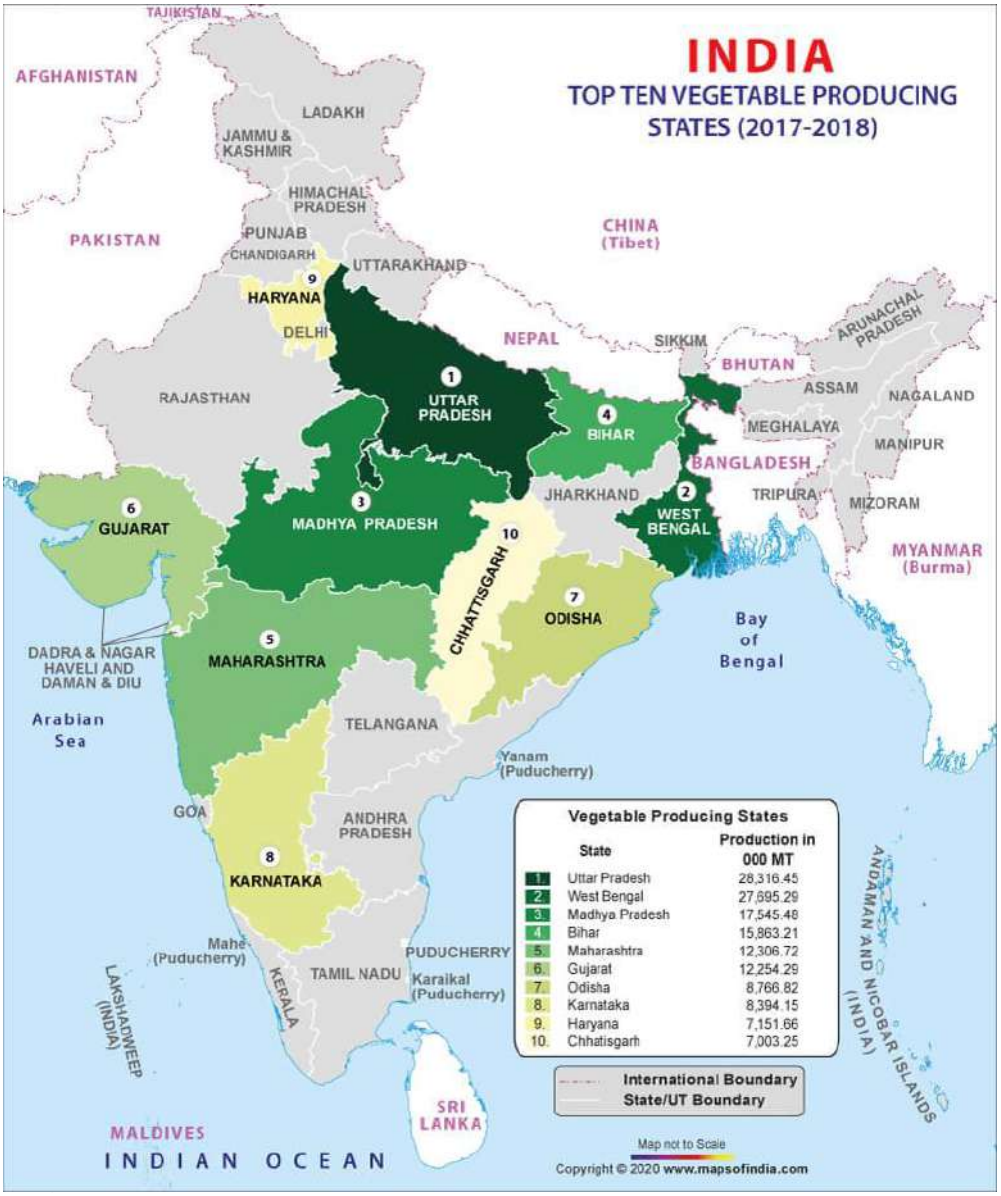
HORTICULTURE

- Horticulture is the branch of agriculture concerned with intensively cultured plants directly used by man for food, medicinal purposes and aesthetic gratification.
- In simpler words, it is cultivation, production and sale of vegetables, fruits, flowers, herbs, ornamental or exotic plants.
- L.H. Bailey is considered the Father of American Horticulture and M.H. Mari Gowda is considered the Father of Indian Horticulture.
- Horticulture is a branch of agriculture relating to the cultivation of fruits, vegetables and ornamental plants.
- Horticulture is a capital- and labor-intensive agriculture.
- India is bestowed with varied agro-climates, which is highly favorable for growing large number of horticultural crops such as fruits, vegetables, spices, root tuber, ornamental, aromatic plants, medicinal species and plantation crops like coconut, arecanut, cashew and cocoa.
- Presently, horticulture crops occupy about 10 per cent of the gross cropped area of the country, producing about 160 million tones.
- India is the second largest producer of fruits and vegetables.
- The total production of fruits has been estimated at about 63 million tons from 5.7 million hectares. Vegetables occupy an area of 7.8 million hectares with a production of 125 million tons (India 2009).
- India's share in world fruit and vegetable production is 12.6 per cent and about 14.0 per cent respectively.

Classification:



- **Pomology:** Planting, harvesting, storing, processing, and marketing of **fruit and nut** crops.



- **Olericulture:** Producing and marketing **vegetables.**
- **Arboriculture:** Study, selection and care of individual **trees, shrubs or other perennial woody plants.**
- **Ornamental Horticulture:** It has two subparts-
- **Floriculture:** Production, use and marketing of **floral crops.**
- **Landscape Horticulture:** Production and marketing of **plants used to beautify** the outdoor environment.

Features of Horticulture in India:

- Horticulture sector has become one of the major drivers of growth as it is **more remunerative than the agricultural sector (food grains mainly).**
- This sector provides **employment possibilities** across primary, secondary and tertiary sectors.
- Horticulture crops, fruits are **more resilient to change in weather conditions** and the **vegetables augment the income** of small and marginal farmers.
- **Water utilisation** is very **low, minimising the risk of crop failure** and it can be done on smaller farms.

- **Multiple crops are planted simultaneously** to get **more yield** and to **use the maximum of the fertilisers.**
- This sector enables the population to eat a **diverse and balanced diet** for a healthy lifestyle.
- It became a **key driver for economic development** in many of the states in the country where **Division of Horticulture of Indian Council of Agricultural Research is playing a pivotal role.**

Fruits:

- Indian climate favors the development of a large range of varieties of fruits.
- Indians share in the total fruit production of the world is **10 per cent.**
- Mango, banana, citrus, pineapple, papaya, guava, sapota (cheekoo), jackfruit, litchi, and grapes, among the tropical and subtropical fruits; apple, pear, peach, plum, apricot, almond, walnut, among the temperate fruits; and aonla, ber, pomegranate, fig, phalsa, among the arid fruits are important.
- **India's top produced fruit is Banana (32%), followed by Mango (21%). On the other hand, Mango is cultivated on largest area in comparison to any other fruit. Top cultivator state of Banana is Tamil Nadu; and of Mango are Uttar Pradesh (24.4%) and Andhra Pradesh (24.5%).**
- India leads the world in the production of mango, banana and nimboo (arid lime), and in productivity of grapes per unit land area.
- About 10 per cent of world's mango and 23 per cent of world's banana are produced in the country.
- **In grapes, India has recorded the highest productivity per unit area in the wor ld**.

Vegetables:

- More than 40 kinds of vegetables are grown in India.
- Important vegetable crops grown in the country are potato, tomato, onion, chilies, carrot, radish, turnip, beans, lady finger, guard, letuce, brinjal, cabbage, cauliflower, spinach, okra, and peas.
- **India's largest produced vegetables are Potato, followed by Tomato. Among vegetables, largest area under cultivation is that of Potato.**
- India is next only to China in area and production of vegetables, and occupies the first position in the production of cauliflower, second in onion, and third in cabbage in the world.
- The area and production of major vegetables during 2004-05 is estimated at 6.30 million hectares with a production 01.93 million tones and average productivity of 11.8 tons per hectare.
- **During 2016-17, total vegetable production was highest in case of Uttar Pradesh (26.4 million tons) followed by West Bengal (25.5 million tons).**

Horticulture in India:

- Horticulture is the cultivation of garden plants, fruits, berries, nuts, vegetables, flowers, trees, shrubs and turf. Horticulturists work for plant propagation, crop production, plant breeding, genetic engineering, plant biochemistry, plant physiology, storage, processing and transportation.
- Horticulturalists use modern nurseries for the production of seedlings and mother plants. These plants are propagated through different methods such as seeds, inarching, budding, veneer grafting, patch budding and soft wood grafting.

- **Tamil Nadu** – This State is suitable for horticulture because of its rich bio diversity and appropriate climate. A wide variety of tropical fruits, temperate fruits, vegetables, **spices, condirnents, plantation crops, medicinal herbs, aromatic plants and commercial flowers** are grown here.
- **Jammu and Kashmir** – The horticulture industry is the mainstay of the rural economy of Kashmir. Every year, this industry earns revenue of over Rs. 50 crores. Fruits cultivated in Kashmir include a variety of **apple, pears, cherries, walnuts, almonds, peaches, saffron, apricots, strawberries and plums.**
- **Odisha** – Here horticulture consists of the cultivation of fruits **like pineapple, mango and cashew, vegetables like mushroom, drumstick, and onions; and spices like ginger and turmeric**. Strategies by the State Government for the promotion of horticulture include supplying better quality planting material at subsidized rates, conducting training programmers; field demonstrations and encouraging cultivation at lift irrigation points.
- **Punjab** – Around 1, 82,600 hectares of land were brought under horticulture crops till 2002. This area has grown a lot since then. Currently, fruits **like sweet orange, kinnow, guava, peace, litchi and mango** are grown in the region.
- **Maharashtra** – Horticulture involves the cultivation of fruits like **banana, fig, grapes, custard apple, wood apple, jhambul, pomegranate, mandarin orange, guava and sweet orange**. Vegetables, medicinal plants and spices are also grown in the state.
- **Tripura** – It the land of high hills and hillocks interspersed with rivers and valleys. It has moderately warm and humid climate coupled with well – distributed annual rainfall of 2500 mm. This terrain and climate is ideally suited for rainfed horticulture. Fruits like **pineapple, jackfruit, orange, litchi, cashew nut, coconut, lime and lemon** are produced in abundance.
- **Assam** – Some of the popular horticulture crops grown in Assam are **carambola, wood apple, jackfruit, ginger, oranges, olives, figs and bamboo shoot**. Almost 75 per cent of the population of the state derives their livelihood from agriculture and horticulture.
- **Andhra Pradesh** – This State has a varied climate and is suitable for a wide range of horticultural crops. It leads in the production of **citrus, chillies, turmeric and oil palm**. Andhra Pradesh is also a **major producer of cocoa, cashew, guava, coriander, banana, ginger and coconut.**

Horticultural Sector in India: Retrospect and Prospect:

- Horticulture has become a key driver for economic development in many of the state in the country and it **contributes 30.4 per cent to GDP of agriculture**.
- Horticultural crops play a unique role in India's economy by improving the income of the rural people.
- Cultivation of these crops is labor intensive and as such they generate lot of **employment opportunities for the rural population**.
- Fruits and vegetables are rich source of vitamins, minerals, protein, and carbohydrates etc. which are essential in **human nutrition**. Thus, cultivation of horticultural crops plays a vital role in the prosperity of a nation and is directly

linked with the health and happiness of the people.

- Globally, **India is the second largest produce r of fruits and vegetables**. It is the **largest producer of mango, banana, coconut, cashew, papaya, pomegranate** etc, in the world and the **largest producer and exporter of spices**.
- It ranks first in productivity of grapes, banana, cashew, peas, papaya etc., and the export growth of fresh fruits and vegetables in term of value is 13 per cent and of processed fruits and vegetables is 17.42 per cent in 2011-12.
- The focused attention on horticulture has paid dividend and resulted in increased production and export. The production of horticultural produce has increased 7 – fold which ensured nutritional security and employment opportunities in the country.
- The total horticulture production has increased from 211.2 million tonnes in 2007-08 to 28.17 million tonnes in 2017-18.

Horticulture Vs Agriculture:

- Horticulture primarily differs from agriculture in two ways.
- First, it generally encompasses **a smaller scale of cultivation**, using small plots of mixed crops rather than large fields of single crops.
- Secondly, **horticultural cultivations generally include a wide variety of crops**, even including fruit trees with ground crops.
- Horticulture sector has marked higher growth as compared to agriculture sector in India from 2012-13 to 2017-18.

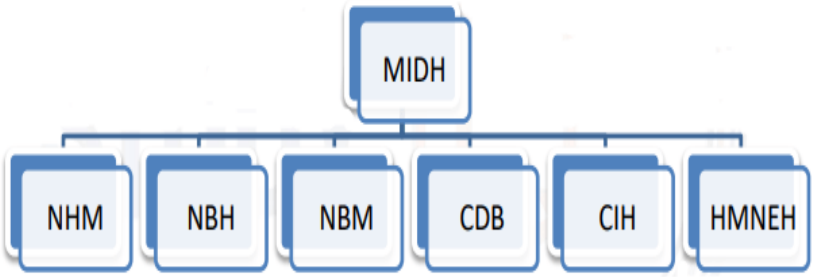
Importance and Scope of Horticulture in India:

- India with more than 68 million tons of fruits and 121 million tons of vegetables in 2011-12 is the second largest producer of fruits and vegetables in the world, next only to China.
- However, per capita consumption of fruits and vegetables in India is only around 46 gram and 130 grams respectively against a minimum of about 92 gram and 300 grams respectively recommended by Indian Council of Medical Research and National Institute of Nutrition.
- With the present level of population, the annual requirement of fruits and vegetables will be of the order of 110 million tons and 360 million tons respectively (Karunakaran and Palanisami, 2012).
- It is estimated that India has 12.66 million hectares of cultivable wasteland as on 2011- 12, which is lying idle, which can be brought under orchard crops without curtailing the area under food crops.
- The country has **abundant sunshine throughout year, surplus labour and widely varied agro – climatic regions, which offer high potential for successful and profitable commercial horticulture. The major crops in case of fruits are mango, banana, citrus, apple, pineapple and in case of vegetables are potato, onion, tomato and other seasonal vegetables.**

Midh (Mission for Integrated Development of Horticulture):

- It is a centrally sponsored scheme that has been launched for the holistic development of horticulture in the country's XII plan.

- The scheme, which has taken off from 2014-15, **integrates the ongoing schemes of National Horticulture Mission, Horticulture Mission for North East & Himalayan States, National Bamboo Mission, National Horticulture Board, Coconut Development Board and Central Institute for Horticulture, Nagaland.**



- MIDH will have the following sub-schemes and area of operation:

SL. NO.	Sub Scheme	Target group / area of operation
1.	NHM	All states & UTs except state in NE and Himalayan Region.
2.	HIMNEH	All states in NE and Himalayan Region.
3.	NBM	All states & UTs
4.	NHB	All states & UTs focusing on commercial horticulture.
5.	CDB	All States and UTs where coconut is grown.
6.	CIH	NE states, focusing on HRD and capacity building.

Objectives:

- Main objectives of the Mission are:
  - Promote **holistic growth of horticulture sector**, including bamboo and coconut through **area based regionally differentiated strategies**, which includes research, technology promotion, extension, post harvest management, processing and marketing, in consonance with comparative advantage of each state/region and its diverse agro-climatic features.
  - **Encourage aggregation of farmers into farmer groups** like FIGs/FPOs and FPCs to bring economy of scale and scope.
  - Enhance horticulture production, augment farmer's income and strengthen nutritional security.
  - **Improve productivity** by way of quality germplasm, planting material and water use efficiency through Micro Irrigation.
  - **Support skill development and create employment generation opportunities** for rural youth in horticulture and post-harvest management, especially in the cold chain sector.

Mission Interventions:

- The Mission will be **demand and need based in each segment**. Technology will play an important role in different interventions. Technologies such as **Information Communication Technology (ICT), Remote Sensing and Geographic Information System** will be widely used for planning and monitoring purposes including identification of site for creating infrastructure facilities for post-harvest management, markets and production forecasts.
- The interventions envisaged for achieving desired goals would be varied and regionally differentiated with focus on potential crops to be developed in clusters by deploying modern and hi-tech interventions, duly ensuring backward and forward linkage.

Key Features of Midh:

- Base line survey
- Involvement of PRI

- Area based Annual and Perspective Plans
- Applied Research with focus on Region (HMNEH) and crop
- Demand driven production based on cluster approach
- Availability of quality seeds and planting material.
- Technology driven programs to improve productivity and quality, e.g.
    - Introduction of improved varieties.
    - Rejuvenation with improve cultivars.
    - High Density Plantation.
    - Use of Plastics.
    - Bee-keeping for crop pollination
    - Capacity building of farmers and personal.
    - Mechanization.
    - Demonstration of latest technologies.
- Post Harvest Management and cold chain storage.
- Marketing infrastructure development.
- Harnessing the capacities of FIGs/FPCs/FPOs
- Data base generation, compilation and analysis.
- Technical Support by NLAs.
- Production & Distribution of Planting Material Nurseries:
    - Production and distribution of good quality seeds and planting material will receive top priority.
    - States will have a network of nurseries for producing planting material, which were established through Central or State assistance.
    - To meet the requirement of planting material (for bringing additional area under improved varieties of horticultural crops and for rejuvenation program for old/senile plantations), assistance will be provided for setting up new hi-tech nurseries and small nurseries under the public as well as private sector.
- **Import of planting material**
    - With a view to procuring best quality planting material of latest varieties of horticultural crops, a component of providing assistance for meeting cost of planting material imported from abroad has been included.
    - **Area expansion will be done in conjunction with Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS)** under which cost on labor component of work such as digging, fencing etc could be met with.
- **Rejuvenation / Replacement of senile plantations / canopy management**
    - Rejuvenation program will address orchards and plantations which have low productivity.
    - It will be implemented through individual farmers, farmer's cooperatives, Self-Help Groups, growers' associations and commodity organizations.
- **Creation of Water Sources**
    - Under the Mission, assistance will be provided for creating water sources through construction of community tanks, farm ponds/reservoirs with plastic / RCC lining to ensure lifesaving irrigation to horticulture crops.
    - **This will be in conjunction with MNREGS** and wherever possible adequate convergence has to be ensured. These water bodies may

be linked with Micro Irrigation facility for judicious use of water.

- **Protected Cultivation**
  - Activities like construction of green houses, shade net house, plastic mulching, and plastic tunnels, anti-bird/hail nets would be promoted under the Mission.
  - NHB will implement projects having area above 2500 sq. m.
  - Provision has been made for selecting a variety of construction material for green houses and shade net houses.
  - The cost is inclusive of irrigation systems**. Preference will be given to using locally available material to minimize cost of construction of such structures**. However, for availing/ subsidy assistance, all material/technologies should conform to BIS standards.
- **Precision Farming Development and Extension through PFDCs:**
  - Existing Precision Farming Development Centres (PFDC) will be involved to develop regionally differentiated technologies for their validation and dissemination.
  - Twenty-two PFDCs are anchored in SAUs, ICAR Institute and IIT, Kharagpur. Because of their experience in conducting applied research on plastic culture application, they have expertise in terms of manpower and equipment.
  - PFDCs will be equipped with necessary hardware and software needed for generating information on precision farming techniques on the farmers' field.
  - The ultimate goal is to provide requisite information to farmers so that they are in a position to apply necessary inputs. Other organizations like ICAR Institutes and Institutes in Private sector will also be involved in technology development. For this purpose, financial assistance would be provided to PFDCs.
- **Promotion of Integrated Nutrient Management (INM) and Integrated Pest Management (IPM)**
  - Assistance for Integrated Nutrient Management (INM) and Integrated Pest Management (IPM) measures will be provided for horticultural crops as well as bamboo.
  - Assistance will also be available for developing facilities like Disease Forecasting Units (DFUs), Bio control Labs, Plant Health Clinics and Leaf/Tissue Analysis labs, both under public and private sector except for DFUs, which will be only in public sector. It will be the responsibility of the beneficiary to get the bio control agents registered for commercial sale.
  - Under INM component, subsidy can be availed for use of **liquid biofertilizer of N, P and K such as Rizobium/Azospirillum/Azotobactor, Phosphate Solubilising Bacteria (PSB) and Potash Mobilizing Bactaria(KMB)**, to be applied in combination, in demonstration and other program, for which total

assistance will be limited to the 50% of cost, or Rs 300.00 per ha, for maximum area of four hectare per beneficiary.

- **Organic Farming:**
  - Organic farming in horticulture will be promoted to harness environmental and economic benefits by way of adoption of organic farming techniques along with its certification.
  - For adopting organic farming for perennial and **non perennial food crops, vegetables, aromatic plants spices etc** additional assistance will be given @50% of cost over and above the area expansion program for a maximum area of 4 ha per beneficiary, spread over the period of three years.
- **Tissue Culture Unit**
  - New Tissue Culture (TC) units will be established and assistance will be provided for rehabilitation/strengthening of existing TC Units.
  - New TC units will produce 25 lakh plants of the mandated crop for which protocols are available for commercial use, except Date palm.
- **Program on horticulture and bamboo R & D**
  - The Program on horticulture and bamboo R & D will be based on applied research in the areas of:
    - Seed & Planting material, including import of planting material,
    - Technology standardization.
    - Technology acquisition.
    - Imparting training & Front-Line Demonstration in a project mode.
- **Production and Productivity Improvement**
  - The Mission will focus primarily on increasing both production and productivity through adoption of improved and appropriate technologies for ensuring quality, including **genetic up gradation of all horticultural crops and addressing challenges of climate change**.
  - Special emphasis will also be given for adoption of area-based cluster approach towards developing regionally differentiated crops, which are agro-climatically most suitable for the State/region. Cluster approach will also help in aggregation of farmers into FPOs/FPCs.
- **Good Agriculture Practices (GAP):**
  - GAP certification has been introduced to encourage farmers to adopt good agricultural practices in line with global GAP, so that farmers are able to get better price for their produce in domestic as well as international market.
- **Centre of Excellence for Horticulture:**
  - Centres of Excellence may be established for different horticultural products which will serve as demonstration and training centres as well as source of planting material and vegetable seedlings under protected cultivation.

- **Human Resource Development (HRD) in horticulture:**
  - Under HRD program training of farmers, entrepreneurs, field level workers and officers will be taken up.
  - Program for providing appropriate training to farmers for adoption of high yielding varieties of crops and farming system will be taken up state level and outside the state
- **Pollination support through bee-keeping**
  - In order to maximize agricultural production, honey-bee can be used as an important input. The responsibility of coordinating the bee keeping development program in state will be vested in the identified state designated agency (SDA) or any institution/society having capability.
  - Nation Bee Board (NBB) will be responsible for coordinating bee keeping activity in states.

- **Horticulture mechanization**
  - Horticulture mechanization is aimed to improve farm efficiency and reduce drudgery of farm work force.
  - Assistance in this regard will be provided for activities such as procurement of power operated machines and tools, besides import of new machines.
- **Technology dissemination through demonstrations/ front line demonstrations.**
  - Latest technologies will be promoted on crop specific cultivation, use of IPM/INM, protected cultivation, organic farming through farmer participatory demonstration in a compact area of one ha, which will be organized at strategic locations in farmer's field for which assistance will be limited to 75% of cost.
- **Integrated post-harvest management.**
  - Under post-harvest management including that for medicinal plants, activities like handling, grading, pre-conditioning, packaging, transient storage, transportation, distribution, queuing and repining and where possible long-term storage can be taken up.
- **Exiting schemes of the Directorate of Marketing and Inspection (DMI) and National Cooperative Development Corporation (NCDC) will be leveraged** to the extent possible.
- **MIDH would include projects relating to establishment of pre-cooling units "on – farms" pack houses**, mobile pre-cooling units staging cold room, cold storage units with and without controlled atmosphere capability, integrated cold chain system, supply of refrigerated vans, refrigerated containers, primary/mobiles processing units, ripening chambers, evaporative/low energy cool chambers preservation units, onion storage units and zero energy cool chambers.
- **Cold Chain Infrastructure**
  - Assistance for setting up of new cold storage infrastructure will available only to multi-chamber cold storage units with technologies which are energy efficient with provision for thermal insulation, humidity

control, advanced cooling system, automation, etc. having specifications and standards approved by the ministry.

- **Processing & Value Addition:**
  - Processing of horticultural produce and value addition is an important activity.
  - While primary/minimal processing units will be promoted under NHM, large scale processing units will be promoted by Ministry of Food Processing Industries (MFPI), out of their ongoing Schemes. However, food processing units in Himanchal Pradesh, Jammu & Kashmir and Uttarakhand will be promoted under HMNEH sub scheme.
- **Creation of Market Infrastructure:**
  - Main objectives of providing assistance under this component are:
    - **To encourage investments from private and cooperative sectors** in the development of marketing infrastructure for horticulture commodities
    - Strengthen existing horticulture markets including wholesale and rural markets.
    - Focus on **promotion of grading, standardization and quality certification of horticulture produce** at farm/market level to enable farmers to realize better price.
    - Create general awareness among farmers, consumers, entrepreneurs and market functionaries on market related agricultural practices.
  - Assistance for setting up markets only be given to those States/UTs which have amended their State Agricultural Produce Marketing Committee (APMC) Act and have also notified the amended rules there under to implement the provisions for:
    - Setting up of new markets in private and cooperative sector
    - Direct marketing (sourcing of horticulture produce directly from growers by wholesalers/bulk retailers/processors/exporters/end users). If trade transaction of horticulture perishables takes place outside the market-yard, no market fee should be levied.
    - Doing away with requirement of having premises within the market yard for grant of license.
    - **Contract farming**.
    - Waiver of market fee on perishable horticulture produces.
- **Horticulture Database:**
  - Provision has been made for strengthening horticulture statistical database, which will be implemented through active involvement of SHMs, Directorate of Horticulture and Institutes like Indian Agricultural Statistical Research Institute etc. on a project mode.

- Institutions like IASRI will be engaged as NLA for undertaking specific project on horticulture statistics

- **Collaboration with international agencies**
  - Attempts will be made to collaborate with international agencies like FAO, Word bank. Asian Development Bank and which have a development modern horticulture sector for taking up program for development of horticulture.
  - Evaluation and other studies will also be the part of program.

Challenges:

- Horticulture **does not enjoy a safety net like the Minimum Support Price (MSP)** for foodgrains.
- **Lack of good cold chain storage and transport networks** to extend the life of perishable products.
- **Very less or limited input by machinery and equipment** so it is tough to minimise the time restraints.
- **Higher input costs** than foodgrains **make it a difficult set up,** especially when there is no support from the local governments to the smaller farmers.
- It gets challenging for marginal farmers to cope with the **high price fluctuations.**
- **Limited availability of market intelligence,** mainly for exports makes it a tougher option to choose.

Steps Taken by the Government:

- **Increased focus** on planting material production and cluster development programmes.
- **Development of improved techniques** for the production of **disease-free quality planting materials**.
- **Technology up-gradation** for **water and nutrient efficiency** through micro-irrigation and fertigation
- **Farm mechanisation** to increase harvesting and processing efficiency and to reduce crop loss has been implemented by developing horticulturalists.
- Development of Good Agricultural Practices (GAP) for various medicinal plants.
- Development of low-cost environment-friendly cool chambers for on-farm storage.
- Regional and Crop-specific Training and Demonstration Programmes.
- **Credit push** through **Agri Infra Fund**, formation and promotion of the **Farmer Producer Organizations** (FPOs) are the right steps in this direction.

OCEAN RESEARCH AND DEVELOPMENT
DEEP OCEAN MISSION (DOM)

About:

- It will be a mission mode project to support the Blue Economy Initiatives of the Government of India.
- Blue Economy is the sustainable use of ocean resources for economic growth, improved livelihoods and jobs, and ocean ecosystem health.
- The technology and expertise needed in such missions is now available with only five countries - US, Russia, France, Japan and China.
- India will now be the sixth country to have it.

Major Components:

- **Development of Technologies for Deep Sea Mining, and Manned Submersible:**
  - A **manned submersible will be developed to carry three people** to a depth of 6,000 metres in the ocean with a **suite of scientific sensors and tools.**
  - An **Integrated Mining System** will be also developed for mining **polymetallic nodules** at those depths in the central Indian Ocean.
    - **Polymetallic nodules** are rocks scattered on the seabed containing iron, manganese, nickel and cobalt.
  - The exploration studies of minerals **will pave the way for commercial exploitation in the near future,** as and when commercial exploitation code is evolved by the International Seabed Authority, an United Nations (UN) organisation.

Development of Ocean Climate Change Advisory Services:

- It entails developing a suite of observations and models to understand and provide future projections of important climate variables on seasonal to decadal time scales.

Technological Innovations for Exploration and Conservation of Deep-sea Biodiversity:

- Bioprospecting of deep sea flora and fauna including microbes and studies on sustainable utilization of deep sea bio-resources will be the main focus.

Deep Ocean Survey and Exploration:

- It will explore and identify potential sites of multi-metal Hydrothermal Sulphides mineralization along the Indian Ocean mid-oceanic ridges.

Energy and Freshwater from the Ocean:

- Studies and detailed engineering design for offshore Ocean Thermal Energy Conversion (OTEC) powered desalination plants are envisaged in this proof-of-concept proposal.
- OTEC is a technology which uses ocean temperature differences from the surface to depths lower than 1,000 meters, to extract energy.

Advanced Marine Station for Ocean Biology:

- It is aimed at the development of human capacity and enterprise in ocean biology and engineering.
- It will translate research into industrial application and product development through on-site business incubator facilities.

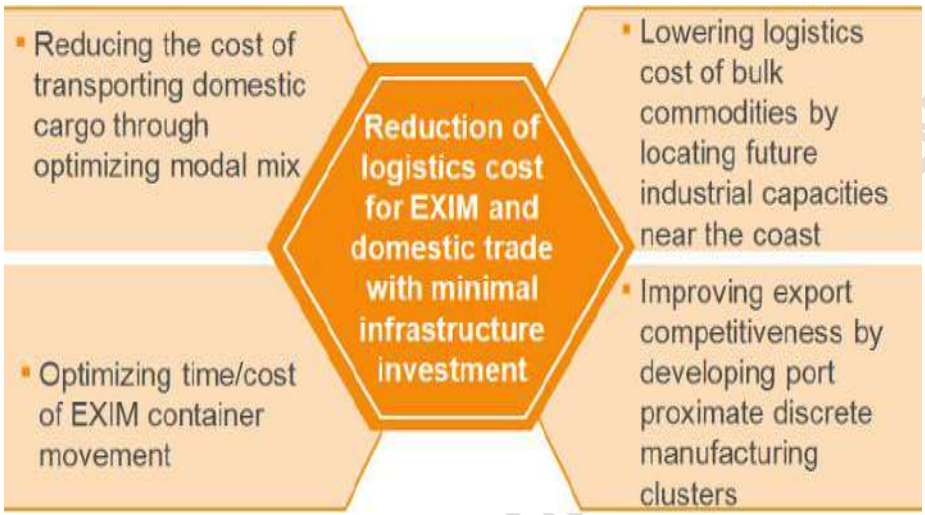
Significance:

- Oceans, which cover 70% of the globe, remain a key part of our life. About 95% of the Deep Ocean remains unexplored.
- Three sides of India are surrounded by the oceans and around 30% of the country's population living in coastal areas, the ocean is a major economic factor supporting fisheries and aquaculture, tourism, livelihoods and blue trade.
- India has a unique maritime position. Its 7517 km long coastline is home to nine coastal states and 1382 islands.
- The Government of India's Vision of New India by 2030 announced in February 2019 highlighted the Blue Economy as one of the ten core dimensions of growth.
- Oceans are also a storehouse of food, energy, minerals, medicines, modulator of weather and climate and underpin life on Earth.

SAGARMALA PROJECT

About:

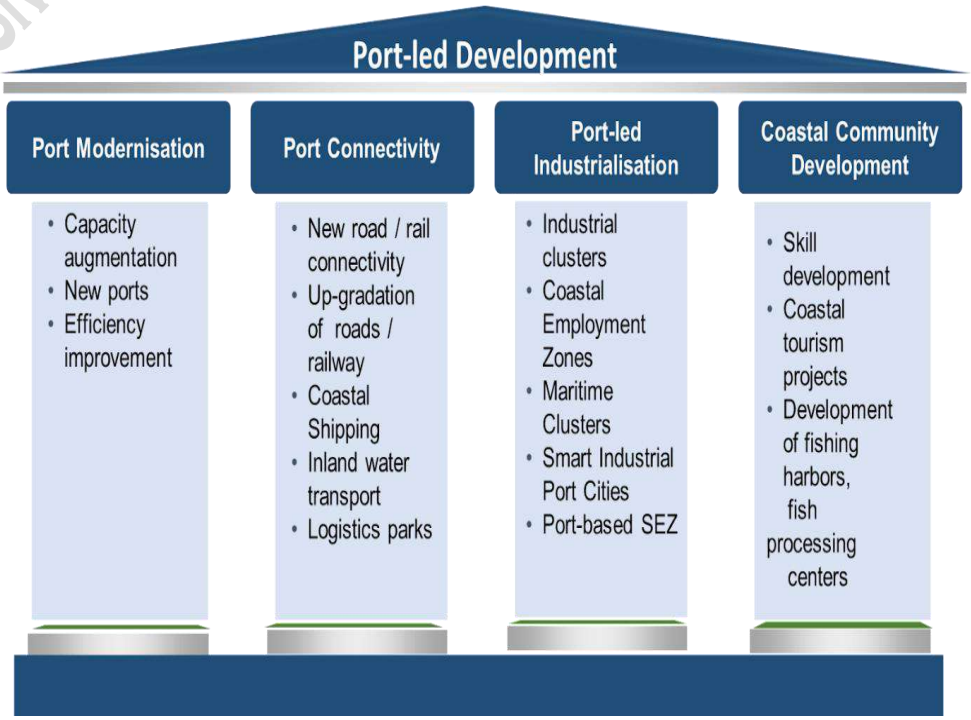
- The Sagarmala Programme was approved by the Union Cabinet in 2015 which aims at holistic port infrastructure development along the 7,516-km long coastline through modernisation, mechanisation and computerisation.
- The vision of the Sagarmala Programme is to reduce logistics costs for EXIM (Export-Import) and domestic trade with minimal infrastructure investment.



- Sagarmala could boost India's merchandise exports to USD 110 billion by 2025 and create an estimated 10 million new jobs (four million in direct employment).
- The Ministry has started the ambitious Project of Sagarmala Seaplane Services (SSPS) with potential airline operators.

Components of the Sagarmala Programme:

- **Port Modernization & New Port Development:** De-bottlenecking and capacity expansion of existing ports and development of new Greenfield ports.
- **Port Connectivity Enhancement:** Enhancing the connectivity of the ports to the hinterland, optimizing cost and time of cargo movement through multi-modal logistics solutions including domestic waterways (inland water transport and coastal shipping).
- **Port-linked Industrialization**: Developing port-proximate industrial clusters and Coastal Economic Zones to reduce logistics cost and time of EXIM and domestic cargo.
- **Coastal Community Development:** Promoting sustainable development of coastal communities through skill development & livelihood generation activities, fisheries development, coastal tourism etc.
- **Coastal Shipping & Inland Waterways Transport:**



Impetus to move cargo through the sustainable and environment-friendly coastal and inland waterways mode.

Issues /Challenges:

- The increased commercial activities through new ports and petrochemical hubs planned on the coast would **hit fishing and also increase the threat of extreme weather events.**
    - Chemical pollution on the coast has already put the **livelihoods of one lakh traditional fishermen under risk.**
- Port development is threatening the lake, and also the nesting grounds of various species.
- Port Developments projects are facing a serious **financial crisis.**

O-SMART SCHEME

- The scheme encompasses a total of 16 sub-projects addressing ocean development activities such as Services, Technology, Resources, Observations and Science.
- The services rendered under the O-SMART will provide economic benefits to a number of user communities in the coastal and ocean sectors, namely, fisheries, offshore industry, coastal states, Defence, Shipping, Ports etc.

Objectives:

The objectives of O-SMART (Ocean Services, Modelling, Applications, Resources and Technology) scheme of Ministry of Earth Sciences (MoES), Govt. of India are

- To generate and regularly update information on Marine Living Resources and their relationship with the physical environment in the Indian Exclusive Economic Zone (EEZ),
- To periodically monitor levels of sea water pollutants for health assessment of coastal waters of India, to develop shoreline change maps for assessment of coastal erosion due to natural and anthropogenic activities,
- To develop a wide range of state-of-the art ocean observation systems for acquisition of real-time data from the seas around India,
- To generate and disseminate a suite of user-oriented ocean information, advisories, warnings, data and data products for the benefit of society,
- To develop high resolution models for ocean forecast and reanalysis system,
- To develop algorithms for validation of satellite data for coastal research and to monitor changes in the coastal research,
- Acquisition of 2 Coastal Research Vessels (CRVs) as replacement of 2 old CRVs for coastal pollution monitoring, testing of various underwater components and technology demonstration,
- To develop technologies to tap the marine bio resources,
- To develop technologies generating freshwater and energy from ocean,
- To develop underwater vehicles and technologies,
- Establishment of Ballast water treatment facility,
- To support operation and maintenance of 5 Research vessels for ocean survey/monitoring/technology demonstration programmes,
- Establishment of state-of-the-art sea front facility to cater to the testing and sea trial activities of ocean technology,
- To carryout exploration of Polymetallic Nodules (MPN) from water depth of 5500 m in site of 75000 sq.km allotted to India by United Nations in Central Indian Ocean Basin, to carryout investigations of gas hydrates,
- Exploration of polymetallic sulphides near Rodrigues Triple junction in 10000 sq. km of area allotted to India in International waters by International Seabed Authority/UN and,

- Submission of India's claim over continental shelf extending beyond the Exclusive Economic Zone supported by scientific data, and Topographic survey of EEZ of India.

Significance and benefits of the scheme:

- Currently, five lakhs fishermen community are receiving the related information daily through mobile which includes allocation of fish potential and local weather conditions in the coastal waters.
- The scheme will help in reducing the search time for fishermen resulting savings in the fuel cost.
- Implementation of O-SMART will help in addressing issues relating to Sustainable Development Goal-14, which aims to conserve use of oceans, marine resources for sustainable development.
- This scheme (O-SMART) also provides necessary scientific and technological background required for implementation of various aspects of Blue Economy.
- The ocean advisory services and technologies being rendered and developed under the scheme play a pivotal role in the development activities over dozen sectors, working in the marine environment including the coastal states of India, contributing significantly to the GDP.
- The State of Art Early Warning Systems established under the O-SMART Scheme will help in effectively dealing with ocean disasters like Tsunami, storm surges.
- The technologies being developed under this Scheme will help in harnessing the vast ocean resources of both living and non-living resources from the seas around India.
- A fleet of research vessels viz., Technology Demonstration vessel SagarNidhi, Oceanographic Research Vessel SagarKanya, Fisheries and Oceanographic Research Vessel SagarSampada and Coastal Research Vessel SagarPurvi have been acquired to provide required research support.

Exclusive Economic Zone (EEZ):

- It is prescribed by the 1982 **United Nations Convention on the Law of the Sea**.
- Every coastal country's EEZ extends to 200 nautical miles (370 km) from its shores and the country has exclusive rights to all resources in the water, including oil, natural gas and fish. Any military activity in the EEZ requires Country's permission
- It is also referred to as a maritime continental margin and, in colloquial usage, may include the continental shelf.

- The term does not include either the territorial sea or the continental shelf beyond the 200 nautical mile limit.

Integrated Coastal Zone Management Plan

It is a process for the management of the coast using an integrated approach, regarding all aspects of the coastal zone, including geographical and political boundaries, in an attempt to achieve sustainability.

- The concept was born in 1992 during the Earth Summit of Rio de Janeiro.
- The specifics regarding ICZM is set out in the proceedings of the summit within Agenda 21.

Implementation:

- It is a World Bank assisted project and is being implemented by the Department of Forests and Environment with assistance from the Union Ministry of Environment, Forests and Climate Change (MoEFCC).
- The **National Centre for Sustainable Coastal Management (NCSCM),** Chennai, is providing scientific and technical inputs.

Objective:

- Formulation of Integrated Coastal Zone Management Plan for the State
- Lessen the coastal erosion
- Reduce vulnerability to disaster
- Biodiversity conservation
- Livelihood security
- Pollution/ environmental quality management
- Improvement and conservation of cultural/ archaeological assets

Components:

Society of Integrated Coastal Management (SICOM) would be implementing the project the national level and state level.

- Till now three coastal states namely West Bengal, Gujarat and Orissa have been selected under the ICZM plan.
- Four main components of the plan include National Coastal Zone Management Programme, ICZM-West Bengal, ICZM-Orissa and ICZM-Gujarat:
  - **National Coastal Zone Management Programme:** The national component will include mapping, delineation and demarcation of the hazard lines, and delineation of coastal sediment cells all along the mainland coast of India.
  - **ICZM approaches in Gujarat, Orissa and West Bengal:** will support capacity building of the state-level agencies and institutions, including preparation of an ICZM plan for the coastal sediment cell, regional coastal process study, and pilot investments.

COASTAL REGULATION ZONE

About CRZ norms:

- In India, the CRZ Rules govern **human and industrial activity close to the coastline**, in order to protect the fragile ecosystems near the sea.
- They **restrict certain kinds of activities — like large constructions, setting up of new industries, storage or disposal of hazardous material, mining, reclamation and bunding** — within a certain distance from the coastline.
- Under the **section 3 of Environment Protection Act, 1986** of India, **Coastal Regulation Zone notification was issued in February 1991** for the first time.
- **In 2018-19, fresh Rules were issued**, which aimed to remove certain restrictions on building, streamlined the clearance process, and aimed to encourage tourism in coastal areas.
- While the CRZ Rules are made by the Union environment ministry, **implementation is to be ensured by state governments through their Coastal Zone Management Authorities**.

Classifications of Coastal Zones under CRZ Notification 2011

CRZ-I (ecologically sensitive areas like mangroves, coral reefs, biosphere reserves etc.).

- **No new construction shall be permitted in CRZ-I except**
- Projects relating to the Department of Atomic Energy;
- Construction of trans-harbour sea link and roads without affecting the tidal flow of water, between LTL and HTL. etc.
- Between **Low Tide Line and High Tide Line** in areas which are not ecologically sensitive, the following may be **permitted**;
- Exploration and extraction of natural gas;
- Construction of basic amenities like schools, roads, etc. for traditional inhabitants living within the biosphere reserves;
- Salt harvesting by solar evaporation of seawater;
- Desalination plants;
- Storage of non-hazardous cargo such as edible oil, fertilizers within notified ports;

CRZ-II (Areas which are developed up to the shoreline and falling within the municipal limits; includes built-up area – villages and towns are that are already well established),

- Buildings are permissible on the landward side of the hazardous line.
- Other activities such as desalination plants are also permissible.
- Some construction is permitted only as per guidelines specified by the notification.

CRZ-III: Areas that are relatively undisturbed and do not fall under either in Category I or II and also include **rural and urban areas that are not substantially developed**.

- Between 0-200 metres from HTL is a No Development Zone where no construction shall be permitted.
- Only certain activities relating to agriculture, forestry, projects of Department of Atomic Energy, mining of rare minerals, salt manufacture, regasification of petroleum products, non-conventional energy sources and certain public facilities may be permitted in this zone.

- Between 200-500 metres of HTL, those permitted in 0-200 metres zone, construction of houses for local communities and tourism projects are permissible.

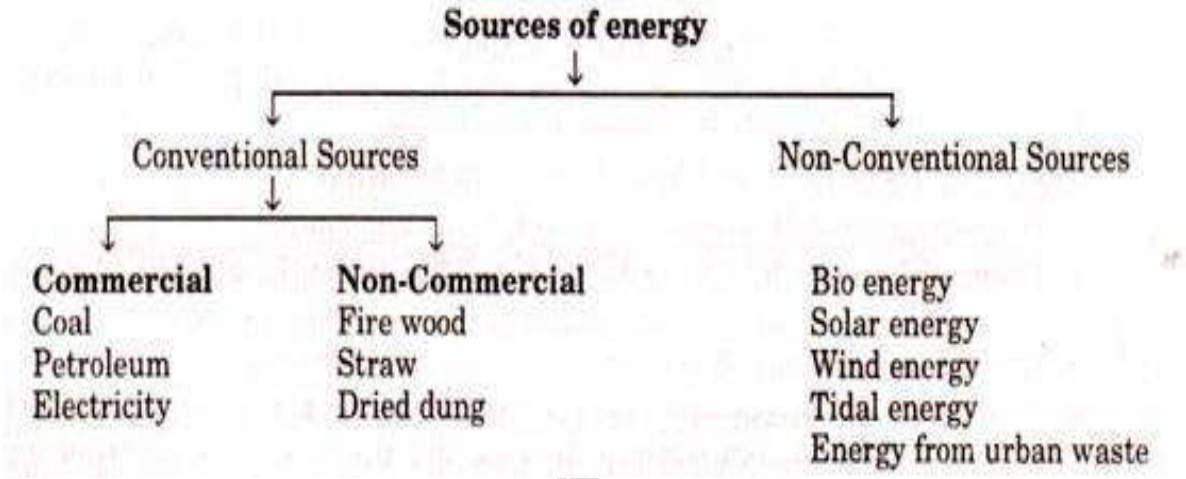
CRZ-IV: The aquatic area from **low tide line up to territorial limits** is classified as CRZ-IV including the area of the tidal influenced water body.

- There is no restriction on the traditional fishing undertaken by local communities.
- No untreated sewage or solid waste shall be let off or dumped in these areas.

New Rules under CRZ regulations

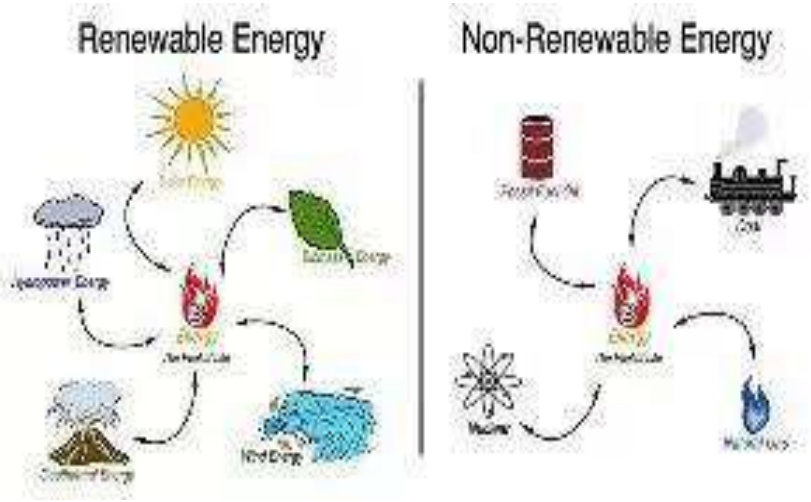
- The government notified new CRZ Rules with the stated objectives of promoting sustainable development and conserving coastal environments.
- For the so-called **CRZ-III (Rural) areas, two separate categories have been stipulated**.
- In the **densely populated rural areas (CRZ-IIIA) with a population density of 2,161** per sq km as per the 2011 Census, the **no-development zone is now 50 m** from the high-tide level, as against the 200 m stipulated earlier.
- In the **CRZ-IIIB category (rural areas with population density below 2,161 per sq km)** continue to have a **no-development zone extending up to 200 m from the high-tide line**.
- The new Rules have a **no-development zone of 20 m for all islands close to the mainland coast, and for all backwater islands in the mainland**.

Energy Resources



- Energy comes from a variety of places.
- Mineral fuels are necessary for the production of electricity, which is needed by industry, transportation, and other economic sectors.
- The traditional energy sources include nuclear energy minerals and fossil fuels including coal, petroleum, and natural gas. These conventional sources are finite, run out and exhaust with time.

Sources of energy:



Difference between Conventional Sources of Energy and Non-Conventional Sources of Energy:

Conventional Sources of Energy	Non-Conventional Sources of Energy
These resources are exhaustible and run out eventually.	These resources are in-exhaustible and never run out.
These resources release smoke and ash, which contribute to pollution.	Typically, these resources don't cause any pollution.
The upkeep, storage, and transmission of these resources are exceedingly costly.	These resources are less expensive, and they are also simple to manage.
Coal, natural gas, petroleum, and water power are among the examples	Solar, biomass, wind, biogas, tidal, and geothermal energy are some examples

Conventional Energy Sources:

1. Coal:

- One of the vital minerals, coal is primarily employed in the production of thermal energy and the smelting of iron ore.
- Gondwana and tertiary deposits are the two main geological eras in which coal can be found in rock sequences.
- In India, bituminous coal accounts for over 80% of the non-coking quality coal reserves.
- The Damodar Valley is home to India's most significant Gondwana coal deposits.
- They are located in the Jharkhand-Bengal coal belt, which has significant coalfields such as Raniganj, Jharia, Bokaro, Giridih, and Karanpura.The largest coal field is Jharia, followed by Raniganj.
- The Godavari, Mahanadi, and Son river valleys are the others that are connected to coal.
- The most significant coal mining areas are Singrauli in Madhya Pradesh, Singareni in Telangana, Pandur in Andhra Pradesh, Talcher and Rampur in Odisha, Korba in Chhattisgarh, Talcher and Rampur in Odisha, Chanda-Wardha, Kamptee and Bander in Maharashtra.
- Assam, Arunachal Pradesh, Meghalaya, and Nagaland all have tertiary coal deposits.
- It is obtained from the Meghalayan regions of Darangiri, Cherrapunji, Mewlong, and Langrin; upper Assamese regions of Makum, Jaipur, and Nazira; the Arunachal Pradesh regions of Namchik-Namphuk; and Kalakot (Jammu and Kashmir).
- In addition, coastal regions in Gujarat, Jammu and Kashmir, Tamil Nadu, and Pondicherry have brown coal, often known as lignite.

2. Petroleum:

- Hydrocarbons in liquid and gaseous forms that vary in chemical composition, colour, and specific gravity make up crude petroleum.
- For all internal combustion engines in automobiles, trains, and aeroplanes, it is a necessary source of energy.
- Petrochemical industries use its myriad byproducts to make fertiliser, synthetic rubber, synthetic fibre, pharmaceuticals, vaseline, lubricants, wax, soap, and cosmetics.
- Tertiary-era sedimentary rocks contain crude petroleum.
- The Oil and Natural Gas Commission was established in 1956, and since then,

oil exploration and production have been actively pursued.

- The sole oil-producing refinery until 1956 was the Digboi in Assam, but things changed after 1956. New oil reserves have been discovered in the country's extreme western and eastern regions in recent years.
- Digboi, Naharkatiya, and Moran are significant oil-producing regions in Assam. Gujarat has several significant oil reserves, including Ankleshwar, Kalol, Mehsana, Nawagam, Kosamba, and Lunej.
- Mumbai High, which is located 160 kilometres off the coast of Mumbai, was founded in 1973, and production there started in 1976.
- In exploratory wells in the Krishna-Godavari and Kaveri basins on the east coast, oil and natural gas have been discovered.
- Crude oil, which has numerous contaminants, is the oil that is extracted from the wells.
- India has two different kinds of refineries: (a) market-based and (b) field-based. Field-based refineries are illustrated by Digboi, while market-based refineries are illustrated by Barauni.

3. Natural Gas:

- In order to transport and market natural gas, the Gas Authority of India Limited was established as a public sector enterprise in 1984.
- It is found in all oil fields alongside oil, however, there are exclusive reserves in Tripura, Rajasthan, Gujarat, and Maharashtra as well as along the eastern coast (Tamil Nadu, Odisha, and Andhra Pradesh).

Non-Conventional Energy Sources:

- Coal, petroleum, natural gas, and nuclear energy all use finite raw materials as their primary energy source.
- Only renewable energy sources like sun, wind, hydro geothermal, and biomass are considered sustainable energy sources.
- These energy sources are more environmentally responsible and evenly dispersed.
- After the initial cost is covered, non-conventional energy sources will offer more consistent, eco-friendly, and less expensive energy.

1. Nuclear Energy:

- In recent years, nuclear energy has shown to be a reliable source.
- Uranium and thorium are significant minerals utilized in the production of nuclear energy.
- The Dharwar rocks contain uranium reserves. Geographically, it is known that uranium ores can be found along the Singbhum Copper belt in a number of areas.
- Additionally, it can be found in the districts of Kullu in Himachal Pradesh, Durg in Chhattisgarh, Alwar, and Jhunjhunu in Rajasthan, and Udaipur, Alwar, and Jhunjhunu in Rajasthan. Monazite and ilmenite in the beach sands of Kerala and Tamil Nadu's coasts are the main sources of thorium.
- The richest monazite deposits in the world are found in the Keralan districts of Palakkad and Kollam, close to Vishakhapatnam in Andhra Pradesh, and near the Mahanadi River delta in Odisha.
- The Atomic Energy Commission was founded in 1948, but advancements couldn't be achieved until the Atomic

Energy Institute in Trombay was founded in 1954 and later renamed the Bhabha Atomic Research Centre in 1967.

- The significant nuclear energy projects are those at Tarapur in Maharashtra, Rahatbhata near Kota in Rajasthan, Kalpakkam in Tamil Nadu, Narora in Uttar Pradesh, Kaiga in Karnataka, and Kakarapara in Gujarat.

2. Solar Energy:

- Solar energy is created by harnessing the sun's rays in photovoltaic cells.
- Photovoltaics and solar thermal technology are two methods that are thought to be particularly effective in harnessing solar energy.
- Comparatively speaking, solar thermal energy has some advantages over all other non-renewable energy sources. It is affordable, environmentally friendly, and simple to build.
- Solar power is 10% more efficient than nuclear power and 7% more efficient than coal or oil-based systems.
- Appliances like heaters, crop dryers, cookers, etc. typically use it more.
- Gujarat and Rajasthan in western India have the most potential for the growth of solar energy.

3. Wind Power:

- Wind power is a limitless, pollution-free source of electricity.
- The process of converting wind energy is straightforward.
- Through the use of turbines, wind energy's kinetic energy is transformed into electrical energy.
- As a source of energy, the trade winds, westerlies, and seasonal wind patterns like the monsoon have all been exploited.
- More than 50,000 megawatts of wind energy can be produced in India, of which only one-fourth is feasible to use.
- Conditions are favorable for wind energy in Rajasthan, Gujarat, Maharashtra, and Karnataka.

4. Tidal and Wave Energy:

- Ocean currents are a never-ending source of energy.
- Continuous efforts have been made from the beginning of the seventeenth and eighteenth centuries to develop a more effective energy system using constant tidal waves and ocean currents.
- The west coast of India is known to experience large tidal waves.
- As a result, India has a lot of potential for tidal energy production along the coasts, but this potential has not yet been realized.

5. Geothermal Energy:

- Extreme heat is emitted as magma from the earth's interior rises to the surface. It is possible to successfully harness and transform this thermal energy into electrical energy.
- In addition to this, thermal energy is also produced from the hot water that spews from gyser wells. It is commonly referred to as geothermal energy.
- These days, one of the main energy sources that can be created as a backup supply is thought to be this energy.
- Since the Middle Ages, people have been using the hot springs and geysers. At Manikaran in Himachal Pradesh, an Indian geothermal energy plant has been put into operation.

6. Bio-energy:

- Bio-energy is defined as energy produced from biological materials, such as municipal, industrial, and other wastes as well as agricultural residues.

- A potential source of energy conversion is bioenergy.
- It can be transformed into gas for cooking, heat energy, or electrical energy. Along with processing waste and garbage, it will also generate energy.
- This would boost the quality of life for rural residents in developing nations, lessen environmental pollution, increase independence, and ease the demand for fuel wood.
- Okhla in Delhi is one such initiative that turns garbage from the city into energy.

Benefits of renewable energy:

- **Opportunity for the private sector:** PM indicated the possibility of a business of around $20 billion per year in the renewable energy sector. A target of setting up 450 GW of renewable energy sources by 2030 means that we need to augment the renewable energy capacity by **almost 25-30 GW per year**. This can be harnessed as a **high return on investment opportunity** by the private sector.
- **Low maintenance cost**: As compared to the traditional sources of energy like coal-based or oil-based thermal power plants, solar energy has the advantage of almost **no requirement of procurement of fuel as well as lesser wear and tear due to lack of movement of parts**. Therefore, return on investment is higher in the long run.
- **Government incentives**: Solar energy is a sustainable source of energy. Therefore, unlike thermal energy where the government policy is to penalise the usage, renewable energy will always be incentivised to invest additional resources and create more energy capacity.
- **Sustainability**: Renewable energy is a cleaner source of pollution, thus, benefitting the environment in general and **reducing pollution and the associated diseases** in particular.
- **Atmanirbhar Bharat**: Investment by the private sector in renewable energy would also be helpful in fulfilling the Government's objective of self-reliance. It will also **create employment** opportunities in the country.
- **Last-mile connectivity:** As renewable energy can also be **decentralised**, therefore, it is better placed to extend last-mile connectivity in remote areas, where it might **not be financially feasible to stretch the main grid**. This is also **economical** for the government and households as decentralised connectivity **decreases the Transmission and distribution losses**.

Challenges:

- **Reliability**: By their very nature, solar and wind energy are variable in availability **both spatially as well as geographically.** They are not available on-demand, unlike thermal or nuclear energy. Therefore, they have to be supplemented with other sources of energy, to maintain the base load.
- **Creation of storage infrastructure**: To overcome the variable nature of renewable sources of energy, it is vital to invest in **affordable batteries of large capacity**. This would require adequate commitment from the government side to inspire confidence in the private sector.
- **Funding**: As already stated, renewable energy requires setting up large projects to harness the economies of scale. This requires a **large initial investment, which can be a deterrent** at the beginning of the project.

- However, it has to be acknowledged that the newly set up projects have actually achieved and sometimes even **overshot the per unit price parity** in comparison to the thermal energy.

- **Building manufacturing capability**: It is important to set up manufacturing capacity in India to **decrease imports** and promote Atmanirbhar Bharat. More manufacturing would also mean an increase in investments and additional employment generation in India.

GOVERNMENT INITIATIVES

SAUBHAGYA Scheme:

About:

- It was launched in 2017 to ensure electrification of all households in the country in rural as well as urban areas.

Objectives:

- Achieving Universal Household Electrification in the country, through last mile connectivity.
- Providing access to electricity to all un-electrified households in rural areas and poor households in urban areas.

Beneficiaries:

- They are identified using Socio Economic and Caste Census (SECC) 2011 data.
- However, un-electrified households not covered under the SECC data would also be provided electricity connections under the scheme by paying Rs 500.

International Solar Alliance:

About:

- The International Solar Alliance (ISA) is an action-oriented, member-driven, collaborative platform for increased deployment of solar energy technologies.
- Its basic motive is to facilitate energy access, ensure energy security, and drive energy transition in its member countries.
- The ISA was conceived as a joint effort by India and France to mobilize efforts against climate change through deployment of solar energy solutions.

Headquarters:

- The Headquarters is in India with its Interim Secretariat being set up in Gurugram.

Member Nations:

- A total of 106 countries have signed the ISA Framework Agreement.
- Out of 106 nations, 86 have signed and ratified the ISA Framework Agreement.
- All member states of the United Nations are eligible to join the ISA.

Objectives of ISA:

- The **ISA** seeks to develop and deploy **cost-effective** and **transformational solar energy solutions.**
- To help member countries develop **low-carbon growth** trajectories, with particular focus on delivering impact in countries categorized as **Least Developed Countries (LDCs)** and the **Small Island Developing States (SIDS).**

One Sun One World One Grid (OSOWOG):

About:

- The OSOWOG focuses on a framework for facilitating global cooperation, building a global ecosystem of interconnected renewable energy resources (mainly solar energy) that can be seamlessly shared.
- The vision behind the OSOWOG is 'The Sun Never Sets' and is a constant at some geographical location, globally, at any given point of time.
- This is by far one of the most ambitious schemes undertaken by any country and is of global significance in terms of sharing economic benefits.
- It has been taken up under the technical assistance program of the World Bank.

ISA Solar Technology and Application Resource Centre (ISTARC):

About:

- To build a network of technical training, entrepreneurship, and research and innovation centres in order to exchange best practices and promote knowledge dissemination and capacity-building.
- To develop and disseminate a range of training materials for all types of

audiences and aim at the setting up of harmonized training programmes using a network of training facilities that would be recognized across the ISA Member countries.
- To work on standardization of solar applications at the regional or sub-regional level and provide testing and technical certification capabilities to key STAR-centres.
- To enable collaborative research and development among the ISA Member countries.

Indian Technical and Economic Cooperation (ITEC) Scheme:

About:

- The Government of India has been supporting the ISA by providing training to master trainers in the field of solar energy through the Indian Technical and Economic Cooperation (ITEC) Scheme.
- The duration of the training is 21 days and all costs are borne by the Government of India.
- In 2018-2019, 133 candidates from 25 countries were trained at the National Institute of Solar Energy, Gurugram, with the support of the ITEC programme.

Self-reliance in Energy Sector

- India's Energy sector is one of the most diversified in the world.
- Sources of power generation range from conventional sources such as coal, lignite, natural gas, oil, hydro and nuclear power, to viable non-conventional sources such as wind, solar, agricultural and domestic waste.
- India was ranked fourth in wind power, fifth in solar power and fourth in renewable power installed capacity, as of 2020.
- Near-universal household access to electricity was achieved in 2019, meaning that over 900 million citizens have gained an electrical connection in less than two decades.
- But, the per capita electricity consumption in India is only one-third of the global average, even though the demand for energy has doubled.
- So, to catch up with the increasing demand for energy, there is a need to make arrangements for a secure and sustainable form of self-reliance in the energy sector.

Need of Becoming Self-Reliant in the Energy Sector:

- India is not energy independent. It spends over Rs 12 lakh crore on importing energy.
- The government is planning to get energy independence before 100 years of independence is completed i.e., by 2047.
- As green power takes precedence in the global scheme of things, the Indian government has already kick-started its green hydrogen journey.
- For a nation, 85% dependent on imports for meeting its oil needs and 50 % for gas requirements, the key is alternate energy sources - from renewable power to hydrogen and switching to electric vehicles from current petrol and diesel-run automobiles.
- From solar energy to Mission Hydrogen to adoption to EVs, we need to take these initiatives to the next level for energy independence.
- India is the world's fifth largest producer of ethanol after the US, Brazil, EU and China.
- Ethanol worldwide is largely used for consumption but nations like Brazil and India also dope it in petrol.

- Self-reliance through green energy initiatives is the foundation of a green and sustainable economy.
- Green energy initiatives focus on clean energy and its availability to all individuals and businesses.

National Hydrogen Energy Mission (NHM):

About:

- Focus on generation of hydrogen from green power resources.
- To link India's growing renewable capacity with the hydrogen economy.
- India's ambitious goal of 175 GW by 2022 got an impetus in the 2021-22 budget which allocated Rs. 1500 crore for renewable energy development and NHM.
- The usage of hydrogen will not only help India in achieving its emission goals under the Paris Agreement, but will also reduce import dependency on fossil fuels.

Hydrogen:

- Hydrogen is the lightest and first element on the periodic table.
- Since the weight of hydrogen is less than air, it rises in the atmosphere and is therefore rarely found in its pure form, H2.
- At standard temperature and pressure, hydrogen is a nontoxic, nonmetallic, odorless, tasteless, colorless, and highly combustible diatomic gas.
- Hydrogen fuel is a zero-emission fuel burned with oxygen. It can be used in fuel cells or internal combustion engines.
- It is also used as a fuel for spacecraft propulsion.

Types of Hydrogen:

Grey Hydrogen:

- Constitutes India's bulk Production.
- Extracted from hydrocarbons (fossil fuels, natural gas).
- By product: CO2

Blue Hydrogen:

- Sourced from fossil fuels.
- By product: CO, CO2
- By products are Captured and Stored, so better than grey hydrogen.

Green Hydrogen:

- Generated from renewable energy (like Solar, Wind).
- Electricity splits water into hydrogen and oxygen.
- By Products: Water, Water Vapor

Asia-Pacific Stance:

- In Asia-Pacific sub-continent, Japan and South Korea are on the front foot in terms of hydrogen policy making.
- In 2017, Japan formulated the Basic Hydrogen Strategy which sets out the country's action plan till 2030, including the establishment of an international supply chain.
- South Korea is operating hydrogen projects and Hydrogen Fuel Cell production units under the auspices of its Hydrogen Economy Development and Safe Management of Hydrogen Act, 2020.
- South Korea has also passed the Economic Promotion and Safety Control of Hydrogen Act, which deals with three key areas - hydrogen vehicles, charging stations and fuel cells.
- This law is intended to bring transparency to the nation's hydrogen pricing system.

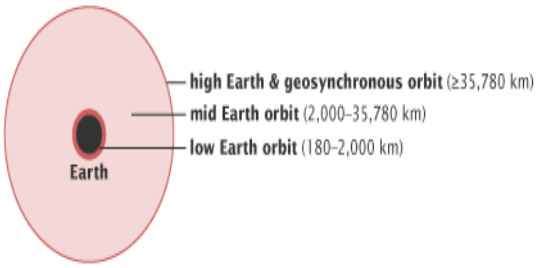
Space Technology

- Space technology is technology for use in travel or activities beyond Earth's atmosphere, for purposes such as spaceflight or space exploration.
- Space technology includes space vehicles such as spacecraft, satellites, space stations and orbital launch vehicles; deep-space communication; in-

space propulsion; and a wide variety of other technologies including support infrastructure equipment, and procedures.

Orbit:

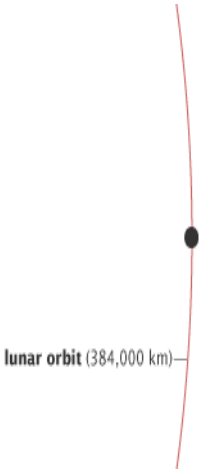
- An orbit is a regular, repeating path that an object in space takes around another one.
- An object moving around a planet in an orbit is called a satellite.
- According to the height of satellites from the earth, the orbits can be classified as High Earth orbit, Medium Earth orbit, and Low Earth orbit.
- High Earth orbit begins about one-tenth of the way to the moon. Many kinds of weather and some communications satellites tend to have a high Earth orbit, furthest away from the surface.
- Satellites that orbit in a medium (mid) Earth orbit include navigation satellites, designed to monitor a particular region.
- Most scientific satellites, including NASA's Earth Observing System fleet, have a low Earth orbit.



Height of Satellite:

- The height of the orbit, or distance between the satellite and Earth's surface, determines how quickly the satellite moves around the Earth. **Higher a satellite's orbit, the slower it moves.**
- An Earth-orbiting satellite's motion is mostly controlled by Earth's gravity. As satellites get closer to Earth, the pull of gravity gets stronger, and the satellite moves more quickly.

  - For Example, NASA's Aqua satellite requires about 99 minutes to orbit the Earth at about 705 kilometres height from Earth's surface.
  - A communication satellite about 36,000 kilometres from Earth's surface takes 23 hours, 56 minutes, and 4 seconds to complete an orbit.
  - At 384,403 kilometres from the centre of the Earth, the Moon completes a single orbit in 28 days.
  - Changing a satellite's height will also change its orbital speed, which **represents a strange paradox.**



  - If a satellite operator wants to increase the satellite's orbital speed, he can't simply fire the thrusters to accelerate the satellite. Doing so would boost the orbit (increase the altitude), which would slow the orbital speed.
  - Instead, he must fire the thrusters in a direction opposite to the satellite's forward motion. This change will push the satellite into a lower orbit, which will increase its forward velocity.

- The same action that on the ground would slow a moving vehicle.

Eccentricity of Orbit:

- Eccentricity refers to the shape of the orbit. A satellite with a low eccentricity orbit moves in a near circle around the Earth.
- An eccentric orbit is elliptical, with the satellite's distance from Earth changing depending on where it is in its orbit.
- The eccentricity (e) of an orbit indicates the deviation of the orbit from a perfect circle.
- A circular orbit has an eccentricity of 0, while a highly eccentric orbit is closer to (but always less than) 1.
- A satellite in an eccentric orbit moves around one of the ellipse's focal points, not the centre.

Inclination of Orbit:

- The inclination is the angle of the orbit in relation to Earth's equator.
- An orbital inclination of 0° is directly above the equator, 90° crosses right above the pole, and 180° orbits above the equator in the opposite direction of Earth's spin.

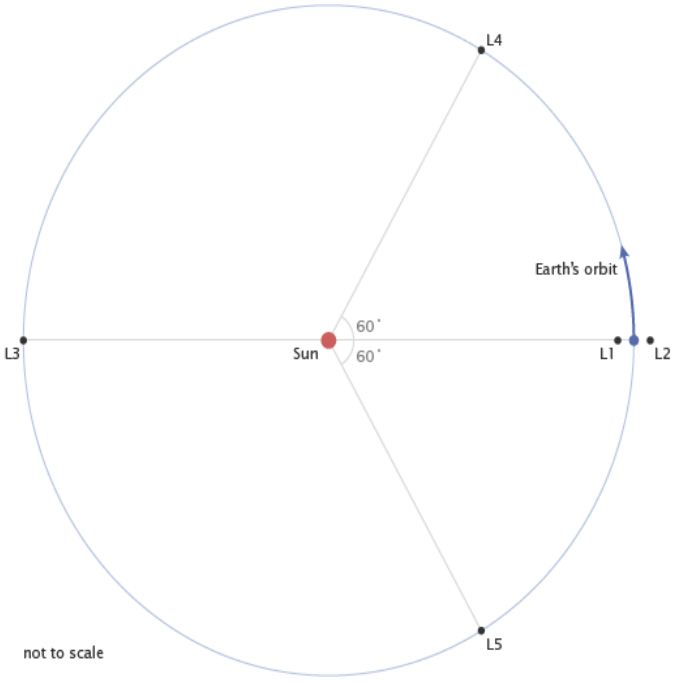
High Earth Orbit:

- High Earth Orbit is when a satellite reaches exactly 42,164 kilometres from the centre of the Earth (about 36,000 kilometres from Earth's surface).
- At this altitude, the satellite enters a sort of "sweet spot" in which its orbit matches Earth's rotation. This special, high Earth orbit is called geosynchronous.
- A satellite in a circular geosynchronous orbit directly over the equator (eccentricity and inclination at zero) will have a geostationary orbit that does not move at all relative to the ground.
- This is because the satellite orbits at the same speed that the Earth is turning, it is always directly over the same place on the Earth's surface.

- Use of a geostationary orbit is extremely valuable for weather monitoring and communication (phones, television, radio) because satellites in this orbit provide a constant view of the same surface.
- Finally, many high Earth-orbiting satellites monitor solar activity, track magnetic and radiation levels in space around them.

Lagrange points:

- The first Lagrange point is located between the Earth and the Sun, giving satellites at this point a constant view of the Sun.
- The Solar and Helio spheric Observatory



(SOHO), a NASA and European Space

Agency satellite tasked to monitor the Sun, orbits the first Lagrange point, about 1.5 million kilometres away from Earth.

- The second Lagrange point is about the same distance from the Earth but is located behind the Earth. Earth is always between the second Lagrange point and the Sun.
- Since the Sun and Earth are in a single line, satellites at this location only need one heat shield to block heat and light from the Sun and Earth.
- It is a good location for space telescopes, including the future James Webb Space Telescope.
- The third Lagrange point is opposite the Earth on the other side of the Sun so that the Sun is always between it and Earth.
- A satellite in this position would not be able to communicate with Earth.
- The extremely stable fourth and fifth Lagrange points are in Earth's orbital path around the Sun, 60 degrees ahead of and behind Earth.
- The twin Solar Terrestrial Relations Observatory (STEREO) spacecraft will orbit at the fourth and fifth Lagrange points to provide a three-dimensional view of the Sun.
    - If a satellite operator wants to increase the satellite's orbital speed, he can't simply fire the thrusters to accelerate the satellite. Doing so would boost the orbit (increase the altitude), which would slow the orbital speed.
    - Instead, he must fire the thrusters in a direction opposite to the satellite's forward motion. This change will push the satellite into a lower orbit, which will increase its forward velocity.
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Eccentricity of Orbit

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- An eccentric orbit is elliptical, with the satellite's distance from Earth changing depending on where it is in its orbit.

Note:

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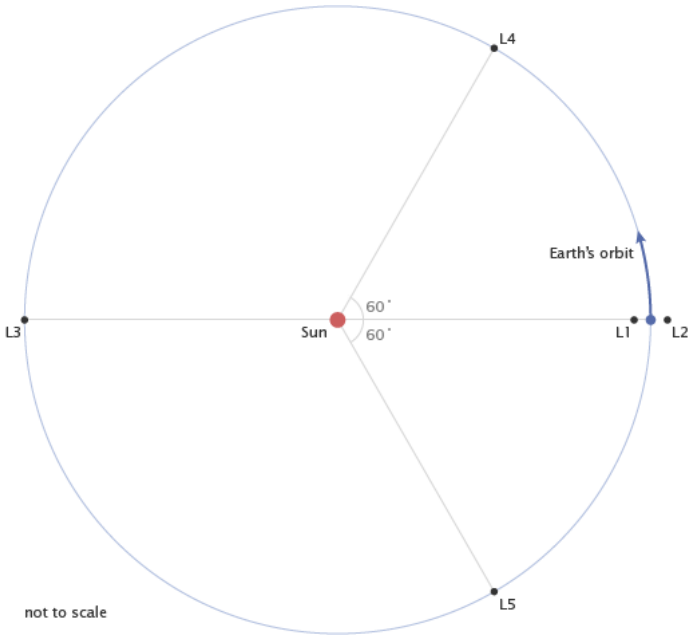

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- **Finally, many high Earth-orbiting satellites monitor solar activity, track magnetic and radiation levels in space around them.**

Note:

- Other orbital "sweet spots," just beyond high Earth orbit, are the Lagrange points.
- At the Lagrange points, the pull of gravity from the Earth cancels out the pull of gravity from the Sun.
- Anything placed at these points will feel equally pulled toward the Earth and the Sun and will revolve with the Earth around the Sun.

Lagrange Points

- The first Lagrange point is located between the Earth and the Sun, giving satellites at this point a constant view of the Sun.
  - The Solar and Helio spheric Observatory (SOHO), a NASA and European Space Agency satellite tasked to monitor the Sun, orbits the first Lagrange point, about 1.5 million kilometres away from Earth.
- The second Lagrange point is about the same distance from the Earth but is located behind the Earth. Earth is always between the second Lagrange point and the Sun.
  - Since the Sun and Earth are in a single line, satellites at this location only need one heat shield to block heat and light from the Sun and Earth.
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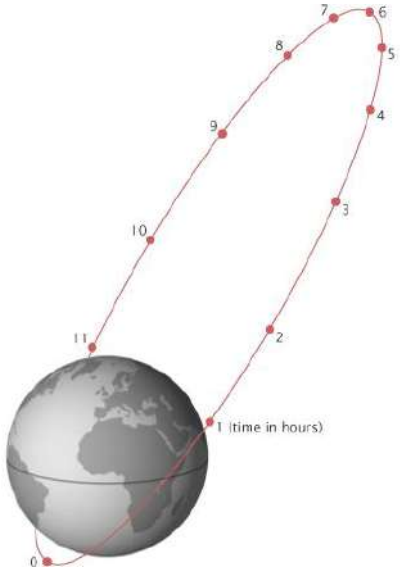
Medium Earth Orbit:

Closer to the Earth, satellites in a medium Earth orbit move more quickly. Two medium Earth orbits are notable: the semi-synchronous orbit and the Molniya orbit.

- **Semi-synchronous orbit** is a near-circular orbit (low eccentricity) 26,560 kilometres from the centre of the Earth (about 20,200 kilometres above the surface).
    - A satellite at this height takes 12 hours to complete an orbit.
    - In 24-hours, the satellite crosses over the same two spots on the equator every day. This orbit is consistent and highly predictable.
    - **It is the orbit used by the Global Positioning System (GPS) satellites.**
- **Molniya orbit** is the second common medium Earth orbit.
    - It was invented by the Russians, the Molniya orbit works well for observing high latitudes.
    - Molniya orbit offers a useful alternative to geostationary orbit, as satellites in a geostationary orbit are parked over the equator, so they don't work well for far northern or southern locations, which are always on the edge of view of geostationary satellites.
    - The Molniya orbit combines high inclination (63.4°) with high eccentricity (0.722) to maximize viewing time over high latitudes.
    - Each orbit lasts 12 hours, so the slow, high-altitude portion of the orbit repeats over the same location every day and night. Russian communications satellites and the Sirius radio satellites currently use this type of orbit.

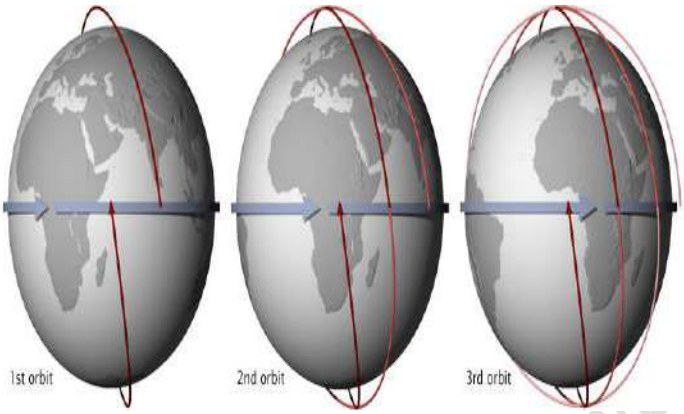
MOLNIYA ORBIT



Low Earth Orbit:

- Most scientific satellites and many weather satellites are in a nearly circular, low Earth orbit.
- The satellite's inclination depends on what the satellite was launched to monitor.
    - The Tropical Rainfall Measuring Mission (TRMM) satellite was launched to monitor rainfall in the tropics. Therefore, it has a relatively low inclination (35 degrees), staying near the equator.
    - Many of the satellites in NASA's Earth Observing System have a nearly polar orbit.

- In this highly inclined orbit, the satellite moves around the Earth from pole to pole, taking about 99 minutes to complete an orbit.
- In a 24-hour period, polar-orbiting satellites will view most of the Earth twice: once in daylight and once in darkness.
- As the satellite completes one orbit, the Earth turns underneath, so by the time the satellite crosses back into daylight, it is over the region adjacent to the area seen in its last orbit.



Path of a Polar Orbit:

- Just as the geosynchronous satellites have a sweet spot over the equator that lets them stay over one spot on Earth, the polar-orbiting satellites have a sweet spot that allows them to stay in one time.
- This orbit is a Sun-synchronous orbit, which means that whenever and wherever the satellite crosses the equator, the local solar time on the ground is always the same.
    - For example, if a polar satellite at 10:30 in the morning crosses the equator in Brazil when the satellite comes around the Earth in its next overpass about 99 minutes later, it crosses over the equator in Ecuador or Colombia at about 10:30 local time.

SATELLITE

- A satellite is a body that orbits around another body in space. There are two different types of satellites – natural and man-made. Examples of natural satellites are the Earth and Moon.
- The Earth rotates around the Sun and the Moon rotates around the Earth. A man-made satellite is a machine that is launched into space and orbits around a body in space.
- Examples of man-made satellites include the Hubble Space Telescope and the International Space Station.

Types of Satellites:

1.Astronomical: Deployed for observation of distant planets, stars, galaxies, and objects in-universe. It is a space Telescope hanging in space to photograph objects in space.

2.Biosatellite: Places animals or plants in space to conduct research on the effects of space on these living objects.

3.Communication: These satellites support telecommunication. Telecasting, Phone calls, Internet connectivity, Radio, and much remote connectivity are typical applications.

4.Earth Observation: Deployed to study environment, monitor climatic changes and mapping the earth for non-military purposes.

5.Navigation: Facilitates to trace the exact location of any objects on the Earth. This leads to the development of new applications, technology, and business cases.

6.Killer (Military): Deployed to attack enemy satellites and space objects during the war period.

7.Space Stations: Designed for human beings to live and conduct research on objects on planets, stars, and galaxies.

8.Reconnaissance: Deployed for spying, surveying and scouting enemy territory during the war period.

9.Crewed Spacecraft: These satellites ferry astronauts to space and bring them back to earth. It has good grounding facilities and helps astronauts in accessing space stations.

10.Recovery: Recovery satellites are mainly used to recover bio, reconnaissance and other satellites back to earth.

11.Solar Power: Space-based satellites gather energy from the Sun and transmit it to earth for consumption.

12.Miniaturized: Smaller sized and lower weight satellites are launched at an economical cost used for the limited purpose of scientific data gathering and radio relay.

13.Weather: These satellites are used to measure and report the Earth's weather, and the reports are used in a weather forecast.

NAVIC

Navigation with Indian Constellation (NavIC) is an independent regional navigation satellite system designed to provide position information in the Indian region and 1500 km around the Indian mainland.

IRNSS would provide two types of services, namely Standard Positioning Services available to all users and Restricted Services provided to authorised users.

Its applications include:

- Terrestrial, Aerial and Marine Navigation.
- Disaster Management.
- Vehicle tracking and fleet management.
- Integration with mobile phones.
- Precise Timing.
- Mapping and Geodetic data capture.
- Terrestrial navigation aid for hikers and travellers.
- Visual and voice navigation for drivers.

How many satellites does NAVIC consist of?

- It is a regional system and so its constellation will consist of seven satellites.
- Three of these will be geostationary over the Indian Ocean, i.e., they will appear

to be stationary in the sky over the region, and four will be geosynchronous – appearing at the same point in the sky at the same time every day.

- This configuration ensures each satellite is being tracked by at least one of fourteen ground stations at any given point of time, with a high chance of most of them being visible from any point in India.

Significance:

1.National security
2.Reliability
3.Accuracy
4.Disaster management
5.South Asian and Regional cooperation.

UNIVERSE

- Everything that exists, from the Galactic Mega clusters to the tiniest subatomic particles, comprises the Universe.
- As for the age of the Universe, scientists agree that it is about 13.79 billion years old as 2015.
- The universe comprises of a number of galaxies.
- Optical and radio telescope studies indicate the existence of about 100 billion galaxies in the visible universe.
- The Big Bang Theory is most acceptable for the origin of the Universe.

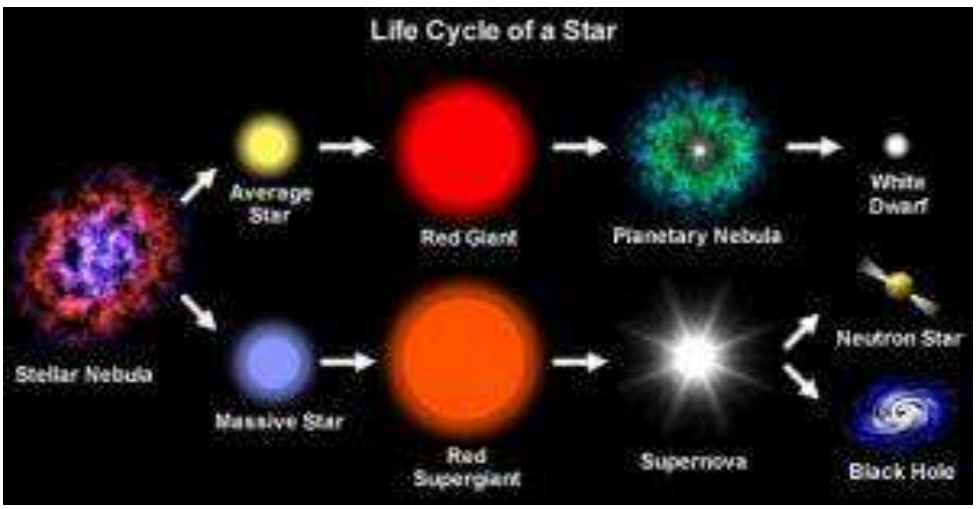
GALAXY

- Galaxy is a collection of millions or billions of stars and planets that are held together by gravitational pull.
- Milky Way is one such galaxy. The earth lies in this galaxy. It is called Milky Way because it looks like a river of milky light flowing from one corner to another of the sky.
- It is spiral in shape.
- We call it Akash Ganga.
- The nearest galaxy to Milky Way is Andromeda.
- Andromeda is a spiral galaxy and approximately 2.5 million light-years from the earth.

STARS

- Luminous heavenly bodies which have their own light and other radiant energy are called a star.
- They are made of extremely hot burning gases.
- Star reflects Looks – Red with low temperature, Yellow with higher and blue with very high temperature.

Star (Birth to Death)



- Star starts its life as clouds of dust and gas known as Nebula.
- The gaseous matter of Nebula further contracts to make dense region named ProtoStar.
- The ProtoStar further condenses to a critical stage of mass where nuclear fusion begins and star finally comes into existence.
- When all the hydrogens of a star are used up then its helium begins fusing into carbon. At a stage helium's fusion and energy production inside the star stops. As a result, stars core contracts under its own weight to a very high density to make a white Dwarf star.
- A white Dwarf star becomes dark balls of matter on cooling to make Black Dwarf Star.
- The mass of white Dwarf Star is less than 1.44 times the mass of the Sun named as Chandrasekhar Limiting Mass.
- White Dwarf Star is a dead star because of the end of fusion reaction and energy production.
- It shines by radiating its stored heat.
- The giant star expands into Red Supergiant after consuming its fuel (H & He). At a stage, it explodes as Supernova or changes into Neutron or Black Holes.
- The nearest star to the Earth is the Sun followed by Proxima and Alpha Centauri and radiant energy. (4.35 Light years)

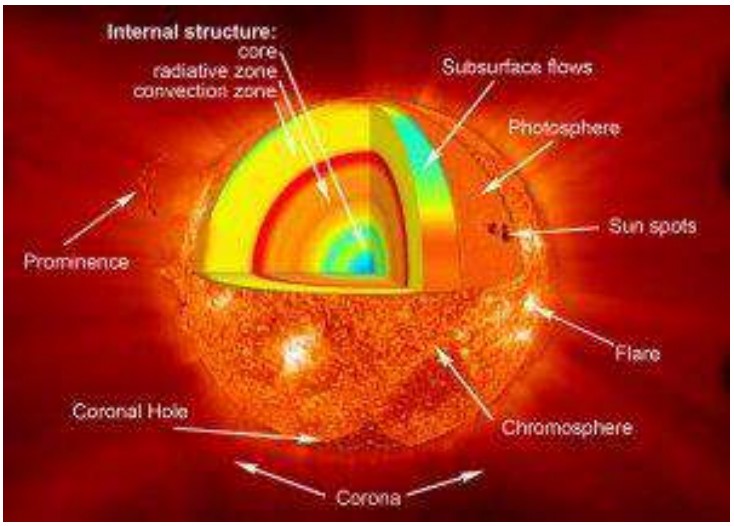
Constellations:

- A Constellation is a group of stars that makes an imaginary shape in the sky at night.
- It helps in navigation of sea vessel during the night as they are seen in a fixed direction at a particular period of time in a year.
- Orian, Big Dipper, Great Bear, Cassiopeia are some examples of constellations.
- Orion or Mriga can be seen in the late evening during winter; Cassiopeia in the Northern Sky is seen during winter.
- Great Bear consists of Ursa Minor (Laghu Saptarishi) and Ursa Major (Vrihat Saptarishi) and can be seen in the early night during summer.

Sun:

- It is a star made up of extremely hot gases, particularly by hydrogen (70%), Helium (26.5%), and others (3.5%) gases.
- It is 109 times bigger than the earth and weighs 2 × 1027 tonnes, and accounts for 99.83% of the mass of the solar system.
- It is 150 million km away from earth. The sunlight takes 8 minutes to reach the earth's surface.
- It has immense gravitational pull which keeps the planets fixed in their orbit, revolving around the sun.
- It continuously gives off energy in the form of visible light, infra-red, ultraviolet, X- rays, gamma rays, radio waves, and plasma gas.
- The sudden flash of brightness observed near the sun's surface which is a collection of magnetic energy including electrons, protons, and nuclei are called solar flares. They are concise particles and are harmful for satellite communication.
- The core of the sun consists of hydrogen atoms which fuse together due to compression and creates helium. This is called nuclear fusion.
- Nuclear fusion produces a huge amount of energy. It is radiated outward to the surface, atmosphere, and beyond.

- The convection zone is the next to the core of the sun. Here the temperature drops to 2-million-degree C.
- The photosphere's temperature is 6,000°C.
- The atmosphere of the sun consists of the chromosphere and corona.
- Corona is seen in a form of spectral lines emitted by iron, calcium, and Nickle ions. The ionization of these elements increases the temperature of the corona.
- The solar flare (wind) is a stream of charged particles released from the upper atmosphere of the sun.
- These changed particles when get trapped by the earth's magnetic field while entering the upper atmosphere of the earth result in the auroral (light) display.
- These auroral display in the northern hemisphere is called as Aurora Borealis (the Northern light) and when occurs in the southern hemisphere is called as Aurora Australis (the Southern lights).
- Sun-spots are dark appearing areas present in the photosphere from where solar flares originate. They are relatively a region cooler than its surrounding. It appears and disappears after every 11 years. This period is called the Sunspot Cycle.
- The cycle is marked by the increase and decrease of sunspots — visible as dark blemishes on the sun's surface, or photosphere. The greatest number of Sunspots in any given solar cycle is designed as "solar maximum" and the lowest number is the "solar minimum ".



- The solar wind is a stream of charged particles released from the upper atmosphere of the Sun, called the corona. This plasma mostly consists of electrons, protons, and alpha particles with kinetic energy between 0.5 and 10 keV.
- A solar storm is a disturbance on the Sun, which can emanate outward across the heliosphere, affecting the entire Solar System, including Earth and its magnetosphere, and is the cause of space weather in the short-term with long-term patterns comprising space climate.

PLANETS

- Planets mean wanderers. There are eight planets in our solar system (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune).
- All these planets move around the sun in a fixed orbit. Which is elongated in shape (elliptical).
- International Astronomical Union (IAU) recognized five dwarf planets such as Ceres, Pluto, Haumea, Make and Sedan.
- The planets are grouped into two: **Terrestrial planets:** These are dense rocky bodies and are called as earth-like planets. Mercury, Venus, Earth, and Mars are included in it. They are also called as inner planets. **Jovian Planets:** The outer planets which are gigantic in size and are gaseous in composition with large satellite are called Jovian planets. These have similar features to that of Jupiter, thus called as Jupiter like planets.

Pluto, the Dwarf Planet:

- Pluto was known as the smallest planet in the solar system and the ninth planet from the sun.
- Today Pluto is called a "dwarf planet".
- On average, Pluto is more than 3.6 billion miles away from the sun.
- Pluto is in a region called the Kuiper Belt. One day on Pluto is about 61/2 days on Earth.
- It has five moons. Its largest moon is named Charon.

The Kuiper Belt:

- Itis a region of the Solar System that exists beyond the eight major planets, extending from the orbit of Neptune (at 30 AU) to approximately 50 AU from the Sun.
- It is similar to the asteroid belt, in that it contains many small bodies, all remnants from the Solar System's formation. But unlike the Asteroid Belt, it is much larger – 20 times as wide and 20 to 200 times as massive.

Mercury:

- Mercury is the smallest planet in our solar system – only slightly larger than the Earth's moon.
- It is the closest planet to the sun at a distance of about 58 million km (36 million miles) or 0.39 AU.
- One day on Mercury takes 59 Earth days.
- Mercury is a rocky planet, also known as a terrestrial planet.
- Mercury's thin atmosphere, or exosphere, is composed mostly of oxygen (O2), sodium (Na), hydrogen (H2), helium (He), and potassium (K). Atoms that are blasted off the surface by the solar wind and micrometeoroid impacts create Mercury's exosphere.
- Only two missions have visited this rocky planet: Mariner 10 in 1974-5 and MESSENGER, which flew past
- Mercury three times before going into orbit around Mercury in 2011.
- Daytime Temperatures can reach 430° Celsius (800° Fahrenheit) and drop to -180° Celsius (-290° Fahrenheit) at night.

Venus:

- Venus is only a little smaller than the Earth.
- Venus is the second closest planet to the sun at a distance of about 108 million km (67 million miles) or 0.72 AU.
- One day on Venus lasts as long as 243 Earth days (the time it takes for Venus to rotate or spin once).
- Venus is a rocky planet, also known as a terrestrial planet. Venus' solid surface is a created and volcanic landscape.

- Venus' thick and toxic atmosphere is made up mostly of carbon dioxide (CO2) and nitrogen (N2), with clouds of sulfuric acid (H2SO4) droplets.
- More than 40 spacecraft have explored Venus. The Magellan mission in the early 1990s mapped 98% of the planet's surface.
- The planet's extremely high temperatures of almost 480° Celsius (900° Fahrenheit) made it seem an unlikely place for life as we know it.
- Venus spins backward (retrograde rotation) when compared to the other planets. This means that the sun rises in the west and sets in the east on Venus.

Earth:

- Earth is the third planet from the sun at a distance of about 150 million km (93 million miles). That's one Astronomical Unit (AU).
- A day on Earth is 24 hours (the time it takes the Earth to rotate or spin once).
- Earth's atmosphere is 78% nitrogen (N2), 21% oxygen (O2) and 1% other ingredients – the perfect balance for living beings to breathe and live. Many planets in our solar system have atmospheres, but only Earth is breathable.
- Earth has one moon. Another name for a moon is a natural satellite.
- Earth is the perfect place for life as we know it.
- Our atmosphere protects us from incoming meteoroids, most of which break up in our atmosphere before they can strike the surface as meteorites.

Mars:

- Mars is the fourth planet from the sun at a distance of about 228 million km (142 million miles) or 1.52 AU.
- One day on Mars takes just a little over 24 hours (the time it takes for Mars to rotate or spin once).
- Mars is a rocky planet, also known as a terrestrial planet. Mars' solid surface has been altered by volcanoes, impacts, crustal movement and movement and atmospheric effects such as dust storms.
- Mars has a thin atmosphere made up mostly of carbon dioxide (CO2), nitrogen (N2) and argon (Ar).
- **Mars has two moons named Phobos and Deimos.**
- Several missions have visited this planet, from flybys and orbiters to rovers on the surface of the Red Planet.
- The first true Mars mission success was Mariner 4 in 1965. At this time in the planet's history, Mars' surface cannot support life as we know it.
- **Mars is known as the Red Planet because iron minerals** in the Martian soil oxidize, or rust, causing the soil and the dusty atmosphere to look red.

Jupiter:

- About 1,300 Earths could fit inside Jupiter.
- Jupiter is the fifth planet from the sun at a distance of about 778 million km (484 million miles) or 5.2 Astronomical Units (AU). Earth is one AU from the sun.
- One day on Jupiter takes about 10 hours (the time it takes for Jupiter to rotate or spin once).
- Jupiter is a gas-giant planet and therefore does not have a solid surface. Jupiter may have a solid, inner core about the size of the Earth.
- Jupiter's atmosphere is made up mostly of hydrogen (H2) and helium (He).
- Jupiter has 50 known moons, with an additional 17 moons awaiting

confirmation of their discovery, that is a total of 67 moons.

- Jupiter has a faint ring system that was discovered in 1979 by the Voyager-1 mission. All four giant planets in our solar system have ring systems.
- Many missions have visited Jupiter and its system of moons. The Juno mission will arrive at Jupiter in 2016.
- Jupiter cannot support life as we know it. However, some of Jupiter's moons have oceans underneath their crusts that might support life.

Saturn:

- Saturn is the sixth planet from the sun at a distance of about 1.4 billion km (886 million miles) or 9.5 AU.
- One day on Saturn takes 10.7 hours (the time it takes for Saturn to rotate or spin once).
- Saturn is a gas-giant planet and therefore does not have a solid surface. Saturn's atmosphere is made up mostly of hydrogen (H2) and helium (He).
- Saturn has 53 known moons with an additional nine moons awaiting confirmation of their discovery, that is a total of 62 moons.
- Saturn has the most spectacular ring system, which is made up of seven rings with several gaps and divisions between them.
- Only a few missions have visited Saturn: Pioneer 11, Voyager 1 and 2 and Cassini-Huygens. Since 2004, Cassini has been exploring Saturn, its moons and rings.
- Fact: When Galileo Galilei was observing the planet Saturn in the 1600s, he noticed strange objects on each side of the planet and drew in his notes a triple-bodied planet system and later a planet with arms or handles. These "handles" were, in fact, the rings of Saturn.

Uranus:

- Uranus is the seventh planet from the sun at a distance of about 2.9 billion km (1.8 billion miles) or 19.19 AU.
- One day on Uranus takes about 17 hours (the time it takes for Uranus to rotate or spin once).
- Uranus is an ice giant. Most (80 % or more) of the planet's mass is made up of a hot dense fluid of "icy" materials – water (H2O), methane (CH4), and ammonia (NH3) – above a small rocky core.
- Uranus has an atmosphere which is mostly made up of hydrogen (H2) and helium (He), with a small amount of methane (CH4).
- Uranus has 27 moons. Uranus' moons are named after characters from the works of William Shakespeare and Alexander Pope.
- Uranus has 13 known rings. The inner rings are narrow and dark and the outer rings are brightly coloured.
- Voyager 2 is the only spacecraft to have visited Uranus.
- Uranus cannot support life as we know it.
- Unlike any of the other planets, Uranus rotates on its side, which means it spins horizontally.

Neptune:

- Neptune is the eighth and farthest planet from the sun at a distance of about 4.5 billion km (2.8 billion miles) or 30.07 AU.
- One day on Neptune takes about 16 hours (the time it takes for Neptune to rotate or spin once).
- Neptune is a sister ice giant to Uranus.
- Neptune's atmosphere is made up mostly of hydrogen (H2), helium (He) and methane (CH4).

- Neptune has 13 moons. Neptune's moons are named after various sea gods and nymphs in Greek mythology.
- Neptune has six rings.
- Voyager 2 is the only spacecraft to have visited Neptune.

Moon:

- The moon is Earth's natural satellite and orbits the Earth at a distance of about 384 thousand km (239 thousand miles) or 0.00257 AU.
- The moon makes a complete orbit around Earth in about 27.32 Earth days (~around 28 days) and rotates or spins at that same rate, or in that same amount of time. This causes the moon to keep the same side or face towards Earth during the course of its orbit.
- The moon is a rocky, solid-surface body, with much of its surface cratered and pitted from impacts.
- The moon has a very thin and tenuous (weak) atmosphere, called an exosphere.
- More than 100 spacecraft have been launched to explore the moon. It is the only celestial body beyond Earth that has been visited by human beings.
- Twelve human beings have walked on the surface of the moon.

Asteroids:

- Asteroids are minor planets especially those of the inner solar system.
- Asteroids orbit our sun in a region of space between the orbits of Mars and Jupiter known as the Asteroid Belt.
- Asteroids are solid, rocky and irregular bodies.
- Asteroids do not have atmospheres.
- More than 150 asteroids are known to have a small companion moon (some have two moons). The first discovery of an asteroid-moon system was of asteroid Ida and its moon Dactyl in 1993.
- Asteroids do not have rings.
- NASA space missions have flown by and observed asteroids. The Dawn mission is the first mission to orbit (2011) a main-belt asteroid (Vesta).
- Asteroids cannot support life.
- Ceres, the first and largest asteroid to be discovered (1801 by Giuseppe Piazzi), encompasses over one-third of the estimated total mass of all the asteroids in the asteroid belt.

Meteorites:

- Meteorites may vary in size from tiny grains to large boulders. One of the largest meteorites found on Earth is the Hoba meteorite from southwest Africa, which weighs roughly 54,000 kg (119,000 pounds).
- Meteor showers are usually named after a star or constellation which is close to the radiant. Meteors and meteorites begin as meteoroids, which are little chunks of rock and debris in space.
- Most meteorites are either iron, stony or stony-iron.
- Leonid MAC (an airborne mission that took flight during the years 1998 – 2002) studied the interaction of meteoroids with the Earth's atmosphere.
- Meteoroids, meteors, and meteorites cannot support life. However, they may have provided the Earth with a source of amino acids: the building blocks of life.
- Meteoroids become meteors or shooting stars when they interact with a planet's atmosphere and cause a streak of light in the sky. Debris that makes it to the surface of a planet from meteoroids are called meteorites.
- Meteorites may look very much like Earth rocks, or they may have a burned appearance. Some may have depression (thumbprint-like), roughened or smooth exteriors.

- Many of the meteor showers are associated with comets.

Comets:

- Comets are cosmic snowballs of frozen gases, rock, and dust.
- A comet warms up as it comes near the sun and develops an atmosphere or coma. The coma maybe hundreds of thousands of kilometres in diameter.
- Comets do not have moons.
- Comets do not have rings.
- Several missions have visited, impacted and even collected samples from comets
- When comets come around the sun, they leave a dusty trail. Every year the Earth passes through the comet tails, which allows the debris to enter our atmosphere where it burns up and creates ferry and colourful streaks (meteors) in the sky.
- Comets may not be able to support life themselves, but they may have brought water and organic compounds, i.e., the building blocks of life — through collisions with the Earth and other bodies in our solar system.

Satellite Launching Vehicles:

SLV:

- Satellite Launch Vehicle-3 (SLV-3) was India's first experimental satellite launch vehicle, which was an all solid, four stage vehicle weighing 17 tonnes with a height of 22m and capable of placing 40 kg class payloads in Low Earth Orbit (LEO).
- The first experimental flight of SLV-3, in August 1979, was only partially successful. Apart from the July 1980 launch, there were two more launches held in May 1981 and April 1983, orbiting Rohini satellites carrying remote sensing sensors.
- The successful culmination of the SLV-3 project showed the way to advanced launch vehicle projects such as the Augmented Satellite Launch Vehicle (ASLV), Polar Satellite Launch Vehicle (PSLV) and the Geosynchronous Satellite Launch Vehicle (GSLV).

ASLV:

- The Augmented Satellite Launch Vehicle (ASLV) Programme was designed to augment the payload capacity to 150 kg, thrice that of SLV-3, for Low Earth Orbits (LEO).
- While building upon the experience gained from the SLV-3 missions, ASLV proved to be a low cost intermediate vehicle to demonstrate and validate critical technologies that would be needed for the future launch vehicles like strap-on technology, inertial navigation, bulbous heat shield, vertical integration and closed loop guidance.

POLAR SATELLITE LAUNCH VEHICLE (PSLV):

- PSLV is the third generation launch vehicle of India, operationalized in 1994.
- It is the first Indian launch vehicle to be equipped with liquid stages.
- PSLV is a **4-stage launch vehicle** that uses an alternate combination of liquid and solid-fueled rocket stages.
- 1st & 3rd stages are solid-fueled.
- 2nd & 4th stages are liquid-fueled.
- PSLV emerged as the reliable and **versatile workhorse launch vehicle** of India with 39 consecutively successful missions by June 2017.
- Primarily used to launch **remote sensing satellite**.
- **PSLV can deliver payloads of up to:**
  1. 3,250kg to LEO (Low Earth Orbit)
  2. 1600 kg to SSO (Sun Synchronous orbit)
  3. 1400 kg to GTO (Geosynchronous Transfer Orbit)

- **Most famous launches by the PSLV:**
    1. Chandrayaan-1 in 2008 and
    2. Mangalyaan/Mars Orbiter Mission in 2013.
    3. PSLV-C37 launched 104 satellites on February 15, 2017, the highest number of satellites launched in a single flight so far
- **Currently, PSLV rockets have 4 variants:**
    1. PSLV-CA (core alone)
    2. PSLV-DL (Dual strap-on motors)
    3. PSLV-QL (4 strap-on motors)
    4. PSLV-XL (6 strap-on motors)

GEOSYNCHRONOUS SATELLITE LAUNCH VEHICLE (GSLV):

- GSLV is a 3-stage Launch vehicle with solid fuel in the 1st stage, liquid in the 2nd stage and cryogenic in the 3rd stage.
- It was developed **primarily to launch communication satellites** (INSAT Series) of 2.5-tonne class in Geostationary Transfer Orbit and about 4.5 tons class in Low Earth Orbit.

GSLV Mk II:

- This is the largest launch vehicle developed by India, which is currently in operation.
- This fourth-generation launch vehicle is a **three-stage vehicle** with **four liquid strap-ons**.
- The indigenously developed **Cryogenic Upper Stage** (CUS) forms the third stage of GSLV Mk II.
- Lift off mass: 4.14 tones.

GSLV Mk III:

- This is a 3-stage **heavy-lift rocket** with an indigenous cryogenic engine in the 3rd stage.
- GSLV Mk III (ISRO's **Fat boy**) is designed to carry 4-ton class of satellites into Geosynchronous Transfer Orbit (GTO) or about 10 tons to Low Earth Orbit (LEO), which is about twice the capability of the GSLV Mk II.
- Most famous launches: injected Chandrayaan-2, India's second Lunar Mission, into Earth Parking Orbit on July 22, 2019, from Satish Dhawan Space Centre SHAR, Sriharikota.

Recent launches:

PSLV-C51 launch:

- PSLV-C51 was successfully launched by ISRO recently.
- This was the 53rd flight of ISRO's launch vehicle and the first dedicated mission of its commercial arm, New Space India Ltd.
- The mission was undertaken under a commercial arrangement with Spaceflight Inc., U.S.

Satellites onboard:

- It carried 19 satellites (Including Brazil's optical earth observation satellite, Amazonia-1, and 18 co-passenger satellites — five from India and 13 from the U.S.).
- Amazonia-1 is the first fully Brazilian-made satellite, which would help to monitor the Amazon forests.
- The Amazonia-1 was injected into its precise orbit of 758 km in a sun-synchronous polar orbit.
- The satellites from India are:
- The Satish Dhawan SAT (SDSAT) built by Space Kids India. It has an engraving of Prime Minister Narendra Modi on the top panel. A nanosatellite intended to study the radiation levels, space weather, and demonstrate long-range communication technologies.
- The UNITY sat, a combination of three satellites for providing radio relay services. Another satellite belonging to the DRDO.

CMS-01 satellite:

- It is a communication satellite launched by the Indian Space Research Organisation (ISRO) on board the PSLV-C50.
- CMS-01 is a communications satellite envisaged for providing services in extended C Band of the frequency spectrum.
- Its coverage will include the Indian mainland, and the Andaman & Nicobar and Lakshadweep islands.
- The satellite is expected to have a life of more than seven years.

GSAT 30:

- GSAT-30 derives its heritage from ISRO's earlier INSAT/GSAT satellite series and will replace INSAT-4A in orbit.
- GSAT-30 is configured on ISRO's enhanced I-3K Bus structure to provide communication services from Geostationary orbit.
- GSAT-30 uses two satellite frequencies:
- It gives the Indian mainland and islands coverage in the Ku band, and extended coverage in a wider area stretching from Australia to Europe in the lower-frequency C-band.
- The Ku and C bands are part of a spectrum of frequencies, ranging from 1 to 40 gigahertz, that are used in satellite communications.

Services:

- With a mission life of over 15 years, GSAT-30 will provide DTH [direct-to-home] television Services, connectivity to VSATs [Very Small Aperture Terminals] for ATM, stock exchange, television up linking and teleport services, Digital Satellite News Gathering (DSNG) and e-governance applications.

RISAT-2BR1:

- It is a radar imaging earth observation satellite. It provides services in the field of agriculture, forestry, and disaster management. Its mission life is 5 years.
- Other satellites on board: The nine customer satellites were from Israel, Italy, Japan, and the USA. These satellites were launched under a commercial arrangement with New Space India Limited (NSIL).
- **Background:** The RISAT, which was first deployed in orbit on April 20, 2009 as the RISAT-2, uses synthetic aperture radars (SAR) to provide Indian forces with all-weather surveillance and observation, which are crucial to notice any potential threat or malicious activity around the nation's borders. Following the 2008 Mumbai terror attacks, the launch of RISAT-2 was prioritised over RISAT- 1, as its C-band SAR radar was not yet ready and RISAT -2 carried an Israeli-built X-band radar.

Cartosat-3:

- Cartosat-3 is a third-generation agile advanced earth observation satellite with high-resolution imaging capability.
- Developed by the Indian Space Research Organization (ISRO), it will replace the IRS series.
- Cartosat-3 has a panchromatic resolution of 0.25 metres making it the imaging satellite with highest resolution and Mx of 1 metre with a high-quality resolution, which is a major improvement from the previous payloads in the Carto sat series.
- Cartosat-2 was used to plan and execute military operations such as 'surgical strikes' across the Line of Control in 2016 and the operations across Manipur-Myanmar border in 2015. Cartosat-2 has got resolution of 65 cm.

Applications of Cartosat-3:

- It will address the increased user's demands for large scale urban planning, rural resource and infrastructure development, coastal land use and land cover etc.
- In its annual report of 2017-18, ISRO laid out a very clear strategy of

developing India's Earth observation (EO) capabilities that is based on capturing different themes of land, water, cartography, ocean, atmosphere, and meteorology.

- New missions such as the Geo Imaging Satellite (GISAT), which will enable real-time imaging, alongside the established Resource sat, Radar Imaging Satellite (RISAT), Carto sat, Ocean sat and the Indian National Satellite System (INSAT) constellation make India's fleet of EO satellites one of the most comprehensive remote-sensing data sets in the world.

GSAT- 11:

- GSAT-11 is ISRO's heaviest satellite ever built and weighs about 5854 kilograms.
- It was launched onboard Ariane-5 launch vehicle from French Guiana.
- ISRO has revealed that the satellite will be initially placed in the Geosynchronous Transfer Orbit and will be later raised to Geostationary Orbit. It will be using the Liquid Apogee Motor which will be onboard the satellite.
- GSAT-11 is part of ISRO's new family of high-throughput communication satellite (HTS) fleet that will drive the country's Internet broadband from space to untouched areas.
- According to ISRO, GSAT-11's multiple spot beam coverage — 32 in Ku band and eight in Ka bands — will deliver an improved service of 16 gbps over the Indian region and nearby islands.
- The satellite will also have VSAT Terminals which basically will ensure that it can handle large capacity platforms to support a huge subscriber base.

Importance of GSAT 11:

- GSAT-11 will bring far greater speeds (16 Gbps of it, no less) and capacity to meet growing demand for mobile and internet in households, businesses, and public organisations.
- Large parts of rural areas still remain untouched by the scope of commercial telecom today — something GSAT-11 is designed to change.
- Under Digital India's Bharat Net project GSAT-11 will boost access to voice and video streaming in most, if not all, of rural India.
- With India moving fast towards implementing 'Smart Villages and Cities', they can be efficiently linked through a large communication satellite.

Project NETRA:

- An early warning system in space to detect debris and other hazards to Indian satellites.
- Under the project, the ISRO plans to put up many observational facilities: connected radars, telescopes; data processing units and a control centre.
- They can, among others, spot, track and catalogue objects as small as 10 cm, up to a range of 3,400 km and equal to a space orbit of around 2,000 km.

Significance of the project:

- The project will give India its own capability in space situational awareness (SSA) like the other space powers — which is used to 'predict' threats from debris to Indian satellites.
- NETRA's eventual goal is to capture the GEO, or geostationary orbit, scene at 36,000 km where communication satellites operate.
- The effort would make India a part of international efforts towards tracking, warning about and mitigating space debris.