



MAINS
365

Science & Technology

Classroom Study Material 2020
(September 2019 to September 2020)



SCIENCE AND TECHNOLOGY

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1. BIOTECHNOLOGY

About Biotechnology

- Biotechnology is the area of biology that **uses living processes, organisms or systems to manufacture products or technology** intended to improve the quality of human life.
- It includes disciplines like **molecular modeling, genomic, bio - informatics, bio - simulation, clinical information and many more.**
- It provides breakthrough products and technologies to **combat debilitating and rare diseases, reduce our environmental footprint, feed the hungry, use less and cleaner energy, and have safer, cleaner and more efficient industrial manufacturing processes.**
- In accordance with its various applications, branches of Biotechnology have been derived namely –
 - **Blue biotechnology** (marine and aquatic application),
 - **green biotechnology** (agriculture processes),
 - **red biotechnology** (medical)
 - **white biotechnology** (industrial).

Biotechnology in India

- The biotechnology sector of India is **highly innovative** and is on a strong growth trajectory.
- **Indian Government has embarked upon various programs** with a view to harness available human and unlimited biodiversity resources.
- **Department of Biotechnology (DBT)** which was setup in the year 1986 is the **nodal agency** under Ministry of Science and Technology which aims to promote large scale use of Biotechnology, support R&D and manufacturing in Biology etc.
- The Department of Biotechnology has also set up **BIRAC (Biotechnology Industry Research Assistance Council)** agency to strengthen and empower emerging biotechnology enterprises to undertake strategic research and innovation.
- India is among **the top 12 destinations for biotechnology in the world**, with approximately **3% share** in the global Biotechnology industry.
- By FY25, **India's biotech industry is estimated to increase to USD100 billion** from USD7 billion in FY15
- The sector is divided into five major segments- **Bio-pharma, Bio-services, Bio-agri, Bio-industrial, and Bio-informatics.**

Government Initiatives

National Biotechnology Development Strategy 2015-2020 (NBDS)

- DBT had earlier announced the First National Biotechnology Development strategy in 2007 which provided an insight into the enormous opportunities.
- After this, NBDS was launched in 2015 with an aim to **establish India as a world class bio manufacturing hub.**
- **It aims to achieve:**
 - Launching Four Major Missions – **Healthcare, Food and Nutrition, Clean Energy and Education** backed with significant investments for the creation of new biotech products
 - **Create a strong infrastructure for R&D and commercialization** and empower India's human by creating a Life Sciences and Biotechnology Education Council
 - **Creating a Technology Development and Translation network** across the country with global partnership
 - To revitalize the knowledge environment at par with the growing bioeconomy, focus of biotechnology tools for inclusive development etc.
- The Mission will be **implemented by Biotechnology Industry Research Assistance Council (BIRAC).**
- The mission **entails an investment of over 1500 crore by Government of India for five years** with 50% cost for the program coming the World Bank loan.

National Biopharma Mission

- It is an **Industry-Academia Collaborative Mission for accelerating discovery research to early development for biopharmaceuticals.**
- The World Bank assisted **INNOVATE IN INDIA (i3)** program under this mission aims to create an enabling ecosystem to promote entrepreneurship and indigenous manufacturing in the sector.
- The **focus of the mission** is to:
 - **Develop new vaccines**, bio-therapeutics, diagnostics and medical devices to address the rising burden of diseases.
 - **Bring isolated centers of excellence (Academia) together**, enhance regional capabilities and strengthen the current bio-clusters network in terms of capacities as well as quantity and quality of output.
 - To **develop platform technologies for product validation, link institutions** to strengthen clinical trial networks, promote partial de-risking for novel products, and build capacities in emerging areas such as bioethics, bioinformatics etc.

Promotion of Biotechnology in North Eastern Region of India

- In 2009-10 DBT had also set up a North Eastern Region – Biotechnology Program Management Cell (NER-BPMC) **for coordinating and promoting the biotechnological activities in the NER** with annual investment of 180 crores.



- The **biopharmaceutical sector accounts for the largest share of the biotech industry** with a share of 55% of total revenues, followed by bio-agri with 22% market share (2018).

How can Biotechnology be used to address various issues in India?

- **Food security:** Biotechnology can help make crops **more productive and tolerant of other stress like pest, insect etc** helping to feed the next billion people.
 - Foods can also **deliver enhanced nutrition**, such as **Golden Rice** with additional vitamin A from the International Rice Research Institute.
 - Making crops resistant to pest attacks (Bt Cotton and Bt Brinjal).
- **Adapting to Climate change:** India faces drought conditions in different states where biotechnology can act as boon by developing drought resistant crops.
 - Biotechnology industry is helping to produce crops that are resistant to the effects of climate change, help farmers convert to no-till practices and develop solutions that decrease carbon-based fertilizers.
- **Tackling diseases:** Biotechnology offers some of the most promising and targeted ways to find solutions to threats like Zika virus and the rise of antibiotic-resistant bacteria.
- **Bioenergy:** There has been increase in use of **bioethanol and biodiesels** in India. These fuels are derived from living organisms such as plants and their by-products, microbes or animal waste. The growing energy needs of India's rural areas have been increasingly met by biomass fuel.
- **Advancement in drugs:** More recently, the meteoric growth of the Indian pharmaceutical industry is a result of process innovation that has given the country a cost advantage in the manufacture of drugs.
- **Biofortification:** Biofortification is the process by which the nutritional quality of food crops is improved through agronomic practices. Biofortification differs from conventional fortification in that biofortification aims to increase nutrient levels in crops during plant growth rather than through manual means during processing of the crops.
- **Animal Biotechnology:** Biotechnological techniques are used to **improve the productivity of livestock** and also for development of affordable new generation vaccines and diagnostics against a plethora of animal diseases.
 - Embryo Transfer Technology is one such technology which has been developed in India.
- **Bioremediation:** It is a waste management technique in which microorganisms (e.g., bacteria, fungi), plants (termed phytoremediation), or biological enzymes are used to consume and break down environmental pollutants, in order to clean a polluted site. Example: oil zappers.
- **Stem cell therapy:** It is also known as regenerative medicine which promotes the reparative response of diseased, dysfunctional or injured tissue using stem cells or their derivatives.

Challenges faced in India

- **Low Research and development:** India's research and development expenditure is quite low at 0.67 per cent of GDP, not only compared to mature biotechnology economies such as Japan and the US (which stands at around 3 per cent) but also in comparison to emerging economies like China (which is at around 2 percent).
- **Intellectual Property Right regime:** More specific to the biotech pharmaceutical sector, there are a few India-specific challenges with the country's IP regime. There are two main areas of contention for the industry in India's approach to intellectual property.
 - The first issue lies in **Section 3(d) of the Patents (Amendment) Act, 2005**, which sets a higher standard for patentability than mandated by TRIPS. The industry argues that India's stricter standards for patents discourages innovation and dampens foreign investment.
 - The second issue is that of **compulsory licensing**, which gives the government power to suspend a patent in times of health emergencies. Although India has used this option only once, the industry feels that such regulations keep investors clear of Indian markets.
- **Lack of Marketisation:** Most of the early research funding, often provided by universities or the government, runs out before the marketisation phase, the funding for which is mostly provided by venture capitalists. This gap has a huge impact in commercialisation of innovative ideas.
- **Public Awareness:** Lack of public awareness of the modern tools of biotechnology and how it could improve our well-being, offer food and energy securities and help in preserving our environment.
- **Less Lucrative:** The number and quality of jobs offered by this sector is presently lesser than the work force supply available. This is making students less interested in this sector.

- **Regulatory Authority:** The Biotechnology Regulatory Authority of India Bill which envisions creating Regulatory body for uses of biotechnology products including genetically modified organisms is pending in the parliament.

Way forward

- **Increase in investment towards research and development and building human capital:** These initiatives have shifted growth trajectories of countries like China away from India. There is a need for development of specialised human resources along with increasing the number and quality of jobs offered by this sector.
- **Collaboration between government and industry:** As for the challenging IP regime, the government needs to come together with the biopharma industry and chalk out a middle ground that recognises the value of innovation and does not hurt its investment attractiveness.
- **Funding Mechanism:** Government can build a mechanism where funding can be provided for select innovative ideas based on their national importance.
- **Strategic Road Map:** There is a need for development of a strategic roadmap for biotechnology where competitive areas and needs for industry-based R&D should be identified and future plans should be made taking into consideration the competencies and resources of the country.
- **Ecosystem of innovation:** With growing convergence of disciplines it is important for the Universities to evolve an ecosystem in which scientists, innovators and future entrepreneurs could be nurtured.
- **Extending Reach:** There is a need for extending the reach of biotechnology investigations to other fields of study as well such as improving other streams of vaccines and plant varieties.

1.1. GENOME SEQUENCING

Why in News?

Recently, many projects like Genome India Project, IndiGen Project etc. were taken for Genome sequencing.

About Genome sequencing

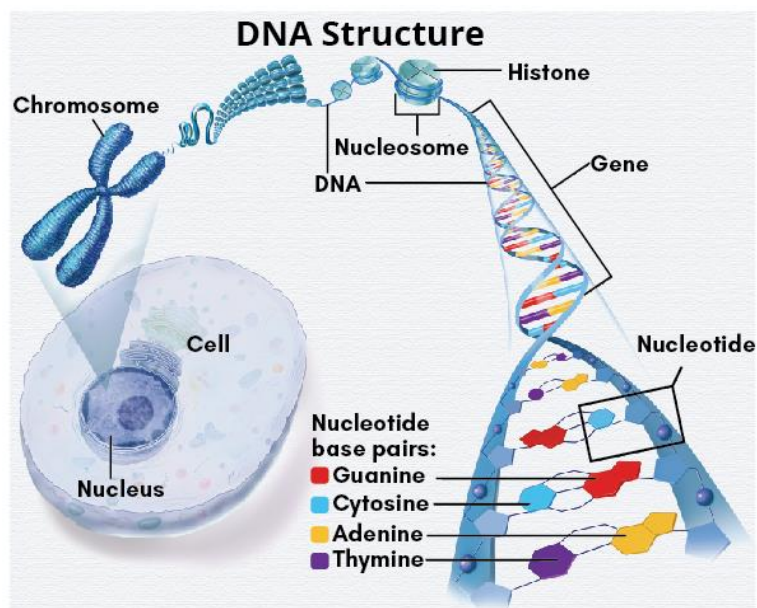
- A genome is an organism's complete set of DNA. It includes all chromosomes, which houses the DNA, and genes.
 - Hence, each genome has approximately 3.2 billion DNA base pairs.
- The genome contains all the data that is needed to describe the organism completely — acting essentially as a blueprint. The genome can be understood through the process described as sequencing.
- **Genome sequencing** is means deciphering the exact order of base pairs in an individual. This data can be analysed to understand the function of various genes, identify genetic mutations and explore how the mutations impact gene functions.

Benefits of Genome sequencing

- **Predictive and Preventive Healthcare:** The outcomes of the project will help in faster and efficient diagnosis of rare genetic diseases.

Important definitions

- **Chromosome:** DNA is tightly coiled to make a thread like structure called Chromosome. Human beings have 46 chromosomes (23 from each parent).
- **Nucleotide:** A nucleotide is an organic molecule that is the building block of DNA and RNA.
- **DNA:** DNA, or deoxyribonucleic acid, is the hereditary material in most of the living beings.
- **RNA:** RNA or Ribonucleic acid molecules are single-stranded nucleic acids. They are hereditary material in some viruses.
- **Genes:** A gene is a 'specific' section of DNA. It is involved in making RNA (transcription) or protein (translation).
- **Gene pool:** A gene pool is the collection of different genes within an interbreeding population.





- This will also help in determining epidemiology of genetic diseases to enable cost effective genetic tests, enabling efficient diagnosis of heritable cancers etc.
- **Precision medicine:** This will help to understand the type and nature of diseases and traits that comprise the diverse Indian population.
 - For example, Vysy community in Andhra Pradesh possess a genetic mutation that renders them susceptible to a category of anaesthetics. Genome sequencing can help to prepare customised and targeted treatments for them.
- **Scientific research:** Mapping the genetic diversity of India would further improve scientific understanding of evolution both from a biological (intra- and inter-species interaction, species-ecology interactions, etc) and sociological (migration patterns, rituals, etc) point of view.
 - The project will enable **collection and preservation** of endangered and economically important species.
- **Prevent biopiracy:** The decoded genetic information will be a useful tool to prevent biopiracy.
 - Biopiracy is **exploitative use of genetic code of plants or animals**, without compensating the countries from which the material or relevant knowledge is obtained.
- **Boost to the field of genomics:** Various projects would provide a boost for the field of genomics and bioinformatics within the country.
 - These projects will help India develop indigenous capacity to generate, maintain, analyze, utilize and communicate large-scale genome data, in a scalable manner.

Challenges in scaling up genome sequencing projects

- **Technological issues:** Like selection of analytical software tools, the speedup of the overall procedure using High-performance computing parallelization and acceleration technology, the development of automation strategies, data storage solutions.
- **Financial issues:** The public exchequer has very limited financial resources for which genetics projects are not as big a priority as national security and social welfare.
- **Legal issues:** Data privacy bill is yet to be passed. Anonymity of the data and questions of its possible use and misuse would need to be addressed.
- **Cyber Security:** Genome sequences of Indians need to be protected with utmost priority. According to Internet Crime Report for 2019, **India stands third in the world among top 20 countries that are victims of internet crimes.**

Related news

UMMID (Unique Methods of Management and treatment of Inherited Disorders)

- Recently, Government launched **UMMID** (Unique Methods of Management and treatment of Inherited Disorders) initiative.
- It aims to **create awareness about genetic disorders amongst clinicians** and **establish molecular diagnostics in hospitals** so that the benefits of developments in medical genetics could reach patients.
- It is **supported by Department of Biotechnology**
- **Three components of UMMID initiative**
 - **To establish NIDAN** (National Inherited Diseases Administration) **Kendras (Diagnostic Centre)**- provide counselling, prenatal testing and diagnosis, management, and multidisciplinary care in Government Hospitals
 - To **produce skilled clinicians in Human Genetics**, and
 - To **undertake screening of pregnant women** and new born babies for inherited genetic diseases in hospitals at **aspirational districts**.

Genome sequencing of the coronavirus

- **India has recently shared nine whole genome sequence data of the novel coronavirus (SARS-CoV-2)** with the **Global Initiative on Sharing All Influenza Data (GISAID)**. The sequences were shared by the **Pune-based National Institute of Virology**.
- The human genome is made up of over 3 billion base pairs. 30,000 base have been identified in the genome of coronavirus.
- **Global Initiative on Sharing All Influenza Data (GISAID)**
 - It is a **platform started by WHO in 2008** and **hosted by the German government in partnership with nonprofit organization Friends of GISAID**.
 - It **promotes the international sharing** of all influenza virus sequences, related clinical and epidemiological data associated with human viruses, and geographical as well as species-specific data associated with avian and other animal viruses,.
 - The Initiative **through its database named EpiFlu** ensures that open access to data is provided free-of-charge and to everyone to help researchers understand how the viruses evolve, spread and potentially become pandemics.

- **Genetic stereotyping and stigmatization-** There is the potential that some of these genomic differences may be treated as retarding and mutually exclusive. This leads to stereotyping of populations on lines similar to caste identities.
- **Interpretational issues-** There are very few trained clinicians and genetic counsellors who could interpret the data in meaningful manner and in the best interest of the patient.

Recent projects launched in genome sequencing

- **Genome India Project**

- It is ambitious gene mapping by **Department of Biotechnology** (under the Department of Science and Technology).
- It involves **20 leading institutions including the Indian Institute of Science** in Bengaluru and a few IITs.
- The Centre for Brain Research, an autonomous institute of IISc, Bengaluru will serve as the nodal point of the project.
- The first stage of the project will look at samples of 10,000 persons from all over the country to form a grid that will enable the development of a Reference Genome.

Related information

Human Genome Project (HGP)

- It was the international research effort to **determine the DNA sequence of the entire human genome**.
- It began in 1990 and completed in 2003.
- The HGP gave us the **ability, for the first time, to read nature's complete genetic blueprint** for building a human being.
- It was coordinated by the **National Institutes of Health, USA and the Department of Energy, USA**.

About Earth BioGenome project

- It is a global effort launched in 2018, involving **scientific partners and funders** from around the globe.
- It aims to **sequence, catalogue and characterise genomes** of all of Earth's **eukaryotic biodiversity** over a **period of ten years**.
- **Vision-** Create a new foundation for biology to drive solutions for **preserving biodiversity and sustaining human societies**.

- **IndiGen programme**

- Recently, **IndiGen programme**, the Council of Scientific and Industrial Research's (CSIR) resource, was completed.
- IndiGen programme aims to **undertake whole genome sequencing of 1000 Indian individuals** representing diverse ethnic groups from India.
- It is **funded by the CSIR India** (autonomous body).
- Its objective is to **create a pilot dataset to enable genetic epidemiology of carrier genetic diseases** towards enabling affordable carrier screening approaches in India.
- It is also seen as a **precursor to a much larger exercise involving other government departments to map** a larger swathe of the population in the country.
- The project involved the Hyderabad-based **Centre for Cellular and Molecular Biology (CCMB) and the CSIR-Institute of Genomics and Integrative Biology (IGIB)**.

- **Indian Initiative on Earth Biogenome Sequencing (IIEBS)**

- Recently, Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI) was selected to take part in **IIEBS**.
- IIEBS aims to **decode the genetic information of all known species of plants and animals** in the country.
- **The National Institute of Plant Genome Research, New Delhi** is the coordinating centre involving a total of 24 institutes.
- The whole genome sequencing of **1,000 species** of plants and animals will be taken up in the **initial phase of IIEBS** to be completed over a **period of five years** at an estimated cost of ₹440 crore.
- The project is **part of the Earth BioGenome Project**.

1.2. NATIONAL GUIDELINES FOR GENE THERAPY

Why in News?

Indian Council of Medical Research (ICMR) published “**National Guidelines for Gene Therapy-Product Development and Clinical Trials**”.

About Gene Therapy

- Gene Therapy refers to the process of **introduction, removal or change** in content of an individual's genetic material with the goal of treating the disease and a possibility of achieving long term cure.
- It is classified into 2 types:

- **Germ-line gene therapy:** The concept of germ-line gene therapy is to introduce gene modified cells into the germline, that can be **transmitted vertically across generations**. Germline gene therapy is prohibited in India, due to ethical and social considerations.
- **Somatic cell gene therapy:** It affects the **targeted cells/tissue/organs in the patient**, and is not passed on to subsequent generations. It is legal in India. This also includes genome modification as done in CRISPR-related and other technologies. It has two categories:
 - ✓ **ex vivo-** cells obtained from an individual are genetically **modified/corrected outside the body** followed by transplantation into the same or a different individual.
 - ✓ **in vivo-** the gene of interest is delivered directly to target cells/tissues/organs (like liver, pancreas, muscle, heart etc.) in the patients. Gene delivery can be carried out by viral or non- viral vector systems.

Some important terms

- **Genotype-** pattern of genes in an organism's DNA that is responsible for a particular trait
- **Phenotype-** refers to the observable physical properties of an organism. These include the organism's appearance, development, and behaviour.
Stem cells: are special human cells that have the ability to develop into many different cell types, from muscle cells to brain cells.
- **Somatic cells** are any body cells that are not involved in reproduction. Most cells in body are somatic cells. They include skin cells, bone cells, red blood cells, and many more.
- **Germ cells** are cells that create reproductive cells called **gametes**. They are found only in the **reproductive glands (ovaries in females and testes in males.)**.
- **Retrovirus:** family of viruses with RNA as genetic material that can integrate their genome into the DNA of host cells, they invade.
- **Transgene:** a genetic material that is artificially introduced into the genome of another organism.

Need of Gene Therapy guidelines

- **Complexity and unpredictability** of human diseases, variety of immune reactions and gene expression in cells leading to failures of human gene therapy trials necessitate one to be cautious for **gene therapies, patient safety, clinical trial design**, production processes and quality required of the actual **gene therapy product**.
- Need of ethical framework to **prevent misuse and premature commercialization**. E.g. Creation of babies using germline gene editing by a Chinese scientist recently, that attracted global criticism.
- Around **70 million Indians** are estimated to suffer from **inherited genetic diseases** which can be cured using gene therapy. These include haemophilia, thalassemia, sickle-cell anaemia etc.
- **Economic benefits:** The worldwide market for treatments for rare diseases is predicted to grow at a compound annual growth rate (CAGR) of 11.3% from 2018 to 2024 and predicted to reach revenues of more than \$250 billion.
- **Guideline to help researchers and regulators:** by providing an enabling environment and guiding scientifically sound practice it is likely to **spur innovation and accelerate research** for rare diseases. It will also facilitate the clearance of such therapies by the Drugs Controller General of India on objective basis.

A **Gene Therapy Product (GTP)** is defined as any biological entity, having the required gene, that could introduce modifications in the genome for therapeutic benefit. GTPs work by repairing, replacing or deactivating dysfunctional disease-causing genes aiming to restore normal function. GTPs include:

- **Recombinant viral vectors:** adenovirus, retrovirus
- **Non-viral vectors:** naked DNA transfection
- **Microbial/bacterial vectors** (Salmonella, E. coli): recombinant bacteria derived vehicles
- Modifications resulting from the use of **CRISPR** and other similar technologies
- **ex vivo genetically modified cells:** gene modified/augmented stem cells, iPS (induced pluripotent stem) cells, CAR-T cells etc.
- **Soluble/particulate/emulsion/Nano based interventions** containing any form of genetic material/ nucleic acid for the purpose of clinical gene therapy
- **DNA vaccines** where the final product is nucleic acid and is administered for vaccination/therapy.

As per the New Drugs and Clinical trial Rules (2019) the GTPs falls under 'new drug' and shall always be deemed to be 'new drug'.

Key guidelines

- **Applicability:** The guidelines apply to **all stakeholders** in the field of gene therapy including researchers, clinicians, regulatory committees, industry, patient support groups etc.

- **General Principles:** Clinical trials on human participants involving GTPs must safeguard **human rights, safety and dignity**. Various principles like Principle of Essentiality, Voluntariness, Non-exploitation, Risk Minimization etc. need to be followed.
- **Mechanism for Review and Oversight:**
 - Proposed establishment of **Gene Therapy Advisory and Evaluation Committee (GTAEC)**.
 - It is mandatory for all institutions and entities engaged in development of GTPs to establish an **Institutional Bio-safety committee (IBSC)**.
 - Research involving development of new GTPs needs to obtain approvals from IBSC and Ethics Committee (EC). Biological material from humans can be procured only from clinics/hospitals that have an **Ethics Committee**.
 - All clinical trials are mandated to be registered with **Clinical Trials Registry-India (CTRI)**. It is an online public record system for registration of clinical trials being conducted in India.
- **Responsibilities of various stakeholders**
 - Investigators should treat the biological material with **utmost respect and adequate care** to avoid its misuse.
 - Storage and disposal of the GTPs or its components should be as per the Regulations and Guidelines on **Bio-safety of Recombinant DNA Research and Bio-containment 2017**.
 - Any GTP of foreign origin or its modified variants that will be first in human use is not permissible for direct first in human trials in India.
 - Investigators should demonstrate **respect for autonomy and privacy of patients**.
- **Good Manufacturing Practise (GMP) Guidelines:**
 - It includes Personnel Training, establishment of quality control processes.
 - Waste materials and by-products of the GTP manufacturing process must be securely decontaminated and transported as per appropriate biohazard disposal protocol.

Way Forward

There remain many hurdles that the scientific and clinical community working in the R&D fields are yet to overcome, primarily the appropriate and timely diagnosis including genetic testing and genetic counselling, prohibitive costs of such gene therapies, adequate insurance coverage and management practices among treating physicians. While prospects are bleak for many individuals with conditions classified as rare diseases, policies such as that proposed by the ICMR may offer hope.

1.2.1. GENE EDITING

Why in news?

The 2020, Nobel Prize in Chemistry was awarded jointly to Emmanuelle Charpentier and Jennifer A. Doudna for **discovering the CRISPR-Cas9 genetic scissors**, which allows scientists to 'cut-paste' inside a genetic sequence.

About the Discovery

- **tracrRNA:** During Emmanuelle charpentier's studies of streptococcus pyogenes, one of the bacteria that cause the most harm to humanity, she discovered a previously unknown molecule, tracrRNA.
 - Further studies revealed that this tracrna was part of the bacteria's immune system and it helps the bacteria destroy viral DNA.
- **Reprogrammed CRISPR-CAS9:** Emmanuelle Charpentier and Jennifer A.

Clusters of Regularly Interspaced Short Palindromic Repeats (CRISPR)

- **CRISPR:** They are specific segments in the bacterial DNA that contain palindromic repeats inter spaced with pieces of DNA (called spacer) that bacteria snip off from attacking viruses.
 - Rodolphe Barrangou discovered that CRISPR is the natural defence mechanism of Bacteria against virus attack.
- **Cas9:** It is a CRISPR-associated (Cas) endonuclease, or enzyme, that acts as "molecular scissors" to cut DNA at a location specified by a guide RNA.
- **CRISPR-Cas9:** It is a unique genome editing technology that enables geneticists and medical researchers to edit parts of the genome by removing, adding or altering sections of the DNA sequence.

Significance of the discovery

- CRISPER cas9 tool is **easier to adapt and genes could be edited within few weeks** with this tool.
- This tool has contributed to many important **discoveries in basic research**, and plant researchers have been able to develop crops that withstand mould, pests and drought.
- In medicine, **clinical trials of new cancer therapies are underway**, and it can help cure inherited diseases.
- These genetic scissors have **taken the life sciences into a new epoch** and, in many ways, are bringing the greatest benefit to humankind.

Doudna succeeded in recreating the bacteria's scissors and reprogramming it. They then proved that they can now use these scissors to cut any DNA molecule at a required site.

Genome editing

- Genome editing is a technology that give scientists the ability to change an organism's DNA.
- This allows genetic material to be added, removed, or altered at particular locations in the genome.
- It is a three-stage complex mechanism of **unwinding, cleaving and rewinding of DNA** to bring desirable changes in the genome of any living beings.
 - Cleaving of the DNA includes editing of genes (cut paste of the DNA).
- **Other genome editing systems** include TALENs and Zinc-Finger Nucleases.

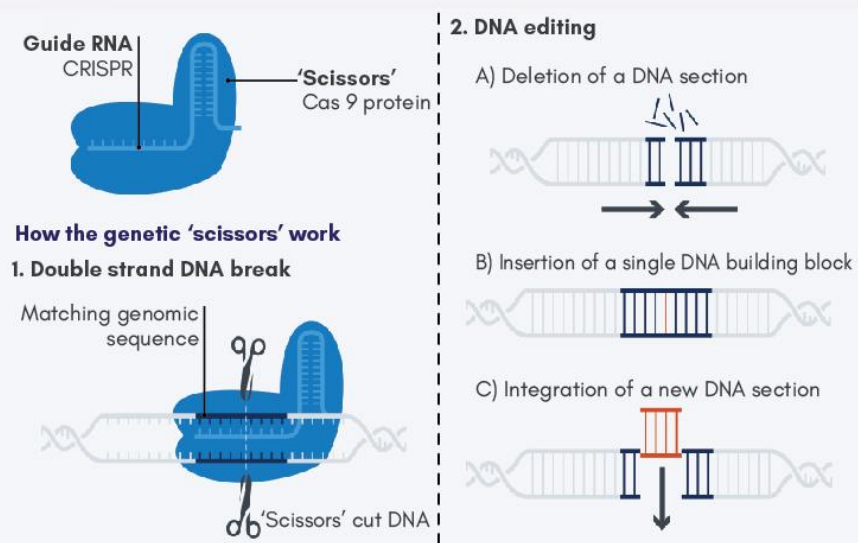
Challenges of Genome editing

- **Ethical issues:** Since there are limits to our knowledge of human genetics, gene-environment interactions, and the pathways of disease, there could be unintended consequences of gene editing on future generations.
 - **Ethical questions that have no concrete answers**
 - ✓ Should we make changes that could fundamentally affect future generations without having their consent?
 - ✓ What if the use of germ line editing veers from being a therapeutic tool to an enhancement tool for various human characteristics (Designer baby)?
- **Off-target effect:** DNA is edited other than the desired site hence creating an unwanted outcome.
 - As happened in China where genetically designed twins were created via in-vitro fertilisation and they were supposed to have a gene that protects them against HIV; however this intended outcome could not be achieved.
 - Instead, the two newborns had host of undesirable mutations.

THE CRISPR/CAS GENETIC SCISSORS

CRISPR/CAS system

An artificially constructed gene editing tool



Conclusion

Even though the CRISPR/Cas-9 system allows a democratic usage in labs across the world to tinker with genomes, it still has not reached the level of precision required to be sure that it does not cause unintentional side effects.

1.2.2. STEM CELL THERAPY

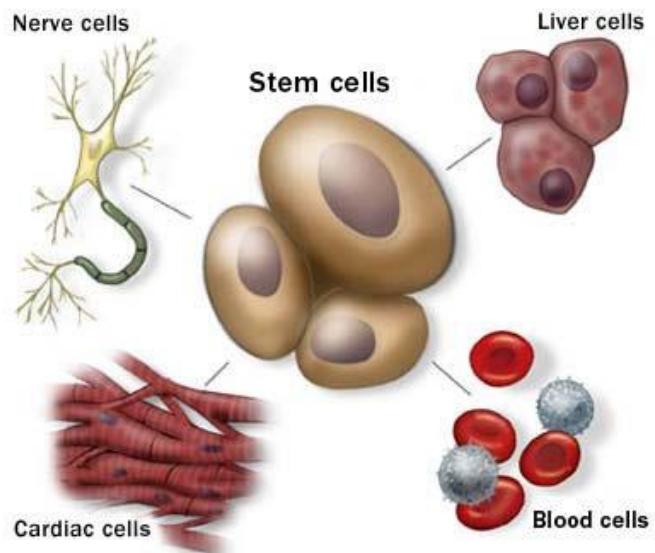
Recently, Stem cells offered a ray of hope in battle against covid-19.

More about research

- This approach involves **intravenous injection of mesenchymal stem-cells (MSC) from a human placenta into a covid-19 patient** to boost body's immune response against infection.
- MSCs are pluripotent stem cells found in bone marrow. Pluripotent stem cells have the ability to differentiate into almost all cell types.
- Stem-cells have strong **anti-inflammatory and immunomodulatory properties**, which can prevent lung inflammation in severe cases of COVID-19.
- It **could help build up regenerative cells in the lungs**, which could protect the epithelial cells of the lungs, prevent lung damage and help patients recover.

About Stem Cells

- Stem cells are **body's raw materials** — cells from which all other cells with specialized functions are generated.
- Stem cells divide to form more cells **called daughter cells**.
- These daughter cells either become new stem cells (self-renewal) or become specialized cells (differentiation) with a more specific function, such as blood cells, brain cells, heart muscle cells etc.
- No other cell in body has natural ability to generate new cell types.
- The **principle underlying stem cell therapy** is to extract stem cells from bone marrow or other body tissues and implant them back into the body to cure diseases.
 - Stem-cells have been successful in treating degenerative diseases, especially Alzheimer's, Type-1 diabetes etc.



National Guidelines for Stem Cell Research (NGSCR) in 2017

- Indian Council of Medical Research (ICMR) released the NGSCR in 2017.
- It aims to ensure that **all research with human cell is conducted in an ethical and scientifically manner**.
- The guidelines focus on:
 - **Monitoring mechanism and regulatory pathway** for basic, clinical research and product development based on categories of research and level of manipulation.
 - **Procurement of gametes, embryos and somatic cells** for derivation and propagation of any stem cell lines, their banking and distribution.
 - **Other important areas** like international collaboration, exchange of cell/lines and education for stakeholders and advertisement.
- **Prohibitions under Guidelines**
 - research related to human germ line gene therapy and reproductive cloning
 - in vitro culture of intact human embryos beyond 14 days of fertilization or formation of primitive streak whichever is earlier
 - Clinical trials involving transfer of xenogeneic cells into a human host

1.3. DNA TECHNOLOGY (USE AND APPLICATION) REGULATION BILL, 2019

Why in news?

Parliamentary Standing Committee on Science and Technology has expressed concerns over some of the provisions of The **DNA Technology (Use and Application) Regulation Bill, 2019**.

Background

- The first attempt to regulate use and application of DNA technology was made in **2003** with the constitution of a **DNA Profiling Advisory Committee**. A draft bill was accordingly prepared.
- After many revisions, the **Bill was introduced in Lok Sabha in 2018**, but it lapsed.
- **In 2019, it was reintroduced and was referred to Parliamentary Standing Committee.**

Key provisions of the Bill

- It provides for the **regulation of use of DNA technology** for establishing the identity of certain persons.
 - DNA testing is allowed only in respect of matters listed in the Schedule to the Bill, like:

DNA Profiling and Sampling

- It is the process where a **specific DNA pattern, called a profile**, is obtained from a person.
- The biological material used to determine a DNA profile include **blood, semen, saliva, urine, faeces, hair, teeth, bone, tissue and cells**.

Potential Benefits of DNA Technology (Use and Application) Regulation Bill, 2019

- **Identifying missing persons, unidentified deceased persons** including disaster victims, burn victims, accident victims etc.
- **Apprehend repeat offenders for heinous crimes** such as rape and murder.
- **Expedite delivery of justice** by reducing wrongful convictions and enhancing accuracy of investigating authorities.



- matters of **offences under Indian Penal Code**,
- **civil matters such as paternity suits** and
- for **establishment of individual identity**.
- **Consent provisions for collection of DNA:**
 - For arrested persons, **authorities are required to obtain written consent** if the **offence carries a punishment of up to seven years**.
 - If the offence carries more than seven years of imprisonment or death, **consent is not required**.
 - If the person is a **victim/relative of a missing person/minor/disabled person**, the authorities are **required to obtain the written consent** of such person.
 - **If consent is not given** in these cases, the authorities can approach a **Magistrate who may order the taking of bodily substances** of such persons.
- Establishment of a **National DNA Data Bank and Regional DNA Data Banks**.
 - DNA laboratories are required to share data prepared by them with the National and Regional DNA Data Banks.
- Bill provides for **removal of the DNA profiles** of the following persons:
 - A **suspect** if a police report is filed or court order given.
 - An **undertrial** if a court order is given.
 - on written request, for persons **who are not a suspect, offender or undertrial**.
- Establishment of a **DNA Regulatory Board** to **supervise the DNA Data Banks and laboratories**.
 - **The Secretary, Department of Biotechnology** will be **ex officio Chairperson** of the Board.
 - Board will comprise **additional members** including: Experts in the field of biological sciences; **Director General of the National Investigation Agency** and Director of the **Central Bureau of Investigation**.
 - **Functions of the Board** include, advising governments on all issues related to establishing DNA laboratories or Data Banks, granting accreditation to DNA laboratories etc.
- **Penal provisions** for offences like **unauthorised disclosure**, obtaining, use and access of DNA samples, destruction, alteration, contamination or tampering with biological evidence etc.

Concerns raised by the Committee

- **Sensitive information:** DNA profiles can reveal extremely sensitive information of an individual such as pedigree, skin colour, behaviour etc. Access to such information can be misused to specifically target individuals and their families with their own genetic data. E.g.: incorrectly linking a particular caste/community to criminal activities.
- **Weak Consent Clause:** Magistrate can easily override it consent thereby making consent perfunctory. There is no guidance on the grounds and reasons of when the magistrate can override consent.
- **Violation of the fundamental right to privacy:**
 - Bill provides **retention of DNA found at a crime scene in perpetuity**, even if conviction of the offender has been overturned.
 - **DNA profiles for civil matters will also be stored in the data banks**, but without a clear and separate index. This violates the fundamental right to privacy and does not serve any public purpose.
- **Absence of robust data protection legislation**, which raises concerns regarding security of a huge number of DNA profiles that will be placed with the National DNA Data bank and its regional centres.

Way Forward

- **Committee suggested the following:**
 - **Independent scrutiny must be done** of the proposals to destroy biological samples and remove DNA profiles from the database.
 - Make provisions to ensure that if a person has been found innocent **his DNA profile has to be removed immediately** from the data bank.
- India first needs **laws to protect privacy and personal data** and also sample collection has to be carefully defined, purpose-based.
- The DATA banks and laboratories should have **highest possible levels of cyber security** to prevent Cyber security breaches.

1.4. ASSISTED REPRODUCTIVE TECHNOLOGY

Why in news?

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

More on news

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

Key provisions of the bill

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

Need for the bill

- **High demand and growth of ART:** India is among countries that have seen the highest growth in the number of ART centres and ART cycles performed every year.
 - According to a 2015 Ernst and Young study, around 27.5 million couples in the reproductive age group are infertile and about 1% (about 2,70,000 infertile couples) seek infertility evaluation. Of the people seeking remedy for infertility, 20-25% undergo IVF treatment and of that small group, one percent may require surrogacy.
 - ✓ **India has become one of the major centres of the global fertility industry (ART)**, with reproductive medical tourism becoming a significant activity. This has also introduced a plethora of legal, ethical and social issues; yet, there is **no standardisation of protocols** and reporting is still very inadequate.
- **Facilitating effective implementation of other laws:** Without registration and a proper database of medical institutions and clinics providing such services, it is impossible to regulate services like surrogacy and abortion under **the Surrogacy Regulation Bill, 2019** and Medical Termination of Pregnancy (Amendment) Bill, 2020.

Types of ARTs

- **In Vitro Fertilization:** It is the most common form of ART that is used by maximum patients. In this, woman's eggs are combined with man's sperm in a laboratory. The fertilised egg is then placed inside the woman's uterus in a procedure called embryo transfer.
- **Gamete intrafallopian transfer (GIFT):** The man's sperm and a woman's egg are made to combine in a lab. Then the eggs are implanted into the fallopian tubes and the fertilization occurs inside a woman's body.

- **Intrauterine insemination (IUI):** Also known as artificial insemination, it involves insertion of the male partner's (or a donor's) sperm into a woman's uterus at or just before the time of ovulation by long narrow tube.
- **Gestational Surrogacy:** In this, the embryo is created via IVF, using the eggs and sperm of the intended parents or donors, and is then transferred to the surrogate. The child is thus not biologically related to the surrogate mother, who is often referred to as a gestational carrier.

1.5. GM CROPS

Why in news?

Recently, environmentalists have asked centre to take a concrete stand over the safety of GM crops.

About GM crops

- A GM or transgenic crop is a plant that has a **novel combination of genetic material obtained through the use of modern biotechnology** mainly using recombinant DNA (rDNA) technology.
- For example, a GM crop can contain a gene that has been artificially inserted instead of the plant acquiring it through pollination.

GM crops in India

- India has **commercialized only one GM crop, the Bt cotton** with the Cry 1 Ac gene (Bollgard I).
- India is at the **4th global position in hectareage under GM crops.**
- Bt cotton greatly contributed to a **significant increase in farm income** and India's transformation from a cotton importer into an exporter.
- The **area under Bt cotton seeds is rising**, official data for the 2018 - 19 kharif season reveals that 88.27 per cent of the 122.38 lakh hectares cultivation is under Bt cotton of all varieties
- GM crops and products are **stringently regulated for their efficacy, biosafety, environmental safety and socio-economic benefits**, through mandatory rules and procedures. No conventionally bred crop or product undergoes any such evaluation.
- Other GM crops currently under process includes **Bt Brinjal, Golden Rice** etc.

Policy framework for GM Crops

- **Codex Alimentarius Commission (Codex):** It is the joint FAO/WHO intergovernmental body responsible for developing the standards, codes of practice, guidelines and recommendations that constitute the Codex Alimentarius, meaning the international food code. Codex developed principles for the human health risk analysis of GM foods in 2003.

STATE OF BT CROPS IN INDIA

BT COTTON

- Bt cotton grown in India for over a decade -output up fourfold since commercial cultivation allowed in 2002
- 95% of 11-12m ha under the crop is GM cotton
- Punjabi & Haryana produce 4m bales (1 bale = 170kg) of India's **total output of 38m bales**

CONTROVERSY

- Bt cotton, supposed to be immune to pests, crumbled under whitefly attack in Punjab in 2015
- Over 95% damaged crop was bt cotton | **Rs 4.5k cr estimate**
- Blamed for over a dozen farmer suicides

FORECAST

- US says India will surpass China as world's largest cotton producer in 2015/2016
- India's cotton forecast for 2015/2016 | **29.5m bales** (Share in world) production | 26.5%

BT BRINJAL

- Approved for cultivation by India's Genetic Engineering Approval Committee in Oct 2009
- Had it not been banned, Bt brinjal would have been India's first GM food crop
- But stiff opposition led to indefinite moratorium on its cultivation in Feb 2010

CONTROVERSY

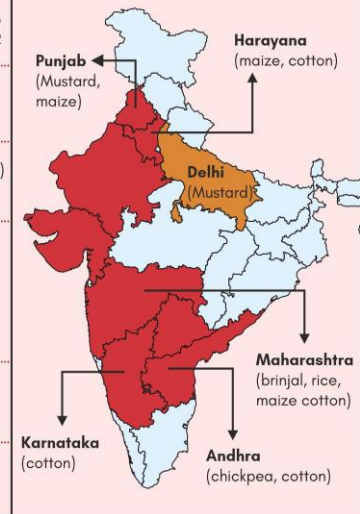
- Activists raised food safety
- Farmers dependent on MNC for seeds from the single firm that makes them

BT MUSTARD

- Earlier the biotechnology regulator deferred a decision to allow commercial cultivation of Mustard DMH-11-a transgenic crop
- Indian's edible oils import bill exceeds \$10bn
- DMH11 (Dhara Mustard Hybrid 11) is said to deliver 25-30% higher mustard-seed yields compared to the best "check" varieties

CONTROVERSY Those opposing DMH-11 mustard are against genetic modification tech over food safety issues

CULTIVATION & FIELD TRIALS





- **Genetic Engineering Appraisal Committee (GEAC):** Since 1989 GEAC under the Ministry of Environment, Forest and Climate Change has been responsible for approving commercial cultivation of GM crops as well as the manufacture, import and selling of processed foods made from GM ingredients.
- **Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Microorganisms/Genetically Engineered Organisms or Cells 1989 (known as 'Rules, 1989') under the Environment (Protection) Act, 1986:** These rules and regulations cover the areas of research as well as large scale applications of Genetically Modified Organism (GMOs) and products made there from throughout India.
- **GM food imports** require approvals under two laws. **Environment Protection Act of 1986** and the **Food Safety and Standards Act of 2006**.

Benefits of GM Crops

- **To Improve Economic Condition:** Many farmers are **very satisfied with GM crops** which is **less labour-intensive** and hence is **cost-beneficial**.
- **Better tolerance:** GM crops are better tolerant to different harsh climatic conditions like cold, heat, drought salinity etc.
- **Improved Crop Protection:** The GM crops aims at an increased level of crop protection through the introduction of resistance against plant diseases caused by insects or viruses or through increased tolerance towards herbicides.
- **Increased food security for growing population:** Biotechnology holds a lot of promise in achieving food security in sustainable manner.
- **Improved agricultural performance (yields) with less labour input and less cost input:** It has led to an increase in production and the costs of cultivation have gone down.
- **Improved processing characteristics** leading to reduced waste and lower food costs to the consumer.
- **Prevention of loss of species to endemic disease**
- **Benefits to the soil of "no-till" farming practice**
- **Reduced usage of pesticides and herbicides**

Concern with GM Varieties

- **Unsafe for Consumption:** Due to inadequate understanding genetic changes made in a plant can make it unsafe for consumption, have adverse impacts on human or animal health, or introduce problems in the soil or neighbouring crops.
 - According to GM expert opponent, some traits of genes start expressing themselves only after several generations, and thus one can never be sure about their safety.
- **Pesticide Poisoning:** In the Maharashtra, 60 labourers and farmers died due to inhalation of pesticides, which were attributed to GM seeds.
 - **Indiscriminate usage of glyphosate** can cause health hazards to humans and cattle, apart from affecting the yield of cotton.
- **Monopolising Market:** GM seeds contain 'terminator technology' meaning they have been genetically modified so that resulting crops do not produce viable seeds of their own.
- **Environmental risks:** There are concerns that the introduction of GM crops might lead to a reduction in biodiversity (the variety of plants and animals in the wild), particularly in areas where a crop originated and a wide range of natural genetic variation is found.
- **Gene transfer:** There might also be unexpected consequences of gene transfer (or 'gene flow') between plants, for example an irreversible or uncontrollable 'escape' of genes into neighbouring wild plants by pollen.
- **Developing resistance:** There is potential for pests to evolve resistance to the toxins produced by GM crops.
- **Monoculture:** There is desperation among farmers as introduction of Bt cotton has slowly led to the non-availability of traditional varieties of cotton leading to monoculture.
- **Regulatory Failure:** The government's dithering attitude on GM crops has often led to regulatory failure.

Way Forward

- **Focus on GM technology:** National policy on GM crops to define the exact areas where GM is required by the country and where the government will encourage public and private investment in GM technology.

- The ministry should examine the impact of GM crops on environment thoroughly and no genetically modified (GM) crop should be introduced in India unless the biosafety and socio-economic desirability is evaluated in a “transparent” process and an accountability regime is put in place.
- **Grievance redressal of all stakeholders:** All the grievances of farmers and the public must be resolved before allowing GM mustard by putting the safety documents online and addressing the concerns in all comments received.
- **Legal measure:** There should be a liability clause, that is, if something goes wrong the liability should be fixed statutorily like in case of US law, liability is huge in case the GM tech effects the regular varieties of crops. It will ensure that case of non-accountability, in case of pink bollworm pest attack on BT cotton, does not repeat itself in case of other GM crops.
- **Stringent Regulation:** With advances in biotechnology, there is an urgent need for stringent regulation or scrutiny in the sector to ensure cultivation and sale of environmentally-safe agro products.
 - The FSSAI must identify all GM products being sold in the market and prosecute companies and traders responsible.

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2. NANOTECHNOLOGY

About Nanotechnology

- **Nanoscience** is the study of materials which are in nanoscale range (size scale range of 1 to 100nm).
- **Conversion of any material in nanoscale results** in alteration of its physicochemical, biological, mechanical, optical, electronic, etc. properties which can be utilized **for different useful activities**.
- Nanotechnologies are the **design, characterisation, production and application of structures, devices and systems** by controlling shape and size on a nanometre scale.

Current status of Nanotechnology in India

- India ranks **third in the number of researches in the field of nanotechnology** after China and USA.
- This significant share in global nanotech research is a result of **sharp focus by the Department of Science and Technology (DST)** to research in the field in the country.
- Nanotechnology in India evolved through years. The **9th Five-Year Plan (1998-2002)** had mentioned for the first time that national facilities and core groups were set up to promote research in frontier areas of S&T which included superconductivity, robotics, neurosciences and carbon and nano materials.
- In 2007 a **Mission on Nano Science and Technology (Nano Mission)** was launched by the DST to foster, promote and develop all aspects of nanoscience and nanotechnology which have the potential to benefit the country.
- According to a report by ASSOCHAM and TechSci Research study, the global nanotechnology industry would require about two million professionals from 2015 onwards and India is expected to contribute about 25% professionals in the coming years.

Initiatives in Nanotechnology in India

Mission on Nano Science and Technology (Nano Mission)

- It is an **umbrella programme for capacity building** which envisages the overall development in the field of nanotechnology in the country and to tap some of its applied potential for nation's development.
- **Objectives of the Nano-Mission are:**
 - **Basic Research Promotion:** Funding of basic research by individual scientists and/or groups of scientists and creation of centres of excellence.
 - **Infrastructure Development for Nano Science & Technology Research.**
 - **Nano Applications and Technology Development Programmes:** To promote application-oriented R&D Projects.
 - **Human Resource Development:** To focus on providing effective education and training to researchers and professionals in diversified fields so that a genuine interdisciplinary culture for nanoscale science, engineering and technology can emerge.
 - **International Collaborations:** It is planned to facilitate access to sophisticated research facilities abroad, establish joint centres of excellence and forge academia-industry partnerships at the international level wherever required and desirable.

Other initiatives

- Eighteen **sophisticated analytical instruments facilities (SAIFs)** established by DST across India play a major role in advanced characterisation and synthesis of nano-materials for various applications.
- **Centre of Excellence** in Nanoscience and Nanotechnology established by DST-Nano mission helps research and PG students in various thrust areas.
- **Thematic units of excellence (TUEs)** for various areas of nanoscience and nanotechnology play a major role in product-based research to support nanotechnology.
- **Visveswaraya PhD fellowships** offered by MeitY supports various nanotechnology activities in the country.
- **INSPIRE scheme** supports research fellows to work in interdisciplinary nanotechnology, nanoscience and nano-biotechnology areas.

Applications of Nano Technology

- **Medical field**
 - **Disease Diagnosis & treatment:** Nano medicine have resulted in formation of Nano scale diagnostic device which are more efficient & able to detect cancer, bacterial and viral infection.
✓ Nanotechnology can help to repair damaged tissue through **tissue engineering**.
 - **Drug Delivery:** For the formation of Nano size drug which will help in lowering overall drug consumption & side effect by depositing active agent at specific places in body.



- **Medical Nanorobot:** These Nano size robots can navigate the human body, transport important molecule, manipulate microscopic object and communicate with physician by way of miniature sensor.
- **Superbugs and anti-microbial resistance:** Nanotechnology holds the key to stopping antibiotic-resistant bacteria and the deadly infections they cause.
- **In Defence sector** like Precision guiding tools, supplement to traditional weaponry for close combat situations.etc.
- **Environment:** Water treatment and remediation through nanomembranes for water purification, desalination and detoxification; Nanosensors for the detection of contaminants and pathogens etc.
- **Construction:** Nanomolecular structures to make asphalt and concrete more robust to water seepage; Heat-resistant nanomaterials to block ultraviolet and infrared radiation; etc.
- **Energy:** Novel hydrogen storage systems based on carbon nanotubes and other lightweight nanomaterials ; Carbon nanotubes in composite film coating etc.
- **Agriculture** like food processing, soil health etc.
 - **In the food processing industry** antimicrobial nanoemulsions are used for applications in decontamination of food equipment, packaging or food, nano-based antigen detecting biosensors for identification of pathogens contamination.

Challenges in Nanotechnology

- **Health and environmental impact:** Nanoparticles is believed might be able to disrupt cellular, enzymatic and other organ related functions posing health hazards. On the other hand nanoparticles might also be non-biodegradable and on disposal, these disposed materials might form a new class of non-biodegradable pollutant and pose a new threat to the environment (air, water, soil) and health.
- **Information asymmetry:** This includes lack of information on the nature and characteristics nanomaterials in applications, insufficient methods for detecting and measuring nanomaterials, inadequate breadth of risk related research.
- **Lack of infrastructure and human resources:** There is poor lab firm integration, which is compounded by the scarcity of skilled manpower that could provide linkages between the technology and commercial domains.
- **High costs of technology:** High nanotechnology costs for acquisitions of intellectual property rights, nanotechnology infrastructure, lack of human and policy capacity, financial constraints often act as an impediment.
- **Governance issues:** As nanotechnology is multidisciplinary and interdisciplinary, it has given rise to various issues. This has led to significant overlaps in the areas to R&D support identified by different agencies.
- **Ethical consequences:** For instance nanotechnology may be used in warfare, may invade people's privacy, or may impinge on the relationship between human beings and technology.
- **Effect on developing and underdeveloped countries:** Reverse effects of nanotechnology developments on material demands and consequently on developing countries' export of raw materials. Properties at the nano-scale maybe used to imitate the properties of rare minerals, thus affecting the export rates of their main producers.

Conclusion

The development of Nano science and technology in India has huge potential to help the country address societal challenges such as provision of drinking water, healthcare, etc., and simultaneously achieve economic gains through growth in the nanotech-based industrial sector. Therefore, it is necessary to develop responsible nanotechnology governance, encourage the development of appropriate products targeted to help meet critical human development needs, and include methods for addressing the safety, appropriateness etc.

Nano-pharmaceutical

- Recently, Department of Biotechnology under Ministry of Science and Technology has prepared **draft guidelines for evaluation of nano-pharmaceuticals in India.**
- **Nano-pharmaceutical** is an emerging field that combines nanotechnology with pharmaceutical and biomedical science with the goal of targeted drug delivery which may improve efficacy and safety profile.
- There are **no uniform internationally acceptable guidelines** for nano-pharmaceuticals.
- **Benefits of nano-pharmaceuticals include:**

- **Overcomes the limitations of the conventional drug** delivery systems and precision targeting via nano-pharmaceuticals reduces toxic systemic side effects, resulting in better patient compliance.
- **Offers the ability to detect diseases** at much earlier stages.

Need for regulation of nano-pharmaceuticals

- The main **challenges faced by regulatory institutions in India** include: regulatory capacity, information asymmetry, Inter-agency coordination, overlapping roles and mandates etc.
- **Possible adverse effects of nanotechnology** on the environment and humans.
- Their use as **undetectable weapon** in warfare.
- Incorporation of nano-devices as performance enhancers in human beings.
- **Ethical and social issues** associated with nano pharmaceuticals.
- **Need for orderly growth of the sector** and commercialization of nano technology innovations.

Salient features of the Draft guidelines

- They aim to **ensure the quality, safety and efficacy** as well as encourage the commercialization of nanotechnology based innovation with high benefit and low risk ratio.
- **Defines nano-pharmaceuticals** as a pharmaceutical preparation containing nanomaterials intended for internal or external application on the body for the purpose of therapeutics, diagnostics and any health benefit.
- **Categorizes nano pharmaceuticals:**
 - **According to degradability of nanomaterial**
 - **Biodegradable nanoparticles** like albumin, chitosan, gelatin, polycaprolactone etc.
 - **Nonbiodegradable nanoparticles** like titanium oxide, iron oxide, metals such as gold, silver, platinum, etc.
 - **According to nature of nanomaterial:** Nanomaterial may be organic or inorganic in nature. It may also be multicomponent nanoparticle.
 - According to nanoform of the ingredient
 - According to the approval status of drug and nanomaterial.
- It **mandates that the stability testing of nanopharmaceuticals** should be done according to the general requirements specified in Drugs and Cosmetics Rules, 1945.

2.1. NANO TECHNOLOGY IN AGRICULTURE

Why in news?

Recently centre has released '**Guidelines for Evaluation of Nano-based Agri-input and food products**' in India.

Nanotechnology in Agriculture

- **Benefits of Nanotechnology in agriculture**
 - **Reduce nutrient run off into ground water**
 - **Increase plant productivity** and better crop protection
 - **Better input management and increases soil fertility through use of nanotubes, biosensors, controlled delivery systems, nanofiltration, etc.**
 - **Help in achieving sustainable agriculture** and doubling Farming Income.
 - **For controlling pests** through products like nanogels.

Highlights of the guidelines

- Guidelines apply to **Nano-Agri-Input Products (NAIPs), Nano-Agri Products (NAPs) and nano composites**, sensors made from Nanomaterials that require direct contact with crops, food and feed for data acquisitions.

Definitions given in Guidelines

- **Nano-Agri-Input Products (NAIPs):** They are agricultural input preparation containing NMs in any of the three dimensions i.e. zero, one or two on the nanoscale or with an internal or surface structure, intended for applications on crop for the purpose of farming through soil, seed, foliar and drip and other means.
- **Nano-Agri Products (NAPs):** They are agricultural preparation containing NMs in any of the three dimensions i.e. zero, one or two on the nanoscale or with an internal or surface structure, intended for consumption or application in food/feed and their supplements as well as nutraceutical delivery.

Concerns regarding Nanotechnology in Agriculture

- **Concerns of Cytotoxic and genotoxic effects** of cellular nanomaterials on Nano Agri Products.
- Risk of nanoparticles **toxicity is higher in plants** due to their miniscule size that can easily translocate within plant body.
- Concerns regarding **high aspect ratio, stiffness and bio durability of nano cellulose.**
- **Insufficient economic interest, regulatory issues and public opinion** in relation to nanotechnology in agricultural sector.
- **Lack of knowledge and developmental methods** for risk and life-cycle assessment of nanotechnology in agriculture.
- It **reduces important bacterial diversity** with declining taxa of Rhizobiales, Bradyrhizobiaceae, and Bradyrhizobium (related to nitrogen fixation) in response to these nanoparticles treatment.

- They **do not apply to the conventional products or formulations** with incidental presence of natural nanomaterials.
- **Objectives**
 - To help researchers in **development of products** for agriculture and human consumption.
 - To help regulators to **assess quality and safety** of nano based agriculture and food products.
 - To **encourage Indian innovators and industries** to develop new nano-based formulations and products in these sectors.
- Guideline provides for **regulation of NAIPs and NAPs**.
 - **Safety, efficacy, functionality, toxicity and other quality data** for proposed NAIPs and NAPs should be conducted under:
 - ✓ Fertiliser (Control) Order, 1985, the Essential Commodities Act, 1955, Insecticides Act 1968,
 - ✓ Food and Drug Administration guidelines, Food Safety and Standards Act, 2006,
 - ✓ Cattle Feed (Regulation of Manufacture and Sale) Order, 2009
 - ✓ Food Safety and Standards Authority of India (FSSAI).
 - **Implementation of standards** should be conducted as per Bureau of Indian Standards (BIS).
 - ✓ **BIS** is a national standards body working under the aegis of Ministry of Consumer Affairs, Food & Public Distribution.

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3. HEALTH

3.1. COVID-19

Why in news?

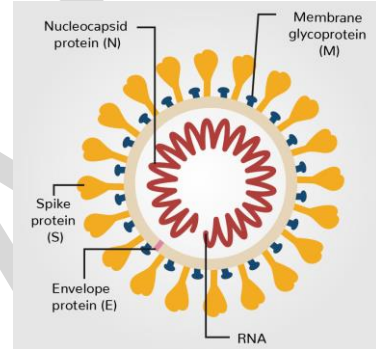
There is a large scale outbreak of COVID-19 (Coronavirus Disease 2019) across the world.

Coronavirus and its origin

- Coronaviruses are a large family of viruses that circulate among a range of animals, such as bats, cats, and birds. Sometimes these viruses make a jump over from animals to humans (known as **Spill over**) causing diseases known as **Zoonotic diseases**.
- This spill over happens **due to factors such as mutations in the virus or increased contact between humans and animals**.
- The virus causes respiratory and gastrointestinal symptoms in humans with infectious diseases ranging from common cold to more severe diseases such as severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS) and CoVID-19.
- While the **SARS coronavirus is thought to have evolved from infecting bats to civet cats to humans** in the Guangdong province of southern China in 2002, the **MERS evolved from bats to camels to humans** in Saudi Arabia in 2012.

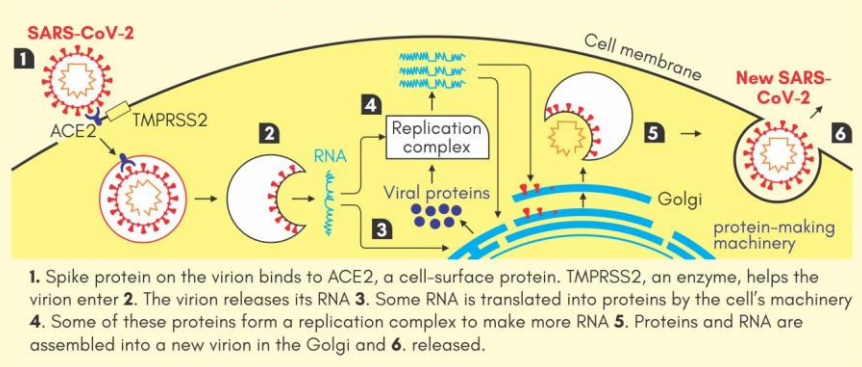
Role of Live animal markets

- Live animal markets (**also known as 'wet markets'** in parts of Asia, such as the Huanan Seafood Market in Wuhan China) are an **important risk factor for zoonotic disease spread**.
- In the Huanan Seafood Market in China, live fish, meat and wild animals are sold putting people and live and dead animals - dogs, chickens, pigs, snakes, civets, and more - in constant, close contact. That makes it **easy for a virus to jump from animal to human**.



- Research suggests that the **original source of the virus that caused COVID-19 was bats, and pangolins might have acted as intermediaries**. The mutation and natural selection might have taken place either inside pangolins or in humans after transfer from pangolins. This virus was **first identified in Wuhan (Hubei province), China in 2019**.

How SARS-CoV-2 replicates itself in the cells of those infected



- Coronavirus was declared global health emergency by WHO. **World Health Organization (WHO) declared COVID-19 an official name for coronavirus disease**.
 - This is the **sixth declared global health emergency** in the past decade. Other five are H1 virus that caused an influenza pandemic (2009), West Africa's Ebola outbreak (2013-2016), polio (2014), Zika virus (2016), and the ongoing Ebola outbreak in the Democratic Republic of Congo (2019).

Structure and physiology of the virus

- Coronaviruses are spherical shaped and consist of a core of genetic material (**RNA**) surrounded by an envelope with mushroom shaped protein spikes. These spikes binds and fuses to human cells allowing the virus to gain entry and replicate itself inside the body.

DNA VIRUSES	VS	RNA VIRUSES
DNA viruses refer to viruses whose genetic information is stored in the form of DNA		RNA viruses refer to viruses whose genetic information is stored in the form of RNA
Contain DNA as their genetic material		Contain RNA as their genetic material
Most are double-stranded		Most are single-stranded
Replicated inside the nucleus of the host cell		First transcribed and then replicated in the cytoplasm
Viral DNA is first transcribed into RNA, and then mRNA is translated into viral proteins		Can bypass transcription during protein synthesis since they already contain RNA in the genome
Stable due to the lower mutation rate		Unstable due to the higher mutation rate
Shows an accurate replication		Shows an error-prone replication
Contain a large genome		Contain a small genome
Newly-synthesized viral DNA is packed into a pre-formed capsid called procapsid		Newly-synthesized viral RNA is not packed in a procapsid
Smallpox, herpes, and chickenpox are diseases of DNA viruses		Aids, Ebola hemorrhagic fever, SARS, common cold, etc. are some diseases of RNA viruses

- Each virus particle is just between 50–200 nanometres in diameter (human hair is 80000nm in diameter).
- The **protein spikes gives the appearance of a crown or a halo around the Sun**. Crown in Latin is called as “Corona” and this is how the virus also got its name.
- **COVID-19 is caused by SARS-CoV-2 also known as novel coronavirus (n-CoV)**, as it is very similar to the one that caused SARS in 2002.
- The spike protein of the novel coronavirus shares **98% sequence identity with the spike protein of the SARS coronavirus**.
- SARS-CoV-2 has spike proteins which contain a receptor-binding domain (RBD). The **RBD facilitates the virus’ entry into target cells by binding with the cellular receptor called angiotensin-converting enzyme-2 (ACE-2)** found in heart, lungs, kidneys and the gastrointestinal tract.
- Once inside, it hijacks the cell’s reproductive machinery to produce more copies of itself, before breaking out of the cell again and killing it in the process.
- **However, unlike in the case of SARS, the spike protein of the novel coronavirus binds to the cell receptor with much higher affinity** — 10-to 20-fold higher. The RBD’s bonding affinity is increased due to mutation within the virus.
- This stronger bonding affinity **partly explains the apparent high human-to-human transmissibility** and COVID-19’s faster spread as compared to SARS epidemic in 2002-2003 across 29 countries.

3.1.1. EPIDEMIOLOGY OF SARS-COV-2

Viral epidemiology is the **scientific discipline concerned with the study of the incidence and spread of viruses** in populations over time the **ultimate goal of which is to devise intervention strategies**.

Geographic distribution	<ul style="list-style-type: none"> • COVID-19 cases have been reported in all continents, except for Antarctica, and have been steadily rising around the world.
Route of transmission —	<ul style="list-style-type: none"> • mainly via respiratory droplets of an infected person. • through aerosols in the air.
Reproduction Number (the number of additional cases that likely result from an initial case)	<ul style="list-style-type: none"> • Ro (R-naught), also called the basic reproduction number, is the rate at which a virus is transmitted. <ul style="list-style-type: none"> ○ Ro= new infections/existing infections; or the average number of new infections over an infectious period. ○ It indicates the average number of people who will contract the virus from an infected person, in a population that does not have immunity (herd immunity or vaccination) for the said disease. ○ Ro=1 indicates constant number of infected people, below 1- transmission to fewer people, above 1- transmission to higher numbers. • According to WHO, COVID 19 reproduction number is understood to be between 2 and 2.5 (may also be as high as 5).
Incubation period (the time between catching the virus and beginning to have symptoms of the disease)	<ul style="list-style-type: none"> • 14 days following exposure, with most cases occurring approximately four to five days after exposure. • An infected person can transmit the virus during this period i.e. in asymptomatic period.
Symptoms	<ul style="list-style-type: none"> • fever, cough, shortness of breath are the classical symptoms. • loss of either smell or taste may also be an early warning sign of COVID-19 • may present with mild, moderate, or severe illness; the latter includes severe pneumonia, ARDS [Acute Respiratory Distress Syndrome], sepsis and septic shock. • Sepsis is an organ dysfunction caused by the body’s immune system overreacting in response to an infection and can be triggered by a variety of pathogens including viruses, bacteria, fungi or parasites.
Fatality rate (the proportion of deaths a disease causes within a group of people who have the disease)	<ul style="list-style-type: none"> • Individuals of any age can acquire severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection, but the fatality rate increases with the age and with pre-existing medical conditions such as cardiovascular disease and diabetes.
Period of infectivity (The interval during which an individual with COVID-19 is infectious)	<ul style="list-style-type: none"> • Determined by evaluating viral RNA detection from respiratory and other specimens after symptom onset and later in the illness. • It is currently uncertain for COVID-19.
Seasonality of the virus (Season/weather during which the virus remains)	<ul style="list-style-type: none"> • Coronaviruses in animals are not always seasonal but have historically been so in humans for reasons that are not fully understood. • There is however no evidence so far about the novel coronavirus’s seasonality.

most active)		
Vertically Transmitted Infection		<ul style="list-style-type: none"> Emerging evidences suggests of vertical transmission is probable in CoVID-19. Vertical transmission refers to the transmission of an infection from a pregnant woman to her child. It can be antenatal (before birth), perinatal (weeks immediately prior to or after birth) or postnatal (after birth). Transmission might occur across the placenta, in the breast milk, or through direct contact during or after birth. Among infections of which vertical transmission has been known to happen are HIV, Zika, rubella and the herpes virus. ICMR has issued a Guidance for Management of Pregnant Women in COVID-19 Pandemic.

3.1.2. DIAGNOSIS

Currently following tests are available for identifying coronavirus infection in a person:

Serological Tests/Rapid Antibody Detection Tests:	<ul style="list-style-type: none"> These are blood/serum/plasma test carried out to determine whether an individual's body has IgM and IgG antibodies developed against the SARS-CoV-2. <ul style="list-style-type: none"> Immunoglobulins, also known as antibodies, are glycoprotein molecules produced by plasma cells (white blood cells). They act as a critical part of the immune response by specifically recognizing and binding to particular antigens, such as bacteria or viruses, and aiding in their destruction. IgM is the first antibody that the body makes when it fights a new infection and it does not stays for long while IgG can take time to form after an infection or immunization thus indicating an old infection. If antibodies are present in the sample, these bind to the antigen immobilised on the test strip and give a coloured reaction. These are carried out for symptomatic individuals and have to be confirmed by molecular tests. It is also helpful tool for scientist to determine the extent to which a disease has spread and how many have developed immunity to it.
Molecular Test/ Reverse-Transcription Polymerase Chain Reaction (RT-PCR) test:	<ul style="list-style-type: none"> This identifies the presence of virus itself based on its genetic fingerprint. RT-PCR Test: When a person is suspected to be suffering from COVID-19, an oral/nasal swab is taken. Viral Ribonucleic Acid (RNA) is isolated from these swabs using a variety of chemicals. Enzymes are then added to transcribe the RNA into DNA. This DNA is put into a real-time PCR (RT-PCR) machine that xeroxes the DNA, making thousands of copies of any genetic material in the samples. Scientists then use sets of DNA fragments that complement fragments found in the coronavirus. If any viral genetic material is present, these fragments will bind to it. Chemical markers attached to the DNA release fluorescence when this DNA binding occurs. It's these flashes of fluorescence that scientists use to determine whether the virus is present in a sample.
Pool Testing Method	<ul style="list-style-type: none"> Developed by German Red Cross Blood Donor Service in Frankfurt It involves simultaneously testing a combined sample from multiple people from a household or a local cluster to widen reach and speed up results. Suitable for expanded testing in larger population groups. In the case of a positive mini-pool result, individual testing is carried out in previously reserved samples. In the case of a negative result, all included samples have a reliable negative result. It was earlier used during large outbreaks and invisible community transmission, such as of HIV. This method can be used in areas where the prevalence of COVID-19 is low, which means a positivity rate of less than two percent.

India's Approach

- ICMR's **initial strategy was of testing those with a travel history and showing symptoms**, and those who have come in contact with persons having a travel history. Later it had been revised from time to time.
- ICMR introduced **Rapid Antibody and Pool Tests** to Speed-Up Coronavirus Testing in India.

- The testing strategy is reviewed and updated by the constituted National Task Force along with a member of the government think-tank, NITI Aayog.
- In India, it has been recommended by ICMR to conduct Rapid Antibody Detection tests **in areas reporting clusters of COVID-19 cases, in large migration gatherings and evacuee centres.**
- Positive Test results from Rapid Antibody tests are confirmed by RT-PCR tests.
 - **Pune based molecular diagnostic company Mylab developed indigenous RT-PCR based diagnostic test kits.**
- Indian Council of Medical Research (ICMR) allowed all national research laboratories including those under the Council of Scientific and Industrial Research (CSIR) to conduct testing for the novel coronavirus.
- **ICMR has suggested Pool Testing Method** for the low prevalence areas, where the positive case rate is less than 2 percent. Here, about five samples are clubbed together for a single test. It is to be avoided in all areas where the positive case rate exceeds five percent.
- Many other diagnosis methods were also developed like **Feluda Test, Chitra GeneLAMP-N, nCoVSENSEs, COVID Sample Collection Kiosk (COVSACK)** etc.

3.1.3. TREATMENT

To date, there is **no vaccine and no specific drug to treat COVID-2019**. The most effective measure has been to isolate people who have tested positive, quarantine them and increase social distancing to contain the spread of virus.

Proposed and potential drugs:

WHO has recommended four drugs and their combination under its Solidarity trial initiative to find out whether any can treat infection. Those are:

- **Remdesivir:** It was **previously tested as an Ebola treatment** and generated promising results in animal studies for MERS and SARS.
- **Chloroquine and hydroxychloroquine:** are very closely related and **used to treat malaria and rheumatology conditions respectively.**
- **Ritonavir/lopinavir:** It is a **licensed treatment for HIV.**
- **Ritonavir/lopinavir with Interferon beta-1a:** **Interferon beta-1a** is a molecule involved in **regulating inflammation in the body** and is used to treat multiple sclerosis.

Convalescent Plasma Therapy:

The US Food and Drug Administration (FDA) approved use of blood plasma from recovered patients to treat severely critical COVID-19 patients.

- **About plasma therapy**
 - It **seeks to make use of the antibodies developed in the recovered patient** against the coronavirus.
 - The whole blood or plasma from such people is taken, and the plasma is **then injected in critically ill patients so that the antibodies are transferred and boost their fight** against the virus.
 - Either a **blood fractionation process** is used to separate the plasma from the donated blood or a special machine called **apheresis machine** can be used to extract the plasma directly from the donor.
 - **WHO guidelines(2014) for plasma therapy:**
 - ✓ **Donor's permission is mandatory** before extracting plasma.
 - ✓ Plasma from **only recovered patients** must be taken,
 - ✓ Donation must be done **from people not infected with HIV, hepatitis, syphilis, or any infectious disease.**
 - ✓ If plasma needs to be collected again from the same person, it must be done after 12 weeks of the first donation for males and 16 weeks for females.

About Plasma

- Plasma is the **liquid portion of blood** "yellowish" in color.
- **About 55% of blood is plasma**, and the remaining 45% are red blood cells (RBC), white blood cells (WBC) and platelets that are suspended in the plasma.
- Plasma serves four **important functions in body**
 - Helps maintain blood pressure and volume.
 - Supply critical proteins for blood clotting and immunity.
 - Carries electrolytes such as sodium and potassium to our muscles.
 - Helps to maintain a proper pH balance in the body, which supports cell function.

- **Previous usage of this therapy**
 - ✓ The United States used plasma of recovered patients to treat patients of **Spanish flu (1918-1920)**.
 - ✓ Hong Kong used it to treat **SARS patients** in 2005.
 - ✓ In 2009, **H1N1 patients** were treated with plasma.
 - ✓ Democratic Republic of Congo and Guinea used it to treat **Ebola patients in 2014**.
 - ✓ In 2015, plasma was used for **treating MERS patients**.
- Delhi government had launched a plasma bank for treating covid-19 patients.
 - ✓ The facility is to be set up at the **Institute of Liver and Biliary Sciences (ILBS)**, and will be made available to government and private hospitals.
 - ✓ **Plasma Bank functions like a blood bank**, and has been created specifically for those who are suffering from COVID-19, and have been advised for plasma therapy by doctors.

India's approach

- Indian health authorities followed the protocol for the treatment of Covid-19 which included antiviral drug **remdesivir**, **malaria drug hydroxychloroquine (HCQ)**, an **anti-HIV combination of lopinavir and ritonavir**, and the **immunomodulator interferon**.
 - The first two are prescribed for moderately ill Covid-19 patients.
- Indian government had declared **Hydroxychloroquine (HCQ) as a schedule H1 drug**, that can be sold on prescription only as per the Drugs and Cosmetics Rules, 1945.
- ICMR has advised use of **HCQ for high risk individuals** like health workers and the asymptomatic household contacts of lab-confirmed cases to shield them from the infection.
- **India has also used the Plasma Therapy to treat COVID 19.**

3.1.4. VACCINE DEVELOPMENT

- There are many vaccines currently in development with some in clinical trial phase involving human testing like **COVAXIN**, **Zyudus Cadila's ZyCoV-D**, **AstraZeneca-Serum Institute of India (SII) etc.**
- **Vaccines developed by Moderna and Oxford university are amongst eight candidates selected and funded by Coalition for Epidemic Preparedness Innovations (CEPI)**, the world body coordinating the efforts against COVID 19.
 - **CEPI** is an innovative global partnership between public, private, philanthropic, and civil society organisations.
 - CEPI is **working to accelerate the development of vaccines against emerging infectious diseases** and enable equitable access to these vaccines for people during outbreaks.
 - CEPI was launched at 2017 World Economic Forum in Davos. CEPI was founded by the governments of Norway and **India**, the Bill & Melinda Gates Foundation, the Wellcome Trust, and the World Economic Forum.
- Other than the eight CEPI-funded vaccines, there are also many other institutions including two **from India: Pune-based Serum Institute of India and Ahmedabad based Zyudus Cadila**, which are engaged in developing vaccine for this infectious disease.
- **Indian government had formed a high-level task force for vaccine and drug testing** for coronavirus disease (Covid-19)
 - The objective of the task force is to speed up national and international efforts towards vaccine development to treat Covid-19.
 - **Department of biotechnology would act as a nodal agency** to identify the pathway for vaccine development, monitor progress of efforts at both national and international level in this area, and provide government facilitation.

Challenges with vaccines development in case of Pandemics

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

Vaccine Development Process

There are six stages of vaccine development which takes around 12-15 years to complete.



- **Exploratory:** This research-intensive phase of the vaccine development process is designed to identify “natural or synthetic antigens that might help prevent or treat a disease.”
- **Pre-clinical:** During this phase, researchers — usually in private industry — use tissue-culture or cell-culture systems and animal testing to determine whether the candidate vaccine will produce immunity. Many candidate vaccines don’t move on to the next stage of development because they fail to produce that immunity or prove harmful to test subjects.
- **Clinical development:** At this point, a sponsor, usually a private company, submits an application for to an authorising agency like FDA of USA. This summarizes findings to date and describes how the drug will be tested and created. An institution that will host the clinical trial holds a review board for approval of the application. Once the proposal has been approved, the vaccine must pass three trial stages of human testing:
- **Regulatory review and approval:** If a vaccine passes through all three phases of clinical development, the vaccine developer submits a Biologics License Application (BLA) to the authorizing agency.
- **Manufacturing:** Major drug manufacturers provide the infrastructure, personnel and equipment necessary to create mass quantities of vaccines. They also reap the profits of successful or widely distributed drugs.
- **Quality control:** Stakeholders must adhere to procedures that allow them to track whether a vaccine is performing as anticipated. Multiple systems — including Phase IV trials (optional studies that can be conducted following the release of a vaccine), the Vaccine Adverse Event Reporting System (VAERS) and the Vaccine Safety Datalink — are designed to monitor the performance, safety and effectiveness of an approved vaccine.

Types of Vaccines

- **Live Attenuated Virus (LAV):**
 - Uses a weakened (or attenuated) form of the germ that causes a disease.
 - Because these vaccines are so similar to the natural infection that they help prevent, they create a strong and long-lasting immune response. Just 1 or 2 doses of most live vaccines are enough to give a lifetime of protection against a germ and the disease it causes.
 - **Used in case of Measles, Rubella (MMR combined vaccine), Tuberculosis, Rotavirus, Oral Polio Vaccine (OPV), Yellow fever etc.**
- **Inactivated vaccines:**
 - Uses the killed version of the germ that causes a disease.
 - These vaccines usually don’t provide immunity that’s as strong as live vaccines so several doses over time (booster shots) is needed to get ongoing immunity against diseases.
 - **Used in case of Polio (IPV), Pertussis, Hepatitis A etc.**
- **Subunit and Recombinant vaccines**
 - use only part of a target pathogen like its protein, sugar, or capsid (a casing around the germ) presenting it as an antigen on its own to provoke a response from the immune system.
 - It can also be created via genetic engineering. A gene coding for a vaccine protein is inserted into another virus, or into producer cells in culture. When the carrier virus reproduces, or when the producer cell metabolizes, the vaccine protein is also created. **The end result of this approach is a recombinant vaccine:** the immune system will recognize the expressed protein and provide future protection against the target virus.
 - **Used in case of Haemophilus Influenza type B(Hib). The Hepatitis B vaccine currently used in the United States is a recombinant vaccine.**
- **Conjugate vaccines**
 - Similar to recombinant vaccines but are made using pieces from the coats of bacteria. These coats are chemically linked to a carrier protein, and the combination is used as a vaccine.
 - Conjugate vaccines are used to create a more powerful, combined immune response: typically the “piece” of bacteria being presented would not generate a strong immune response on its own, while the carrier protein would.
 - The vaccines **currently in use for children against pneumococcal bacterial infections** are made using this technique.
- **Toxoid vaccines**
 - Uses a toxin (harmful product) made by the germ that causes a disease.
 - They create immunity to the parts of the germ that cause a disease instead of the germ itself.



- booster shots are needed to get ongoing protection against diseases.
- **Used in case of Tetanus and Diphtheria.**
- **RNA vaccine**
 - Unlike a normal vaccine, RNA vaccines **work by introducing an mRNA sequence (the molecule which tells cells what to build) which is coded for a disease specific antigen**, once produced within the body, the antigen is recognised by the immune system, preparing it to fight the real thing.
 - RNA vaccines are **faster and cheaper to produce than traditional vaccines**, and an RNA based vaccine is also safer for the patient, as they are not produced using infectious elements.
 - Production of RNA vaccines is **laboratory based, and the process could be standardised and scaled**, allowing quick responses to large outbreaks and epidemics.
 - Most **current research is into RNA vaccines for infectious diseases and cancer.**
 - **No vaccine made from genetic material – RNA or DNA – has been approved till date.**

3.1.5. STEPS TAKEN BY INDIA TO DEAL WITH THE OUTBREAK

Indian government took multi-pronged and timely actions as the virus spread from China to many parts of the world.

Quarantine, Lockdown, Social Distancing and Awareness Generation

Suspending visas and quarantining all incoming travelers with subsequent International travel ban.

- **Restrictions on International traffic through land borders.**
- **Nationwide lockdown** involving closure of all non-essential public places, suspension of railways, intercity bus services and urban metros.
- **Cluster containment strategy** adopted in the states with high threat of community transmission. The strategy is to contain the virus in a defined geographic area, and help detect the cases at an early stage, break the chain of transmission and prevent its spread to new areas.
- **Increasing awareness on importance of social distancing practices.**
- **Guidelines were issued on use of masks by public and self-quarantine measures.**
- **Information, Education, & Communication (IEC) material (posters and pamphlets)** regarding coronavirus (COVID-19) are being prominently displayed for awareness of the general public in local languages at railway stations and in trains and are also being distributed to patients visiting hospitals and in railway colonies.
- **Dedicated TV and Radio Spots (English & Hindi) disseminating information and precautionary measures for public.**
- **Comic book “KIDS, VAAJU and CORONA” for children** by Ministry of Health and Family Welfare (MoHFW) to provide correct information about COVID-19.
- **Awareness material specifying Do's and Don'ts during COVID-19 outbreak by MoHFW in English and Hindi.**
 - Many other awareness generation and grievance redressal steps were taken like **CovidGyan Website, PRACRITI- Prediction And Assessment Of Corona Infections And Transmission In India, National Monitoring Dashboard on COVID 19 Grievances, Young India Combating COVID with Knowledge, Technology and Innovation (YUKTI) Portal** etc.

Legislative Actions for Better Coordination with States

- **Disaster Management Act 2005** under which powers conferred on Union Home Secretary were delegated to Secretary, Ministry of Health and Family Welfare to enhance preparedness and containment of the disease. **COVID-19 was declared as a "notified disaster"** enabling states to spend a larger chunk of funds from the State Disaster Response Fund (SDRF) to fight the pandemic.
- **Epidemics Diseases Act of 1897, under** which states were allowed to take appropriate measures that are needed to implement the prevention of infection, and anyone contravening the provisions is amenable to prosecution.
- **Essential Commodities Act, 1955** under which masks (2ply & 3ply surgical masks, N95 masks) and hand sanitisers were declared as essential commodities to regulate their production, quality, distribution and logistics and to ensure prevention of hoarding, black marketing and profiteering of these items.
- An advisory was also issued under the **Legal Metrology Act, 2009** for States to ensure that these items are not sold for more than their MRP.

- **High level multi-disciplinary Central teams were deputed** by Ministry of Health and Family Welfare to assist the States and State Health Department in activities pertaining to cluster containment plan and hospital preparedness (ICU & Ventilator management for COVID-19 patients).
- **Emergency Response and Health System Preparedness package** to the states aimed at boosting national and state health systems to support the procurement of essential medical equipment and drugs, and the strengthening of surveillance activities.
- **Lifeline UDAN** an initiative of Ministry of Civil Aviation for air transport of medical cargo and essential supplies across India amid lockdown.
- **11 Empowered groups were set up** for ensuring a comprehensive and integrated response to the COVID-19 pandemic.

Leveraging the Use of Technology

- **PM Innovate challenge** inviting applications from individuals, startups and companies to provide innovative technological solutions to fight the virus.
- For the first time, the government has released data sets for researchers, including those on genome sequencing, epidemiological data repository by Johns Hopkins University Center, Genetic Sequences related to COVID-19, etc.
- **Fight Corona IDEathon** a 2-day online ideathon to find accessible and affordable technological solutions that can contain the rapid spread of COVID-19 was held.
- It was organised by **All India Council for Technical Education** and MHRD Innovation Cell and other partners.
- Proposals were invited by Science & Engineering Research Board (SERB) as part of its **Intensification of Research in High Priority Areas (IRHPA) scheme** to ramp up national R&D efforts for new antivirals, vaccines, and affordable diagnostics.
- **'Samadhan' challenge** launched by the Innovation Cell of the Ministry of Human Resource for student innovators, researchers, educators and startups to invite ideas and innovations that can help fight against the coronavirus outbreak.
- Indigenously ventilators were developed in India includes **PRANA-VAYU, Ruhdaar etc.**
- **Centre for Augmenting WAR with COVID-19 Health Crisis (CAWACH)** initiative of Department of Science and Technology to extend timely support to potential start-ups by way of the requisite financial assistance and fund deployment targeting innovations to control COVID-19 that are deployable in the market within next 6 months.
- **Steps taken for tracking and surveillance includes** COVID Quarantine Alert System, National Analytical Platform for Dealing with Intelligent Tracing, Tracking and Containment (NAADI), Saiyam App,

Global Best Practices in Fighting COVID 19

- **South Korea:** It has tested more than a quarter-million people for the virus; there are over 600 testing sites nationwide, with a capacity to test up to 20,000 people each day. Results are released, on average, within 6 hours via text.
- **Taiwan:** Taiwan rolled out an "electronic fence" strategy that utilizes location-tracking services in mobile phones to ensure people who are quarantined stay in their homes.
- **UNESCO: Combat COVID-19, Keep learning:** This is an online platform launched by UNESCO Institute for Information Technologies in Education (IITE). Platform hosts various resources provided by the partners like educational courses, webinars, distance learning portals, communities and technical solutions that can be used to organize online learning.

Domestic Best Practices in Fighting COVID 19

- **Kerala's Walk-in Sample Kiosks (WISK):** which looks like a glass cabin, is made in such a way that the environment inside it where the medical staff stands, is always sterile. Healthcare professionals in the kiosk can collect swabs of people who will stand outside the kiosk.
- **Bhilwara model:** The measures taken by the Rajasthan government included
 - Imposing a curfew in the district which also barred essential services.
 - Extensive screening and house-to-house surveys to check for possible cases.
 - Detailed contact tracing of each positive case so as to create a dossier on everybody they met ever since they got infected.
- **Indian Railways:** It aimed to convert 5,000 coaches into isolation wards for coronavirus patients. It has already converted around 2,500 coaches into 40,000 isolation beds, which are now ready for contingency.
- **Fact checking portal by Press Information Bureau (PIB):** PIB had set up a portal for fact-checking issues related with the novel coronavirus pandemic, and it will receive messages by email and send its response in quick time.
- **Engaging ASHA Workers (Odisha):** Anganwadi workers and Panchayati Raj institution members have been asked to check the food availability in people's houses. Also, they have been asked to note the return of migrant labourers in their villages and whether they have gone through screening.

Supercomputer using Artificial Intelligence, Machine Learning, Healthcare Analytics based Research, Covid-19 (SAMHAR) etc.

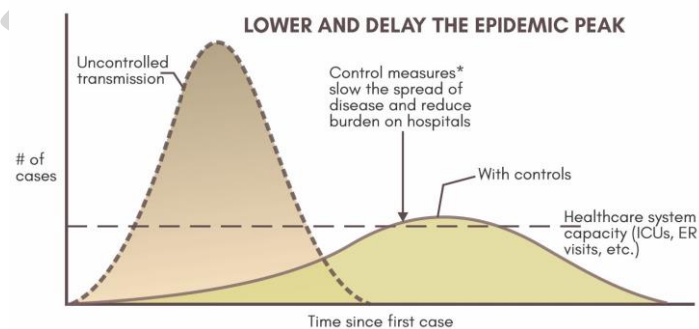
- COVID-19 National Teleconsultation Centre (CoNTeC) is a **Multi-modal Telemedicine Hub established by AIIMS, New Delhi**, wherein expert **doctors from various clinical domains will be available 24x7** to answer the multifaceted **questions from specialists from all over the country for treatment of the COVID-19 patients.**
 - It has been conceptualised by the **Ministry of Health & Family Welfare.**

Other Steps

- To provide relief to the affected, a public charitable trust under the name of **'Prime Minister's Citizen Assistance and Relief in Emergency Situations Fund' (PM CARES Fund)** was set up.
- **Evacuations of Indians from various COVID-19 affected countries.**
- **Ban on the exports** of personal protective equipment, including surgical masks, gloves and N95 respirators.
- **Exemptions from basic customs duty and health cess** on the import of ventilators, face masks, surgical masks, personal protection equipment (PPE), COVID-19 test kits.
- **Incentive scheme** to boost domestic manufacturing of active pharmaceutical ingredients (APIs),
- **Allowing 'high quality' private labs to test** for COVID-19 to increase testing capacity in India
- **Quarantine facilities were set up by Indian Defence Forces.**
- 30% pay cut for all members of Parliament and suspension of the **Member of Parliament Local Area Development (MPLAD) fund.**
- **For Capacity Building And Promoting Innovation steps included** Integrated Govt. Online training' (iGOT) portal, Integrated Geospatial Platform and SAHYOG App, Challenge Covid-19 Competition (C3), Hack the Crisis – India etc.
- **For protecting Marginalized and Vulnerable Sections steps** were taken like under the **National Food Security Act (NFSA), 2013** government announced distribution of 5 kg of wheat or rice and one kg of preferred pulses free-of-cost every month for three months to 80 crore poor across the country to ensure availability food to poor people during lockdown due to COVID-19 etc. (Kindly refer to Mains 365 Economy & Social for other such steps taken under Atmanirbhar Bharat Abhiyan package)

Concept of Flattening the Curve

- The WHO has repeatedly underlined the importance of “flattening the curve” in order to tackle the coronavirus outbreak, calling on countries around the world to impose sweeping public health measures.
- **This approach is saving lives and buying time for the development of vaccines and treatments.**
- In epidemiology, the **curve refers to the projected number of new cases** over a period of time.
- The idea of flattening the curve is **to stagger the number of new cases over a longer period, so that people have better access to care.**
- It **explains why so many countries are implementing draconian policies**, such as social-distancing guidelines, “shelter in place” orders, restrictive travel measures and asking citizens to work or engage in schooling from home.



- The above chart shows two curves with two very different virus reproduction rates.
- **In the steepest curve, the virus reproduces quickly in a short period of time.** In this scenario, emergency rooms, intensive care units and other parts of the health care system are overwhelmed. In an overwhelmed system, mortality rates can be high and those infected may not get the treatment they need.
- **In the second, flatter curve, controls help slow the spread of the virus.** Infections occur, but over a longer period of time. Since health care workers and facilities are not overwhelmed, those infected receive better treatment and fewer deaths occur.

3.1.6. HERD IMMUNITY

Why in news?

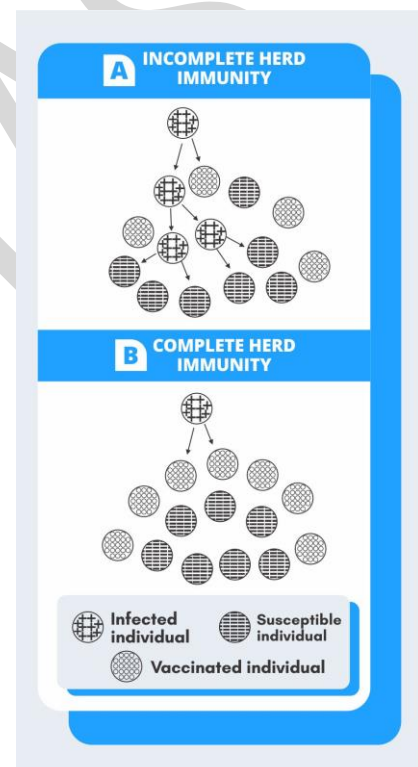
Natural herd immunity was **advocated for some time by the UK government as a strategy to contain the COVID-19 pandemic** in their country.

About the concept

- It is the **indirect protection from a contagious infectious disease** that happens when a population is immune **either through vaccination or immunity developed through previous infection**.
- **Vaccinated or immune people act as a buffer** between the infected persons and people who aren't vaccinated, or in whom the vaccine doesn't trigger immunity.
- Once herd immunity has been established for a while, and the **ability of the disease to spread is hindered**, and can eventually be eliminated.
- Mass vaccination has been highly successful in inducing herd immunity for many diseases, protecting those that are unable to build up immunity, such as people with immune deficiencies or whose immune systems are being suppressed for medical reasons.
- Herd immunity was **recognized as a naturally occurring phenomenon in the 1930s during the measles outbreak**.
- It **does not apply to all diseases, just those that are contagious**, meaning that they can be transmitted from one individual to another. **Tetanus, for example, is infectious but not contagious, so herd immunity does not apply**.

Challenges in creating Herd Immunity

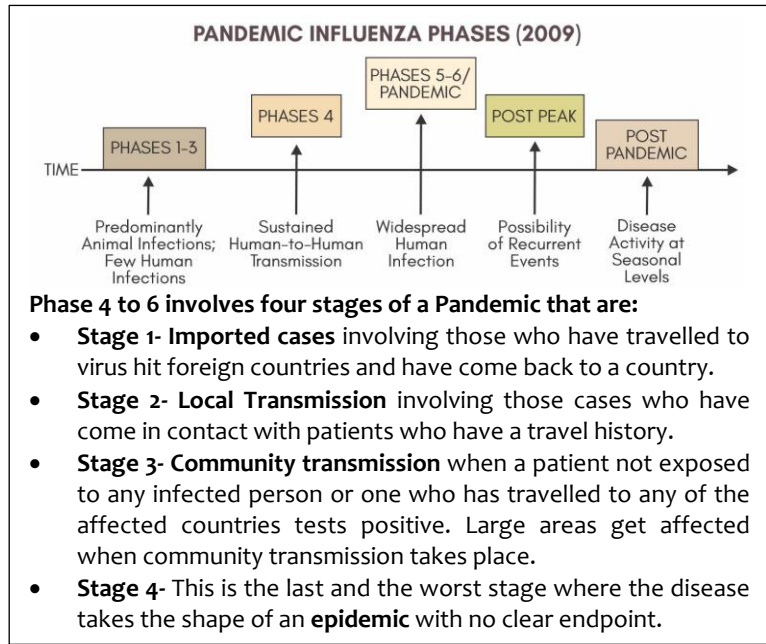
- **Percentage of immune population**
 - The **more infectious a disease, the greater the population immunity needed** to ensure herd immunity.
 - For example, measles is highly contagious and one person with measles can infect up to 18 other people. In this case around 95% of people need to be immune in order for the wider group to have herd immunity.
 - The new coronavirus has a lower infection rate than measles, with each infected person passing it on to two or three new people, on average. For this, herd immunity should be achieved when around 60% of the population becomes immune to COVID-19.
- **Natural herd immunity**
 - It is **achieved through infection rather than vaccination**.
 - It can be challenging to induce it through unchecked infection as there would be a very high rate of serious illness and death, with health systems overwhelmed well beyond their surge capacity, even in high-income countries.
 - This is why herd immunity is generally pursued through vaccination programmes.
- **Mutation within the organism**
 - Even when vaccines are available, it is **not always possible to achieve herd immunity for very long**.
 - Some viruses, such as seasonal flu, mutate frequently, evading the body's immune response.
 - So immunity doesn't always last forever, which is why the flu shot is necessary every single year.
- **Free Riders Problem**
 - When herd immunity is well established, however, some people choose to behave as **'free riders', essentially benefitting from everyone else getting vaccinated**, while abstaining from vaccination either because they choose not to or are actively anti-vaccination.
 - When a population has too many of these free riders, the overall immunity level is compromised and herd immunity can be lost, putting everyone at risk.



3.1.7. PANDEMIC DISEASE

- In March, 2020 WHO publicly characterized **COVID-19 as a pandemic**.

- According to the World Health Organization, a **pandemic is declared when a new disease for which people do not have immunity spreads around the world and between people sustainably beyond expectations.**
- Declaring a pandemic has nothing to do with changes to the characteristics of a disease, but is instead associated with concerns over its geographic spread.
- **The use of this term highlights the importance of countries throughout the world working cooperatively and openly with one another** and coming together as a united front in efforts to bring the situation under control. However, if declaring a pandemic triggers global panic, this can defeat the purpose of trying to raise awareness.
- **There is no threshold, such as a certain number of deaths or infections, or number of countries affected, that needs to be met in order to declare a disease as pandemic.** For example, the SARS coronavirus, identified in 2003, was not declared a pandemic by the WHO despite affecting 26 countries. However, its spread was contained quickly, and only a handful of nations were significantly affected, including China, Hong Kong, Taiwan, Singapore and Canada.
- **COVID-19 is the first pandemic known to be caused by the emergence of a new coronavirus.** In the past century, there have been four pandemics caused by the emergence of novel influenza viruses. As a result, most research and guidance around pandemics is specific to influenza.
- **The last pandemic declared was in 2009 during the outbreak of H1N1 flu,** commonly known as the swine flu which killed up to 575,000 people in the past decade.
- **Pandemics of the past century were influenza-related** and charted in six phases WHO used to make recommendations based on the severity of a disease's spread.



EPIDEMIC VERSUS ENDEMIC	
EPIDEMIC	ENDEMIC
A widespread occurrence of an infectious disease in a community at a particular time	A regularly found disease among particular people or in a certain area
Cause a significant damage to the living organisms within a short period of time	Prevalent in a certain region or population
Rate of infection continuously increases	Rate of infection is constant
Ex: smallpox, H1N1, black plague	Ex: malaria, tuberculosis, chicken pox, etc.

- Public health emergency of international concern (PHEIC)**
- Earlier in January 2020, the World Health Organization declared the COVID-19 outbreak a “**public health emergency of international concern**” (PHEIC).
 - **PHEIC is a formal declaration by the International Health Regulations Emergency Committee** of World Health Organization (WHO) of "an extraordinary event which is determined to constitute a public health risk to other States through the international spread of disease and to potentially require a coordinated international response", formulated when a situation arises that is "serious, sudden, unusual or unexpected".
 - It is **not only confined to infectious diseases**, and may cover an emergency caused by a chemical agent or a radio nuclear material.
 - **PHEIC declarations so far:** Since 2009 there have been six PHEIC declarations: the 2009 H1N1 (or swine flu) pandemic, the 2014 polio declaration, the 2014 outbreak of Ebola in Western Africa, the 2015–16 Zika virus epidemic, the ongoing 2018–20 Kivu Ebola epidemic, and the ongoing 2019–20 coronavirus pandemic.
 - **The recommendations are temporary and require reviews** every three months.

3.2. COVID-19 THERAPIES AND ANTIMICROBIAL RESISTANCE (AMR)

Why in News?

There are concerns that potentially **fatal bacterial respiratory infections** may arise during hospital stays and **because of therapies given to COVID-19 patients**.

What is AMR?

- AMR happens **when microorganisms** (such as bacteria, fungi, viruses, and parasites) **change when they are exposed to antimicrobial drugs** (such as antibiotics, antifungals, antivirals, antimalarials, and anthelmintics).
- Microorganisms that develop AMR are sometimes referred to as superbugs.
- As a result, the **medicines become ineffective and infections persist in the body**, increasing the risk of spread to others.
- AMR occurs naturally over time, usually through genetic changes. However, misuse and overuse of antimicrobials is accelerating this process.

Reasons for AMR

- **Inappropriate use of medicines:** Overuse, underuse and misuse of medicines drives development of drug resistance.
- **Lack of quality medicine:** Weak drug quality assurance systems leading to poor quality medicines and creating conditions for drug resistance to develop.
- **Animal Husbandry:** Sub-therapeutic doses of antibiotics are used in animal-rearing for promoting growth or preventing diseases. This can result in resistant microorganisms, which can spread to humans.
- **Poor infection prevention and control:** It can increase the spread of drug-resistant infections. Hospitalised patients are one of the main reservoirs of resistant microorganisms.
- **Weak surveillance systems:** It impairs the ability to detect emergence of resistance and take prompt actions.

Why is AMR a concern?

- **New resistance mechanisms are emerging and spreading globally**, threatening our ability to treat common infectious diseases, resulting in prolonged illness, disability, and death.
- A growing list of infections such as pneumonia, TB, blood poisoning and gonorrhoea are becoming harder, and sometimes impossible, to treat as antibiotics become less effective.
- Without effective antimicrobials for prevention and treatment of infections, **medical procedures and major surgery become very high risk**.
- AMR **increases the cost of health care** with lengthier stays in hospitals and more intensive care required.
- AMR is **putting the gains of the Millennium Development Goals at risk** and endangers achievement of the Sustainable Development Goals.

Initiatives by World Health Organisation (WHO) to address AMR

- **Global Antimicrobial Resistance Surveillance System (GLASS):** supports a standardized approach to the collection, analysis and sharing of data related to antimicrobial resistance at a global level.
- **AWaRE tool:** aimed at guiding policy-makers and health workers to use antibiotics safely and more effectively. It classifies antibiotics into three groups:
 - Access — antibiotics used to treat the most common and serious infections
 - Watch — antibiotics available at all times in the healthcare system
 - Reserve — antibiotics to be used sparingly or preserved and used only as a last resort
- **Global Antibiotic Research and Development Partnership (GARDP):** encourages research and development through public-private partnerships.
- **Interagency Coordination Group on Antimicrobial Resistance (IACG):** established by United Nations Secretary-General to improve coordination between international organizations and to ensure effective global action.
- **Global Action Plan** aims to ensure prevention and treatment of infectious diseases with safe and effective medicines.
- **One Health approach:** to promote best practices to avoid the emergence and spread of antibiotic resistance, including optimal use of antibiotics in both humans and animals.

WHO recommended steps to prevent and control AMR

- **Individuals** to use antibiotics when prescribed by a certified health professional, not to share or use leftover antibiotics, prevent infections by regularly washing hands etc.
- **Policy makers** can ensure a robust national action plan, improve surveillance of antibiotic-resistant infections, make information available on the impact of antibiotic resistance etc.
- **Healthcare industry** can Invest in research and development of new antibiotics, vaccines, diagnostics and other tools.
- **Agriculture sector** can vaccinate animals to reduce the need for antibiotic, improve biosecurity on farms and prevent infections through improved hygiene and animal welfare etc.

AMR Situation in India

- A study published by the Indian Council of Medical Research (ICMR) has found **antibiotic resistant organisms in the digestive tracts of two out of every three healthy persons** that it tested.
- It was based on analysis of stool samples of 207 individuals who had not taken any antibiotic for at least a month and did not suffer from any chronic illness.
- As per the 2017 Scoping report on antimicrobial resistance in India:
- AMR bacteria and their genes **have been reported from different water sources**. The major sources are the pharmaceutical waste waters and hospital effluents that are released into the nearby water bodies without adequate treatment.
- Antimicrobial agents are being **used in abundance to increase the productivity in Animal husbandry**.

Steps taken

- **National Anti-Microbial Resistance Research and Surveillance Network** to strengthen the surveillance of AMR by compilation of National Data of AMR at different levels of Health Care.
- **National Action Plan to combat Antimicrobial Resistance** that aims to understand emergence, spread and factors influencing AMR.
- **Red Line Campaign** for antibiotics packaging to curb their over-the-counter sale

3.3. ONE HEALTH

Why in news?

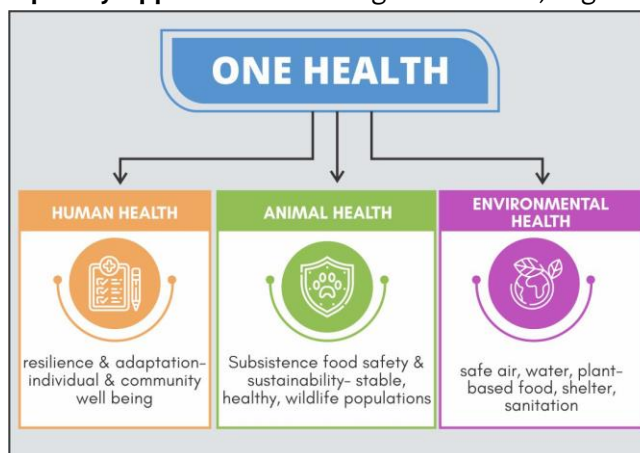
There has been an increased focus across the world on one health approach in the light of global outbreak of COVID-19.

About the concept

- The term ‘One Health’ was **first used in 2003–2004, in association with the emergence of severe acute respiratory disease (SARS)** in early 2003 and subsequently by the spread of highly pathogenic avian influenza H5N1, and by the series of strategic goals known as the ‘**Manhattan Principles**’.
- It is a **collaborative, multisectoral, and transdisciplinary approach** — working at the local, regional, national, and global levels — with the goal of achieving optimal health outcomes **recognizing the interconnection between people, animals, plants, and their shared environment**.
- Successful public health interventions **require the cooperation of Professionals in human health** (doctors, nurses, public health practitioners, epidemiologists), **animal health** (veterinarians, paraprofessionals, agricultural workers), **environment** (ecologists, wildlife experts) along with other relevant players including law enforcement agencies, policymakers, agriculture, communities, and even pet owners.

Manhattan Principles

- These were **derived at a meeting of the Wildlife Conservation Society in 2004**, which clearly recognised the link between human and animal health and the threats that diseases pose to food supplies and economies.
- These are **the set of 12 principles** as a vital step in recognising the critical importance of collaborative, cross-disciplinary approaches for responding to emerging and resurging diseases, and in particular, for the inclusion of wildlife health as an essential component of global disease prevention, surveillance, control, and mitigation.



- **One Health issues include** zoonotic diseases, antimicrobial resistance, food safety and food security, vector-borne diseases, environmental contamination, and other health threats shared by people, animals, and the environment.

Relevance of one health

In recent times, many factors have changed interactions between people, animals, plants, and our environment and have led to the spread of existing or known (endemic) and new or emerging zoonotic diseases:

- **Climate and land use change:** The earth has experienced changes in climate and land use, such as deforestation and intensive farming practices. Disruptions in environmental conditions and habitats can provide new opportunities for diseases to pass to animals.
- **Animals also share our susceptibility to some diseases and environmental hazards.** Because of this, they can sometimes serve as early warning signs of potential human illness. For example, birds often die of West Nile virus before people in the same area get sick with West Nile virus infection.
- **Geographic expansion of human habitats:** Human populations are growing and expanding into new geographic areas. As a result, more people live in close contact with wild and domestic animals, both livestock and pets.
- **Role of animals:** Animals play an important role in our lives, whether for food, fiber, livelihoods, travel, sport, education, or companionship. Close contact with animals and their environments provides more opportunities for diseases to pass between animals and people.
- As per the studies, **60% of known human infectious diseases have their source in animals** (whether domestic or wild).
- **Increased global interactions:** International travel and trade has led to the unprecedented flow of commodities, people and animals. This gives pathogens of all kinds of opportunities to spread and multiply around the world.

Systemic challenges that must be addressed to implement one health

- **Institutions:** The creation of One Health organizations at various levels, with integrated missions to improve human, animal, and environmental health, would improve global health.
- **Funding and capacity:** This need to be addressed by creating more schools of veterinary medicine, both domestically and globally.
- **Education, and Jobs:** Few qualified veterinarians are pursuing careers in livestock and wildlife health, probably because limited jobs are available. Successfully implementing One Health also requires a global network of qualified individuals.

3.4. RARE DISEASES

Why in news?

Ministry of Health and Family Welfare recently released the **draft National Policy for Rare Diseases**.

Background

- Ministry of Health and family Welfare, formulated a **National Policy for Treatment of Rare Diseases (NPTRD) in July, 2017**.
 - It envisaged the setting up of a corpus fund of ₹100 crore towards funding treatment of rare genetic diseases, but this never picked up due to budget constraints.
- Implementation of the policy was, however, **faced with certain challenges** like bringing States on board and lack of clarity on how much Government could support in terms of tertiary care.
- To solve this, there was need for wider consultation and recommendations, hence a decision was taken to **reframe the National Policy for Treatment of Rare Diseases**.
- An Expert Committee was constituted by Ministry of Health and Family Welfare in November, 2018 to review the NPTRD, 2017.
- Based on the report of expert committee, draft **National Policy for Rare Diseases** was released.

What are Rare Diseases?

- It is a **health condition of low prevalence**, affecting a small number of people, as compared to other prevalent diseases in the general population.



- **WHO** defines rare disease as often debilitating lifelong disease or disorder condition with a prevalence of 1 or less, per 1000 persons. However, different countries have their own definitions.
- They include **genetic diseases, rare cancers, infectious tropical diseases and degenerative diseases**. 80% of rare diseases are genetic in origin and hence **disproportionately impact children**.
- Despite being less prevalent and individually rare, collectively they affect **between 6% and 8% of total population in any country**.

Indian Scenario

- In India, **about 95% rare diseases have no approved treatment** and less than one in 10 patients receives disease-specific treatment.
- Very few pharmaceutical companies manufacture drugs to treat rare diseases and **India has no domestic manufacturer**.
- The **most common rare diseases** include Haemophilia, Thalassemia, Sickle-cell Anaemia and Primary Immuno Deficiency in children, auto-immune diseases etc.

Why are they a Public health issue?

- **Lack of epidemiological data:** It impedes understanding of the extent of the burden of rare diseases and associated morbidity and mortality. Economic burden of most rare diseases is also unknown.
- **Varying definitions and prevalence thresholds:** Different countries have their own definitions to suit their specific requirements and resources. Inconsistent definitions and diverse terminology can result in confusion. India, like many other developing countries, currently has no standard definition of rare diseases.
- **Diagnosis of a rare condition:** It may take up to several years, due to difficulty in diagnostic modalities and lack of awareness among doctors as well as general public.
 - For many rare diseases, diagnostic facilities are unavailable or no diagnostic method exists.
 - Delay in diagnosis or a wrong diagnosis increases the suffering of the patients exponentially.
- **Impact of disease:** In most cases, rare diseases are serious, chronic, debilitating and life threatening, often requiring long and specialised treatments.
 - They place a huge physical, psychological, and socioeconomic burden on patients and their families. Also, they often result in some form of handicap, sometimes extremely severe.
- **Challenges in research and development:** The clinical explanation may be skewed or partial because of a very small pool of patients and lesser known pathophysiology, natural history of these diseases.
- **Challenges in treatment: Unavailability** of treatment as around 95% of them do not have any approved treatment. Only 300 therapies are available to treat them.
 - **Prohibitive cost of treatment:** Due to lack of a significant market for drug manufacturers, there is no incentive to develop drugs for them. For this reason, rare diseases are also called 'orphan diseases' and drugs to treat them are called '**orphan drugs**'.

Salient Features of Draft Policy

- It lists **450 diseases as rare** but does not provide a detailed roadmap on treatment.
- It creates **three categories of rare diseases-**
 - diseases requiring one-time curative treatment,
 - diseases which need long-term treatment, but cost is low,
 - diseases that require life-long treatment and cost is high.
- **Standardisation and monitoring: National Registry for Rare Diseases** will be created at Indian Council of Medical Research which will help to arrive at a definition of rare diseases, best suited to India.
- **Financial support for treatment:** Provide financial support to patients of rare diseases living below the poverty line under its umbrella scheme **Rashtriya Arogya Nidhi**.
 - It will also fund one-time treatment cost to the tune of ₹15 lakh for certain treatable rare diseases, for patients under its health insurance scheme, **Ayushman Bharat/ Pradhan Mantri Jan Arogya Yojana**, which covers 40% of the population.
 - There is no clarity of Centre and State responsibilities and on category III patients.
- **Institutional framework:** Government plans to notify certain medical institutes as **Centers of Excellence for Rare Diseases**.
 - Constituting an inter-ministerial **Consultative Committee** at National Level to co-ordinate and oversee activities on rare diseases.
 - Constituting a **Rare Diseases Cell** within MoHFW, ICMR and DoP in the Ministry of Chemicals and Fertilizers.

- **Funding framework:** Creating a **corpus fund** at Central and State Level for rare diseases.
 - It recommends **crowd funding as a source to fund treatment of rare diseases and** advises hospitals to report such cases on digital platforms to gather funds.
- **Awareness generation:** developing materials for generating awareness in the general public, patients and their families and for training of health care providers.

Conclusion

- There is an immediate need to create **awareness** among general public, patients and their families and doctors. Any policy on treatment of rare diseases will have to strike a **balance** between access to treatments and health system sustainability.
- In US, Orphan Drugs Act provides incentives to drug manufacturers to encourage them to manufacture drugs for rare diseases, and similar incentives are also provided in the UK and certain other developed countries. Similar steps can be taken in India.

3.5. INDIA TUBERCULOSIS REPORT 2020

Why in news?

Union Minister for Health and Family Welfare released the **annual India Tuberculosis Report 2020**.

Key statistics in report

- **Number of cases**
 - **2.4 million cases of tuberculosis (TB) were reported in 2019** (14% higher than last year) and 79,000 deaths.
 - **Reduction in number of missing cases** to 2.9 lakh cases as against more than 10 lakhs in 2017.
 - **Missing cases refer to** the gap between the estimated and notified incident cases.
 - Provision of HIV testing for all notified TB patients increased from 67% in 2018 to 81% in 2019.
- **Treatment**
 - Due to easy availability of molecular diagnostics, **proportion of children diagnosed with TB increased** to 8% in 2019 compared to 6% in 2018
 - **Improvement in treatment success rate** is 81% in 2019 (69% in 2018).
 - More than 4.5 lakh DOT Centers provide treatment covering almost every village across the country.
- **Ranking of states:** In 2020, Central TB Division (CTD) introduced a quarterly ranking on TB elimination efforts by all States and UTs.
 - In the categories of larger states with more than 50 lakh population, **Gujarat, Andhra Pradesh and Himachal Pradesh** were awarded as best performing States.
 - In the category of smaller states with less than 50 lakh population, **Tripura and Nagaland** were awarded.
 - In the category of Union Territory, **Dadara and Nagar Haveli, and Daman & Diu** were chosen as the best performers.

About Tuberculosis (TB)

- TB is caused by **bacteria (Mycobacterium tuberculosis)** that most often affect the lungs.
- It spreads from person to person through cough, sneeze or spit
- It typically affects the lungs (**pulmonary TB**) but can also affect other organs (**extrapulmonary TB**).
- **Drug Resistant TB:**
 - **Multidrug Resistance TB (MDR):** It is TB that does not respond to at least isoniazid and rifampicin (2 of the most powerful first line drugs).
 - **Extensively drug-resistant tuberculosis (XDR-TB):** It is resistant to at least four of the core anti-TB drugs. It involves multidrug-resistance (MDR-TB), in addition to resistance to any of the fluoroquinolones (such as levofloxacin or moxifloxacin) and to at least one of the three injectable second-line drugs (amikacin, capreomycin or kanamycin).
 - **Totally drug-resistant tuberculosis (TDR-TB):** TB which is resistant to all the first- and second-line TB drugs.
- **India being the country with highest TB burden** (Global TB report 2019, World Health Organization) requires complete surveillance coverage to detect cases.

Recent key initiatives and achievements

- **National Strategic Plan for Tuberculosis Elimination (2017 - 2025):** It is a framework to guide the activities of all stakeholders including the national and state governments, development partners, civil society organizations, international agencies, research institutions, private sector, and many others whose work is relevant to TB elimination in India.

- Under this, India is committed to eliminate TB by 2025, 5 years ahead of Sustainable Development Goal-3, 2030.
- **Revised National Tuberculosis Control Program (RNTCP):** It has been renamed as “**National Tuberculosis Elimination Program (NTEP)**” to accelerate momentum towards eliminating Tuberculosis in the country by 2025.
 - NTEP receives funding from **The Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM)**, **The World Bank** and other donors.
- **Early accurate diagnosis** being done.
 - **Ziehl-Neelsen acid-fast staining /Fluorescence Microscopy** are the primary tools for diagnosis of patients with **Pulmonary Tuberculosis** presumed to be drug sensitive.
 - Patients at risk of **Multi-Drug Resistant TB (MDR-TB)** are diagnosed using WHO endorsed rapid diagnostics (WRD) like **Cartridge Based Nucleic Acid Amplification Test (CBNAAT) / Line Probe Assay (LPA)/ TrueNAT.**
- **700 TB Forums have been established** as part of community-based response for TB to reach the unreached and to support TB patients.
- On-line notification of TB patients through the **NIKSHAY portal.**
 - **NIKSHAY is the National TB information system** which acts a one-stop solution to manage information of patients and monitor program activity throughout the country.
 - It acts as a **Surveillance tool under NTEP.**
 - It provides a **National Data repository of TB information** for advanced analytics.
 - It **performs Direct Benefit Transfers to the patients** through integration with Public Financial Management System (PFMS).

Global findings related to TB (according to WHO’s Global Tuberculosis Report, 2019)

- **The world is not on track to reach the 2020 milestones of the End TB Strategy.** For instance:
 - The END TB strategy by the WHO aimed to reduce TB by 20% from 2015-18. However, between 2015 and 2018, only 6.3% TB cases showed a cumulative decline.
- **Funding challenges:**
 - In 2019, the low- and middle-income countries, accounting for 97% of reported TB cases, received a global funding of \$6.8 billion. This amount is \$3.3 billion less than the \$10.1 billion estimated to be required in the **Stop TB Partnership’s Global Plan to End TB 2018–2022.**
 - **Funding gap for TB research was US\$ 1.2 billion** in 2017.
- **Under reporting of the cases:** Of the 10 million new cases worldwide, 3 million cases went unreported to the authorities. In India 1.99 million of the 2.69 million in India were reported.
- Globally, TB claimed **15 lakh lives in 2018, including 2.51 lakh with HIV.** The 15 lakh included 4.49 lakh deaths in India down from over 6 lakh in 2000.
- **66% of that burden came from eight countries:** India (27%), China (9%), Indonesia (8%), etc.
- **Key five risk factors attributable to new cases of TB:** undernourishment, smoking (especially among men), alcohol abuse, HIV infection, and diabetes.

Global Efforts for TB

- **SDG Target 3.3** includes ending the TB epidemic by 2030.
- **Moscow Declaration to End TB:** It is the outcome of first **global ministerial conference on ending TB**, in 2017.
- The **first UN General Assembly high-level meeting on TB** was held in New York in September 2018, titled **United to End TB: An Urgent Global Response to a Global Epidemic.**
- **WHO- End TB Strategy**
 - Vision: A world free of TB with zero deaths, disease and suffering due to TB.
 - It has three high-level, overarching indicators and related targets:
 - ✓ 95% reduction by 2035 in number of TB deaths compared with 2015.
 - ✓ 90% reduction by 2035 in TB incidence rate compared with 2015.
 - ✓ Zero the level of catastrophic costs for TB-affected families by 2035.
- **Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM)**
 - It is an international financing institution based on a unique **partnership between governments, civil society, the private sector and affected communities.**
 - It was created to raise, manage and disburse large amounts of **additional financing to fight three of the world’s most devastating diseases (AIDS, Tuberculosis and Malaria)**, and to direct those resources to areas of greatest need.
 - It is **registered as a Non-Profit Foundation in Switzerland** and maintains its **secretariat in Geneva, Switzerland.**
 - **India has recently announced a contribution of \$22 million** to the GFATM for the 6th replenishment cycle (2020-22).

- India is one of the first countries to adopt the **Communities, Rights and Gender Tools** developed by the **Stop TB Partnership**.
- **Nikshay Poshan Yojana** has been implemented since 2018, wherein 500 rupees per month is being provided to All TB patients towards nutritional support for the duration of their treatment.
 - The scheme is financed by the Centre, with partial financing provided through World Bank.
- **TB Harega Desh Jeetega Campaign:** It aims to improve and expand the reach of TB care services across the country, by 2022.
 - The campaign has three pillars - clinical approach, public health component and active community participation.

3.6. POLIO

Why in news?

Recently, Global Commission for the Certification of Poliomyelitis Eradication officially declared that **wild poliovirus type 3 has been eradicated**.

More about news

- This is the second wild poliovirus to be declared eliminated — **the first was in 2015 when type 2 wild poliovirus was declared as eliminated**.
- With two of the three wild polioviruses eliminated, **only type 1 wild poliovirus** is still in circulation and is restricted to just two countries — **Afghanistan and Pakistan**.
- It opens up the possibility of switching from the currently used **bivalent oral polio vaccine** containing type 1 and type 3 to a **monovalent vaccine containing only type 1**.

About Polio

- It is highly infectious viral disease which **invades the nervous system** and **can cause irreversible paralysis within hours**.
- Polio spreads in vulnerable populations in areas **where there is no immunity and sanitation is poor**.
- There are **three individual and immunologically distinct wild poliovirus strains: wild poliovirus type 1 (WPV1), wild poliovirus type 2 (WPV2) and wild poliovirus type 3 (WPV3)**.
 - Symptomatically, all three strains are identical, but there are **genetic and virological differences**, which make these three strains three separate viruses that must each be eradicated individually.
- There are **two vaccines** used to protect against polio disease, **oral polio vaccine and inactivated poliovirus vaccine**.
 - **Oral polio vaccine:** It consists of a mixture of **live attenuated strains** of polioviruses of three (now only two OPV 1 and OPV 3) different types of serotypes.
 - ✓ These **viruses mimic the immune response of the actual polioviruses**, but with a reduced ability to spread and affect the central nervous system
 - ✓ In rare cases, the OPV virus can **accumulate changes over time and become like wild poliovirus (WPV) infect new individuals**. These new viruses are called **vaccine-derived polioviruses (VDPV)** and can cause polio disease.
 - ✓ OPV vaccines also **produce a local immune response in the lining of the mucous membrane of the gut** (developing gut immunity) which is the primary site for multiplication of poliovirus.
 - **IPV or inactivated poliovirus vaccine** is produced from wild-type poliovirus strains of each serotype that have been inactivated (killed) with formalin.
 - ✓ This vaccine is in **the form of an injection** and can be administered in combination with other vaccines as well.
 - ✓ IPV protects people against all **three types of poliovirus**.

Related news

Acute flaccid myelitis

- **Acute flaccid myelitis (AFM)**, being referred to as a 'polio-like condition', has been **tested negative for the polio virus**, according to the Centers for Disease Control and Prevention (CDC) of the United States.
- AFM is a **neurological illness**, with weakness or paralysis of the limbs and inflammation of the spinal cord.
- Acute flaccid myelitis (AFM) is a **rare** but serious condition. The symptoms of AFM, particularly, weakening of limbs, are similar to polio.
- **In India incidence rate of AFM was 120 per million population in 2010.**

- ✓ **IPV does not contain live virus**, so people who receive this vaccine **do not shed the virus** and cannot infect others and the vaccine cannot cause disease.
- India's ambitious **Pulse Polio oral vaccination campaign** launched nationwide in **1995** brought down polio cases from 50,000-100,000 each year in the 80s **to zero in 2012**.
- Though, India is a **wild, poliovirus, disease-free country currently**. But, the cases of Vaccine Derived Polio Virus (VDPV) disease, can be seen.

3.7. TRADITIONAL MEDICINE

Why in News?

Recently, Ministry of AYUSH hosted World Health Organization meeting on developing **Standardized Terminologies and Benchmarks documents for Practice for Traditional Medicine**.

More in News

- **WHO is developing Benchmarks Document** for Practice of Ayurveda, Panchakarma & Unani and International Terminologies Documents in Ayurveda, Siddha & Unani.
- Development of these benchmarks documents is included in the Project Collaboration Agreement (PCA) signed between World Health Organization (WHO) and Ministry of AYUSH on **Cooperation in the field of Traditional and Complementary Medicine under WHO Traditional Medicine Strategy 2014-2023**.

WHO Traditional Medicine Strategy 2014-2023

The strategy has two key goals:

- To support Member States in harnessing the potential contribution of Traditional Medicine to health, wellness and people centered health care
- To promote the safe and effective use of Traditional Medicine through the regulation of products, practices and practitioners.

These goals will be reached by implementing three strategic objectives:

- Building the knowledge base and formulating national policies;
- Strengthening safety, quality and effectiveness through regulation; and,
- Promoting universal health coverage by integrating Traditional Medicine services and self-health care into national health systems.

What is Traditional Medicine?

- Traditional medicine describes **a group of health care practices and products with a long history of use**.
- It frequently **refers to medical knowledge developed by indigenous cultures** that incorporates plant, animal and mineral-based medicines, spiritual therapies and manual techniques designed to treat illness or maintain wellbeing.
- **Major traditional medicines in India include:** Ayurveda, Yoga, Siddha, Unani, Sowa-Rigpa, Naturopathy etc.
 - **Ayurveda:** The treatment approach in the Ayurveda system is holistic and individualized having preventive (Svasth-Vritta), curative Aushadhi (drugs), Ahara (diet) and Vihara (life style), mitigative, recuperative (Rasayana) and rehabilitative aspects.
 - **Unani:** Originating in Greece (Yunan), it was introduced in India by the Arabs and Persians around the eleventh century.
 - **Siddha:** The Siddha System of medicine in India having **its close relation with Dravidian culture**.
 - **Yoga:** It is primarily a way of life, first **propounded by Maharshi Patanjali in systematic form Yogsutra**. The discipline of Yoga consists of eight components namely, restraint (Yama), observance of austerity (Niyama), physical postures (Asana), breathing control (Pranayam), restraining of sense organs (Pratyahar), contemplation (Dharna), meditation (Dhyan) and Deep meditation (Samadhi).
 - **Naturopathy:** It is a **cost effective drugless, non-invasive therapy** involving the use of natural materials for health care and healthy living.
 - **Homoeopathy:** It was introduced as a scientific system of drug therapeutics by a German Physician, Dr. Christian Frederick Samuel Hahnemann in 1805.

Benefits of Traditional Medicine

- **Addresses gaps in health services:** Traditional medicine therapies are generally available and commonly used in low- and middle-income countries.
 - According to data provided to WHO, in India 70 percent of the population depends on Traditional Medicine for primary health care.
 - Traditional medicines provide low cost services and are perceived to have lower side effects.

- **Treatment of major disease:** World Health Organisation has acknowledged that traditional medicine and its practitioners play an important role in treating chronic illnesses, and improving the quality of life of those suffering from certain incurable diseases.
- **Holistic approach to treatment:** In Ayurveda, a human being is seen as a combination of body, mind, soul and senses. So, in order to treat any illness, the system takes all four into account and treats the patient more holistically.
- **New drug development:** Traditional knowledge can provide valuable guidance in selecting and obtaining plant material of potential therapeutic interest.
 - Traditional medicines are the source of some modern antimalarial drugs.

Issues with Traditional Medicine

- **Unregulated:** Traditional Medicine products are unregulated in many countries, and therefore many of the concerns about the risks for consumers relate to the safety and quality of medicinal products.
 - Reported problems include sales of incorrect plant species and the contamination and adulteration of Traditional medication therapies.
- **Untrained practitioners:** WHO notes that "inappropriate use of traditional medicines or practices can have negative or dangerous effects".
- **Lack of financial support:** Traditional Medicine often lacks required financial support for the development and conservation of traditional knowledge.
- **Lack of human resources:** Practitioners are moving away from traditional system for better opportunities.

Other steps taken for Traditional Medicine

- **International Conference on Standardisation of Diagnosis and Terminologies in Ayurveda, Unani and Siddha Systems of Medicine (ICoSDiTAUS) 2020:** It was jointly organized by the Ministry of AYUSH and the World Health Organization (WHO).
 - 'New Delhi Declaration on Collection and Classification of Traditional Medicine (TM) Diagnostic Data' was adopted and emphasised the commitment of the countries to Traditional Medicine as a significant area of health care.
- **Pharmacopoeia Commission for Indian Medicine & Homoeopathy (PCIM&H):** Cabinet has approved re-establishment of PCIM&H as Subordinate Office under Ministry of AYUSH (MoA) by merging into it Pharmacopoeia Laboratory for Indian Medicine and Homoeopathic Pharmacopoeia Laboratory.
 - PCIM&H is an autonomous body under aegis of MoA established since 2010.
 - Merger is aimed at **optimizing use of infrastructural facilities, technical manpower and financial resources** of three organizations for **enhancing standardization outcomes of Ayurveda, Siddha, Unani and Homoeopathy drugs** towards their effective regulation and quality control.
- **Ayush Grid:** Ministry of AYUSH has conceptualized this new project for digitization of AYUSH sector.
- **Centrally Sponsored Scheme of National AYUSH Mission** and the strategy of **mainstreaming of AYUSH under National Health Mission and National Health Policy-2017** are implemented for promoting and strengthening AYUSH sector. Under it, AYUSH facilities are being set up in PHCs, CHCs and District hospitals.
- **Under Ayushman Bharat**, 10% of the Sub-centres are to be upgraded as Health and Wellness Centres (HWCs) which will be developed by the Ministry of AYUSH to provide comprehensive Health care to the needy community.

Way forward

- **Promotion of Traditional Medicine:** The knowledge of traditional medicine, treatments and practices should be respected, preserved, promoted and communicated widely and appropriately based on the circumstances in each country.
- **Improve regulatory framework:** Governments have a responsibility for the health of their people and should formulate national policies, regulations, and standards as part of comprehensive national health systems to ensure appropriate, safe and effective use of traditional medicine.
- **Training and qualified practice for practitioners:** Governments should establish systems for the qualification, accreditation or licensing of traditional medicine practitioners. Traditional medicine practitioners should upgrade their knowledge and skills based on national requirements.
- **Collaboration between conventional and traditional medicine providers:** Since consumers often use both treatments simultaneously, it is necessary to improve collaboration between registered/licensed traditional practitioners and conventional health care providers.

3.7.1. LAWS PASSED ON TRADITIONAL MEDICINES

Why in news?

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

Background and Necessity of the Bills

- **Indian Medicine Central Council Act, 1970** and Homoeopathy Central Council Act, 1973 have not kept pace with time.
- **Various bottlenecks with these medicine systems are**
 - **Irregularities in regulation** of AYUSH medical institutions.
 - **Ineffective role of members** and Executive Committee.
 - **Lack of standard curriculum** and education.
 - **Absence of ethics** in practice of Indian System of Medicine and Homeopathy.
 - **Failure to provide transparent system** of inspection.
 - **Alleged irregularities in grant of recognition & de-recognition of education system** have crept into the system with serious detrimental effects on medical education and by implication on delivery of quality health services.

The National Commission for Indian System of Medicine Act (NCISM), 2020

- The Act **seeks to repeal the Indian Medicine Central Council Act, 1970** and to provide for a medical education system which ensures:
 - availability of adequate and high-quality medical professionals of Indian System of Medicine
 - adoption of the latest medical research by medical professionals
 - periodic assessment of medical institutions and an effective grievance redressal mechanism.
- **Constitution of National Commission for Indian System of Medicine (NCISM) and State Medical Councils.** NCISM would have the following responsibilities:
 - **To frame policies for the regulation of medical professionals and institutions** for Indian System of Medicine
 - **To assess the human resources and infrastructure** required in relation to healthcare
 - **To ensure that the State Medical Councils of Indian System of Medicine adhered to the regulations** laid down by the Act
 - **To ensure that the autonomous boards set up under the Act worked in coordination** with each other.
- **Autonomous boards:** It sets up certain autonomous boards under the supervision of the NCISM. These boards are:
 - The Board of Ayurveda and the Board of Unani, Siddha, and Sowa-Rigpa
 - The Medical Assessment and Rating Board for Indian System of Medicine
 - The Ethics and Medical Registration Board
- **Advisory Council for Indian System of Medicine**
- **Uniform National Eligibility-cum-Entrance Test** for admission to under-graduate education and **common final year National Exit Test** for the students graduating from medical institutions to obtain the license for practice. Further, there will be a **uniform post-graduate National Entrance Test** for admission into post-graduate courses in each of the disciplines of the Indian System of Medicine in all medical institutions.
- **National Teachers' Eligibility Test** for postgraduates of each discipline of Indian System of Medicine who wish to take up teaching that particular discipline as a profession.

The National Commission for Homoeopathy (NCH) Act, 2020

- The Act **seeks to repeal the Homoeopathy Central Council Act, 1973** and provide for a medical education system which ensures availability of adequate and high quality homoeopathic medical professionals, etc.
- **Constitution of the National Commission for Homoeopathy (NCH) and State Medical Councils for Homoeopathy**
 - **Functions of NCH:** same as of NCISM but with regards to homeopathy
- **Autonomous boards:** The Act sets up certain autonomous boards under the supervision of the NCH. These are:

- Homoeopathy Education Board:
- Medical Assessment and Rating Board for Homoeopathy
- Board of Ethics and Medical Registration for
- **Advisory Council for Homoeopathy**
- **Entrance examinations for UG, PG and license for practice.**
- **National Teachers' Eligibility Test**
- **Appeal on matters related to professional and ethical misconduct:** The State Medical Councils and the Board of Ethics and Medical Registration for Homoeopathy have the power to take disciplinary action against the medical practitioner including imposing a monetary penalty.

The Institute of Teaching and Research in Ayurveda (ITRA) Act, 2020

- It seeks to merge three Ayurveda institutes into one institution by the name of Institute of Teaching and Research in Ayurveda (ITRA). The proposed Institute will be situated in the campus of Gujarat Ayurveda University, Jamnagar and **will be an institution of National Importance.**
- The existing institutes which will be merged into the Institute are: (i) the Institute of Post Graduate Teaching and Research in Ayurveda, Jamnagar, (ii) Shree Gulabkunverba Ayurveda Mahavidyalaya, Jamnagar, and, (iii) the Indian Institute of Ayurvedic Pharmaceutical Sciences, Jamnagar.
- **Objectives of the Institute:**
 - **develop patterns of teaching** in medical education in Ayurveda and pharmacy,
 - **bring together educational facilities for training of personnel** in all branches of Ayurveda,
 - **attain self-sufficiency** in postgraduate education to meet the need for specialists and medical teachers in Ayurveda, and
 - make an **in-depth study and research in the field of Ayurveda.**
- **Composition of Institute:** Institute will consist of 15 members including the Minister of AYUSH, Director-General, Central Council for Research in Ayurveda, three experts in Ayurveda with expertise in education, industry and research, and three Members of Parliament.
- **Functions of Institute:**
 - **provide for undergraduate and postgraduate teaching** in Ayurveda (including pharmacy),
 - **prescribe courses and curricula and hold examinations and grant degrees, diplomas and other distinctions and titles** in education in Ayurveda and pharmacy
 - **provide facilities for research** in the various branches of Ayurveda,
 - **maintain well-equipped colleges and hospitals for Ayurveda** supporting staffs such as nurses and pharmacists.

Institute of National Importance (INI)

- As per MHRD, Institute of National Importance (INI) is a **status that may be conferred on a premier public higher education institution** in India which serves as a pivotal player in developing highly skilled personnel within the specified region of the country/state'.
- The status is **granted by an act of Parliament of India.**
- **ITRA will be the first institution with INI status in the AYUSH Sector,** and will enable the institution to be independent and innovative in the matter deciding course content and pedagogy.

Conclusion

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

3.8. TELEMEDICINE GUIDELINES

Why in news?

Ministry of Health and Family Welfare issued guidelines for telemedicine. The guidelines were prepared in collaboration with **NITI Aayog and Medical Council of India.**

About Telemedicine

- **World Health Organization defines telemedicine** as the delivery of health-care services by health-care professionals using **information and communications technologies** for diagnosis, treatment and prevention of disease and injuries, with the aim of advancing the health of individuals and communities.



- Telemedicine comprises **remote diagnosis and treatment of patients by means of telecommunications such as video, phone, chatting apps, etc.**

Key features of guidelines

- Only registered medical practitioners (RMPs) under the **Indian Medical Council Act 1956**, are entitled to provide telemedicine consultation, after completing an online course.
- Telemedicine **consultations should not be anonymous**, both patient and doctor should know each other's identity.
- It provides provisions for protecting **privacy and confidentiality** of the patients.
- It **mentions platforms** that can be used for diagnosis and treatment and how the technology can be integrated to provide robust healthcare services. The government has also listed out certain drugs that cannot be prescribed through telemedicine.
- It **provides norms and protocols** relating to physician-patient relationship; issues of liability and negligence; evaluation, management and treatment; continuity of care; referrals for emergency services; privacy and security of the patient records and exchange of information; prescribing; and reimbursement; health education and counseling.

Advantages of Telemedicine

- **Increased access of healthcare:** Telemedicine can overcome geographic barriers to healthcare, especially for specialized providers. Telemedicine can be particularly beneficial for patients in medically underserved communities and those in rural geographical locations where clinician shortages exist.
- **Reduced healthcare costs:** Telemedicine can **increase efficiency** of care delivery, **reduce expenses** of caring for patients or transporting to another location, and can even keep patients out of the hospital.
- **Enhances traditional face-to-face medicine:** With telemedicine care providers **can continue to care for patients in-person care** while still providing the **flexibility and convenience** of seeing patients remotely for follow up visits, check-ups, and education when appropriate or necessary.
- **Improved patient engagement and satisfaction:** Telemedicine makes it easier and convenient for patients to stay engaged in their health care. The convenience, flexibility and real-time care with their providers enhances overall quality of health.

Challenges of Telemedicine

- **Accessibility to technology:** Due to cost, low digital literacy, lack of awareness, non-availability in local languages- make telemedicine inaccessible to the vulnerable and those in rural areas.
- **Privacy Concerns:** Telemedicine services be a gateway to security and privacy issues, while accessing patient data over the Internet.
- **Patient preference**, as patients still prefer **in-person exams over virtual visits**, due to various reasons like, concerns related to privacy, technological literacy etc. Also, patients might prefer telehealth visits with physicians they know.

Conclusion

Telemedicine guidelines are a much-needed step in right direction. Rapid advancements in connected care technology, big data and analytics will move telemedicine into the mainstream. The **proliferation of smart devices coupled with democratization of the internet** poised to make teleconsultations much more convenient, accessible.

3.9. PHARMACEUTICAL AND MEDICAL DEVICES INDUSTRY IN INDIA

Why in news?

Recently, **Cabinet approved** a series of Schemes to give an impetus to the Pharmaceutical and Medical Devices Industries in India.

Background

- India is the **largest provider of generic medicines globally**, occupying a 20% share

About API and KSM

- **Active pharmaceutical ingredient (API)**, is biologically active component of a drug product (e.g. tablet, capsule).
 - Drug products are usually composed of several components. The aforementioned API is the primary ingredient.
 - 70% of India's API imports are imported from China.
- **KSM (key starting material)** are the building block for the API.

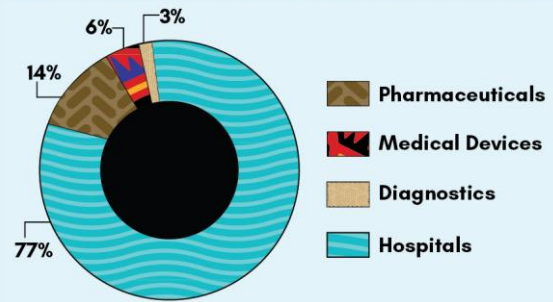
in global supply by volume, and also supplies 50% of global demand for vaccines. (Leader in Global Supply of **DPT** (Diphtheria, Tetanus, Pertussis), **BCG** (Bacillus Calmette–Guérin) and **Measles Vaccine**)

- India **ranks 3rd worldwide for production by volume** and 13th by value.
- India is the source of 60,000 generic brands and manufactures more than **500 different Active Pharmaceutical Ingredients (APIs)**.
- The pharmaceutical industry was **valued at \$ 36.7 bn in 2018** and is expected to reach \$ 55 bn over 2015-20.
- **100% Foreign Direct Investment (FDI)** is allowed under the automatic route for greenfield pharma.
- The Department of Pharmaceuticals aims to make the country a hub for end-to-end drug discovery under its '**Pharma Vision 2020**'.
- **Medical Device is also growing sector** and its potential for growth is the highest among all sectors in the healthcare market.
 - It is valued at Rs. 50,026 crores for the year 2018-19.
 - Medical devices are **segregated into different major segments**, of which equipment and instruments (surgical and non-surgical) form the largest portion.
 - Other segments include Consumables and Disposables; Patient Aid; Implants; Stents etc.
 - India depends on **imports up to an extent of 85% of total domestic demand of medical devices**. In some specific bulk drugs, the import dependence is 80 to 100%.

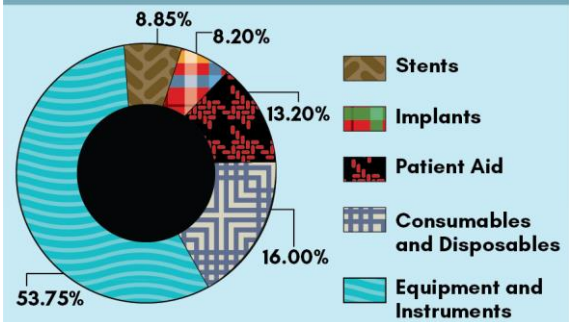
Challenges of Pharmaceutical and Medical Devices Industry

- **Global factors:** Globally, following aspects have led to a severe impact on exports in manufacturing, which have also brought a slowdown in the domestic market. These include-
 - higher level of customer consolidation,
 - increased competition & number of products approvals,
 - decreased value from new product launches
 - increased pricing control & protectionism.
- **Generic Drugs sector facing challenges:** Our strong position as a global supplier of high quality, affordable and accessible generic medicines has been impacted due to **recent compliance challenges and low productivities**.
- **Evolving regulatory landscape:** Several interventions over the years have had an impact across the value chain- from development, manufacturing and supply chain to pricing and customer engagement.
 - Compliance issues are affecting the reliability of supply as while many Indian companies have fared well in regulatory audits others continue to face challenges.
- **Import dependency:** India continues to rely on imports of key starting materials, intermediates and API's for, China. This potentially exposes us to **raw material supply disruptions and pricing volatility**.
 - The industry should therefore, also explore **alternate sourcing locations (such as Vietnam, Indonesia)** while indigenous capabilities & capabilities ramp up.
 - Recent lockdown in China due to COVID 19 had caused disruption in Indian pharmaceutical industry.
- **Inadequate R&D:** The Indian pharma industry faces lack of research components and real time good manufacturing practices.

INDIAN HEALTHCARE MARKET



INDIAN MEDICAL DEVICE MARKET



Medical Devices Sector: Growth Drivers

- **Nascent industry:** Importing more than 90% of sophisticated devices, the domestic industry has a huge scope for R&D capacity.
- **Demographics:** Ageing population, life expectancy to cross 70 years by 2022, thereby requiring home-based healthcare devices.
- **Increasing disposable income:** 8% Indians could earn more than \$ 12,000 p.a. by 2026
- **Industrial Parks:** 4 medical devices parks in India are under-development.
- **Government commitment:** New rules and regulatory processes for the medical devices sector, 100% FDI allowed etc.

- The government should promote incubators' establishment to establish small scale, raw material manufacturing units/ incubators in all states of the country.
- **Manufacturing disability:** The medical device sector suffers from a cost of manufacturing disability of around 12 to 15 %, vis-a-vis competing economies, among other factors, on account of
 - lack of adequate infrastructure,
 - domestic supply chain and logistics,
 - high cost of finance,
 - limited design capabilities
- **Medical devices,** are dependent on a mix of technologies such as engineering, electronics, material sciences and information technology. However, India has not been able to bridge the gap between investments, skilled resources and innovation to fully capitalize on these opportunities.

Pharmaceutical Industry: Growth Drivers**Demand-side Factors**

- **Accessibility:** Over \$200 Billion to be spent on medical infrastructure in the next decade.
- **Affordability:** Rising income could drive 73 million households to the middle class over the next 10 years.
- **Epidemiological Factors:** Patient pool expected to increase over 20% in the next 10 years, mainly due to the rise in population, New diseases & lifestyle changes.

Supply-side Factors

- **Patented Drugs:** Following the introduction of product patents, several multinational companies are expected to launch patented drugs in India
- **Medical Infrastructure:** Pharma companies have increased spending to tap rural markets and develop better medical infrastructure. Hospitals' market size is expected to increase by 2024.
- **Cost Efficiency:** India's cost of production is nearly 33 % lower than that of the US and almost half of that of Europe.
- **Generics Market:** India's generics drug market accounts for around 70% of the India pharmaceutical industry.
- **Talent Pool:** India has a skilled workforce as well as high managerial and technical competence in comparison to its peers in Asia.

In the light of above challenges the Union government has therefore, approved these New Schemes to boost Manufacturing of Medical Devices as well as Bulk Drugs production in India:

About the Schemes

- **Promotion of Medical Device Parks:** It aims to promote Medical Device Parks in the country in partnership with the States. A maximum grant-in-aid of Rs.100 crore per park will be provided to the States.
 - It will be implemented by a State Implementing Agency (SIA).
 - The target is to provide financial assistance for Common Infrastructure Facilities for 4 Medical Device parks.
- **Production Linked Incentive Scheme for promoting domestic manufacturing of medical devices:** Incentive @ 5% of incremental sales over base year 2019-20 will be provided on the segments of medical devices identified under the Scheme.
 - It will be implemented by a Project Management Agency (PMA) to be nominated by Department of Pharmaceuticals.
 - The target is to aid **about 25-30 manufacturers** under the following categories of medical devices: -
 - ✓ **Cancer care/Radiotherapy** medical devices,
 - ✓ **Radiology & Imaging medical devices** and Nuclear Imaging Devices,
 - ✓ **Anaesthetics & Cardio-Respiratory** medical devices
 - ✓ **All Implants** including implantable electronic devices like Cochlear Implants and Pacemakers.
- **Promotion of Bulk Drug Parks: Under this scheme,**
 - Decision is to develop **3 mega Bulk Drug parks in India** in partnership with States.
 - Government of India will give **Grants-in-Aid to States** with a maximum limit of Rs. 1000 Crore per Bulk Drug Park.
 - Parks will have common facilities such as **solvent recovery plant**, distillation plant, power & steam units, common effluent treatment plant etc.
 - A sum of Rs. **3,000 crores** have been approved for this scheme **for next 5 years.**

Significance of the Schemes

- **Providing affordable healthcare.**
- **Way to achieve self-reliance.**
- **Role of China:** China supplies around two-thirds of India's pharmaceutical raw materials, and in certain segments like antibiotics, the proportion is as high as 90%. The issue gains significance after the novel coronavirus epidemic shut down factories in China, which in turn hit supplies of raw materials.
- **Achieving economy of scale.**
- **Attracting investment.**
- **Providing hand-holding support to the manufacturers.**
- **Generate an additional employment** of 33,750 jobs over a period of five years.

- It will be implemented by State Implementing Agencies (SIA) to be set up by the respective State Governments.
- **Production Linked Incentive Scheme for promotion of domestic manufacturing of critical KSMs/Drug Intermediates and APIs**
 - Financial incentive will be given only to eligible manufacturers of identified 53 critical bulk drugs on their incremental sales over the base year (2019-20) for a period of 6 years.
 - A sum of **Rs. 6,940 crores** have been approved for **next 8 years**.
 - The scheme will be implemented through a **Project Management Agency (PMA) to be nominated by the Department of Pharmaceuticals**.

3.10. E-CIGARETTES

Why in news?

Recently, Parliament has passed the **Prohibition of Electronic Cigarettes (Production, Manufacture, Import, Export, Transport, Sale, Distribution, Storage, and Advertisement) Act, 2019**. It will replace an Ordinance promulgated in September 2019.

Key provisions of the Act

- **Definition of E-cigarette:** Act defines electronic cigarettes (e-cigarettes) as **electronic devices that heat a substance, which may contain nicotine and other chemicals, to create vapour for inhalation**. These e-cigarettes can also contain different flavours and include all forms of electronic nicotine delivery systems (ENDS), heat-not-burn products, e-hookahs, and other similar devices.
- **Prohibition on e-cigarettes-** It makes production, manufacture, import, export, transport, sale, distribution or advertisements of e-cigarettes a **cognizable offence**.
- **Storage of e-cigarettes:** No person is allowed to use any place for the storage of any stock of e-cigarettes. If any person stores any stock of e-cigarettes, he will be punishable with an imprisonment of up to six months, or a fine of up to Rs 50,000 or both.
 - Moreover, the owners of existing stocks of e-cigarettes will have to declare and deposit these stocks at the nearest office of an authorised officer.
- **Powers of authorised officers:** If an authorised officer believes that any provision of the act has been contravened, he can search any place where trade, production, storage or advertising of e-cigarettes is being undertaken. The authorised officer can seize any record or property connected to e-cigarettes found during the search. Further, he may take the person connected with the offence into custody.

About e-cigarettes

- They are **battery-operated devices that produce aerosol by heating a solution containing nicotine**, which is the addictive substance in combustible cigarettes.
- These include all forms of **Electronic Nicotine Delivery Systems, Heat Not Burn Products, e-Hookah** and the like devices.
- Smoking e-cigarettes is also called **vaping**.

Rationale for banning

- **Health impacts:** Both the WHO and the Indian Council of Medical Research (ICMR) have highlighted the negative health impact of using e-cigarettes.
 - Nicotine is the addictive component of tobacco products. In addition to dependence, nicotine can have adverse effects on the development of the foetus during pregnancy and contribute to cardiovascular diseases.
 - In addition to nicotine, **the cartridges of e-cigarettes are filled with chemicals, flavourings, and metals** that have been demonstrated to be responsible for causing cancers and diseases of the heart, lungs, and brain.
- **Increase in usage:** WHO has observed that e-cigarettes are heavily marketed towards youth through the use of flavourings and promotional strategies. This has resulted in a rapid increase in the use of e-cigarettes amongst youth.
 - For instance, the percentage of youth using e-cigarettes in USA has increased from 1.5% in 2011 to 20.8% in 2018. In India, **e-cigarettes worth \$ 1,91,781 were imported between 2016-16 and 2018-19**.
- **Passive smoking:** The smoke which is exhaled by the users of e-cigarettes contains very high level of residual nicotine badly affects the people around standing as passive smokers, who accidentally inhale.
- **Not a Cessation aids:** E-cigarettes are usually promoted by the industry as smoking cessation aids but their efficacy and safety as a quitting aid has not yet been established. WHO does not endorse e-cigarettes as cessation aids that help people quit tobacco use.

- **Government's responsibility:** Under **Article 47 of Indian constitution**, government has the responsibility to raise the level of nutrition and the standard of living and to improve public health. The widespread use and unchecked proliferation of e-cigarettes and the like devices would seriously undermine and derail government's efforts to reduce the prevalence of tobacco use.
- **Lack of regulation of E-cigarettes-** unlike traditional cigarettes, e-cigarettes do not contain tobacco and therefore are not regulated under the COTPA Act.
 - Cigarettes and Other Tobacco Products Act (COTPA), 2003 regulates the sale, production, and distribution of cigarettes and other tobacco products in India, and prohibits advertisement of cigarettes.
- **International experience:** India is a signatory to the **WHO Framework Convention on Tobacco Control (WHO FCTC)**. In 2014, the WHO FCTC invited all its signatories to consider prohibiting or regulating e-cigarettes in their countries. E-cigarettes have been completely banned in 25 countries including Brazil and Singapore.

Arguments against banning e-cigarettes

- **More needs to be done on tobacco-** as rather than banning e-cigarettes, the government should have done more on banning original cigarettes to stop tobacco consumption.
- **Illegal operations may continue-** Already, 16 of 29 states have banned vaping products, but they are still prevalent in stores and available for purchase online.
- **Number of smokers has reduced-** in India from 275 million in 2010 to 200 million in 2016-17 as per the Global Adult Tobacco Survey, which highlights the efficacy of e-cigarettes.

Conclusion

Rather than a blanket ban on e-cigarettes, experts have suggested that government should work at regulating it and further towards promoting healthy lifestyle among adolescents.



फाउंडेशन कोर्स सामान्य अध्ययन प्रारंभिक एवं मुख्य परीक्षा 2021

इनोवेटिव क्लासरूम प्रोग्राम

- प्रारंभिक परीक्षा, मुख्य परीक्षा और निबंध के लिए महत्वपूर्ण सभी टॉपिक का विस्तृत कवरेज
- मौलिक अवधारणाओं की समझ के विकास एवं विश्लेषणात्मक क्षमता निर्माण पर विशेष ध्यान
- एनीमेशन, पावर प्वाइंट, वीडियो जैसी तकनीकी सुविधाओं का प्रयोग
- अंतर - विषयक समझ विकसित करने का प्रयास
- योजनाबद्ध तैयारी हेतु करंट ओरिएंटेड अप्रोच
- नियमित क्लास टेस्ट एवं व्यक्तिगत मूल्यांकन

- सीसैट कक्षाएं
- PT 365 कक्षाएं
- MAINS 365 कक्षाएं
- PT टेस्ट सीरीज
- मुख्य परीक्षा टेस्ट सीरीज
- निबंध टेस्ट सीरीज
- सीसैट टेस्ट सीरीज
- निबंध लेखन - शैली की कक्षाएं
- करेंट अफेयर्स मैगजीन

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लॉकडाउन तक कक्षाएं ऑनलाइन होंगी।
लॉकडाउन के बाद, ऑफलाइन कक्षाएं शुरू की जाएंगी

4. INTELLECTUAL PROPERTY RIGHTS

Why in News?

Recently **International Intellectual Property Index 2020** was released by US Chamber of Commerce's Global Innovation Policy Centre (GIPC).

More on news

- **India's ranked 40th among 53 countries**, while in 2019 India was ranked at **36th position out of 50 countries**.
- However, **India's score increased** from 36.04 per cent in 2019 to 38.46 per cent in 2020, a 2.42 per cent jump in an absolute score.
- The **US, the UK, Sweden, France and Germany remained the top five** economies on the index.

Other observations by GIPC with respect to India

- Since the **National IPR Policy 2016**, the Government of India has **made effort to support investments in innovation and increasingly robust IP protection and enforcement**.
- The policy has improved the speed of processing for patent and trademark applications, increased awareness of IP rights among Indian innovators and creators.
- However, it noted that **"job is not yet done"** on establishing stronger IP protections.
- India needs to do more in the field of patent enforcement, compulsory licensing, regulatory data protection, transparency in reporting seizures by customs, signing **Singapore Treaty on Law of Trade Marks and Patent Law Treaty**.

What is Intellectual Property?

- It refers to **creations of mind such as inventions, literary and artistic works, designs and symbols**, names and images in commerce.
- By striking the right balance between the interests of innovators and wider public interest, the IP system aims to **foster an environment in which creativity and innovation can flourish**.
- IPR are the rights which allow creators of patents, trademarks or copyrighted work to benefit them for their own work or investment. These rights have been outlined in **Article 27 of Universal Declaration of Human Rights**.
- The importance of IPR was first recognized in the **Paris Convention for the protection of Industrial Property (1883)** and **Berne Convention for the Protection of Literary and Artistic Works (1886)** (both administered by WIPO).
- IP activity in India is showing remarkable upward movement in the last 15 years with the number of Patents filed increasing nearly nine times.



WIPO-Administered Treaties for Classifications

- **The Nice Agreement (1957)** establishes a classification of goods and services for the purposes of **registering trademarks and service marks** (the Nice Classification).
- **The Locarno Agreement (1968)** establishes a classification for **industrial designs** (the Locarno Classification).
- **The Vienna Agreement (1973)** establishes a classification (the Vienna Classification) for marks that consist of, or contain, **figurative elements**.
- **The International Patent Classification (1971)** is used to classify **patents and utility models** according to the different areas of technology to which they pertain. It was established by the **Strasbourg Agreement**.

Types of IPR

• Patent

- A patent is granted for an invention which is a new product or process that meets conditions of novelty, nonobviousness and industrial use.
- Patents in India are governed by “The patent Act 1970” which was amended in 2005 to make it compliant with TRIPS.

• Trademark

- A trademark means a mark capable of being represented graphically and which is capable of distinguishing the goods or services of one undertaking from those of other undertakings. ○ Trade marks in India are governed by Trade Marks Act 1999 which was amended in 2010.
- Trade Mark Rules, 2017 has been notified which provides for ease of filing trademarks, rationalised trademark fee etc.
- Modalities for determining well-known trademarks has been introduced for the first time

• Geographical Indications

- It is a sign used on agricultural or natural or manufactured goods as originating or manufactured in a particular region of a country. It denotes its origin where a specific quality, characteristic or reputation of the product is essentially attributable to that origin.
- Geographical Indicators in India are governed by “The Geographical Indications of Goods (Registration & Protection) Act, 1999”.

• Copyright

- Copyright is a right given by the law to creators of literary, dramatic, musical and artistic works and producers of cinematograph films and sound recordings.
- This right allows its creator the rights of reproduction, communication to the public, adaptation and translation of the work.
- Copyrights in India are governed by “The Copyright Act, 1957”.

• Design

- An industrial design consists of the creation of a shape, configuration or composition of pattern or color, or combination of pattern and color in three-dimensional form containing aesthetic value. ○ Designs in India are governed by “The Designs Act 2000”.

• Plant Variety Protection

- It refers to the protection granted for plant varieties. These rights are given to the farmers and plant breeders to encourage the development of new varieties of plants.
- Plant variety protection in India is governed by “The Protection of Plant Varieties and Farmers’ Rights (PPV&FR) Act, 2001”.

Cell for IPR Promotion and Management (CIPAM)

- It is a professional body under the aegis of Department for Promotion of Industry and Internal Trade (DPIIT) to ensure focused action on issues related to IPRs to ensure effective implementation of the National IPR Policy.
- It assist in simplifying and streamlining of IP processes, apart from undertaking steps for furthering IPR awareness, commercialization and enforcement.
- CIPAM has launched ‘Scheme for IPR Awareness – Creative India; Innovative India’ under the aegis of DPIIT.
 - It aims at raising IPR awareness among students, youth, authors, artists, budding inventors and professionals to inspire them to create, innovate and protect their creations and inventions across India including Tier 1, Tier 2, Tier 3 cities as well as rural areas.

Other steps taken by India for strengthening IPR focused on technology and innovation

- Filing of Patents and Trademarks applications has been made online.
- Almost all IP records have been digitized.
- Automated Electronic modules have been adopted to process Patents and Trademarks applications which enabled achieving enhanced speed, accuracy and transparency.
- IP office has been transformed to enhance efficiency in processing of applications, uniformity and consistency in the examination of applications, bilateral cooperation at the international level, and raising awareness level of public.
- To increase transparency and dissemination of information, the real time status of IP applications and e-registers is now open to the public MSMEs.
- Recently, DPIIT launched the website and mobile application L2Pro India (Learn to Protect, Secure and Maximize Your Innovation) on IPRs.
 - It has been developed by CIPAM-DPIIT in collaboration with Qualcomm and National Law University (NLU), Delhi.
 - It will aid and enable in understanding IPRs for their ownership and protection, integrate IP into business models and obtain value for their R&D efforts.

IPR scenario in India

In order to promote Intellectual Property in India Department of Industrial Policy and Promotion has taken various initiatives to ensure that intangible assets of the country are adequately protected such as:

- **National IPR Policy 2016**
 - An all-encompassing IPR Policy will **promote a holistic and conducive ecosystem to catalyse the full potential of intellectual property** for India's economic growth and socio-cultural development, while protecting public interest.
 - The rationale for the National IPR Policy lies in the **need to create awareness about the importance of IPRs** as a marketable financial asset and economic tool.
 - It is completely compliant with the WTO's agreement on Trade Related aspects of IPRs (TRIPS).
 - **Department for Promotion of Industry and Internal Trade (DPIIT)** will be the nodal agency for all IPR issues and the policy will be renewed every five years in consultation with all the stakeholders.
 - **Seven objectives –**
 - ✓ **IPR Awareness** - To create public awareness about the economic, social and cultural benefits of IPRs among all sections of society.
 - ✓ **Generation of IPRs** - To stimulate the generation of IPRs.
 - ✓ **Legal and Legislative Framework** - To have strong and effective IPR laws, which balance the interests of rights owners with larger public interest.
 - ✓ **Administration and Management** - To modernize and strengthen service oriented IPR administration.
 - ✓ **Commercialization of IPR** - Get value for IPRs through commercialization.
 - ✓ **Enforcement and Adjudication** - To strengthen the enforcement and adjudicatory mechanisms for combating IPR infringements.
 - ✓ **Human Capital Development** - To strengthen and expand human resources, institutions and capacities for teaching, training, research and skill building in IPRs.
 - The policy retains the **provisions on Compulsory Licensing (CL) (in the National Manufacturing Policy and Section 84 of India's Patents Act) as well as Section 3(d) of India's Patents Act (preventing ever-greening of drug patents)** in spite of the EU and US objections terming CL as inconsistent with WTO's TRIPS agreement.
 - It also **suggest incentives such as tax benefits and fee waivers** to encourage R&D and IP creation to strengthen the Make In India/Start-up/Digital India initiatives.
 - To protect 'small inventions' developed especially in the informal / unorganised sectors, policy will **promote 'utility patents'** (with lower compliance burden and shorter period of protection, when compared to the normal patents) only for mechanical innovations.
- **Limitations of IPR Policy 2016**
 - The policy is based on the premise that more IPRs mean more innovation. However, there is **little research that backs this assumption**.
 - **Openness, sharing and access to knowledge have been given back seat** in the policy document.
 - Policy suggests researchers in public funded research organizations to mandatorily convert all research into IP. However, it is best left at the **discretion of the inventor**.
 - **Criminalizing the civil wrong of unauthorized copying** such as movies and literature is prone to misuse.
 - To create an **atmosphere of creativity and innovation**, a holistic approach is required and not just IPR protection.

Challenges in IPR regime in India

- **Lacks effective enforcement**, for which “least priority given to adjudication of IP matters” is often quoted as a reason.
- **No proper funding**: Challenges also lie in having an IP fund, which can be utilized for further developing the IP culture in the country.
- **IPR protection in agriculture** is a sensitive topic in India.
- **Traditional knowledge and products acquired over the centuries** using local know-how, have been kept out the reach of patents

4.1. PATENT POOLS

Why in news?

International science collaborations on Covid-19 started a discussion on patent pooling.

More on news

- Recently, **Costa Rica suggested pooling of rights** to deal with the pandemic through free or minimal, affordable licensing to ensure that the outcomes of efforts can be used by countries with limited economic resources to deal with the problem.
- This proposal received full support, except from the US and the UK.

Patent Pooling

- According to **World Intellectual Property Organisation (WIPO)**, patent pools are defined as an **agreement made between two or more patent holders** for licensing their patents to one another or any third party for the purpose of sharing their intellectual property rights.
- Generally, patents pools are made for complex technologies which **necessitate complementary patents** for providing productive technical solutions such as vaccines in the present Covid-19 crisis.
- **'Sewing Machine Combination" of 1856** is considered as the first modern patent pool in the United States.
- Patent pooling structures were actively discussed and considered in response to the SARS outbreak of 2002-03, the H5N1 influenza outbreak of 2005, and the H1N1 influenza pandemic of 2009.
- **Patent pooling ensures:**
 - **innovation** between companies while minimizing potential legal issues related to the use of other protected concepts.
 - **lower transaction costs and better process efficiencies** as businesses that hold complementary patents can effectively agree not to sue each other for infringement as they work to get new products to the marketplace.

International steps towards patent pooling:

- **C-TAP:** The **COVID-19 Technology Access Pool (C-TAP)(hosted by WHO)** compiles pledges of commitment made under the Solidarity Call to Action to voluntarily share COVID-19 health technology related knowledge, intellectual property and data.
- **GISAID:** It promotes the rapid sharing of data from all influenza viruses and the coronavirus causing COVID-19.
 - This includes genetic sequence and related clinical and epidemiological data associated with human viruses, and geographical as well as species-specific data.
 - **According to Global Initiative to Sharing of All Influenza Data (GISAID)**, as of June 2020, **49,781 genome sequences** of the COVID virus have been shared, voluntarily, by researchers from around the world.
- **Medicines Patent Pool (MPP):** It has facilitated the development of generic drugs for HIV, tuberculosis, and hepatitis C, allowing them to be sold at an affordable price.
 - MPP is a United Nations-backed public health organisation working to increase access and facilitate development of life-saving medicines for low- and middle-income countries.
- **Trade Related Intellectual Property Regime (TRIPS):** It allows countries to grant compulsory licences to companies to produce a patented product at times of emergencies.
- **Nagoya Protocol under Convention on Biodiversity (CBD):** Article 2 (e) of the protocol can be interpreted as **including the genetic sequence information** that forms the basis for all ongoing research and development on Covid treatment and prevention.
 - Protocol requires the contracting parties to provide options for access and benefit sharing when genetic resources are used for commercial purposes, which indirectly provides a scope for patent pooling.

India and Patent Pooling:

- The concept of 'patent pooling' is new in India and has been primarily focused to have solutions for the affordable health care.
- **Indian Patents Act (IPA), 1970** does not render for any provisions related to formation of patent pools or any guidelines for the same but at the same time it neither restrain for creation or formation of patent pools.
- Under IPA, Central Government can set up patent pool by acquiring inventions and patents which are required in the public interest.
- However, in India, patent pooling is viewed as **restrictive practice by Competition Act, 2002**, which are anticompetitive in nature.

5. SPACE

5.1. ISRO

Achievement of Indian Space Sector

- India began investing in Space science and technologies in the 1960s. Indian Space Research Organisation (ISRO), has historically viewed space technology **applications primarily for societal development** and not for addressing strategic or security objectives.
- India's space programme has grown exponentially since its modest beginnings five decades ago and has finally earned its right to be **considered an established space player**.
 - Today, the **value of the global space industry is estimated to be \$350 billion** and is likely to exceed \$550 billion by 2025.
- Despite ISRO's impressive capabilities, **India's share is estimated at \$7 billion** (just 2% of the global market) covering broadband and Direct-to-Home television (accounting for two-thirds of the share), satellite imagery and navigation.
- India's space programme stands out as one of the **most cost-effective in the world**. India has earned worldwide recognition for launching lunar probes, built satellites, ferried foreign satellites up and has even succeeded in reaching Mars.
 - Already, **over a third of transponders used for Indian services are leased from foreign satellites** and this proportion will rise as the demand grows.
- **Various achievements are as follow:**
 - **Telecommunication:** The first area was of satellite communication, with **INSAT and GSAT** as the backbones, to address the **national needs for telecommunication, broadcasting and broadband infrastructure**.
 - ✓ Gradually, bigger satellites have been built carrying a larger array of transponders providing services linked to areas like **telecommunication, telemedicine, television, broadband, radio, disaster management and search and rescue services**.
 - ✓ **GSAT-11**, the heaviest satellite drive the country's Internet Broadband from space

Planned missions by ISRO

- **Gaganyaan project:** It is a crewed orbital spacecraft which is expected to carry three people into the space for seven days.
 - It is expected to be complete before 2022.
 - Recently, Human Space Flight Centre (HSFC) was inaugurated to coordinate Indian Human Spaceflight Programme (HSP) and will be responsible for the implementation of Gaganyaan Project.
- **Aditya-L1:** It will be India's first solar observatory to be launched around 2021 which will be placed at the first Lagrangian point (L1) between the Sun and Earth, where the dynamic gravitational attraction between these two bodies roughly cancel out.
 - It will observe the Sun's surface and atmosphere with its seven instruments.
- **Shukrayaan:** It is a Venus orbiter mission to be launched in 2025 with the objective objectives of studying of Venus' surface and subsurface, its atmospheric chemistry and solar wind interactions with the planet.
 - The atmosphere of Venus **contains a gas that on Earth can be attributed to living organisms**. With this new signs of potential life beyond Earth, many missions to Venus have been proposed.
 - In September 2020, scientists have detected phosphine molecules on Venus, which **could be a biosignature of microbial life**.
 - Scientists also use **Venus as a reference to understand how Earth-sized planets** around other stars evolve and what conditions might exist there.
- **X-ray Polarimetry Satellite (XPoSat):** It will be the country's second space telescope, will be smaller and specialized. It will study the polarization of X-rays emitted by cosmic objects from Earth orbit.
- **Indian Data Relay Satellite System:** India plans for its own space-to-space tracking and communication of its space assets this year by putting up a new satellite series called IDRSS.
 - A set of 2 IDRSS satellites will be placed in geostationary orbit, enabling satellite to satellite communication and transfer of data.
 - It will track, send and receive real-time information from other Indian satellites, in particular those in low-earth orbits (LEO) which have limited coverage of earth.
 - It will also be useful in monitoring launches and benefitting crew members of the Gaganyaan mission ensuring mission control throughout their travel.
- **Chandrayaan-3 in 2021** which will include a rover and a lander to Moon.

- to untouched areas. It is built to provide throughput data rate of 16 gbps.
- ✓ **GSAT 29** is a multi-beam, multiband communication satellite of India which will bridge the digital divide of users including those in Jammu & Kashmir and North Eastern regions of India.
 - **Earth Observatory:** Beginning with the **Indian Remote Sensing (IRS) series** in the 1980s, today the **RISAT, Cartosat and Resourcesat** series provide wide-field and multi-spectral high resolution data for land, ocean and atmospheric observations.
 - ✓ These resources cover **weather forecasting, disaster management, agriculture and watershed, land resource, and forestry managements**. With higher resolution and precise positioning, Geographical Information Systems' applications today cover all aspects of rural and urban development and planning.
 - ✓ **EMISAT** developed by DRDO under Project Kautilya is India's 1st Electronic Intelligence Satellite which will increase the situational awareness of the armed forces by providing the location and information of hostile radars placed at the borders.
 - ✓ Recently, ISRO successfully **launched Cartosat-3 and 13 commercial nanosatellites** into Sun synchronous polar orbit.
 - Cartosat-3 satellite is a third-generation agile advanced satellite having high resolution imaging capability.
 - 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.
 - It also has uses in **Disaster Management Support Programmes** like Cyclone and Floods Mapping & Monitoring, Landslide Mapping & Monitoring, Agricultural Drought, Forest Fire, Earthquakes etc.
 - ✓ **RISAT-2BR1** was also launched recently which is the second radar imaging satellite in the RISAT-2B series and along with the CARTOSAT-3 is part of a group of satellites that will boost India's earth imaging capabilities from space.
 - The satellite will help in agriculture, mining, forestry and coastal management, soil monitoring, disaster management support and round the clock border surveillance.
 - ✓ Recently, India has launched the **Gagan Enabled Mariner's Instrument for Navigation and Information (GEMINI) device**, a satellite-based advisory service for deep-sea fishermen.
 - **Space Observatory: Astrosat** launched in 2015 is India's first dedicated multi wavelength space observatory. It enables the simultaneous multi-wavelength observations of various astronomical objects with a single satellite.
 - **Navigation:** The **GPS-aided GEO augmented navigation (GAGAN)**, a joint project between ISRO and Airports Authority of India, augmented the GPS coverage of the region, improving the accuracy and integrity, primarily for civil aviation applications and better air traffic management over Indian airspace.
 - ✓ This was followed up with the **Indian Regional Navigation Satellite System (IRNSS)**, a system based on seven satellites in geostationary and geosynchronous orbits to provide accurate real time positioning and timing services to users in India as well as region upto 1500 km from its boundary. In 2016, the system was renamed NavIC (Navigation with Indian Constellation).
 - ✓ **NAVIC provides two types of services:** Standard positioning services (meant for all users) & Restricted services (encrypted service). It has applications like Terrestrial, marine navigation, vehicle tracking, precise time mapping etc.

Some of the obstacles faced by ISRO in launching missions

- **Training of astronauts:** India lacks training facilities for astronauts, though ISRO has demanded for indigenous training centers for its astronauts since early 2000s, no action have been taken yet.
- **Large investments** needed in projects
- **Biosciences:** While ISRO has perfected the engineering aspects of the mission, bioscience is a new field for ISRO that requires greater technological knowhow and collaboration and support from other organizations.
- **Upgrading GSLV Mk III:** Gaganyaan needs a large rocket that can lift a heavy capsule. Geo-synchronous Satellite Launch Vehicle (GSLV) Mark III has been designed to inject large satellites into orbit, the launcher will now have to be human rated.
- **Precision in technology:** The reliability of a system has to be as high as to allow a failure rate of only one in 500 launches.



- **Small Satellites:** Globally, 17,000 small satellites are expected to be launched between now and 2030. ISRO is developing a small satellite launch vehicle (SSLV) expected to be ready in 2019. It is a prime candidate, along with the proven PSLV, to be farmed out to the private sector.
 - ✓ ISRO has also launched a **capacity building programme on Nanosatellite development** named UNNATI. It is an initiative to commemorate the 50th anniversary of the first United Nations conference on the exploration and peaceful uses of outer space (**UNISPACE+50**).
- **Space exploration missions:** The most notable of these have been **the Chandrayaan and the Mangalyaan** missions, with a **manned space mission, Gaganyaan**, planned for its first test flight in 2021. These missions are not just for technology demonstration but also for expanding the frontiers of knowledge in space has also started to undertake more ambitious space science and exploration missions sciences.
- **Launch Vehicles:** None of the above missions would have been possible without mastering the launch-vehicle technology. Beginning with the Satellite Launch Vehicle (SLV) and the Augmented Satellite Launch Vehicle (ASLV), ISRO has developed and refined the Polar Satellite Launch Vehicle (PSLV) and GSLV as its workhorse for placing satellites etc.
 - ✓ India's second rocket launch pad is also being setup in **Thoothukudi** district in **Tamil Nadu**. The project will house one launch pad exclusively for **small satellite launch vehicles (SSLV)**.
 - ✓ India presently has one rocket port at **Sriharikota** in **Andhra Pradesh** with **two launch pads**.
 - ✓ India prefers its spaceports as close to the equator as possible and located on the east coast for two reasons:
 - Earth's rotation provides a speed boost to rockets launched and **strength of the boost is higher closer to the equator**.
 - In the **event of a failure, debris from an explosion would fall into the Bay of Bengal** instead of land, potentially saving property and lives.
- **Outreach programmes:**
 - ✓ **Village Resource Centres:** ISRO launched the idea of Village Resource Centres to work in collaboration with local panchayats and NGOs. Expanding this for rural areas is a formidable challenge but has the potential to transform rural India if properly conceived as a part of the India Stack and the Jan Dhan Yojana.
 - ✓ **Young Scientist Programme:** Its ISRO programme for school students which aims to inculcate and nurture space research fervor in young minds.
 - ✓ **Samvad with Students:** ISRO launched a student outreach programme called Samvad with Students where ISRO chairman meets the students during his outstation visits and address their queries and quench the scientific thrust.
 - ✓ **ISRO-Student Collaborations:** ANUSAT (Anna University Satellite), Student Satellite (STUDSAT), YOUTHSAT, SRMSAT, Jugnu etc.

5.1.1. PRIVATE SECTOR IN SPACE ACTIVITIES

Why in News?

Government, under **Aatma Nirbhar Bharat Abhiyaan (Self-Reliant India Mission)**, announced role for **private sector in India's space programme**, including in satellites, launches and space-based services.

More on news

- **Following announcements were made under Aatma Nirbhar Bharat Abhiyaan (Self-Reliant India Mission)**
- **Level playing field provided to private companies** in satellites, launches and space-based services.
- **Predictable policy and regulatory environment** to private players.
- **Private sector will be allowed to use ISRO facilities** and other relevant assets **to improve their capacities**.
- Recently, ISRO **opened up its facilities for private players**, which includes helping a consortium of companies to build **polar satellite launch vehicle**.
- Future projects for **planetary exploration, outer space travel** etc. shall also be **open for private sector**.
- There will be **liberal geo-spatial data policy** for providing remote-sensing data to tech-entrepreneurs.

Benefits of private sector in space activities

- **Increasing Demand for satellites with need to launch** 18-20 satellites every year. With existing ISRO manpower, it is difficult and private sector can play role here meeting global requirements too.

- **Getting latest innovations and trends:** Collaboration with private players is vital for **capacity building, getting cutting-edge technology, latest innovations** etc.
- **Freeing up resources:** A large chunk of ISRO's manpower is involved in manufacturing and launch vehicles, so active involvement of the private sector would allow ISRO to **devote more time to core research, deep-space missions** etc.
- **Reducing dependence on taxpayer's money:** Privatizing activities in space sector will allow economic contribution from private sector and will reduce dependence on funds from government.
- **Job creation:** Creation of new jobs in high-skilled-labour market in **private space industry**.
- **Securing our space capabilities** by distributing them across different satellites and spacecraft, so that business continuity is unaffected even if an adversary manages to disable one or more satellites. This becomes increasingly important with concept of **Space warfare**.
- **Meeting India-centric needs:** Private-sector help is needed to cater rapidly changing technological scenarios and to contribute to digitalization.

Way forward

- **Creating a separate Space Commerce body:** that is independent of ISRO, for space-related activities or a dedicated road map within ISRO for commercial space in India.
- **Promoting startups** as they have potential of leapfrogging product/service offerings out of India and are scalable globally.
- **ISRO providing mentorship** allowing private sector to leverage technical expertise built by ISRO in an appropriate manner.
- **Enactment of space legislations:** To define **regulatory, legal and procedural regimes** with transparent timelines for pursuing space activities by private space industry.
- **Draft Space Activities Bill, 2017** was proposed to **promote and regulate space activities** of India. It talked about **participation of private sector agencies in space activities** in India under guidance and authorization of Department of Space.

Related News

Indian National Space Promotion and Authorization Centre (IN-SPACe)

- Government of India has created **IN-SPACe** to boost private sector participation in entire range of space activities.
- It is the **new entity of the Department of Space** which will have its own chairperson and board.
- It will **regulate and promote building of routine satellites**, rockets and commercial launch services through Indian industry and startups.
- It will **have its own directorates for technical, legal, safety and security**, monitoring and activities promotion.
- It will **act as an interface between ISRO and private parties**, and assess how best to utilise India's space resources and increase space-based activities.
- It will function autonomously and parallel to ISRO.
- It is the **second space organisation** created by the government in the last two years. The first one was **New Space India Limited (NSIL)** after it was announced in 2019 Budget.
 - NSIL is the commercial arm of ISRO with the primary responsibility of enabling Indian industries to take up high technology space related activities.
- **Key Benefits of IN-SPACe:**
 - It will **provide a level playing field for private companies** to use Indian space infrastructure.
 - It will also **hand-hold, promote and guide** the private industries in space activities through **encouraging policies** and a **friendly regulatory environment**.
 - It aims to **empower private companies in creation of launch vehicles and launch pads** with technological input and consultation from ISRO.
 - It will **allow ISRO to allocate more time and resources** for R&D endeavours.
 - It will also **enhance the socio-economic use of space assets and activities**, including through improved access to space assets, data and facilities.

Concerns associated with private sector participation

- Security and strategic concerns as critical and sensitive information may fall into the wrong hands.
- It is a highly risky business involving negative returns and failures. Very few companies may have the appetite to bear the cost of such for failures.

Steps by ISRO:

- ISRO has set up a **Space Technology Park in Bengaluru** where range of facilities has been set up for use by industry.
- In 2018, ISRO had signed a contract with three industries **to build 27 satellites in three years**.
- **New Space India Limited** was founded in 2019, by **Department of Space to bridge gap between ISRO and private sector** and facilitate transfer of ISRO technologies to industry.

- **Establishing Think-tank** constituting **distinguished experts in space field**. It will provide key insights on space programme management, dual-use of technologies, space law, international space agreements, etc.
- **Setting up industry-academia linkups** for creating systemic changes in establishing a leading research environment.

5.1.2. CHANDRAYAAN 2

Why in news?

ISRO launched Chandrayaan-2 mission to the Moon in July 2019, but its lander failed to reach the lunar surface.

About mission

- Chandrayaan-2, a completely indigenous mission, is India's **second lunar exploration mission** which the following basic components-
 - **Orbiter**- will observe the lunar surface and relay communication between Earth and Chandrayaan 2's Lander.
 - **Lander (called Vikram)**- designed to execute India's first soft landing on the lunar surface.
 - **Rover (called Pragyan)**- a 6-wheeled, AI-powered vehicle, which will move on the lunar surface and perform on-site chemical analysis.
- **Launcher**- It was launched by Geosynchronous Satellite Launch Vehicle GSLV MkIII-M1. It is India's most powerful launcher to date, and has been completely designed and fabricated from within the country.
- **Some notable features of Chandrayaan 2 Mission**-
 - 1st space mission to conduct a soft landing on the **Moon's south polar region**.
 - 1st Indian expedition to attempt a soft landing on the lunar surface with home-grown technology.
 - 1st Indian mission to explore the lunar terrain with home-grown technology.
 - 4th country ever to soft land on the lunar surface after the United States, the U.S.S.R. and China.
- **Primary Objective**: To demonstrate the ability to soft-land on the lunar surface and operate a robotic rover on the surface. It seeks to
 - foster a new age of discovery,
 - increase our understanding of space,
 - stimulate the advancement of technology,
 - promote global alliances,
 - inspire a future generation of explorers and scientists.

Chandrayan-1

- Chandrayan-1 was launched by India in October, 2009 using PSLV-C11.
- **Primary Objective**: To prepare a three-dimensional atlas of both near and far side of the moon and chemical, mineralogical and photo-geological mapping of moon.
- **Findings of Chandrayan-1**
 - **Detection of Water** – Major finding was the detection of Water (H₂O) and Hydroxyl (OH) on the surface of the moon. The data revealed its presence in abundance around the polar region.
 - **Magma Ocean Hypothesis** – It confirmed the Ocean Magma Hypothesis i.e. the moon was once completely in molten state.
 - **New Spinel-rich Rock** – Data from Chandrayaan-1 have led to detection of new spinel-rich rock type on lunar far-side.
 - **X-Ray signals detected**– It detected x-ray signals during weak solar flares thus indicating presence of magnesium, aluminium, silicon and calcium on lunar surface.

Mission Payloads

Orbiter payloads-

- Terrain Mapping Camera-2 (TMC-2),
- Chandrayaan-2 Large Area Soft X-ray Spectrometer (CLASS),
- Solar X-ray monitor (XSM),
- Orbiter High Resolution camera (OHRC)
- Dual Frequency L and S band Synthetic Aperture Radar (DFSAR),
- Imaging IR Spectrometer (IIRS),
- Chandrayaan-2 Atmospheric Compositional Explorer 2 (ChACE-2),
- Dual Frequency Radio Science (DFRS) experiment.

Vikram payloads

- Radio Anatomy of Moon Bound Hypersensitive Ionosphere and Atmosphere (RAMBHA),
- Chandra's Surface Thermo-physical Experiment (ChaSTE),
- Instrument for Lunar Seismic Activity (ILSA)

Pragyan payloads

- Alpha Particle Induced X-ray Spectroscopy (APXS),
- Laser induced Breakdown Spectroscopy (LIBS)

Passive Experiment- Laser Retroreflector array (LRA)

Scientific Objectives of Chandrayaan 2

- Moon provides the **best linkage to Earth's early history**.
 - It offers an undisturbed historical record of the inner Solar system environment.
 - Though there are a few mature models, the origin of Moon still needs further explanations.
 - It will conduct detailed topographical studies, comprehensive mineralogical analyses, and a host of other experiments on the lunar surface.
- Evidence for water molecules discovered by Chandrayaan-1, requires further studies on the extent of water molecule distribution on the Moon.
- It will also study new rock types with unique chemical composition.

Why explore the Lunar South Pole?

- The lunar surface area remains in shadow, which is much larger than that at the North Pole. There is a possibility of the **presence of water in permanently shadowed areas around it**.
- In addition, South Pole region has craters that are cold traps and **contain a fossil record of the early Solar System**.
- Its regolith has traces of hydrogen, ammonia, methane, sodium, mercury and silver- making it an **untapped source of essential resources**.
- Its elemental and positional advantages make it a suitable pit stop for **future space exploration**.

Related news

Geotail

- Recently Chandrayaan-2 had detected charged particles in **Moon's soil during the orbiter's passage through the "geotail"**.
- The Sun emits the **solar wind, which is a continuous stream of charged particles** (like electrons, protons, alpha particles etc). These particles are present in the upper atmosphere of the Sun, called the **Corona**.
- Since the Earth has a magnetic field, it **obstructs** this solar wind plasma.
- This interaction results in the formation of a **magnetic envelope** around Earth called **magnetosphere**. (see figure).
- On the Earth side facing the Sun, this magnetosphere is compressed into a region that is approximately three to four times the Earth radius.
- On the opposite side, the envelope is **stretched into a long tail**, which extends beyond the orbit of the Moon. **It is this that is called the geotail**.

Joint Lunar Polar Exploration (LPE) mission

- Recently, details of Joint Lunar Polar Exploration (LPE) mission were released by Japan Aerospace Exploration Agency (JAXA).
- LPE Mission was conceptualized as joint mission between JAXA and Indian Space Research Organisation (ISRO) in 2017 which aims **to put a lander and a rover on the Moon's surface**. It will be launched after 2023.
- The mission would last for about six months and will target a constantly sunlit region near the **Moon's South Pole**.
- JAXA would be building the overall **landing module and rover** and ISRO would develop **lander system**.
- Rover will conduct an observation of the areas where **water may be presently distributed**. If it detects hydrogen, the rover will then mine the surface to collect samples.

Unified Geologic Map of the Moon.

- It is **first ever** digital, unified, global, geological map of the moon shows the moon's geology in incredible detail (1:5,000,000 scale).
- It is developed by USGS in collaboration with **National Aeronautics and Space Administration (NASA) and Lunar Planetary Institute**.
- In this the **entire lunar surface** has been mapped and classified into 43 geologic units, based on characteristics like materials of craters, basins, terra, plains and volcanic units.

5.1.3. MARS EXPLORATION

Why in news?

Indian Space Research Organisation's (ISRO) Mars Orbiter Mission completed six years of orbiting Mars.

Why Mars exploration is done?

- Exploring Mars helps scientists learn about **momentous shifts in climate that can fundamentally alter planets**.
- It lets us look for **biosignatures, signs that might reveal whether life** was abundant in the planet's past—and if it still exists on Mars today.

- Mars is an excellent place to investigate this question because it is the most similar planet to Earth in the Solar System.
- Mars is also the most accessible place in the solar system.
- In the strategic sense, exploring Mars **demonstrates our political and economic leadership as a nation**, improves the quality of life on Earth, helps us learn about our home planet.
- Exploring Mars can provide a means to satisfy our thirst for knowledge and improve our **understanding of ourselves and our place in the universe**.
- It can **facilitate space mining** as many objects around the solar system are made of similar minerals and chemical compounds that exist on Earth. That means that some asteroids, moons, and planets could be rich in minerals and rare elements.

About Mars Orbiter Mission (MOM)

- MOM also called Mangalyaan was the **first interplanetary mission** of ISRO, **launched in 2013 by PSLV-C25** and got inserted into Martian orbit in 2014 in its first attempt.
- Its **scientific objectives** include **exploration of Mars surface features**, morphology, mineralogy and Martian atmosphere by indigenous scientific instruments.
- **Technological objectives** included deep space communication, navigation, mission planning and management.
- Mars Orbiter Mission carried five payloads to accomplish its scientific objectives.
 - Methane Sensor for Mars: It is designed to **measure Methane (CH₄) in the Martian atmosphere** and map its sources.
 - **Mars Color Camera (MCC)**: Tri-color MCC gives images & information about the surface features and composition of Martian surface.
 - **Lyman Alpha Photometer**: It **measures the relative abundance of deuterium and hydrogen** from Lyman-alpha emission in the Martian upper atmosphere. Measurement of D/H (Deuterium to Hydrogen abundance Ratio) helps to understand the **loss process of water from the planet**.
 - **Mars Exospheric Neutral Composition Analyser (MENCA)**: It is a quadruple mass spectrometer capable of analysing the neutral composition in the range of 1 to 300 amu with unit mass resolution.
 - **Thermal Infrared Imaging Spectrometer (TIS)**: It **measures the thermal emission** and can be operated during both day and night. Many minerals and soil types have characteristic spectra in TIR region. TIS can map surface composition and mineralogy of Mars.

How MOM has helped so far?

- Helped prepare a **Martian Atlas** based on the images provided by the orbiter.
- **Phobos and Deimos**, the two moons of Mars, were also imaged from close distances by the Mars Colour Camera.
- It made a finding that **dust storms on the Mars** can rise up to hundreds of kilometres.
- **Albedo map of Mars** has been prepared using MOM will be useful to **study the surface properties of Mars**.
- Albedo is the fraction of solar energy reflected from planetary surface back into space.

Other Mars Mission

- **Hope Spacecraft** is developed by Mohammed Bin Rashid Space Centre (MBRSC), United Arab Emirates (UAE) to explore the Mars planet.
 - It is claimed to be the **first Martian true weather satellite**, launched from Japan, in July 2020.
- **Tianwen-1** is China's first Mars exploration mission.
- **Mars 2020 by NASA**: Under this, NASA's Perseverance rover will seek signs of ancient life and collect rock and soil samples for possible return to Earth.
- **ExoMars Trace Gas Orbiter** by European Space Agency (ESA).
- **Mars Reconnaissance Orbiter** by NASA.

Related News

Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission

- Recently, **NASA's InSight mission** detected quakes and magnetic pulses on the planet Mars.
- InSight is the **first mission** dedicated to looking deep beneath the Martian surface.
- It is embedded with **seismometer** for detecting quakes, **sensors** for gauging wind and air pressure, **magnetometer and heat flow probe** designed to take the planet's temperature.
- The mission has **two objectives**
 - **Formation & Evolution**: Understand the formation and evolution of terrestrial planets through investigation of the interior structure and processes of Mars.
 - **Tectonic Activity**: Determine the present level of tectonic activity and meteorite impact rate on Mars.

What InSight told us so far?

- **At the Surface of Mars**
 - InSight mission is the **first on the surface of Mars to detect magnetic signals** with help of magnetometer.

- It also says most **surface rocks at InSight's location are too young and this magnetism must be coming from ancient rocks underground.**
- There is **variation in magnetic signals by day and night.**
- **Underground**
 - Seismic Experiment for Interior Structure (**SEIS**) has found more than 450 seismic events, the largest quake was about magnitude 4.0, **less strong than earthquakes** detected on Earth, **but a lot stronger than the moonquakes** on Moon.
 - ✓ **SEIS** enables to hear multiple trembling events from hundreds to thousands of miles away.
 - Mars **doesn't have tectonic plates like Earth**, but it does have volcanically active regions, one of this is **Cerberus Fossae**, that can cause rumbles.
 - These seismic waves are affected by the materials they move through, which **provide way to study the composition of the planet's inner structure.**
 - **'Low velocity layer' in the mantle slows down s- waves**, possibly because it is not fully solid.
- **In the wind**
 - The spacecraft's weather sensors have **detected thousands of passing whirlwinds**, which are called **dust devils** when they pick up grit and become visible.
 - SEIS feels these whirlwinds pulling on the surface like a giant vacuum cleaner.
 - These **whirlwinds will help in subsurface seismic exploration** over planet Mars.

5.1.4. DR. VIKRAM SARABHAI

Why in news?

ISRO is planning for a year long programme for commemorating the birth centenary of its founder father Dr. Vikram Sarabhai.

About Dr. Vikram Sarabhai

- Born in Ahmedabad in 1919, Dr. Vikram Sarabhai is considered as the **father of India's space program.**
- He was a great institution builder and established or helped to establish a large number of institutions in diverse fields.
- He was instrumental in establishing the Physical Research Laboratory (PRL) in Ahmedabad in 1947.
- He also founded the **Ahmedabad Textile Industry's Research Association in 1947** and looked after its affairs until 1956.
- After Russia's Sputnik launch, he managed to convince the Indian government on the need for India, a developing country, to have its own space program. For this he **established the Indian National Committee for Space Research** in 1962, which was later, **renamed the Indian Space Research Organization (ISRO).**
- He helped **set up the Thumba Equatorial Rocket Launching Station in Thiruvananthapuram**, with its inaugural flight in 1963. It was later **renamed as the Vikram Sarabhai Space Centre (VSSC).**
- He along with other Ahmedabad-based industrialists played a major role in the creation of the **Indian Institute of Management, Ahmedabad.**
- He had worked on India's first satellite '**Aryabhata**'.
- Some of the other well-known institutions established by Dr. Sarabhai are:
 - Community Science Centre, Ahmedabad
 - Darpan Academy for Performing Arts, Ahmedabad (along with his wife)
 - Space Applications Centre, Ahmedabad (This institution came into existence after merging six institutions/centres established by Sarabhai)
 - Faster Breeder Test Reactor (FBTR), Kalpakkam
 - Variable Energy Cyclotron Project, Calcutta
 - Electronics Corporation of India Limited (ECIL), Hyderabad
 - Uranium Corporation of India Limited (UCIL), Jaduguda, Bihar
- After the death of physicist Homi Bhabha in 1966, Sarabhai was appointed chairman of the Atomic Energy Commission of India. Carrying forward Bhabha's work in the field of nuclear research, Sarabhai was largely responsible for the establishment and development of India's nuclear power plants. He laid the foundations for the indigenous development of nuclear technology for defense purposes.

Awards and honours

- He received the Shanti Swarup Bhatnagar Award in 1962, Padma Bhushan in 1966 and was conferred the Padma Vibhushan posthumously in 1972.

- In 1973, a crater on the moon was named after him.
- Lander of Chandrayaan 2, India's 2nd mission to moon is named 'Vikram' to honour late Dr. Vikram Sarabhai.

5.2. VOYAGER-2

Why in news?

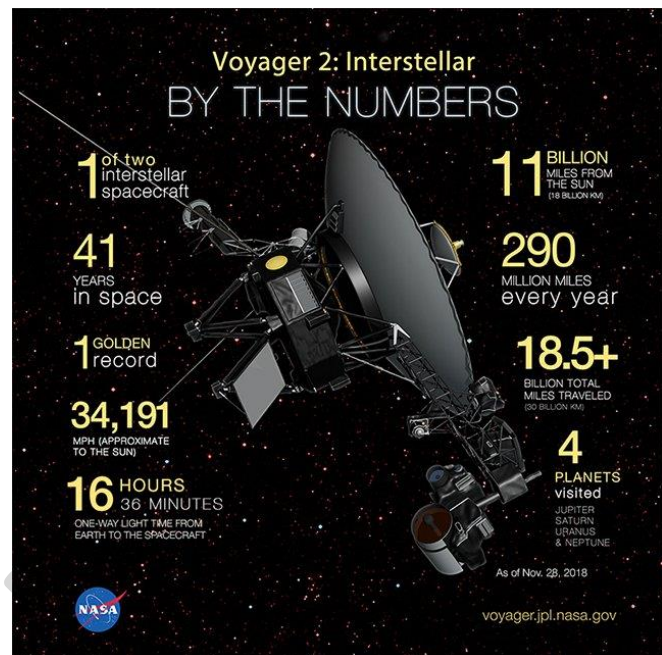
Recently, the NASA fixed a glitch in its Voyager-2 probe.

More on news

- Voyager 2 is now 11.5 billion miles from the Earth and, at that distance, light takes 17 hours to reach it or for messages from it to reach mission control on Earth.
- Given that it takes 17 hours to send information from Earth to the shuttle and another 17 hours to find out if a command did what it was supposed to do, the process can be both tedious and stressful for the engineers.

About Voyager 2

- The two-spacecraft Voyager-1 and Voyager-2 missions, were designed to replace original plans for a "Grand Tour" of the planets that would have used four highly complex spacecraft to explore the five outer planets during the late 1970s.
- Like Voyager 1, Voyager 2 also was designed to find and study the edge of our solar system.
- Voyager **gets its power from a radioisotope thermoelectric generator (RTG)** which turns heat from the decay of a radioactive material into electricity.
 - Because of the way it uses the decay of the material, the power budget for the craft drops by about four watts per year.
- It is the only spacecraft to study all four of the solar system's giant planets- Jupiter, Saturn, Uranus and Neptune at close range.
 - It officially entered '**interstellar space**' in November 2018. It joined its twin—Voyager 1—as the only human-made objects to enter the space between the stars.
 - ✓ This space between the stars, is **dominated by the plasma** that was ejected by the death of nearby giant stars millions of years ago.
 - The sun sends out a constant flow of charged particles called the solar wind, which ultimately travels past all the planets to some three times the distance to Pluto before being impeded by the interstellar medium.
 - This forms a giant bubble around the sun and its planets, known as the **heliosphere**.
- It was the first human-made object to fly past Uranus in 1986 and Neptune in 1989, making it the only spacecraft to have had a close look of the icy planets.



5.3. SPACE DEBRIS

Why in News?

The European Space Agency (ESA) is planning to launch a four-armed robot, Chaser under ClearSpace-1 mission, to clean up Earth's orbit in 2025.

More about News

- Chaser is to be developed by a Swiss start-up **ClearSpace** under ClearSpace-1 mission.
- Once launched into space, it will **grab the chosen piece of space trash, one at a time, using its robotic arms and fall back** towards Earth in a controlled descent.

About Space Debris

- Space debris encompasses **both natural (meteoroid) and artificial (man-made) particles**. Meteoroids are in orbit about the sun, while most artificial debris is in orbit about the Earth. Hence, the latter is more commonly referred to as orbital debris.
- **Earth's orbit is home to more than 3,500 defunct satellites** and an estimated 750,000 smaller fragments, posing a potential danger to the 780-odd satellites operating in the area
- More debris could lead to more collisions - a cascade effect known as the **Kessler syndrome** which may render space eventually inoperable for important services like navigation, communications, weather forecasting etc.

Why Space Debris is a concern?

- **Obstruction to various space endeavours:** Space junk travels at speeds up to 30,000 km an hour, which turns tiny pieces of orbital debris into deadly shrapnel that can damage satellites, space shuttles, space stations and spacecraft with humans aboard.
- **Increase the cost of missions-** Various space agencies have to manoeuvre their space programme in light of increasing space debris thus adding to extra economic and human resource on space programme.
- **Debris is bound to increase-** Space-scientists concern about the inexpensive, tiny satellites called CubeSats, which are going to add space junk around 15% in next 10 years.

Other Similar missions & initiatives for cleaning space debris

- **RemoveDEBRIS mission** is a satellite research project intending to demonstrate various **space debris removal technologies**. The mission is led by the Surrey Space Centre from the University of Surrey. Some technologies are:
 - **Net capture:** It involves a net that will be deployed at the target CubeSat.
 - **Harpoon Capture:** Which will be launched at a target plate made of “representative satellite panel materials”
 - **Vision-based navigation:** Using cameras and LiDAR (light detection and ranging), the platform will send data about the debris back to the ground for processing.
 - **De-orbiting process:** As it enters Earth's atmosphere, the spacecraft will burn up, leaving no debris behind
- Japan earlier launched a cargo ship which will use a 700m long tether **to remove some of the debris from Earth's orbit**. The tether, made of aluminium strands and steel wire, is designed to slow the debris, pulling it out of orbit.
- **Committee on the Peaceful Uses of Outer Space, and Inter-Agency Space Debris Coordination Committee (IADC):** It advocates Global mitigation measures including preventing the creation of new debris, designing satellites to withstand impacts by small debris, and improving operational procedures such as using orbital regimes with less debris, and predicting and avoiding collisions. However, these guidelines are only voluntary in nature and there is no international treaty on space debris currently.
- **European Space Agency- e. Deorbit mission**, which would target an ESA-owned derelict satellite in low orbit, capture it, then safely burn it up in a controlled atmospheric reentry.
- **India:** A team of ISRO and Physical Research Laboratory are working on setting up an observatory to track the space junk.
 - A multi- object tracking radar (MOTR) developed by the Satish Dhawan Space Centre allows ISRO to track 10 objects simultaneously.
 - It tracks India's space assets and space debris, for which India was solely dependent on data provide by the US space agency NASA till early 2016.

5.4. ANNULAR SOLAR ECLIPSE

Why in news?

Recently, the annular solar eclipse and summer solstice occurred on the same day for the first time in 19 years.

About Solar eclipse

A solar eclipse **occurs at New Moon**, when the moon moves

Summer Solstice

- It is the longest day of the year. It **is on June 21st in Northern Hemisphere**.
- According to NASA, the **amount of incoming energy the Earth received from the Sun on this day is 30 per cent higher at the North Pole than at the Equator**.
- Solstices are opposite on either side of the equator, so the summer solstice in the Northern Hemisphere is the winter solstice in the Southern Hemisphere, and vice versa.

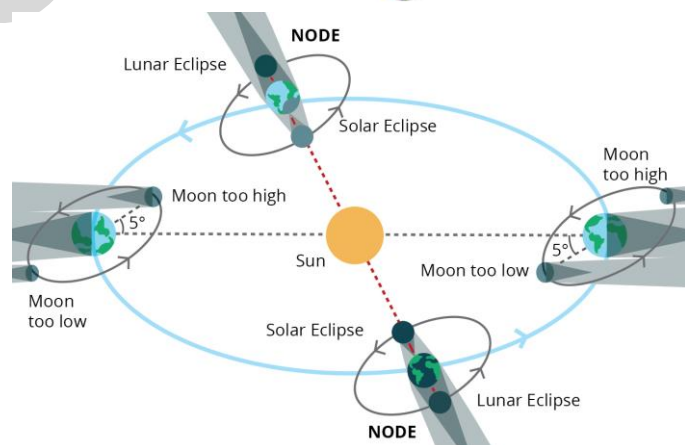
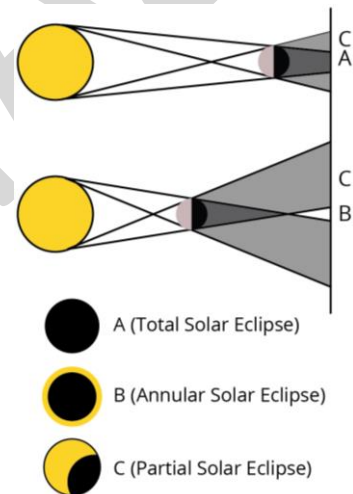
between the Sun and the Earth. Solar eclipses happen once every 18 months. Unlike lunar eclipses, solar eclipses only last for a few minutes.

There are four types of eclipses:

- **Total solar eclipse:** Total solar eclipses are rare at any particular location because totality exists only along a narrow path on the Earth's surface traced by the Moon's **full shadow or umbra**.
 - It happens when:
 - ✓ it is New Moon.
 - ✓ the Moon is near **perigee** (the closest point of the Moon from Earth).
 - ✓ the Moon is at (or very near) a lunar node, so the Earth, the Moon, and the Sun are aligned in a straight (or nearly straight) line.
 - It is visible only from a small area on Earth.
 - People who are able to view the total solar eclipse are in the centre of the moon's shadow as and when it hits the Earth.
- **Partial solar eclipse:** This happens when the sun, moon and Earth are not exactly lined up. The sun appears to have a dark shadow on only a small part of its surface.
- **Annular solar eclipse (ASE):**
 - It occurs when the angular diameter of the Moon falls short of that of the Sun so that it cannot cover up the latter completely.
 - Since the moon does not block the sun completely, it looks like a "dark disk on top of a larger sun-colored disk" forming a "ring of fire" (or **annulus**).
 - For an ASE to take place, three things need to happen-
 - ✓ there should be a **New Moon**
 - ✓ the Moon **should be at or very near a lunar node** so that the Sun, Moon and the Earth all are in a straight line
 - ✓ the Moon **should be near the apogee** (the farthest point of the Moon from Earth) so that the outer edge of the Sun is visible.
 - During one of the phases of the ASE a phenomena called **Bailey's Beads'** are visible. This is a thin fragmented ring caused by passage of sunlight through the rough edge of the Moon.
 - This is the only time when one can find **two shadows** for everything in all the sides under the sunlight because the light source during Annularity is a giant illuminating ring.
 - During an ASE, NASA uses ground and space instruments to view top layer of the sun or **corona** when the sun's glare is blocked by the moon.
 - During partial and annular solar eclipses, it is dangerous to view sun without proper equipment and techniques. Not using proper methods and equipment for viewing can cause permanent eye damage or severe visual loss.
- **Hybrid Eclipse:** This is a very rare eclipse where the eclipse will only be annular for the first few seconds. For the rest it will be a total eclipse.

Lunar nodes

- The Moon's orbit around the Earth is tilted with relation to the Earth's orbital plane by **5 degrees** with two intersecting points – '**Ascending Node**' and '**Descending Node**.'
- Thus, despite the Moon being between the Earth and Sun on every new Moon, the three do not always come on a straight line or cause an eclipse.
- These nodes also rotate around the Earth once in **18 years**.
- In this way, if a new Moon takes place when a node is also between the Earth and Sun, the three come in a straight line and an eclipse takes place.



5.5. HYPERSONIC TECHNOLOGY DEMONSTRATION VEHICLE (HSTDV)

Why in news?

Recently, India successfully tested the hypersonic technology demonstration vehicle.

More on news

- The test was performed by **Defence Research and Development Organisation (DRDO)**.
- The test flight **took off from the APJ Abdul Kalam Launch Complex (at Wheeler Island)**, off the Odisha coast, and, after separating from its launch vehicle at an altitude of 30 km, **flew at Mach 6 for more than 22 seconds**.
 - The launch vehicle used for this flight was the **ISRO's Advanced Technology Vehicle (ATV)**.
- Apart from India, **only three countries** have flown a vehicle at hypersonic speeds in the atmosphere- **Russia, USA and China**.

About HSTDV

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

Mach Number

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

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

Air-breathing engines: How they work?

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

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

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

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

- **Reduces the overall fuel need for satellite missions:** Nearly 70% of the propellant (fuel-oxidiser combination) carried by today's launch vehicles consists of oxidiser. Therefore, using atmospheric oxygen would considerably reduce the overall propellant required to place the satellite in the orbit.

- **Potential for reusing launch vehicles:** Air breathing propulsion systems enable a **powered return cruise flight** for launch vehicles, thus making them reusable. The possibility of reusing the launch vehicle will significantly **reduce the cost of launching the satellites**.
- **Testing of ancillary technologies:** A successful demonstration proved the efficacy of many other critical technologies (apart from the scramjet engine) such as **aerodynamic configuration of hypersonic manoeuvres** and **separation mechanism at hypersonic velocities**.
- **Faster civilian air transportation:** Further development of Scramjet and Dual Mode Ramjet technology could improve the fuel efficiency and peak speeds for civilian transportation.
- **Faster and long range cruise missiles:** The HSTDV is capable of **powering missiles to attain a speed of around Mach 6**. Most cruise missiles fly today at sub-sonic speeds. This renders them vulnerable to interception by the enemy's supersonic fighter jets before they strike their targets. However, a hypersonic cruise missile, flying faster than any fighter, would strike its target well before it can be intercepted.
 - Also, a hypersonic missile is a **"quick reaction missile"** which can be **used to intercept incoming missiles** in the outer atmosphere or in the inner atmosphere.

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6. IT, COMPUTERS & ROBOTICS

6.1. ARTIFICIAL INTELLIGENCE

Why in news?

Government think-tank NITI Aayog has proposed setting up an oversight body for artificial intelligence (AI).

More about News

- According to NITI Aayog's draft '**Working Document: Enforcement Mechanisms for Responsible #AIforAll**', Oversight body will play an enabling role regarding technical, legal, policy and societal aspects of AI.
- Oversight body will have **industry representatives as well as experts from legal, humanities and social science fields.**

About Artificial Intelligence (AI)

- It is **simulation of human intelligence processes** by machines, especially computers.
- It refers to the **ability of machines to perform cognitive tasks** like thinking, perceiving, learning, problem solving and decision making and execute tasks in real time situations without constant supervision.
- Particular applications of **AI includes expert systems, speech recognition and machine vision.**
- It encompasses machine learning, where machines can learn by experience and acquire skills without human involvement.
- **Significance of Artificial Intelligence (AI)**
 - It has the potential to overcome the physical limitations of capital and labour and open up new sources of value and growth.
 - It has the potential to drive growth by enabling
 - **Intelligent automation** i.e. ability to automate complex physical world tasks.
 - **Innovation diffusion** i.e. propelling innovations through the economy.
 - **Role in social development and inclusive growth:** access to quality health facilities, addressing location barriers, providing real-time advisory to farmers and help in increasing productivity, building smart and efficient cities etc.
 - The **exponential growth of data** is constantly feeding AI improvements.
 - AI has varied applications in fields like **Healthcare, Education, Smart Cities, Environment, Agriculture, smart Mobility etc.**
 - **Examples of AI use in India-**
 - ✓ A Statement of Intent has been signed between NITI Aayog and IBM to develop **Precision Agriculture using Artificial Intelligence (AI)** in Aspirational Districts.
 - ✓ **National Payment Corporation of India (NPCI) launched Pai** which is an AI based chatbot, to create awareness around NPCI's products like FASTag, RuPay, UPI, AePS on a real time basis.

Need for regulating Artificial Intelligence (AI)

- **Ethical concerns-** With popularization of a new technology, its virtues are not guaranteed. For instance, the internet made it possible to connect with anyone and get information from anywhere, but also easier for misinformation to spread.
 - There are real concerns about the potential negative consequences of AI, from **deep fakes** to nefarious uses of **facial recognition technology.**
- **Data Management-** as there is lack of clarity on data flow and data ownership which might result into **data colonialism** (data generated by developing countries yet not benefitting them).
 - Further, data collection for feeding AI algorithms has its associated **privacy concerns e.g. mass surveillance.**
 - AI could contribute to the forgery of documents, pictures, audio recordings, videos, and online identities which can and will occur with unprecedented ease.
- **Biasedness:** The algorithms used in artificial intelligence are discrete and, in most cases, trade secrets. They can be biased, for example, in the process of self-learning, they can absorb and adopt the stereotypes that exist in society or which are transferred to them by developers and make decisions based on them.

- **Accountability:** If an AI system fails at its assigned task, someone should be made responsible for it. e.g. an anti-terrorism facial recognition program revoked the driver's license of an innocent man when it confused him for another driver.
 - Similarly, when any AI algorithm takes a decision related to social dimensions, it is crucial is taken on transparent parameters. These AI algorithms can and do make decisions that create significant and serious issues in people's lives.
- **Super-intelligence:** A sufficiently intelligent AI system can redesign itself or can create a better successor system and so on leading to **intelligence explosion**. It is crucial to ensure this super-intelligence will be good to human kind and that will depend upon its technological capabilities and ethicality.

Implementational Challenges of AI in India

- **Lack of awareness:** There still exists a lack of familiarity with high tech machine learning solutions in farms across most parts of the world.
- **Data related issues:** Lack of standards, perceived poor transparency around data use and ownership, and the difficulty of gathering and sharing data has lead to a situation where AI algorithm developers are still starved for data.
- **Lack of Funding:** Obtaining funding for developing AI driven solutions is a challenge that any emerging economy faces in the present day.
- **Lack of enabling infrastructure:** In India, infrastructural pre-requisites for the successful and cohesive implementation of AI driven solutions have not yet been developed.
- **Regulating challenges**
 - **Excessive Regulation-** Since the AI is still in its preliminary stages, some critics believe that, excessively strict regulation is neither necessary nor desirable.
 - **Lack of consensus & Conflict of Interests** - among the countries over the mechanisms and tactics in regulation of AI.
 - **Absence of widespread expertise in AI technologies-** This could lead to policy decisions being taken based on a narrow spectrum of opinions. There are large gaps in data collection, preparation, and benchmarking capabilities.

Way Forward

- International agencies could be guided by the **Asilomar AI Principles** (by Future of Life Institute, a non-profit organization) which are **23 guidelines** for the research and development of AI.
- **Need for a responsible AI-** Resolutions can be brought to regulate Robotics, and code of ethical conducts can be brought for Robotic engineers, as well as Research ethics committees. **Following set of ethical principles** could be adopted like-

Various steps for AI

- **OECD Principles on Artificial Intelligence** - adopted by 42 countries including OECD members and non-members.
- **United States' AI strategy-** has so far been led by corporations such as Google and Microsoft, who are focusing on self-regulation and rapid technological development.
 - **Google-** published their own **AI principles** to help guide ethical development and use of the technology.
 - Also in January, 2020 the US has issued broader set of draft principles for federal agencies' treatment of artificial intelligence.
- **European Union - The Communication on Artificial Intelligence** document which among other issues, outlines the need to have an ethical and legal framework is in place.

Steps taken by India

- **National Strategy for Artificial Intelligence-** NITI Aayog has identified five areas where AI can be useful. It has noted the lack of regulation around AI as a major weakness for India.
- **Center of Excellence in Artificial Intelligence (CoE in AI)** by National Informatics Centre (NIC) which is a platform for innovative new solutions in AI space, a gateway to test and develop solutions for projects undertaken by NIC at central and state level.
- **Global Partnership on Artificial Intelligence (GPAI):** Recently, India joined GPAI as a founding member.
 - GPAI is multi-stakeholder international partnership to promote responsible and human centric development and use of AI, grounded in human rights, inclusion, diversity, innovation, and economic growth.

Asilomar AI principles



- Research goal
- Research funding
- Science-policy link
- Research culture
- Race avoidance



- Safety
- Failure transparent
- Judicial transparency
- Responsibility
- Value alignment
- Human values
- Personal privacy
- Liberty and privacy
- Shared benefit
- Shared prosperity
- Human control
- Non-subversion
- AI arms race



- Capability caution
- Importance
- Risks
- Recursive self-improvement common good

- Minimize Biasedness and arrest inequalities and discrimination arising out of it
- Robots should act in the best interests of humans.
- Human interactions with robots should be voluntary.
- Ensuring equitable benefits to all
- AI systems should be **made legally liable** for their actions through making their programmers and users accountable.
- Regulation must be **continuous** and adapt with evolution of technology.
- There is need to **find country specific** data, trained workforce, fine-tuned algorithms and technology suited to local needs.

6.2. BLOCKCHAIN TECHNOLOGY

Why in news?

National Informatics Centre (NIC) has set up the **Centre of Excellence (CoE) in Blockchain Technology** in Bengaluru, Karnataka.

More on news

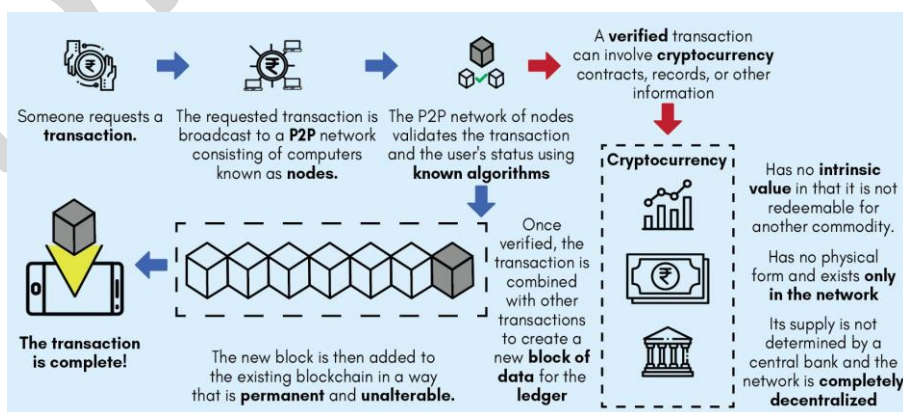
- It aims to provide Blockchain as a service and allowing all stakeholders to benefit from shared learning, experiences and resources.
- It will **facilitate the Government Departments** in building proof of concepts for use of Blockchain technology in different dimensions of governance leading to large scale deployment of some such applications.
- New and previously unforeseen applications of Blockchain in the Government are expected to **enhance transparency, traceability and trust in e-governance systems.**

About Blockchain technology

- A blockchain is a **specific type of data structure which can be used to transact across nodes or participants.** The ownership rights are recorded in **cryptographically** stored and **linked blocks** which contain records of ownership of assets among the participants that can remain anonymous.
- Blockchains are **open, distributed ledger that can chronologically record transactions between two parties** efficiently in near real time.
- The prerequisite for each subsequent transaction to be added to the ledger is the respective consensus of the network participants (called nodes), thereby creating a continuous mechanism of control regarding manipulation, errors, and data quality.
- The blockchain technology generally has **key characteristics of decentralization, persistency, anonymity and auditability.** With these traits, blockchain can greatly save the cost and improve the efficiency.

Applications of Blockchain

- **Banking & Capital Market-** For efficient banking operations and efficiently using the KYC procedures offered by this technology. For instance-
 - **SBI** leads as the first bank to use KYC and facilitate remittances based on blockchain.
 - **Cross border remittances** can be made faster and less costly.
 - **Trade Settlement-** Faster transfer of securities and payments and reduced trading cost by removing intermediaries
- **Cybersecurity-** Sensitive data moved to the blockchain can effectively manage access by minimizing the risk of leaks to hackers. For instance-
 - The Block Armour solution is the company which ring-fences an organization’s critical resources, securely providing access to authorized users and devices.



- **Healthcare and pharmaceuticals**- It involves a lot of **sensitive clinical data** which demands a secure and reliable system. For instance- Blockchain-enabled mobile platform “**HealthPro**” to connect hospitals, insurance companies and host medical records of patients.
- **Agriculture**- The food supply chain is one characterized by asymmetry of information. The complex network comprises farmers, brokers, distributors, processors, retailers, regulators and consumers.
 - Improved data sharing will result in stakeholders getting their dues (particularly poor farmers with small land holdings) and consumers having control on food quality.
- **Telecom**- to eliminate spam calls and financial fraud by unregistered telecom marketers and open up new revenue streams for the telecom companies etc.
- **Governance**- Digital identities, maintaining digital certificates of citizens, monitoring welfare programs, tracking of health records of all citizens, cybersecurity of critical infrastructure etc are some of the key applications of Blockchain technology
 - E.g. Andhra Pradesh has piloted two projects on **managing land records** and streamlining **vehicle registrations**. West Bengal has implemented Blockchain based issuance of Birth certificates to newborn.

Challenges in Adoption of Blockchain Technology

- **Lack of Scalability** can put a strain on the adoption process, especially for public blockchains. The processing speed is way less than the traditional transaction networks.
- **Lack of interoperability**: Most of the blockchains present in the market **work in silos**. With so many different networks and approaches, the blockchain space is in a state of confusion with **no clear approach** and **a lack of standards** do not allow different networks to communicate with each other.
- **Data Portability**- As with other record keeping systems, once data is logged in one system, transferring that data to a new system may be problematic.
- **Regulation**- Some technologies like the permissionless Bitcoin Blockchain **bypass regulation completely** to tackle inefficiencies in conventional intermediated payment networks. India is **yet to implement clearly defined regulations** on blockchain technology.
- **Lack of awareness, high cost** and **limited availability of skilled workforce** is also a major impediment in the development of blockchain technology.
- **51% attack**: It is a potential attack on a blockchain network, where a single entity or organization is able to control the majority of the hash rate, potentially causing a network disruption.

Government Steps

- Ministry of Electronics and Information Technology (MeitY) has supported a multi institutional project titled **Distributed Centre of Excellence in Blockchain Technology** with C-DAC, IDRBT and VJTI as executing agencies. **Objectives of this initiative are**
 - Evolving an ecosystem around R&D organizations, Government departments and Academia to foster Blockchain technology
 - Design, development and pilot deployment / prototyping of Blockchain based applications in the domains of Governance, Banking & Finance and Cyber Security
 - Conduct research to address the issues and challenges related to Blockchain usage in identified application domains
- Ministry of Skill Development and Entrepreneurship (MSDE) in partnership with NASSCOM has launched **FutureSkills platform**. It focuses on 10 emerging technologies including Blockchain, Artificial Intelligence, etc.
- **Department of Science and Technology** has launched **National Mission on Interdisciplinary Cyber Physical Systems (NM-ICPS)**. It has a roadmap to develop Blockchain, AI, Internet of Things, Big Data Analytics, Robotics etc.

Conclusion

Although blockchain is in its infancy, India is pacing towards its adoption and inclusion. Implementing this technology across all spheres of business will certainly prove to be a game-changer despite the roadblocks in its adoption.

Related News
Blockchain Bill of Rights

- **World Economic Forum** Global Blockchain Council launched Presidio Principles: the foundational values for a decentralized future which is also called as **Blockchain Bill of Rights**.
- It aims to **establish a global baseline for developers, corporates and governments** building blockchain applications.
- It will help in creating “the foundational values for a decentralized future” which will help unlock the potential of a technology that is poised to massively transform multiple sectors.
- It contains sixteen principles which **aim to protect users and preserve the values of the technology** so that all can benefit.
- **16 principles have been set out in four categories:**
 - Transparency & Accessibility
 - Agency & interoperability
 - Privacy & security
 - Accountability & governance

Need for the principles

- **Risks to users:** Blockchain’s properties as a foundational technology make the considerations on data protection particularly important, given the harm and follow-on effects that can come from potential breaches.
- **Potential for transformational change can be undermined:** Those with sophisticated knowledge may have the opportunity to exploit their advantages – whether to intentionally harm consumers or to suppress the market through anti-competitive actions.
- **Financial sector:** Most of the banks and financial institutions are exploring blockchain technology such as Central Banks Digital Currency project, which brought together 45 central banks to explore parameters for the successful deployment of a CBDC. These rights will help in alleviating the effects of frauds.

6.3. CRYPTOCURRENCIES

Why in News?

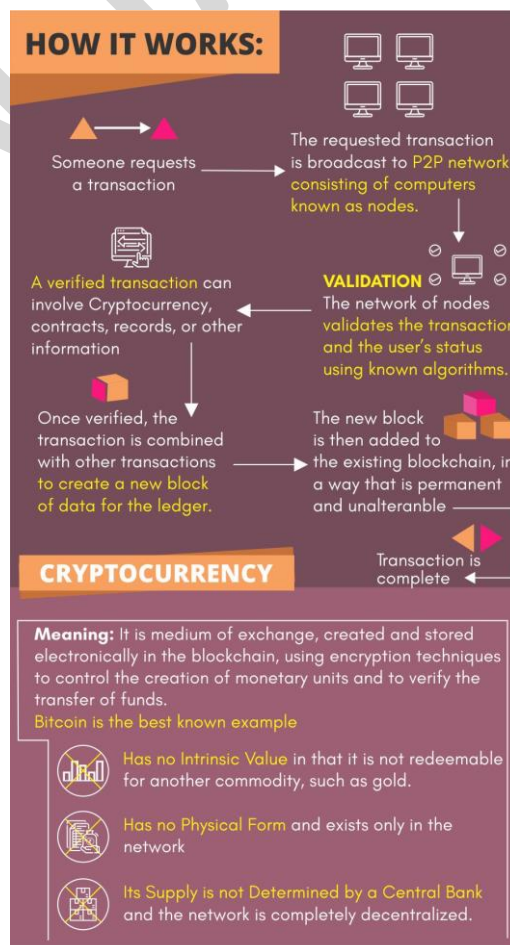
Recently, Supreme Court has set aside an RBI’s April 2018 circular banning regulated financial institutions such as Banks and NBFCs from trading in virtual currency/cryptocurrency.

What is Cryptocurrency?

- Cryptocurrency is a **type of digital currency that uses cryptography** for security and anticounterfeiting measures.
- It is normally **not issued by any central authority**, making it **immune to government interference** or manipulation.
- The control of each cryptocurrency works through distributed ledger technology called **blockchain**.
- **Examples** include Bitcoin, Ethereum, Ripple etc.
- **Various benefits of cryptocurrencies include:**
 - **Difficult to counterfeit** as compared to physical currency.
 - **There aren’t usually transaction fees** for cryptocurrency exchanges because the miners are compensated by the network.
 - **Benefits for customers:** The rise of cryptocurrencies offers ordinary people the rare opportunity to choose among multiple currencies in the marketplace.
 - Blockchain technology can be used for **enhancing the efficiency of the financial system**.

Arguments for banning of cryptocurrencies by RBI

- **Financial stability:** Lack of any underlying fiat and excessive volatility in their value was seen as an immediate threat to financial stability. Its far-reaching **potential impact on the effectiveness of monetary policy itself was unknown**.
- **Investor protection and security risks:** There were risks and concerns about **data security, consumer protection** and their use for speculation.



- Theft of cryptocurrencies from exchanges soared in the first half of this year to three times the level seen for the whole of 2017.
- **Use in illegal activities:** Concerns were raised that anonymous nature and lack of a central regulator in cryptocurrency transactions can lead to funding of a host of illegal activities such as child pornography, drug dealing, gun supplies etc.
- Their **anonymous nature** goes against global money-laundering rules.
- **International examples:** Countries like China have also unleashed a regulatory crackdown.

Why ban was Challenged?

- Virtual Currencies are **not legal tender but tradeable commodities and therefore that they fell outside the RBI’s regulatory ambit.**
- Even assuming VCs were amenable to regulation by the RBI, **RBI’s directive violates the freedom of business, trade and profession under Article 19(1)(g).**
- Petitioner had argued that trading in cryptocurrencies in the absence of a law banning those was a “legitimate” business activity under the Constitution and RBI could not have denied them access to banking channels to carry on such business.

Supreme Court Observation

- Supreme Court held that **Virtual Currencies eluded precise definition so ban did not pass the “proportionality” test** and lifted the curbs imposed by the RBI on regulated entities.
- Doctrine of Proportionality postulates that the nature and extent of the State’s interference with the exercise of a right must be proportionate to the goal it seeks to achieve.
- Also, bench noted that the rules governing the matter would depend on what Parliament decides, based on the currently pending draft **Banning of Cryptocurrency and Regulation of Official Digital Currency Bill, 2019.**
- It added that the RBI and the central government would have a monopoly on the creation and circulation of any official digital currency whenever such a situation arose.
- The bench, however, said that virtual currencies are neither good nor commodities and can’t be regarded as real money.
- Once virtual currencies are accepted as valid payments for the purchase of goods and services, the activity falls squarely within the RBI’s purview.

6.4. BIG DATA

Why in News?

Recently IIT-Delhi researchers used Big Data to detect diseases and automate pathology process.

About Big Data

- Big data is a **term applied to data sets whose size or type is beyond the ability of traditional relational databases** to capture, manage and process the data with low latency.
- Big data analytics is the **use of advanced analytic techniques against very large, diverse data sets that include structured, semi-structured and unstructured data**, from different sources, and in different sizes from terabytes to zettabytes.
- **Potential of Big Data**
 - Global Big Data market is growing rapidly and is expected to reach \$118.52 billion by 2022.
 - Analytics, data science and big data industry in India is currently estimated to be Rs 17,615 crore annually (FY18) in revenues, growing at a healthy rate of 33.5% CAGR. It is estimated to become a Rs 1,30,000 crore industry in India by 2025.
 - This is largely because of the emergence of new technologies and jobs getting repositioned in the IT sector because of it.



Benefits of Big Data

- **Improves decision making:** Big data allows businesses to analyze information immediately. Instead of focusing only on profit and loss, it integrates a wide range of insights, taking into account each and every factor that could possibly influence the business.
- **Protects company and client information:** Since big data can immediately detect irregularities in any business network, it can help evade cybercrimes and enhance the overall security of the network.
- **Enables effective marketing:** Big data keeps us informed about marketing trends and it also ensures that right marketing method is picked up which is best suited to needs and objectives. It helps providing businesses with better insights about their clients.
- **Facilitates cost and time reduction:** Big data helps cut down costs by streamlining processes and improving operational efficiency. It can be used to identify trends, patterns, and probabilities in incurring costs.
- **Better product designing:** With better information and analysis of the data, it helps to design products in a better way.

Applications of Big Data in various sectors

- **Banking:** With large amounts of information streaming in from countless sources, banks are faced with finding new and innovative ways to manage big data. Big data brings big insights, but it also requires financial institutions to stay one step ahead of the game with advanced analytics.
- **Education:** By analyzing big data, educators can identify at-risk students, make sure students are making adequate progress, and can implement a better system for evaluation and support of teachers and principals.
- **Government:** When government agencies are able to harness and apply analytics to their big data, they gain significant ground when it comes to managing utilities, running agencies, dealing with traffic congestion or preventing crime.
- **Health Care:** When big data is managed effectively, health care providers can uncover hidden insights that improve patient care.
- **Manufacturing:** Big data can provide, manufacturers can boost quality and output while minimizing waste – processes that are key in today's highly competitive market.
- **Agriculture:** Sensor data to optimise crop efficiency can be used. This is used to measure how plants react to changes in various conditions by planting test crops and running simulations.

Initiatives in India

- NITI Aayog is planning to develop **National Data and Analytics Platform** in collaboration with private tech players.
- Government of India is also working towards an **Open Data Policy**, to encourage sharing information between departments and across ministries.
- **National Data Sharing and Accessibility Policy (NDSAP), 2012** aims to provide an enabling provision and platform for proactive and open access to the data generated by various Government of India entities.
- Government launched a project called **Project insight in 2017**, to catch tax evaders. The project leveraged data mining techniques and analysed the data to achieve its objective of a corruption-free country.

Challenges

- **Lack of data Scientists:** India reportedly has fewer than 10% of data scientists available globally while the US has over 40% skilled professionals in the big data and analytics domain.
- **Privacy issue:** Privacy has become a big concern when it comes to the use of customer data. Big Data analytics have the potential to reveal sensitive personal information by uncovering hidden connections between pieces of data that seems unrelated.
- **Security issues due to outsourcing:** Outsourcing of data analysis only increases the security risks as information like customers' earnings, mortgages, savings and insurance policies are required to be shared for the purpose.
- **Availability of quality data:** One of the major challenges in the sector to enable the use of Big Data is the availability of quality data. Most of the data in the development sector is yet to be digitised.
- **Ethics of big data:** It comes into role as huge amount of private data is available and how and where it should be put to use raises the question.
- **Need for synchronization across data sources:** As data sets become more diverse, there is a need to incorporate them into an analytical platform. If this is ignored, it can create gaps and lead to wrong insights and messages.

Way Forward

- **Wider acceptance of Big data:** All the departments in government as well as private sector should be aware about the use of big data.
- **Cyber security:** Policies should be drawn to strengthen the cyber security framework for making the data safe.
- **Privacy:** Data Management should address the ethical issues regarding big data analytics and formulate a policy regarding data privacy. Guidelines formulated by Justice BN Srikrishna committee on data protection can be followed in this regard.
- **Increase R&D and funding to master technologies:** Research and other institution need to develop R&D to learn about all the important technologies in order to better utilize the applications of big data.
- **Establish data centers:** Government needs to set up data center for effective collection, segregation and analyzing.
- **Training:** Data scientists needs to be trained to learn on handling the big data.

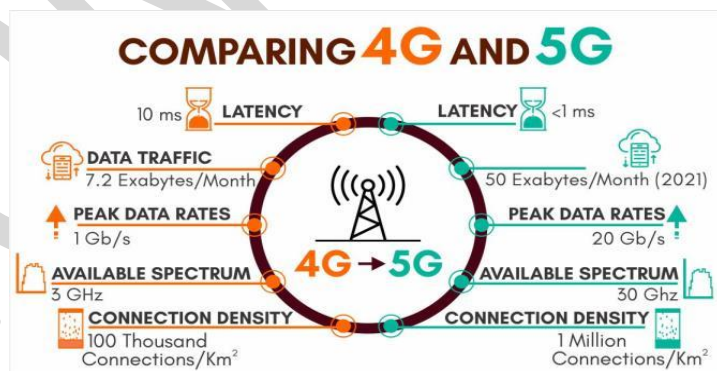
6.5. 5G TECHNOLOGY

Why in news?

Recently, Reliance Jio announced Made in India 5G network, the first time an Indian company is venturing into mobile technology.

What is 5G Technology and how it works?

- 5G is a next generation mobile network technology after 4G LTE networks.
- It promises to provide **seamless coverage, high data rate, ultra-low latency** and as a result **highly reliable communications**.
- 5G technology is **not a single technology** but an **amalgamation of various technologies** which make the aforesaid performance possible. Following are the major technologies used in 5G:
 - mmWave (millimetre Wave)
 - Massive multi-user MIMO (Multiple input multiple output)
 - Small Cell stations
 - Mobile Edge Computing (MEC)
- A recent 5G Economy study has estimated that by the year 2035 5G technology will **generate \$13.2 Trillion dollars of global economic output** by supporting a wide range of industries.



Advantages of 5G

- **High speed use cases:** 5G will help speed up a range of applications such as enhanced consumer experience via high quality streaming, faster storage and access of cloud by businesses, better communication between public institutions and citizens.
- **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.
- **Massive Internet of Things (IoT):** 5G is meant to seamlessly connection which is easily showcased in areas like Smart City Infrastructure and Traffic Management, Industrial Automation, Wearables and Mobile devices, Precision agriculture etc.
- **Various fields:**
 - **In agriculture,** 5G can enable improvement in the entire value-chain, from precision farming, smart irrigation, improved soil and crop monitoring, to livestock management.
 - **In manufacturing,** 5G will enable use of robotics for precision manufacturing, particularly where humans cannot perform these functions safely or accurately.
 - **In the energy sector,** 'smart grids' and 'smart metering' can be efficiently supported. With the rise of renewable and storage technologies, low latency communications will be critical to manage these grids.

- In health-care, 5G can enable more effective tele-medicine delivery, tele-control of surgical robotics and wireless monitoring of vital statistics.

Challenges

- **Huge Investment Required:** India needs a massive Rs 5 lakh crore (\$70 billion) investment to bring in 5G.
- **Expensive spectrum:** Indian spectrum prices are some of the highest in the world and the allocated quantity is well below global best practices, while 40% of the spectrum is lying unsold.
- **Lack of uniform policy framework:** Delays due to complex procedures across states, non-uniformity of levies along with administrative approvals have impacted telecom service providers in rolling-out Optical Fibre Cables (OFC) and telecom towers.
- **Debt scenario in the industry:** According to ICRA, the collective debt of telecommunications service providers (TSPs) stands at Rs 4.2 lakh crore.
- **Low optical fibre penetration:** India lacks a strong backhaul to transition to 5G. Backhaul is a network that connects cell sites to central exchange. As of now 80% of cell sites are connected through microwave backhaul, while under 20% sites are connected through fibre.
- **High Import of Equipment's:** Imports account for a 90 per cent of India's telecom equipment market. However due to lack of local manufacturing and R&D, Indian telecom providers have no option other than to procure and deploy 5G technologies from foreign suppliers.
- **Security:** According to the Global Cyber Security Index released by the International Telecommunication Union (ITU), only about half of all the countries had a cybersecurity strategy or are in the process of developing one. The index, which was topped by Singapore at 0.925 saw India at 23rd position.

Huawei Case: 5G Technology and Global Geopolitics

- Recently, US formally designated **Huawei Technologies Company and ZTE Corporation**, leading companies in 5G technology research, as “**national security threats**”. (Huawei Technologies is a Chinese multinational company which designs, develops, and sells telecommunications equipment and consumer electronics.)
- There is an apprehension that Huawei Technologies may provide an inner system to enable **surveillance and cyber-espionage for China**.
- The **Confederation of All India Traders (CAIT)** have asked to **ban Chinese companies Huawei and ZTE** from participating in 5G network roll-out in the country. It also urged that technology and equipment of both companies should be banned from use in 5G network rollout by any company.
- In the context of strained India-China ties, government has been **citing security and strategy related issues** and thus indicating towards exclusion of these firms from the 5G roll-out in India.

Way Forward

- **Technology and Infrastructure provisions:**
 - **Core Technology and Manufacturing:** Building India's capacity in core technology development (Design and IP) and manufacturing for 5G and more broadly for all Information Technologies needs a deep and long-term effort.
 - **Securing data center and cloud components** becomes critical as mobile network components are virtualized and potentially deployed on virtualized software infrastructure. To cover these unique software related risks, network providers will need to collaborate with cyber security firms to **develop solutions for encryption, network monitoring, and more.**

Steps already taken by Government to kick-start 5G

- **5G High Level Forum** was set up by the Government in 2017 to **articulate the Vision for 5G in India** and to recommend policy initiatives and action plans to realize this vision.
 - It aims to achieve a globally-competitive product development and manufacturing ecosystem targeting 50% of India's market and 10% of global market over 5-7 years.
- To improve **testing capabilities:**
 - The Government has launched a program titled '**Building an End-to-End 5G Test Bed**'. The programme envisages close collaboration between the universities and startups and create an ecosystem that closely resembles a real-world 5G deployment.
 - The Department of Telecommunications (DoT) has simplified the testing method by making the **spectrum available for demonstration purposes**.
- **National Digital Communication Policy-2018 (NDCP-2018)** also lays out the following objectives with respect to 5G services in India:
 - **Enabling Hi-speed internet, Internet of Things and M2M (Machine to machine)** by rollout of several 5G technologies.
 - **Enhancing the backhaul capacity** to support the development of next generation networks.

- **Privacy provisions:**
 - **Creating a strong data protection policy and law** to provide a legal framework which supports adoption of 5G technology.
 - **Data prioritization:** Mobile operators need to adopt a hybrid cloud-based approach where sensitive data is stored locally and less sensitive data stored in the cloud.
- **Security provisions:**
 - **Providing End-to-end security solutions:** 5G Security must address multiple end-to-end operations such as IoT and devices, security operations, etc.
 - **Centralized reporting to build trust:** This could be done by integrating 5G security systems with centralized reporting (integration) thus improving overall accountability of the system.
 - **National Cyber Security Strategy (NCSS) of India: Government is planning to rollout NCSS** by upgrading **National Cyber Security Policy, 2013**. The policy could incorporate the cybersecurity issues faced by 5G technology, providing it a legal framework from security perspective.
- **Policy provisions:**
 - **Spectrum Policy:** 5G spectrum can be allocated in multiple phases based on readiness of the various bands appropriately divided between wireless access, backhaul access and WiFi access.
 - **Participation in International Standards:** Telecom networks need standards to ensure interoperability and to avoid market fragmentation. Getting active in **global standards development eco-system** will open up a new realm of opportunities for India.

Conclusion

5G technology presents India with an opportunity to become a leader in one of the omnipresent technologies of the future. India must embrace this opportunity by deploying 5G networks early, efficiently, and pervasively. Though there are several challenges from domestic deficiencies to geopolitical quagmires. But, India has often leapfrogged the curve in adoption of the latest telecommunications technologies like 4G in the past. Amid the rising connectivity demands during COVID-19, the time is ripe to make rapid strides towards 5G deployment.

6.6. QUANTUM COMPUTING

Why in News?

Recent paper from Google's quantum computing lab announced that the company had achieved quantum supremacy.

More in News

- **Quantum supremacy means** 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.
- Google's quantum computer, **named Sycamore**, claimed 'supremacy' because it reportedly did the task in 200 seconds that would have apparently taken a supercomputer 10,000 years to complete.

Related News

Quantum Key Distribution

- Recently, a **satellite-based communication between two ground stations** was activated by entangled-based quantum key distribution (QKD).
 - The communication between two stations more than 1,120 kilometers apart was activated by QKD.
 - This was achieved by **Micius** (also known as the Quantum Experiments at Space Scale), **World's first quantum-enabled satellite**. Micius was launched by China in 2016.
- QKD is a technique that **allows for secure distribution of keys to be used** for encrypting and decrypting messages.
- In **traditional cryptography**, the security is usually based on the fact that an adversary is unable to solve a certain mathematical problem.
- In QKD, security is achieved through the **laws of quantum physics**.
- Two such most important laws are **Superposition and Entanglement**.
 - **Superposition** means that each **quantum bit** (basic unit of information in a quantum computer) can represent both a 1 and a 0 at the same time.
 - In **quantum entanglement**, subatomic particles become "entangled" (linked) in such a way that any change in one disturbs the other even if both are at opposite ends of the universe.
- Quantum Satellite serves **as source of pairs of entangled photons, twinned light particles** whose properties remain intertwined no matter how far apart they are.



About Quantum Technology

- Quantum technology seeks to **harness laws of quantum physics**, which describe the behaviour of matter and energy at the atomic and subatomic level.
- **This is unlike classical physics**, in which an object can exist in one place at one time. E.g. classical computers operate using binary physical state, meaning its operations are based on one of two positions (1 or 0).
- Quantum principles will be used for **engineering solutions to extremely complex problems** in computing, communications, sensing, chemistry, cryptography, imaging and mechanics.
- **Some applications of Quantum Technology are:**
- **Quantum Computing** with potential applications in precise navigation for defence and civilian applications, accelerated drug development by accurate chemical simulations etc.
- **Quantum metrology** to provide more capable means of detecting stealth aircraft, submarines and also mineral exploration and water resource management etc.

What is quantum computing?

- Quantum computing is the area of study **focused on developing computer technology based on the principles of quantum theory**, which explains the nature and behaviour of energy and matter on the quantum (atomic and subatomic) level.
- Quantum Computers encode information **as quantum bits, or qubits**, which can exist in superposition.
- Qubits represent atoms, ions, photons or electrons and their respective control devices that are working together to act as computer memory and a processor.
- Because a quantum computer can contain these multiple states simultaneously, it has the potential to be millions of times more powerful than today's most powerful supercomputers
- **Application:**
 - Quantum computers could spur the development of new breakthroughs in science,
 - medications to save lives,
 - machine learning methods to diagnose illnesses sooner,
 - materials to make more efficient devices and structures,
 - financial strategies to live well in retirement,
 - algorithms to quickly direct resources such as ambulances.
- There are **no quantum computers in India** yet.
 - In 2018, the Department of Science & Technology unveiled a programme called **Quantum-Enabled Science & Technology (QuST)** to accelerate research on Quantum computing.

Quantum computers vs classical computer

- **Classical computers process information in a binary format, called bits**, which can represent either a 0 or 1. **Quantum computers, in contrast, use logical units called quantum bits**, or qubits for short, that can be put into a quantum state where they can simultaneously represent both 0 and 1 and their correlations.
- While the **bits in a classical computer all operate independently from one another**, in a **quantum computer, the status of one qubit effects the status of all the other qubits** in the system, so they can all work together to achieve a solution.

6.7. EDGE COMPUTING

Why in news?

According to a research, by 2025 companies will generate and process more than 75% of their data outside of traditional centralised data centres — that is, at the “edge” of the cloud.

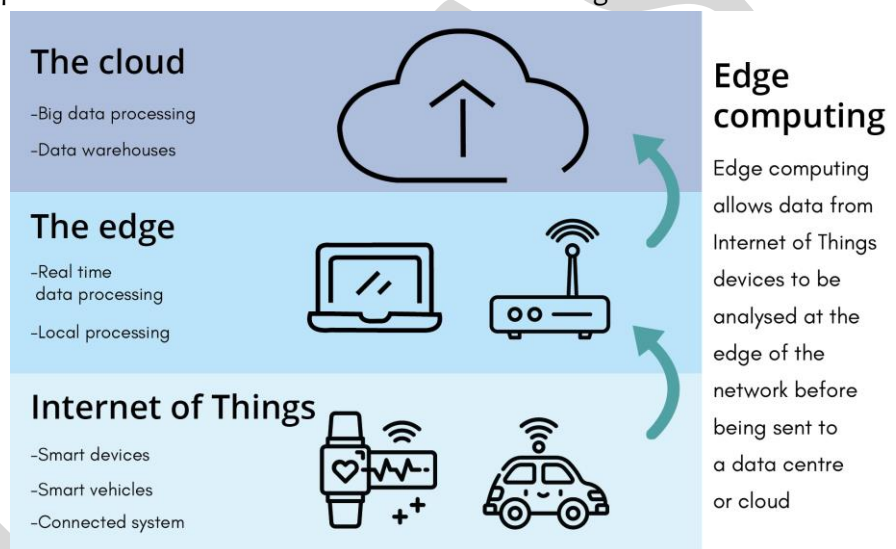
What is Edge computing?

- Edge computing **enables data to be analysed, processed, and transferred at the edge of a network**. Meaning, **the data is analysed locally**, closer to where it is stored, in real-time without latency.
- **How it differs from cloud computing?**
 - The basic difference between edge computing and cloud computing lies in where the data processing takes place.

- In simple terms, cloud computing means storing and accessing data and programs over the Internet instead of your computer's hard drive.
- Currently, the existing Internet of Things (IoT) systems perform all of their computations in the **cloud using data centres**.
- Edge computing, on the other hand, manages the massive amounts of data generated by IoT devices by **storing and processing data locally**.

Benefits of edge computing

- **Speed:** The most important benefit of edge computing is its ability to increase network performance by reducing latency (ability to process very high volumes of data with minimal delay). It allows for quicker data processing and content delivery.
- **Security:**
 - **Centralized cloud computing** architecture is vulnerable to distributed denial of service (DDoS) attacks and power outages.
 - **Edge computing distributes** processing, storage, and applications across a wide range of devices and data centers, which makes it difficult for any single disruption to take down the network.
 - Since more data is being processed on local devices rather than transmitting it back to a central data center, edge computing also reduces the amount of data actually at risk at any one time.
- **Scalability:**
 - Expanding data collection and analysis no longer requires companies to establish centralized, private data centers, which can be expensive to build, maintain, and replace when it's time to grow again.
 - Edge computing offers a far less expensive route to scalability, allowing companies to expand their computing capacity through a combination of IoT devices and edge data centers.
- **Versatility:** The scalability of edge computing also makes it incredibly versatile. By partnering with local edge data centers, companies can easily target desirable markets without having to invest in expensive infrastructure expansion.
- **Reliability:** With IoT edge computing devices and edge data centers positioned closer to end users, there is less chance of a network problem in a distant location affecting local customers. This increases reliability.



Edge computing

Edge computing allows data from Internet of Things devices to be analysed at the edge of the network before being sent to a data centre or cloud

6.8. DARK NET

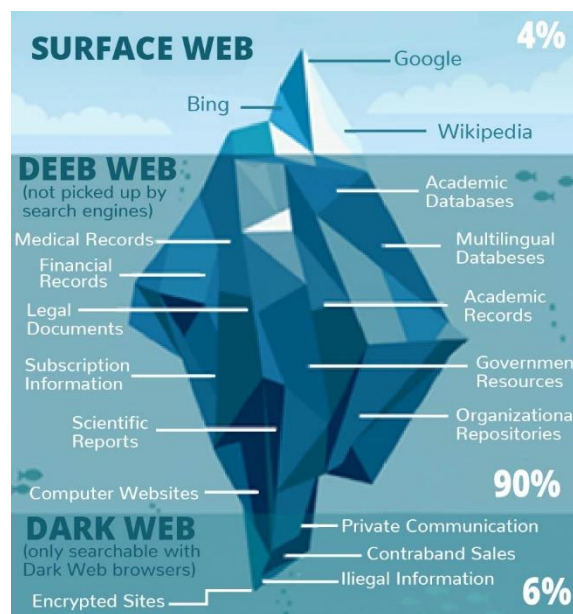
Why in news?

Recently, **The Narcotics Control Bureau (NCB) arrested the country's first 'darknet' narcotics operative**, who allegedly shipped hundreds of psychotropic drug parcels abroad.

What is Dark Net?

- **Also known as Dark Web**, Dark Net is that **part of the Internet that cannot be accessed through traditional search engines** like Google nor is it accessible by normal browsers like Chrome or Safari.
- It **generally uses non-standard communication protocols** which makes it inaccessible by internet service providers (ISPs) or government authorities.
- **The content on Dark Net is encrypted** and requires specific browser such as **TOR (The Onion Ring)** browser to access those pages.

- **TOR browser was developed in the mid-1990s** by the United States Naval Research laboratory employees to protect US intelligence communications online.
- **Dark Net itself is only a part of the Deep Web** that is a broader concept, which includes sites that are protected by passwords. For e.g.- A person's bank statements which are available online but will not be pulled up in generalised Internet searches. Only difference is that while the **Deep Web is accessible, the Dark Net is deliberately hidden.**
 - The part of internet that is readily available to general public and searchable on standard search engines is called as **Surface Web.**



Uses of Dark Net

- By **journalists and citizens working in oppressive regimes**, to communicate without any government censorship.
 - It was used by activists during the Arab Spring and is known to have been used by Chinese citizens.
- By **researchers and students to do research on sensitive topics** as it is known to have large virtual libraries.
- By **law enforcement agencies for sting operations.**
- To **access connect** blocked by local Internet service providers
- To **maintain privacy** of sensitive communications or business plans.

Concerns associated

- **Anonymity:** Because of their end-to-end encryption dark net offers a high degree of anonymity and thus it is near-impossible to track.
- **Haven for illicit activity:** In a study titled Cryptopolitik and the Darknet, it was highlighted that **of the 2,723 websites on Darknet, 57 % hosted illicit content.** Malicious actors like cyber criminals, terrorists and state-sponsored spies use dark web for various activities like payment card fraud, illicit finance, selling banned drugs, etc.
 - One of the most infamous dark web marketplaces was the **Silk Road**, best known for selling illegal drugs that was eventually busted by the Federal Bureau of Investigation.
- **Technical-challenges to establish digital evidence in courts :** As most users are tracked in foreign countries, it offers multiple complexities and roadblocks in investigation.
- **Privacy and ethical concerns:** Decrypting communications to catch criminals has been opposed by activists as it would risk everyone's data present on the dark web.
- **Use of crypto currencies:** Deals done on darknet are mostly through crypto currencies like Bitcoin. As identities remain anonymous, enforcement agencies are unable to trace Dark Net criminals.

Steps taken in India

- The Centre has directed all **law enforcement agencies to have control over foreign-based content providers of data and meta data** and to make **legislative changes to provide immunity for cyber hackers**, which law enforcement agencies use to counter Dark web transactions.
- Centre for Development of Advanced Computing (CDAC) is working with CSIR on developing a **darknet/network telescope-based cyber security monitoring and interference framework.**
 - This will help law enforcement agencies track cyber criminals who sell illegal products and services on such platforms and also track terrorism-related communications and activities,
- **Kerala police have established a specialised darknet lab in Cyberdome** and four officers have been trained as darknet analysts to monitor these activities.
 - To keep up with increasing the cyber security threats, the police are trying to maintain a high level of awareness regarding the latest cyber security trends and events.

Need of the hour

- **International collaboration** in strengthening cyber security framework to deal with challenges posed by Dark Net.
- **Investment in research and development and training and capacity building** of personnel in the field of cyber security.

- To amend the **Information and Technology Act and Evidence Act** to deal with the new age cyber-crimes.
- A **code of criminal procedures dealing with cyber-crime** that would come under the Ministry of Home Affairs, which deals with policing issues.

6.9. ROBOTICS

Why in News?

Recently, All India Council for Robotics and Automation (AICRA) (not-for-profit organization) has announced the launch of a new initiative, **AICRA Tech Startup Programme**.

AICRA Tech Startup Programme

- The programme will act as an **incubation environment for startups and other early stage adopters working on robotics and robotic process automation (RPA) in India**, in a bid to expand the entire industry with increased urgency.
 - RPA is an application of technology, governed by business logic and structured inputs, aimed at automating business processes.
 - Using RPA tools, a company can configure software, or a “robot,” to capture and interpret applications for processing a transaction, manipulating data, triggering responses and communicating with other digital systems
- It will **cater to the essential needs of a startup** like technology, funding, market placement support, and promotion.

Robotics in India

- The term “Robotics” applies to **how robots are designed, manufactured, programmed, and used**.
- According to the Institute of Electronics and Electrical Engineers (IEEE), the world’s robot population had reached 4.49 million in 2008, **a number likely to almost triple by 2035**.
- One of the biggest impacts of robotics on the world **economy resulted from automation**. “Automation” refers to robots whose actions are dictated by a computer program.
- Although India has only three robots for every 10,000 workers, **the domestic robotics industry is growing at an exponential rate**.
 - According to a report by the International Federation of Robotics (IFR) published last year, around 3,412 new industrial robots were installed in India in 2017 — an increase of 30 per cent over the 2,626 units that were installed in 2016.
 - The **automotive industry saw the highest adoption**.
- India has a **unique opportunity to apply the technology to solve some of its biggest problems** such as shortage of healthcare facility, low quality of education, etc. It is not possible to meet the target of providing good healthcare or quality education using conventional methods.
- **Applications**
 - Besides automotive, robots are used in electronics, **food and packaging, education and banking sector for routine jobs**.
 - Robots are also being introduced in **healthcare for operations & other applications in hospitals** that require greater precision
 - ✓ **Ex: KARMI Bot** was a robot deployed by a government hospital in Ernakulam, Kerala to serve food and medicines to coronavirus patients with an aim to reduce risk of infections for doctors and health workers.
 - **Bandicoot to clean sewers** and manholes in the city in which robot’s mechanical arms reaches inside the manhole and reportedly cleaned out the sludge in a few minutes, a task that earlier required three people and several hours of hard labour.
 - Today, the **automotive industry** is the largest adopter of robotic solutions in India.

Benefits of Robotics

- RPA provides organizations with the ability to **reduce staffing costs and human error**.
- Companies can serve their business better by **automating the low-value tasks**
- By 2020, automation and artificial intelligence will **reduce employee requirements** in business shared-service centers by 65 percent,
- Robots **easily and safely perform tasks** that would otherwise endanger human lives, and do so faster and more efficiently than is possible with conventional methods.
- Robots play a vital role in maintaining **the competitive edge in national security**.

Challenges

- **Low adoption rate:** India still lags Japan, the US and Germany when it comes to robotics adoption. When it comes to density of robots, the China roughly uses 189 robots for every 10,000 workers while in India we have hardly 3 robots for every 10,000 workers, according to IFR.
- **Not standardized processes:** many processes in Indian market are not very standardized and many business still run in an unstructured way with lower levels of digitization compared to other developed markets.
- **High cost of deployment:** Deploying a robot can cost as low ₹5 lakh for entry-level robots, and can go up to ₹30- ₹40 lakh depending on the application, nature of job and the payload involved.
- **Elimination of Jobs:** RPA has the potential to eliminate jobs, which presents challenges of managing talent. It threatens the livelihood of 230 million or more knowledge workers, or approximately 9 percent of the global workforce.

Way Ahead

- The next level of automation will be **unlocked when machine learning abilities and artificial intelligence become smart enough** to deploy RPA intelligently. In any case, to take a look at automation as the most important thing in the world is to miss the master plan, one where automation is just a single part of achieving process excellence.
- It's a section that should be orchestrated with regards to that **broader vision, close by different tools that deliver what RPA alone can't:** visibility, intelligent optimization, and a direct impact on overarching business outcomes.
- **Government has a major role to play** in infrastructure development, applications in public sector, policy and regulations, technology development etc.

6.10. DRONE REGULATION

Why in news?

Ministry of Civil Aviation announced a scheme **providing a window up to January 31, 2020 for voluntary registration of all drones and their operators.**

More about News

- On successful submission of voluntary disclosure of possessing drone, a **Drone Acknowledgement Number (DAN) and an Ownership Acknowledgement Number (OAN) will be issued online** which will help in validation of operation of drones in India.
- However, the **DAN and the OAN do not confer any right to operate drones in India** if it does not fulfil the DGCA's drone regulations.
- Further, ownership of drones in India without a valid DAN or OAN shall invite **penal action as per applicable laws.**

Drones in India

- As per Ministry of Civil Aviation, drones are **defined** as a technology platform that has wide-ranging application from photography to agriculture, from infrastructure asset management to insurance.
- Drones range in **size** from very small and those that can carry multiple-kilograms of payload. The DGCA has defined five different categories of drones:
 - **Nano:** Less than or equal to 250 grams
 - **Micro:** From 250 grams to 2kg
 - **Small:** From 2kg to 25kg

About Digital Sky Platform

- It is a software-based **self-enforcement unmanned traffic management (UTM) system** which is expected to facilitate registration and licensing of drones and operators in addition to giving instant (online) clearances to operators for every flight.
- The Platform **regulates all drones** in the micro and higher categories.
- It allows operators to **apply for a Unique Identification Number (UIN)**, that needs to be issued for all drones and Unmanned Aircraft Operator Permit online for approval by the civil aviation regulator.

About Unmanned Aircraft Operator Permit (UAOP)

- UAOP is a permit required by the owners of the drones to fly them which can be obtained from the **Director General of Civil Aviation.**
- These UAOPs are not transferrable and shall be applicable for not more than five years.

- **Medium:** From 25kg to 150kg
- **Large:** Greater than 150kg
- The **industry value** of unmanned aircraft systems (UAS) in India is projected to touch \$885.7 million by 2021, while the global market size is expected to reach \$21.47 billion.
- However, the number of **illegal drones** in India is likely to be between 50,000 and 60,000, as on October 2019 which requires a regulation of drones in India.

Drone Regulation in India

- In August 2018, the Centre came up with the first set of norms **Drone Regulations 1.0** which are intended to enable **visual line-of-sight daytime-only** and a **maximum of 400 ft** altitude operations of Drones.
- Under these guidelines, air space has been partitioned into:
- **Red zone** denotes “**no fly zone**” (include airspace around airports; near international border, Vijay Chowk in Delhi; State Secretariat Complex in State Capitals, strategic locations/vital and military installations; etc.)
- **Yellow zone** is controlled airspace which signifies airspace requiring Air Defence Clearance or Air Traffic Control clearance.
- **Green zone** signifies unrestricted airspace zones. However, even for the Green zone, there is a **need to get clearance** from the Digital Sky Platform.
- Under these regulations, a process has been prescribed for drone operators to obtain **Unique Identification Number (UIN), Unmanned Aircraft Operator Permit (UAOP)** and other permissions.
- Currently, India has a ‘**No Permission-No Take off**’ (NPNT) clause, which implies that a drone cannot be operated in Indian skies unless the regulatory permission is received through **the Digital Sky Platform**.
- Users will be required to do a **one-time registration** of their drones, pilots and owners. **For every flight** (exempted for the nano category), users will be required to ask for permission to fly on a **mobile app** and an automated process permits or denies the request instantly.
- The pilot also needs certification, requiring a **remote pilot licence** before operating a drone.
- In January 2019, a white paper on drone policy 2.0 was released, that paved the way for wider application of drones, such as the **delivery of goods beyond visual line of sight (BVLOS)**.
- Foreigners are currently not allowed to fly drones in India. For commercial purpose, they need to lease the drone to an Indian entity who in-turn will obtain Unique Identification Number (UIN) and UAOP from DGCA.

India's Draft Drone Policy 2.0 (Released in 2019)

- **New forms of air freight permitted:** It recommends expanding operations to beyond VLOS and beyond the current limit of 400 feet.
- **Drone corridors:** The policy conceives of drone corridors to keep commercial UAS operations out of non-segregated airspace in which manned aircraft operate.
- Additionally, designated areas known as ‘**Droneports**’ to facilitate the landing and take-off of drones.
- **Life cycle for drones:** Proposes maximum life cycle for drones to ensure airworthiness and operators must apply for re-certification at the end of a drone's life cycle.
- **Drone Directorate:** Recommends establishing a Drone Directorate within the Directorate General of Civil Aviation (DGCA).
- **DigitalSky service providers (DSPs):** It introduces new players DSPs which would be public or private agencies registered in India.
- **Permissible Night-time Operations:** Permissions and other necessary requirements to be obtained to enable night-time drone flights.
- **FDI:** It proposes 100% FDI under automatic route in UAS and RPAS-based commercial civil aviation services. Under Drone Policy 1.0, there is no mention of FDI.

Need for drone regulations

- **For leveraging drone's potential for commercial operations:** It will foster various new forms of air freight capabilities, allowing transport of **temperature and time sensitive commodities** like bodily organs, life-saving medicines etc.
- They can also be used to discharge materials for **supplementing agricultural irrigation**, survey landscapes, actively monitor rail/road traffic, or survey/inspect agricultural land.
- **Security imperatives:** A well-articulated drone policy is required, given the new risks and the potential that it has to **jeopardise the overall safety environment**, including that of the aviation sector.
- **Drone Weaponization:** Without proper regulation of the commercial drone market, drone weaponization could be added to our growing list of cyber threats and could result in concerns for public safety.

- **Recent global attacks** such as, on Saudi Arabian refineries and killing of Iran's top military commander are few such instances.
- **Privacy concerns:** In this day and age of social media and constant digital communication, **drones' imaging capabilities** pose a bigger threat as they can be used to **breach privacy** by blackmailing people or capturing unwanted surveillance.
- **For boosting Drone startup ecosystem:** The drones/UAVs are still considered as an emerging technology and currently, just about 40 drone startups are active in India.
- A robust drone industry by start-ups and manufacturers alike has the power to help India leapfrog innovation cycles in aviation.

Conclusion

While India has crafted a world leading drone policy framework, formalizing the use of drones will need synchronised efforts of policy makers and industry for practical and secure implementation across the country.

6.11. CYBER-PHYSICAL SYSTEM (CPS)

Why in News?

Recently cabinet approved the launching of **National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS)** which is to be implemented by **Department of Science & Technology** for a period of five years.

What is Cyber-physical system (CPS)?

- CPS is an **interdisciplinary field** that deals with the deployment of computer-based systems that do things in the physical world. It integrates sensing, computation, control and networking into physical objects and infrastructure, connecting them to the Internet and to each other.
- **Examples of cyber physical systems** are Smart Grid Networks, Smart Transportation System, Enterprise Cloud Infrastructure, Utility Service Infrastructure for Smart Cities, etc.
- **CPS and its associated technologies**, like Artificial Intelligence (AI), Internet of Things (IoT), Machine Learning (ML), Deep Learning (DP), Big Data Analytics, Robotics, Quantum Computing, Quantum Communication, Quantum encryption (Quantum Key Distribution), Data Science & Predictive analytics, Cyber Security for physical infrastructure and other infrastructure plays a transformative role in almost every field of human endeavor in all sectors.

About National Mission on Interdisciplinary Cyber-Physical Systems

- It is a comprehensive mission which would address technology development, application development, human resource development, skill enhancement, entrepreneurship and start-up development in CPS and associated technologies.
- **Implementation:**
 - It aims at establishment of 15 numbers of **Technology Innovation Hubs**, six numbers of Application Innovation Hubs and four numbers of **Technology Translation Research Parks (TTRP)**.
 - These **Hubs & TTRPs will connect to Academics, Industry, Central Ministries and State Government** in developing solutions at reputed academic, R&D and other organizations across the country in a hub and spoke model.
 - They mainly **focus on four areas:** Technology Development, HRD & Skill Development, Innovation, Entrepreneurship & Start-ups Ecosystem Development and International Collaborations.
- **Significance of Mission**
 - It will **support other missions of the government**, provide industrial and economic competitiveness.
 - It would act as an **engine of growth** that would benefit national initiatives in health, education, energy, environment, agriculture, strategic cum security, and industrial sectors, Industry 4.0, SMART Cities, Sustainable Development Goals (SDGs) etc.
 - It will bring a paradigm shift in entire **skill sets requirement and job opportunities**.
 - It is aimed to give **impetus to advanced research in CPS, technology development and higher education in science, technology and engineering disciplines**, and place India at par with other advanced countries and derive several direct and indirect benefits.

Advantages of CPS technologies

- **Enhanced security capabilities:** It can play role in expediting design and delivery of trustworthy, adaptable and affordable systems, operations in cyberspace and autonomous systems to augment security operations.

- **Disaster Management:** CPS technologies including next generation public safety communications, sensor networks, and response robotics can dramatically increase the situational awareness of emergency responders and enable optimized response through all phases of disaster events.
- **Energy:** They are essential for the creation of energy infrastructure, optimization and management of resources and facilities and allowing consumers to control and manage their energy consumption patterns like smart meters.
- **Healthcare:** CPS correct-by-construction design methodologies are needed to design cost-effective, easy-to-certify, and safe products.
- **Transportation:** They can (potentially) eliminate accidents caused by human error, Congestion control, traffic-based grid jams.
- **Agriculture:** They will play a key role in helping to increase efficiency throughout the value chain, improving environmental footprint and creating opportunities for a skilled and semi-skilled workforce.

Challenges in CPS

- **Privacy issues:** CPS technologies that enhance privacy and enable the appropriate use of sensitive and personal information while protecting personal privacy are needed.
- **Computational Abstractions:** Physical properties such as laws of physics and chemistry, safety, resources, real time power constrained etc. must be captured by programming abstractions.
- **Data related challenges:** It allows flexible control and resource use; provides conduits for information leakage; prone to mis-configurations and deliberate attacks by outsiders and insiders.
- **Infrastructural bottlenecks:** This system requires a Sensor and mobile networks hence essential requirement to increase system autonomy in practice requires self-organization of mobile and Adhoc CPS networks.
- **Human Interaction:** Human interaction with CPSs often encounter a critical challenge when interpreting the human-machine behavior and designing appropriate models that consider the current situational measurements and environmental changes which are crucial in the decision-making processes, particularly in systems such as air traffic systems and military systems.
- **Technical barrier:** One of the biggest problems that such integrations face is the lack of consistent language and terminology that need to exist to describe cyber-physical interactions.
- **Consistency:** There are challenges in maintaining the same required level of accuracy, reliability, and performance of all system parts.

Related News

- Government has set up the **Empowered Technology Group**, headed by the Principal Scientific Advisor.
- It is **12-Member group** including the chairmen of the Atomic Energy Commission, the Space Commission and the Defence Research and Development Organisation and the secretaries of the IT, telecommunications and science & technology ministries.
- It is **mandated to render timely policy advice on latest technologies; mapping of technology and technology products; commercialisation of dual use technologies;** developing an indigenisation road map for selected key technologies; facilitate cross-sector collaboration and selection of appropriate R&D programs leading to technology development.
- The group seeks to address problems such as:
 - **silo-centric approaches** to development of technology
 - **technology standards either not developed** or applied, leading to sub-optimal industrial development
 - **dual use technologies** not being optimally commercialised
 - R&D programs not aligned to efforts at technology development
 - need for mapping of **technologies important for applications in society** and industry.
- Under this **all ministries are to include technological implications of their proposals** along with the interministerial comments in their Cabinet notes. For this govt also modified the handbook on preparation of Cabinet notes.
- 'Technology Group' will **evaluate all department proposals exceeding Rs 500 crore** for the procurement of technology/products before they are submitted to Expenditure Finance Committee.

6.12. SPACE-BASED INTERNET

Why in News?

American company **SpaceX** recently sent 60 small satellites (under 500 kg each) into Low Earth Orbit (LEO). This project, named **Starlink network**, seeks to build a 42,000-strong constellation aiming to supply non-stop, low-cost Internet everywhere on Earth.

Benefits of space internet

- **Better accessibility**- Traditional ways to deliver the Internet like fibre-optic cables or wireless networks cannot take it in remote areas or difficult terrains.
- **More affordability**- because of economies of scale and near zero investment on costly ground physical infrastructure.
- **Availability**- 24*7 availability of internet without any interruption.
- **Internet of Things (IoT) technology** is likely to be revolutionised. For ex. services such as autonomous car driving will become seamless.

Differences from earlier attempts

Space-based Internet systems have been in use for several years but only for a small number of users. The differences between earlier systems and Starlink project are-

Parameters	Earlier systems	Starlink
Orbit	Geostationary orbit (35,786 km)	Low Earth Orbit (LEO) (350 km to 1,200 km)
Time lag or latency in signal transmission	600 milliseconds	20-30 milliseconds
Serviceable area on Earth by each satellite	Covers about a third of Earth's area	Area covered is comparatively very less

Concerns

- Increased risk of **collisions** leading to more **space debris**.
- **Increased light-pollution** i.e. light reflected from these man-made satellites can interfere with and be mistaken for light coming from other heavenly bodies.
- Can **obstruct the line of sight** to observe other space objects and to detect their signals.

6.13. INFLIGHT WIFI

Why in news?

Union government recently issued a notification to announce that all airlines operating in India can now provide in-flight wi-fi services to its passengers.

More on the news

- The Civil Aviation Ministry specified that the availability of the Wi-Fi during flights will be broadly subjected to two conditions:
- The **main captain will have the authority to switch on or switch off the Wi-Fi in flights**, and the captain will be required to follow certain guidelines on this matter. For example, Wi-Fi would be switched on only when the plane is at the cruising speed and not during take-off or landing.
- **Each plane that offers in-flight Wi-Fi will have to be certified by DGCA** for this purpose before fliers in it can enjoy connectivity.

How does Inflight Wifi work?

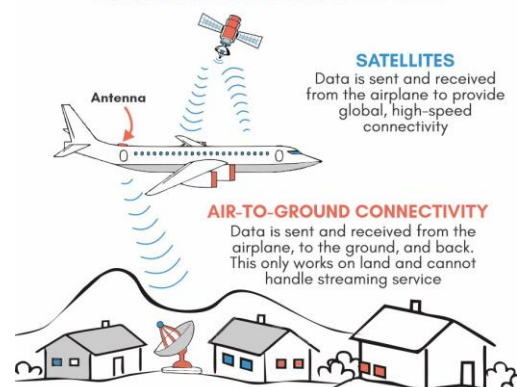
There are two operating systems for airplane WiFi:

Wi-fi

- The term Wi-Fi stands for wireless fidelity.
- It is a **radio transmission technology** and is built upon a set of standards that allow high-speed and secure communications between a wide variety of digital devices, access points, and hardware.
- The typical range of a standard Wi-Fi network can reach up to 100 meters in the open air.
- They transmit at frequencies of 2.4 GHz or 5 GHz.

Hotspot: A hotspot is a physical location where people can access the Internet, typically using Wi-Fi, via a wireless local area network (WLAN) with a router connected to an Internet service provider.

TWO DIFFERENT WAYS WiFi WORKS ON AIRPLANE



- **Air-to-ground WiFi System**
 - It works in a similar way to a cell phone.
 - Airplanes have an antenna located underneath their body, which links up with cell towers on the ground.
 - As the aircraft travels, it simply connects to the nearest transmitter/towers on a rolling basis.
 - The airplane becomes a hotspot, so passengers can access internet.
 - However, this system can't work when the plane is flying over large expanses of water or particularly remote terrain, like on transatlantic routes.
- **Satellite based WiFi System**
 - It uses a network of orbiting satellites to allow a connection.
 - Information is passed between the ground and the plane via the satellite.
 - The satellite is linked to ground stations.
 - The airplane connects to the satellite using a satellite antenna on the top of the fuselage.
 - Wi-Fi signal is distributed to plane passengers via an on board router.
 - The plane uses whichever satellite is nearest as it travels and thus can operate over large expanses of water or remote terrain as well.
 - Satellite WiFi operates on two different bandwidths: narrowband and broadband. Both allow passengers full Internet access, although the narrower options are less suitable for streaming movies.

Related News

Wifi Calling

- Bharti Airtel recently introduced India's first Voice over Wi-Fi (VoWiFi).
- VoWiFi is a Wi-Fi-based **Voice over Internet Protocol (VoIP)** service, which allows users to make high definition (HD) voice calls using Wi-Fi even in places with poor or no cellular network.
- Calls made over VoWiFi provides users with a **shorter call connection time** along with **superior call quality** compared to calls made over VoLTE or any existing cellular technology.
- Users **don't have to pay extra** for these calls as it is using a Wi-Fi network. VoWiFi service does not need any separate app or a new number or any log-in to work.
- This is similar to a voice call using WhatsApp or any other over-the-top messaging platform, but here the **call is from one number to another**, and not using an app.

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7. ALTERNATE ENERGY

7.1. FUEL CELL

Why in news?

Recently, **India's first indigenous fuel cell system** was unveiled.

More about the news

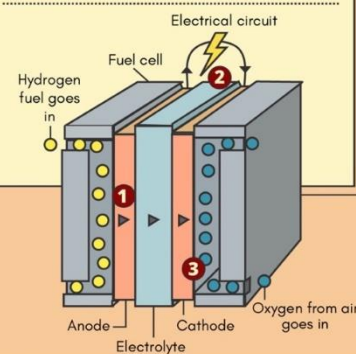
- It is **developed by Council of Scientific and Industrial Research (CSIR)** in partnership with Thermax Ltd, a Pune-based engineering firm.
- It is developed under the flagship program named **'New Millennium Indian Technology Leadership Initiative (NMITLI)**.
 - NMITLI is an **initiative of CSIR** and is the largest public-private-partnership effort within the R&D domain in the country.
- It will be a **5 kW fuel cell system** and will **use methanol/bio-methane** to generate power **with 70% more efficiency** than other sources.

About Fuel cell technology

- A fuel cell is like a battery that generates **electricity from an electrochemical reaction**.
- It **uses a source of hydrogen as fuel** but involves **no combustion**.
- With the help of oxygen present in the air, oxidation of hydrogen atoms occur and in the process, electrons are released which flow through an external circuit as an electric current.
- The **byproducts** of fuel cell include heat and water.
- Fuel cells can vary from tiny devices producing only a few watts of electricity, right up to large power plants producing megawatts.

HOW A FUEL CELL WORKS

Fuel cells generate heat and electricity from an electrochemical reaction between hydrogen and oxygen. Hydrogen is the most common element in the universe



- Hydrogen reacts with a catalyst when it reaches the anode. This makes positively-charged particles that go through the electrolyte and electrons that travel along a circuit to make an electrical current
- When the particles and electrons reach the cathode they react with oxygen to form water and useable heat

Related News

Microbial fuel Cells

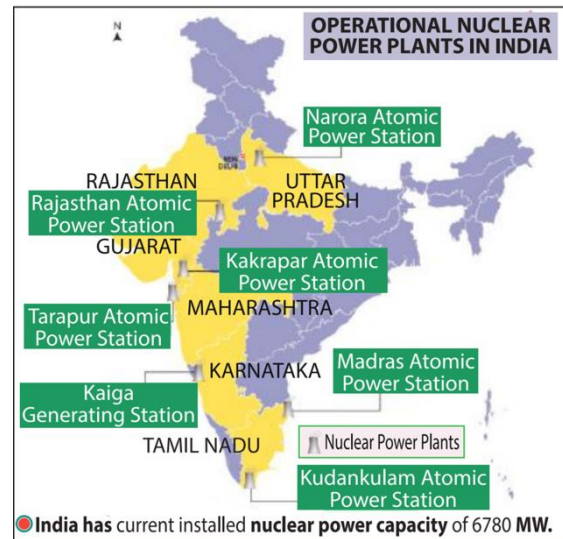
- Zoological Society of London (ZSL) scientists used **plants to power sensors in the wild by installing microbial fuel cells**.
- A microbial fuel cell (MFC) is a **bio-electrochemical device that harnesses the power of respiring microbes to convert organic substrates** directly into electrical energy.
 - It transforms chemical energy into electricity **using oxidation reduction reactions**
 - It **relies on living biocatalysts** to facilitate the movement of electrons throughout their systems instead of the traditional chemically catalyzed oxidation of a fuel at the anode and reduction at the cathode.
- It has **various application especially where there is low power requirement** where replacing batteries may be impractical, such as wireless sensor networks, biosensors etc.
- Microbial fuel cells work by **allowing bacteria to oxidize and reduce organic molecules**.
 - Bacterial respiration is basically one big redox reaction in which electrons are being moved around.
 - ✓ An oxidation-reduction (redox) reaction is a type of chemical reaction that involves a transfer of electrons between two species.
 - Whenever you have moving electrons, the potential exists for harnessing an electromotive force to perform useful work.
 - A MFC consists of an anode and a cathode separated by a cation specific membrane.
 - Microbes at the anode oxidize the organic fuel generating protons which pass through the membrane to the cathode, and electrons which pass through the anode to an external circuit to generate a current.

7.2. NUCLEAR PROGRAMME IN INDIA

Nuclear power sector in India

- Nuclear energy has emerged as a **viable source** in recent times.
- Important minerals** used for the generation of nuclear energy are uranium and thorium.
- Uranium deposits occur in the **Dharwar rocks**. Geographically, uranium ores are known to occur in several **locations along the Singbhum Copper belt**.

- **Atomic Energy Commission** was established in 1948, progress could be made only after the establishment of the Atomic Energy Institute at Trombay in 1954 which was renamed as the Bhabha Atomic Research Centre in 1967.
- The important nuclear power projects are Tarapur (Maharashtra), Rawatbhata near Kota (Rajasthan), Kalpakkam (Tamil Nadu), Narora (Uttar Pradesh), Kaiga (Karnataka) and Kakrapar (Gujarat).
- **India's three stage nuclear programme:** The long-term goal of India's nuclear program has been to develop an advanced heavy-water thorium cycle.
 - **Stage 1- Pressurized Heavy Water Reactor (PHWR)**
 - ✓ PHWRs are **fuelled by natural uranium, and light water reactors**, which produce plutonium incidentally to their prime purpose of electricity generation.
 - ✓ Heavy water is used as moderator and coolant.
 - ✓ $U-238 \rightarrow$ Plutonium-239 + Heat
 - **Stage 2-Plutonium fuelled Fast Breeder Reactor**
 - ✓ It uses fast neutron reactors burning the plutonium-239 with the blanket around the core having uranium as well as thorium, so that further plutonium (ideally high-fissile Pu) is produced as well as U-233.
 - **Stage 3- Advanced Heavy Water Reactors (AHWRs)**
 - ✓ It will burn thorium-plutonium fuels in such a manner that breeds U-233 which can eventually be used as a self-sustaining fissile driver for a fleet of breeding AHWRs.
 - ✓ An alternative stage 3 is molten salt breeder reactors (MSBR), which are firming up as an option for eventual large-scale deployment.



Apsara-U

- It is the **indigenously made upgraded version of "Apsara"**, the first research reactor in Asia which had become operational in 1956 and was shut down in 2009.
- It uses plate type dispersion fuel elements made of **Low Enriched Uranium (LEU)**.
- Owing to higher neutron flux, this reactor will increase indigenous production of radio-isotopes for medical application by about 50%.
- It would also be used for **research in nuclear physics, material science and radiation shielding**.

Need for nuclear development in India

- **Energy security:** Nuclear security is an important component of achieving energy security. Nuclear energy has the potential to provide a large scale of electricity generation that itself would help lift the standard of living for millions of population.
- **Reduction in carbon emission:** Nuclear power is the key to reducing global emissions of carbon dioxide (CO₂) and sulphur dioxide (SO₂).
- **Less impact on climate:** Nuclear reactors do not produce greenhouse gases like power plants using coal and, therefore, can increase electricity generation without contributing to climate change.
- **Replacing conventional energy resources:** Increased share of nuclear power in the Indian energy mix will help diminish the reliance on fossil fuels and it will replaced conventional coal based energy plants.
- **Continuous supply of electricity:** They can provide a steady supply of electricity because unlike solar and wind power sources, nuclear plants can operate when there is no sun or wind and are not affected by fluctuations in water availability like hydroelectric plants.
- **Nuclear Energy and Foreign Policy Nexus:** Nuclear energy plays a substantial role in the formation of bilateral relations among nations. For example, the 2008 Indo-US nuclear agreement did not just support India's domestic power plants but strengthened Indo-US bilateral relations while giving India the recognition of being a responsible nuclear weapon state with strong non-proliferation credentials

Challenges

- **Uranium contamination of ground water due to Mining:** Recently, a study has found uranium contamination in groundwater from aquifers in 16 Indian states. For example most of the wells tested in Rajasthan and Gujarat had more uranium than the WHO's recommended limit of 30 µg/L.

- **Purity of Uranium:** In comparison to world occurrences, uranium deposits established in India are mostly of low-grade (less than 0.15 per cent U).
- **Shift towards Renewable energy:** This has often been cited as a factor that calls for a shift away from nuclear fuel. The plants, with a shorter processing route, need to incorporate measures to maximize the re-use of water, high recovery of the product and minimum discharge of effluents.
- **Anti-nuclear protests:** Following the 2011 Fukushima nuclear disaster in Japan, populations around proposed Indian Nuclear power plant sites have launched protests. **E.g. Protests in Jaitapur protests and Mithi Virdi.**
- **Syncing with foreign players:** India's current manufacturing capability only covers the supply chain for 700 MW pressurized heavy-water reactor (PHWR) with foreign reactors inevitably requiring foreign supplier agreements. Engaging with foreign suppliers means dealing with problems of capacity, queued bookings and uncertainty
- **Manpower needs:** To scale up nuclear energy in India, human resource for nuclear engineering is paramount. India currently faces a shortfall in nuclear scientists and engineers.
- **Other Issues:** Factors such as problems on land acquisition, rehabilitation/resettlement of affected persons, reserve forest/tiger sanctuary locations, socio-political issues, public consensus, etc. also influence the decisions on mining and exploitation of established uranium and thorium resources in the country.

Need for new uranium mines

- **Fuel for current Nuclear Plants:** The scarcity of uranium has often made the nuclear power plants to run below their capacities. A stockpile of 15,000 tonnes of uranium is required to achieve supply security of fuel for nuclear plants in the country.
- **Need Domestic Uranium for Non-IAEA plants:** Domestic uranium is used in nuclear plants which are not under the international nuclear energy watchdog, International Atomic Energy Agency (IAEA).
- **Fuel for Future capacity addition:** The government has planned 22,480 MW nuclear power capacity addition target by the year 2031-32.

Way forward

Certain steps need to be taken to ensure the safety and security of using nuclear power. This includes:

- ensure maintenance of the skills base
- maintain continued effective safety regulation
- foster progress on facilities for waste disposal and management must be given serious consideration.
- maintain and reinforce international non-proliferation arrangements.
- It would be necessary to train and recruit scientists and engineers every year in R&D units.

7.2.1. INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR (ITER)**Why in news?**

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

Tokamak

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

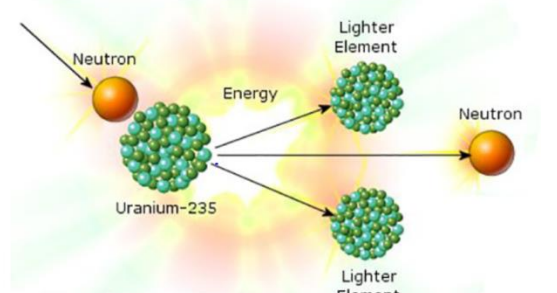
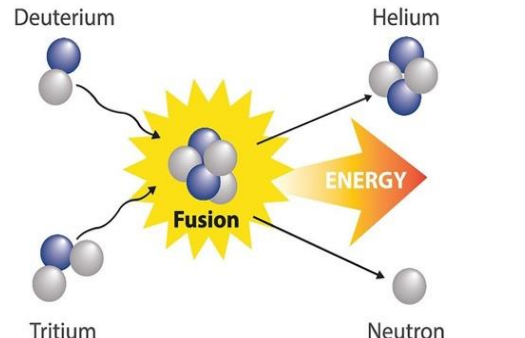
About ITER Project

- Launched in 1985, ITER is an **experimental fusion reactor facility** currently under construction in Cadarache, south of **France**.
- It aims to prove the feasibility of **nuclear fusion as a future source of energy** and build the world's largest **tokamak** through an international collaboration.
- Once complete, ITER will be the first fusion device to produce **net energy**.
- **ITER Members:** Signatories to the ITER Agreement include **China, the European Union, India, Japan, Korea, Russia** and the **United States** (35 nations).
 - These countries share the **cost of project construction, operation and decommissioning**, and will also share in the **experimental results and any intellectual property** generated by the project.
 - European Union being the host party contributes 45% while the rest of the parties contribute 9% each. Most of these contributions (around **nine-tenths**) are through 'in-kind' procurement of ITER components.
 - Each Member has created a **Domestic Agency** to fulfill its procurement responsibilities to ITER.
- **India's contribution:** India which formally joined the ITER project in **2005**, is responsible for delivery of cryostat, in-wall shielding, cooling water system, cryogenic system, heating systems, Diagnostic Neutral Beam System, power supplies and some diagnostics.
 - India is contributing resources worth about \$2.2 billion to this effort.
 - ITER-India is the Indian domestic agency, a specially empowered project of the **Institute for Plasma Research (IPR)**, an aided organization under Dept. of Atomic Energy.

Related News

- Recently, third unit at Kakrapar Atomic Power Plant (KAPP-3) achieves criticality.
- KAPP-3 is India's first 700 MWe (megawatt electric) unit, and **biggest indigenously developed variant of Pressurised Heavy Water Reactor (PHWR)**. Until now, biggest reactor size of indigenous design was 540 MWe PHWR (Tarapur).
- First two units at Kakrapar were based on Canadian technology.
- PHWR is a nuclear power reactor commonly using **unenriched natural uranium** as its fuel, that uses **heavy water** (deuterium oxide) as its coolant and moderator.
- A reactor **achieves criticality (and is said to be critical)** when each fission event releases a sufficient number of neutrons to sustain an ongoing series of reactions.

Differences between Nuclear Fission and Fusion

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

Advantages of fusion energy

- **Abundant energy:** Fusing atoms together in a controlled way releases nearly four million times more energy than a chemical reaction such as the burning of coal, oil or gas and four times as much as nuclear fission reactions.
- **Sustainability:** Fusion fuels are widely available and nearly inexhaustible. Deuterium can be distilled from all forms of water, while tritium will be produced during the fusion reaction as fusion neutrons interact with lithium.
- **Zero carbon emissions:** Fusion doesn't emit harmful toxins like carbon dioxide (CO₂) or other greenhouse gases into the atmosphere. Its major by-product is helium: an inert, non-toxic gas.
- **No high activity long-lived radioactive waste:** The activation of components in a fusion reactor is low enough for the materials to be recycled or reused within 100 years.
- **Limited risk of proliferation:** Fusion doesn't employ fissile materials like uranium and plutonium. There are no enriched materials in a fusion reactor like ITER that could be exploited to make nuclear weapons.
- **No risk of meltdown in a tokamak fusion device:** It is difficult to reach and maintain the precise conditions necessary for fusion. Thus if any disturbance occurs, the plasma cools within seconds and the reaction stops.
- **Cost:** The average cost per kilowatt of electricity is expected to be slightly more expensive than that of a fission reactor at the beginning, but less expensive as economies of scale bring the costs down.

Issues related to India's participation in ITER

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

Conclusion

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

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

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8. MISCELLANEOUS

8.1. SCIENTIFIC SOCIAL RESPONSIBILITY (SSR)

Why in News?

Department of Science and Technology (DST) released a **draft of its proposed Scientific Social Responsibility (SSR) policy**.

About Scientific Social Responsibility (SSR)

- India is going to be **possibly the first country in the world to implement a Scientific Social Responsibility (SSR) Policy** on the lines of Corporate Social Responsibility (CSR).
- It is the **confluence of scientific knowledge with visionary leadership and social conscience**.
- SSR is **about building synergies among all stakeholders in scientific knowledge community** and also about developing linkages between science and society.
- It aims to **encourage science and technology (S&T) institutions and individual scientists** in the country to proactively engage in science outreach activities to connect science with the society.
- SR policy would involve **four different categories of stakeholders**:
 - beneficiaries (students; school/college teachers; local bodies; communities; women's groups etc.),
 - implementers (institutions, science centers, Central Ministries, State Governments etc.),
 - assessors (Internal assessment cell or external agency) and
 - supporters (government agency, Corporate bodies etc. providing grants/funds).
- The **main objective of SSR policy** is to harness the voluntary potential that is latent in the country's scientific community to strengthen science and society linkages so as to make S&T ecosystem vibrant through
 - **Science-society connect**: Facilitating inclusive and sustainable development by transferring the benefits of scientific work to meet existing and emerging societal needs.
 - **Science-science connect**: Creating an enabling environment for the sharing of ideas and resources within the knowledge ecosystem.
 - **Society-science connect**: Collaborating with communities to identify problems and develop scientific and technological solutions.
 - **Cultural change**: Inculcating social responsibility among the individuals and institutions practicing science; creating awareness about SSR within society; and infusing scientific temperament into day-to-day social existence and interaction.

Benefits

- **Providing solutions**: SSR has the potential to bring scientific and innovative solutions to societal problems in rural areas also, especially marginalized sections of society & students, thereby transforming the country.
- **Start-up ecosystem**: SSR would inculcate moral responsibility amongst scientific community which may trigger social entrepreneurship and start-ups impacting S&T ecosystem and society and also complement initiatives such as Transformation of Aspirational Districts, Make in India, Swachh Bharat and Digital India, leading to inclusive growth and development.
- **Strengthen institutions and integration of S&T with society**: This policy would strengthen the existing efforts of institutions in an organised and sustainable manner and also how the investments on S&T benefit society.
- **Cooperative environment**: Creating an opportunity for cooperation and sharing of S&T resources in laboratories with other researchers in universities and colleges.
- **Skill and technical upgradation**: Providing training for skill development and upgrading scientific knowledge.
- **Best practices & scientific temperament**: Identification of best practices and success models on SSR for replication with multiplier effect in the country.

Policy directives

- **10 person-days of SSR per year**: Individual scientists or knowledge workers will be required to devote at least 10 person-days of SSR per year for exchanging scientific knowledge to society.
- **Outreach activities**: It recognises the need to provide incentives for outreach activities with necessary budgetary support. Every knowledge institution would prepare its implementation plan for achieving its SSR goals.
- **Appraisal and evaluation**: It has also been proposed to give credit to knowledge workers/scientists for individual SSR activities in their annual performance appraisal and evaluation.

- **No institution would be allowed to outsource** or sub-contract their SSR activities and projects.
- All knowledge workers would be **sensitised** by their institutions about their ethical responsibility to contribute.
- There should be an SSR monitoring system in each institution to assess institutional projects and individual activities.
- **Implementation agency:** A central agency will be established at DST to implement the SSR. Other centre & state ministries would also be encouraged to make their own plans to implement SSR as per their mandate.
- **National portal:** For implementation of the policy, a national portal will be developed up to capture societal needs requiring scientific interventions and as a platform for implementers and for reporting SSR activities.

Conclusion

The policy envisages strengthening science-society linkages in an organic manner by building synergy among all the stakeholders so as to usher in a cultural change in the conduct of science for the benefit of society at large in the country.

8.2. FIFTH STATE OF MATTER

Why in news?

NASA Scientists recently **observed the fifth state of matter in space for the first time** as part of **Bose Einstein Condensates (BEC) Experiments** aboard the **International Space Station (ISS)**.

About fifth state of matter

- The existence of **Bose Einstein Condensate**, also known as the fifth state of matter was predicted by **Albert Einstein** and Indian mathematician **Satyendra Nath Bose** in early 1920s.
- **Solids, liquids, gases and plasma** are the other **four states of matter**.
- BEC is a **supercooled gas that no longer behaves as individual atoms and particles**, but rather an entity in a single quantum state.
- BECs are formed when atoms of certain elements are **cooled to near absolute zero (0 Kelvin, minus 273.15 Celsius)**.
- **When they reach that temperature**, the atoms become a **single entity with quantum properties**, wherein each particle **also functions as a wave of matter**.
- BECs are **extremely fragile** and the slightest interaction with the external world is enough to warm them past their condensation threshold.
- This makes it nearly **impossible for scientists to study them on Earth**, where **gravity interferes** with the magnetic fields required to hold them in place for observation.
- **BEC experiments** will help in
 - Tests of **general relativity**
 - Searches for **dark energy** and **Gravitational waves**
 - **Spacecraft navigation**
 - **Quantum mechanics** on a macroscopic level
 - Prospecting for **subsurface minerals** on moon and other planetary bodies.

About Plasma – Fourth state of matter

- Plasma is like a **gas, but comprised of positive ions and free electrons** with little or no overall electric charge.
- Because of presence of charged ions, plasma is **highly electrically conductive** and **responds strongly to magnetic and electric fields** (unlike gas).
- Plasmas have **no fixed shape or volume**, and are less dense than solids or liquids.
- Plasma is the **most common state of matter** in the **Universe** comprising more than **99% of our visible universe**.
- Plasma **occurs naturally** in **sun, the core of stars, quasars, X-ray beam emitting pulsars and supernovas**.
- **On Earth**, plasma naturally occurs in **flames, lightning and the auroras**.
- Plasmas can be formed by **heating a gas to high temperatures**, as, when heated, the atoms in the gas either gain or lose electrons (ionization).

8.3. NOBEL PRIZES 2019

8.3.1. NOBEL PRIZE IN PHYSIOLOGY OR MEDICINE

Why in news?

The Nobel Prize in Physiology or Medicine has been awarded to **William Kaelin, Peter Ratcliffe** and **Gregg Semenza** for discovering the complex processes behind how human cells respond to change in levels of oxygen.

More on news

- The research has tried to explain how cells adapt to higher or lower amounts of the molecule in the atmosphere.
- When the body detects that less oxygen is present, the kidneys release a hormone called **erythropoietin**, or **EPO**, which tells the body to make more red blood cells to carry more oxygen around.
- They found that a protein called **hypoxia-inducible factor**, or **HIF**, rises when there's less oxygen around.
 - HIF then bonds to sections of DNA near the gene that produces EPO.
 - Extra HIF protein around the EPO gene acts like a turbo charge for the hormone's production, which is how the body knows to make more red blood cells.
 - When there's sufficient oxygen available again, HIF levels drop, as do red blood cell counts.

Significance

- **Understand body functioning-** This research can help understand the processes behind the generation of new blood vessels, the production of red blood cells, certain immune system functions and even fetal and placenta development.
- **Tackling diseases-** Much more information can be obtained about the diseases arising from these pathways, such as cancers that proliferate using the oxygen-sensing system to grow tumors.
 - The new knowledge would help to treat major diseases like **cancer** and **anaemia**.
- **Formulation of drugs-** Already, a number of drugs have been developed on the back of the understanding of this oxygen-sensing pathway. More experimental drugs on blocking blood vessel formation, aiming to prevent tumor growth in some cancers can be introduced.

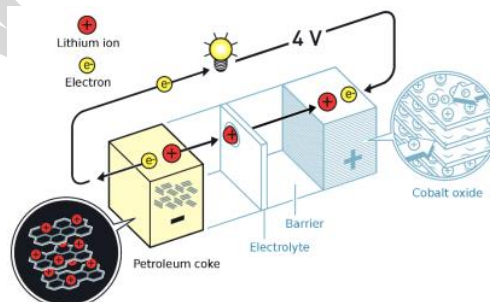
8.3.2. NOBEL PRIZE IN CHEMISTRY

Why in news?

The 2019 Nobel Prize in Chemistry was awarded to **John D. Goodenough, M. Stanley Whittingham and Akira Yoshino** for their roles in the development of **lithium-ion batteries**.

More in news

- **M. Stanley Whittingham:** laid foundations of Lithium (Li) ion batteries in 1970s, when he used titanium disulphide as cathode and metallic lithium, which is highly reactive, as anode.
- **John B. Goodenough:** In 1980s, he replaced titanium disulphide with cobalt oxide as the cathode doubling the battery's potential. However, the use of reactive lithium remained a concern.
- **Akira Yoshino:** The first commercially viable lithium-ion battery was developed by him in 1991. He replaced lithium anode with petroleum coke anode, which drew Li-ions towards it from the Lithium Cobalt oxide cathode.



About Lithium ion batteries

- A lithium-ion battery is a type of rechargeable battery.
- Lithium-ion batteries are commonly used for portable electronics (smartphones, laptops etc) and electric vehicles and for military and aerospace applications.
- **Advantages:**
 - It is **light weight and has high energy density** (i.e. stores more energy per unit of weight when compare to other kind of batteries.) It is able to store 150 watt-hours electricity per kg of battery.
 - Li-ion battery cells can **deliver up to 3.6 Volts, 3 times higher** than technologies such as Nickel Cadmium (Ni-Cd) batteries.
 - Rechargeable lithium-ion batteries **have 5000 cycles or more** compared to just 400-500 cycles in lead acid batteries.
 - Li-ion batteries are also **comparatively low maintenance**, and do not require scheduled cycling to maintain their battery life.
 - Li-ion batteries have **no memory effect**, a detrimental process where repeated partial discharge/charge cycles can cause a battery to 'remember' a lower capacity.
 - Li-ion batteries also have **low self-discharge rate** of around 1.5-2% per month.

- They **do not contain toxic cadmium**, which makes them easier to dispose of than Ni-Cd batteries.
- **Limitations of Li-ion batteries:**
 - They have a tendency to overheat, and can be damaged at high voltages. In some cases this can lead to combustion. This can cause transportation restrictions on large quantities of Li-ion batteries.
 - Li-ion batteries require safety mechanisms to limit voltage and internal pressures, which can increase weight and limit performance in some cases.
 - Another factor limiting their widespread adoption is their cost, which is around 40% higher than Ni-Cd.

Lithium Batteries in India

- As per Government reply in Lok Sabha, **India has quadrupled its imports and more than tripled its import bill of lithium-ion (Li-ion) batteries** and more than tripled its import bill on the product, from 2016-2018.
 - **Indian manufacturers** source Li-ion batteries from China, Japan and South Korea and the country is **among the largest importers in the world**.
 - Around 450 million Li-ion batteries were imported in 2019 (till November).
 - The cost of these imports rose from ₹2,600 crores in 2016 to ₹6,500 crores in 2019
- **Steps taken by India**
 - Union Cabinet in 2019 approved a programme, **National Mission on Transformative Mobility and Battery Storage** in the NITI Aayog to drive clean, connected, shared, sustainable and holistic mobility initiatives.
 - **ISRO has commercialized indigenously developed li-ion battery technology** and has selected 14 companies for transfer of technology.
 - Central Electro Chemical Research Institute (CECRI), under Council of Scientific & Industrial Research (CSIR) and RAASI Solar Power Pvt Ltd have **signed a Memorandum of Agreement for transfer of technology for India's first Li-ion Battery project in 2018**.

8.3.3. NOBEL PRIZE IN PHYSICS

Why in news?

The Nobel Prize in Physics 2019 was awarded to three scientists- James Peebles, Michel Mayor and Didier Queloz **“for contributions to our understanding of the evolution of the universe and Earth’s place in the cosmos”**.

More about the news

- **James Peebles** was awarded for “theoretical discoveries in physical cosmology”.
- Peebles’ theoretical tools are the foundation of our modern understanding of the universe’s history, **from the Big Bang to the present day**. His theoretical tools and calculations helped interpret traces from the infancy of the universe.
- **Michel Mayor and Didier Queloz** were awarded for discovering “an exoplanet orbiting a solar-type star”.
- They discovered **the first planet outside our solar system**, an exoplanet, named **51 Pegasi B** orbiting a solar-type star in our home galaxy, the Milky Way, in 1995.
- It started a **started a revolution in astronomy as more than 4,000 exoplanets** have since been discovered in the Milky Way since then.
- These discoveries challenged the world’s existing ideas about planetary systems and building up on them in the future might just help **find answer humanity’s eternal quest about whether life exists outside of the earth and the solar system**.

Note: Nobel Prize 2020 will be covered in Mains 365: Updated document

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