VISIONIAS
INSPIRING INNOVATION

Science & Technology

Classroom Study Material 2018

(September 2017 to June 2018)

www.visionias.in
+91 8468022022

DELHI | JAIPUR | PUNE | HYDERABAD | AHMEDABAD | LUCKNOW

SCIENCE AND TECHNOLOGY

SEPTEMBER 2017 – JUNE 2018

Table of Contents

1. BIOTECHNOLOGY

Biotechnology harnesses cellular and bio-molecular processes to develop technologies and products that help us to improve our lives.

Modern biotechnology 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. It incorporates a wide variety of procedures and inputs from various disciplines of science, thereby increasing the complexity and making it multi-disciplinary.

Globally, biotechnology industry is expected to witness the fastest growth as a consequence of substantial development in this field. In 2016 the Biotech Market in Asia-Pacific had the maximum share followed by Europe.

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) and **white biotechnology** (industrial).

Applications of Biotechnology

- **Medical Biotechnology**– It is defined as the application of **biotechnology** tools for producing **medical** products that can be used for the diagnosis, prevention, and treatment of diseases. The best-known products of **medical biotechnology** are antibiotics that are used to treat bacterial infections.
    - Various target areas include – infectious disease biology, human development and disease biology, chronic disease biology, vaccines and diagnostics, human genetics and genome analysis, stem cell research and regenerative medicines.
    - While different fields of operation include **Pharmacogenomics-** helps to analyse how genetic mark-up affects individual's response to drugs, **gene therapy**- involves correction of a genetic disorder through delivery of a normal gene into the individual or embryo to take over the functions of and compensate for the non-functional gene, etc.
- Crop biotechnology is being used in two major **ways to enhance human nutrition**: to **improve global food security** by making more food available, especially locally grown and familiar foods in the developing world, and by **enhancing the nutritional composition of foods** that would interest both the developed and developing worlds.
- **Bioenergy** – These fuels are **derived from living organisms** such as plants and their by-products, microbes or animal waste. Fuels such as bioethanol and biodiesel are being used presently.
- **Bioresources and Environment** – Under this branch various means of research is utilized to develop microbial technologies for environmental improvement, sustainable processes of commercial interests, accelerated R&D using modern tools of biosciences etc.
    - **Bioremediation** is one such application under which waste management techniques are developed in which microorganisms (bacteria, fungi etc.), plant or biological enzymes are used to consume and break down environmental pollution. E.g. Oil Zappers
- **Animal Biotechnology** – Under this technology 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.
- **Marine Biotechnology** –
    - Under this technology development of diagnostics and vaccines is carried along with development of new feed, fish nutrition, breeding and reproduction etc.
    - Government had also launched Aquaculture & Marine Biotechnology program during 1988-89 to support R&D and demonstrate nature projects towards development of useful products and process from the marine resources.

Biotechnology Sector in India

- Biotechnology is one of the sunrise sectors in India. 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.
- India is a world leader in biotechnology sector as it holds about 2% of the global share of Biotech Industry. It is among the 12 top biotech destinations in the world and ranks third in Asia Pacific region.
- Biotech Sector in India is highly dominated by Pharmaceutical Sector which accounts for about 60% of revenues.

Challenges in Biotechnology Sector in India

- **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.
- **Specialised Human Resources** - There is a need for development of specialised human resources along with increasing the number and quality of jobs offered by this sector.
- There is **lack of early stage funding** in the biotech sector.
- **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.
- **Collection and Integration of Data** - Life sciences researchers face the problems of bringing various data together and further integrate the data for using the different technologies.
- **Competitive Edge** - India is also losing its competitive edge over China and Japan due to regulatory and infrastructural challenges.
- **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 since 2008.
- **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.

Government Initiatives

Government has laid down various policies and legislations to support Biotechnology Sector in India as mentioned below:

National Biotechnology Development Strategy 2015-2020 (NBDS)

- **DBT** had earlier announced the First National Biotechnology Development strategy in September 2007 which provided an insight into the enormous opportunities.
- After this, NBDS was launched on December 2015 with an aim to establish India as a world class bio manufacturing hub.
- It intends to launch a major mission, backed with **significant investment**s for the creation of new biotech products, create a **strong infrastructure for R&D** and commercialization and empower India's human.
- 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.
- **Key Elements of NDBS** are to revitalize the knowledge environment at par with the growing bio-economy, focus of biotechnology tools for inclusive development etc.
- **Strategy –**
  - To build a skilled workforce and improve research facilities in basic, disciplinary and interdisciplinary streams of scientific studies.
  - Nurturing innovation, translational capacity and entrepreneurship.
  - Ensuring a transparent, efficient and globally best Regulatory system and communication strategy
  - Creating a technology development and translation network across the country with global partnership.
  - Making India ready to meet the challenge of achieving US$100bn by 2025
  - Launching Four Major Missions – Healthcare, Food and Nutrition, Clean Energy and Education

- Strategic and focused investment in building the human capital by creating a Life Sciences and Biotechnology Education Council.

Conclusion

- NBDS would provide the impetus for building indigenous capabilities in health, food and environment. It also lays the foundation for offering research support to biotech industries through launching of major PPP programs and spearheaded new frontiers of biotech research.
- However, there is a need to enhance our own capacity to comply with our commitments and to enable our flow of resources.
- Thus, government initiatives and responsiveness are essential in this regard so that the strategy laid out in the NBDS is met with continued success in Biotechnology sector in India.

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.
  - Deliver 6-10 new products in the next five years and create several dedicated facilities for next generation skills.
  - 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.
- The initial focus will be on Vaccines for HPV, Dengue and biosimilars for cancer, diabetics and rheumatoid arthritis and medical devices and diagnostics.

Guidelines on Similar Biologics: Regulatory Requirements for Marketing Authorisation in India

- These Guidelines have been prepared by Central Drugs Standard Control Organisation and Department of Biotechnology which lays down pathway for a Similar Biologic claiming to be Similar to an already authorised Reference Biologic.
- The guidelines address regulatory pathways regarding manufacturing processes and safety, efficacy and quality aspect for Similar Biologics.
- They also address the pre-market regulatory requirements including comparability exercise for quality, preclinical and clinical studies and post market regulatory requirements.
- They will cover all the stakeholders and will not substitute the rules made under **Drugs& Cosmetics Act, 1940.**

Similar Biologics
A similar biologic product is that which is similar in terms of quality, safety and efficacy to an approved Reference Biological product based on comparability.

Key components

- **Strengthening the pilot-to-market innovation ecosystem** for providing grant funding to support innovation, training, and technology transfer.
- **Accelerating the pilot-to-market process** for specific products to provide grant funding to consortia of private, public, and academic institutions to accelerate the development of low-cost select vaccines, biopharmaceuticals, diagnostics, and medical devices.
- Project management and monitoring and evaluation aims to cover the operating costs incurred
- Biotechnology Industry Research Assistance Council (BIRAC), a public-sector enterprise under Department of Biotechnology (DBT), is the implementing agency of the mission.

Other government initiatives include

- Biotech sector in India has seen a growth of more than 20%, mainly due to increasing investment, outsourcing activities, exports and government's focus on the sector.

- Major Steps taken by government are –
  - **Accelerated clearance** of brownfield and greenfield projects.
  - **100% Foreign Direct Investment** is allowed under automatic route for green pharma and manufacturing medical devices and 74% under automatic route for brownfield projects.
  - Setting up of **national research laboratories**, centre of academic excellence in biosciences.
  - A **Network of Technology Centres and promotion of start-ups** by Small Industries Development Bank of India (SIDBI) have been put in place to promote innovation and entrepreneurship in agro-industry
  - Also, **industry-oriented institution** – Biotechnology Industry Research Assistance Council (BIRAC) has been established, to support biotech start-ups and SMEs through funding and mentoring.
  - The Budget allocation for DBT has been increased by over 65% between 2014-2018 for continued implementation of national biotech strategy.
  - Certain tax exemptions have also been provided to promote the development of the sector.
  - Government launched **National Biopharma Mission** (discussed in the next section) to make India a hub for design and development of novel, affordable and effective biopharmaceutical products such as vaccines etc.
  - There has also been an international collaborative surge through Nobel Prize Series Indian, Foldscope etc.
  - Government also launched various schemes to promote start ups and entrepreneurship such as Student Innovation for Advancement of Research Exploration (SITARE), Encouraging Youth for Undertaking Innovative Research through Vibrant Acceleration (eYuva) etc.
- DBT has also taken following initiatives for North Eastern Region –
  - **Phyto-Pharma Plant Mission -** The mission would work towards conservation and cultivation of endangered and threatened species. Major objectives of the mission are captive cultivation of selected medicinal plants, development of packaging technology and production of safe efficacious phyto-pharmaceutical drugs.
  - **Brahmaputra Biodiversity and Biology Boat (B4) -** Under this program, large boats will be set up in the river which will have a **well-equipped laboratory** along with **cold storage facility** to store samples. It will also have a number of satellite boats and rafts will also venture in the river to collect samples and monitor entire ecosystem.
  - **Human Resource Skilling Programs** launched under this are Twinning R&D Program, Biotechnology Labs in Senior Secondary Schools (BLiSS) Program, Bioinformatics, Biotech Industrial Training Program, DBT e-Library consortium (DeLCON) etc.

Promotion of Biotechnology in North-Eastern Region (NER) of India

- NER is one of the **biodiversity hotspots** of the world. The unique **bio-geographical conditions** of the region provide huge potential to the region for development of agriculture and other activities such as biotechnological research, research in pharmaceuticals etc. thus furthering the economic development of the region.
- In this endeavour to exploit the potential of NER, DBT has been carrying out consistent efforts for biotechnological research and development work which will help to obtain highly profitable patent on endemic species.
- 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. DBT also dedicated 10% of the budget to NER.
- In order to bring a paradigm shift in the development of NER of India and ensure **democratisation of science**, DBT has established a dedicated **'North-Eastern Region Biotechnology Program Management Cell'** to evolve, implement and foster biotechnological research in the NER states.

  - **Infrastructure and Resource binding - Infrastructural support** has been provided by establishment of 126 biotech Hubs at various institutions. Also, **Animal House facility at Regional Medical Research Centre (RMRC), Dibrugarh** has been sanctioned.
  - **DBT** has also launched a **major network programme on chemical ecology of NER** in collaboration with IISc, NCBS, and UAS Bangalore for conservation of delicate ecology of NER.
- Government is also looking to increase its engagement with industry through the following initiatives-
  - **Biotechnology Industry Partnership Program**
    - ✓ It is a government partnership with Industries for support on a cost sharing basis for path-breaking research in frontier futuristic technology areas having major economic potential and making the Indian industry globally competitive.

- ✓ It is focused on IP creation with ownership retained by Indian industry and wherever relevant, by collaborating scientists.

- **Biotechnology Industrial Training Program**
  - ✓ The programme provides industry-specific training to Biotech students for skill development and enhancing their job opportunities in biotech industry.
  - ✓ It has been launched by DBT and is being implemented by Biotech Consortium India Limited.

1.1. GENE THERAPY

Why in news?

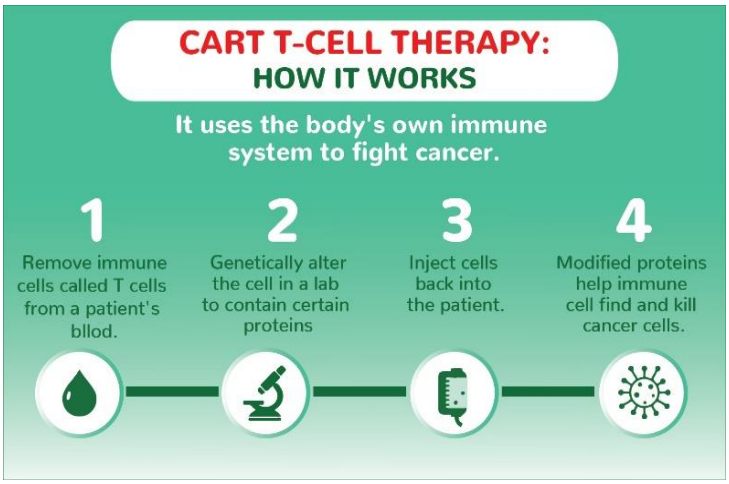
U.S. Food and Drug Administration (USFDA) approved a **Yescarta (axicabtagene ciloleucel) therapy** to treat adults with certain types of large B-Cell lymphoma (blood cancer).

What is Gene Therapy?

- Gene therapy is designed to **introduce genetic material into cells** to compensate for abnormal genes or to make a beneficial protein. Through this technique doctors can treat diseases such as cystic fibrosis, haemophilia, muscular dystrophy, sickle cell anaemia, large B-cell lymphoma etc.
- Human body, as we know, is made up of thousands and thousands of cells which contain genes, making them potential for gene therapy.
- There are of two types of cells – **Somatic Cells and Cells of the germ line**. In theory it is possible to transform either of the cells.
- **Gene therapy using Germ line cells** results in permanent changes that are passed down to subsequent generations.
- It has potential of offering a permanent therapeutic effect for all who inherit the target gene and a successful therapy could eliminate the disease from a family completely.
- **Somatic Cells** are non-reproductive and somatic cell therapy is much safer approach. This is because it affects only targeted cells in the patient and is not passed on to the future generations.
- However, the somatic cell gene therapy is a **short-lived treatment** as the cells of most tissues ultimately die and are replaced by new ones therefore repeated treatments over the life span of individual is required to maintain the therapeutic effect.
- Although this technique is still in its infancy, gene therapy can be achieved by the alteration of an existing gene and includes solutions for diseases. Even though gene therapy is a promising treatment option for a number of diseases but the technique remains risky and still remains largely unregulated.

About Yescarta therapy

- It is a CD19-directed genetically modified autologous T-Cell immunotherapy indicated for the treatment of adult patients with relapsed or refractory large B-cell lymphoma after at least two types of systemic therapy (such as chemotherapy).
- It is a type of gene therapy that turns cells in the patient's body into a "living drug" that targets and kills cancer cells i.e. this therapy is designed to help one's own body to fight against cancer.
- **Limitation –** It is only for adults who have been earlier diagnosed with large B-cell lymphoma (a specific type of non-Hodgkin lymphoma).
- It has been given **Orphan Drug Designation,** under which it will be provided with financial incentives to encourage the development of drugs.
- **Side Effects:** It might **cause Cytokine Release Syndrome (CRS)**, a response to the activation and proliferation of CAR T-cells, which leads to high fever and neurological problems. **Other side effects** include serious infections, low blood cell counts and a weakened immune system.



How does Gene therapy work?

- A gene is not inserted directly, but through a genetically engineered carrier known as vector, also called a **retro virus**.
- The retro-virus can be programmed to carry a gene or a DNA that will overwrite the mutation and correct it.
- The retro-viruses are modified as well so that they do not cause any disease when used in people.

Application of Gene Therapy

- **The four potential levels** of application of genetic engineering for the insertion of a gene into a human being –
  - **Somatic cell gene therapy** - This would result in correcting a genetic defect in the somatic (i.e., body) cells of a patient.
  - **Germ line gene therapy -** This would require the insertion of the gene into the reproductive tissue of the patient in such a way that the disorder in his or her offspring would also be corrected.
  - **Enhancement genetic engineering** - This would involve the insertion of a gene to try to 'enhance' a known characteristic; for example, the placing of an additional growth hormone gene into a normal child.
  - **Eugenic genetic engineering** - This is defined as the attempt to alter or 'improve' complex human traits, each of which is coded by a large number of genes; for example, personality, intelligence, character, formation of body organs, and so on.
- Gene therapy could be used to treat diseases such as cancer, AIDS, Cystic fibrosis, haemophilia B etc.

Living Drug - Genetically modified cells are that are infused back into patients in **CAR T-cell therapy**, continue multiplying to fight disease for months or years. That's why these immunotherapy treatments are called **"living drugs."**
Orphan Drug - A biological product or medicine that is intended to treat diseases so rare that sponsors are reluctant to develop them under usual marketing conditions.

CRISPR-Cas9

- **Genome editing** (also called gene editing) is a group of technologies that give scientists the ability to change an organism's DNA. These technologies allow genetic material to be added, removed, or altered at particular locations in the genome. A recent approach to genome editing is known as **CRISPR-Cas9**, which is short for clustered regularly interspaced short palindromic repeats and CRISPR-associated protein 9.
- It was adapted from a naturally occurring genome editing system in bacteria. It is faster, cheaper, more accurate, and more efficient than other existing genome editing methods.

Germline Editing

- "Germ line" refers to the egg and sperm, which combine to form an embryo. Germline editing is a genome-editing technology that can, in principle, be developed to make specific and targeted genetic alterations in embryos, which will be carried by all the cells of a resulting child and passed on to his/her offspring, a part of the human gene pool.
- By editing the DNA of egg and sperm or the embryo itself, it could be possible to correct disease genes and pass those genetic fixes on to future generations.
- There are various ethical and technical issues involved with germline editing. It can create unforeseen changes in the genome which are undesirable.
- It has also been ethically questioned whether editing gene to create babies that parents desires would make them more like commodities.

Issues with Gene Therapy

- **Short lived nature of gene therapy** - The therapeutic DNA introduced into target cells must remain functional and cells containing the therapeutic DNA must be long-lived and stable. Problems with integrating therapeutic DNA into the genome and the rapidly dividing nature of many cells prevent gene therapy from achieving any long-term benefits. Patients will have to undergo multiple rounds of gene therapy. Moreover, the new gene fails to express itself or the virus does not produce the desired response.
- **Immune response -** Anytime a foreign object is introduced into human tissues, the immune system has evolved to attack the invader. The risk of stimulating the immune system in a way that reduces gene therapy effectiveness is always a possibility. The immune system's enhanced response to invaders makes it difficult for gene therapy to be repeated in patient.
- **Insertional mutagenesis** - The main problem that geneticists are encountering is the virus may target the wrong cells. If the DNA is integrated in the wrong place in the genome, for example in a tumour suppressor gene, it could induce a tumour.
- **Grey areas in treatment** - The treatment of human diseases through gene therapy for solely medical purpose is argued to be correct, however enhancement of human reproductive cells or

altering/improving a normal person by gene manipulation are controversial areas as it may turn mankind into commodity.

- **Other Ethical concerns**
  - Deciding what is normal and what is a disability
  - Deciding whether disabilities are diseases and whether they should be cured
  - Deciding whether searching for a cure demeans the live of people who have disabilities
  - Deciding whether somatic gene therapy is more or less ethical than germ line gene therapy
- **Equal Access to treatment** – The gene therapy at present has high cost and has limited application. The technology at present treats only the rarest of rare diseases which are of little interest to the pharmaceutical industry.
- **Regulating Body** – At present there is no regulating body to keep a check on the practices and applications of the technology. It may therefore lead to reduced transparency, low quality and may also increase the unnecessary delay in the treatment of patients. The Gene therapy technology though is a novel technology; it therefore requires standardization and harmonization.
- **Uncontrolled clinical trials** – There are at present no standard norms for standardisation of norms for clinical trials for checking the efficacy of the treatment.
- **Transfer of diseases** – It is believed that a bit of cytoplasm which is usually transferred along with the pronuclei may transfer unacceptably high numbers of disease carrying mitochondria. Therefore, the technology should be restricted to serious diseases for which there is no effective diagnosis available.

1.2. STEM CELL RESEARCH GUIDELINES 2017

Why in News?

Indian Council of Medical Research (ICMR) released the National Guidelines for Stem Cell Research in 2017.

More on News

- 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.
- **General Principles** - The research on human participants involving cells and tissues derived from human foetus, embryos or any other sources must safeguard human rights, safety, dignity and fundamental freedom. The guidelines thus ensure principle of essentiality, voluntariness, social responsibility, privacy and confidentiality, environmental protection etc.
- **Intellectual Property Rights and Social Responsibility –** Guidelines provide the option of sharing IPR should be provided on the consent form. Thus, it will ensure that the benefits accrued from the commercial use of donated cells are returned to the community.
- **Monitoring and Overseeing –** A National Apex Committee for Stem Cell Research and Therapy

Stem Cells

- They are a class of **undifferentiated cells** that are able to **differentiate into specialized cell types.** Commonly, stem cells come from two main sources: **Embryos (embryonic stem cells)** and **Adult tissue (adult stem cells).** Both are generally characterized by their potency, or potential to differentiate into different cell types.
- For e.g.: Pluripotent stem cells have the ability to **differentiate into almost all cell types**.
- **Induced pluripotent stem (iPS) cells:** iPSCs are body (somatic) cells which have been **reprogrammed to function like embryonic stem cells**, thereby **sidestepping the controversial use of killing the embryos** while harvesting the stem cells. They are capable of forming any cell types of the body.

Significance of Stem Cell Therapy

- 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 offer new potentials for treating diseases such as diabetes, Retinitis pigmentosa, heart diseases, cancer etc.
- To screen new drugs and to develop model systems to study normal growth and identify causes of birth defects.
- Study how an organism develops from a single cell and how healthy cells replace damaged cells in adult organisms.

has been established for monitoring and overseeing activities at the national level and lays guidelines for basic and clinical research.

- **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
  - Any clinical research on Xenogeneic Human hybrids
  - Use of genome modified human embryos, germ-line stem cells or gametes for developmental propagation
  - Research involving implantation of human embryos (generated by any means) after in vitro manipulation, at any stage of development, into uterus in humans or primates;
  - breeding of animals in which any type of human stem cells have been introduced at any stage of development, and are likely to contribute to chimeric gonadal cells.

Significance

- The guidelines are significant due to the fact that the stem cell biology has emerged as an important area of biomedical research with potential applications in developmental biology, disease modelling etc and it requires a sound scientific rationale and also strict adherence to ethical, legal and social issues.
- These guidelines also address the concerns related to use of embryos for creating human embryonic stem cells lines as these may lead to commoditization of human cells and tissues.
- The guidelines set out suitable procedures for handling of pluripotent cells which are now easily available for clinical trials.

1.3. DNA TECHNOLOGY (USE AND APPLICATION) REGULATION BILL 2018

Why in news?

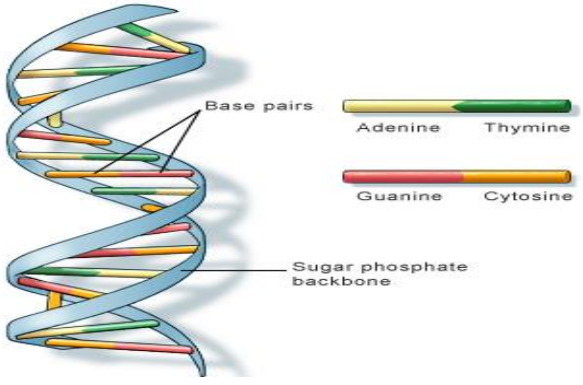
Recently, Cabinet has approved DNA Technology (Use and Application) Regulation Bill, 2018.

About the Bill

- DNA Technology and analysis is an extremely useful and accurate technology in ascertaining the identity of a person from his/her DNA sample, or establishing biological relationships between individuals.
- It is also being increasingly relied upon in investigations of crime, identification of unidentified bodies, or in determining parentage. However, there is greater risk of misuse of the information thus obtained.
- Earlier DNA Profiling Bills were introduced in 2007 and 2015. However, Law Commission Report of July 2017 proposed new amendments which largely modelled the current Bill.
- The Cabinet has thus, recently approved the Regulation Bill whose primary purpose for is expanding the application of DNA-based forensic technologies **to support and strengthen the justice delivery system** and making it speedier and also **increasing the conviction rate** in the country.

What is DNA?

- DNA stands for **Deoxyribonucleic Acid,** a hereditary material in human and almost all the other organisms.
- Most DNA is **located in the cell nucleus** (called nuclear DNA) but some small amount of DNA can be **found in Mitochondria** (called mitochondrion DNA).
- It is composed of two chains which coil around each other to form a **double helix carrying the genetic instructions** used in the growth.
- It is made up of 23 pairs of chromosomes and provides **instructions for building an entire organism and the proteins.**
- The information in DNA is stored as a code made up of four chemical bases: **adenine (A), guanine (G), cytosine (C), and thymine (T)**. Human DNA consists of about 3 billion bases, and more than 99 percent of those bases are the same in all people.
- An important property of DNA is that it can replicate, or make copies of itself. Each strand of DNA in the double helix can serve as a pattern for duplicating the sequence of bases.



- The bill also seeks to ensure **expanded use of this technology** in the country and along with it, it will also be an assurance that the DNA test results are reliable and remain protected from the misuse or abuse thus promoting the privacy.
- It will facilitate cross matching between persons who have been reporting missing and also identifying dead bodies found in various parts of the country.
- The Bill also provides for collection of Samples from the witness to the crime, people looking for their lost relatives etc will have to volunteer in writing to offer their DNA for a specific purpose.
- A Suspect also can deny/ refuse the collection of DNA. If the DNA is considered essential for the investigation, the samples can only be collected only after approval of magistrate.
- **DNA Regulatory Board** – The Board will certify labs authorised to carry out DNA testing, approve the establishment of DNA Data Banks and supervise their functioning and also lay down procedures and guidelines for collection, storing, sharing and deletion of DNA information.

DNA Fingerprinting

- DNA fingerprinting is a chemical test that shows the genetic makeup of a person or other living things.
- It's used as evidence in courts, to identify bodies, track down blood relatives, and to look for cures for disease.
- Blood, bones, hair with root, saliva, semen, teeth, and tissue can also be used to study the DNA.

- **DNA Databank** – A National DNA Databank and regional DNA Databanks will store DNA Profiles from DNA labs in a specified format. It will have various categories of indices such as crime scene index, suspect index etc.
- **Safeguards against misuse** – Disclosure of DNA information to unauthorised person or unauthorised purpose could attract a penal action such as jail upto 1 year and fine upto 1 lakh.
- **Limitations** –
  - The DNA Profile under the bill has a limited scope as it shall only be used for the purpose of **identification of the person** in **criminal cases** in accordance with the rules of admissibility of evidence for the purpose of prosecution or defence and no other purpose.
  - The identity of the person as stated above will be stored under various indices. If the person is not an offender, suspect or under-trail, his/her DNA cannot be matched.
  - Bill provides for taking consent from an arrested person prior to taking DNA information and provides exceptions only for specified offences which have not been elaborated in the bill.

1.4. THREE PARENTS BABY

Why in news?

UK became the first country to have officially approved procedures to create "three-parent" babies.

Mitochondrial DNA

- Some DNA is also found in the mitochondria inside all cells in the body, it is called **mitochondrial DNA (mtDNA).** Mitochondria are structures found within cells that convert the energy form the food into a form that cells can use.
- In addition to energy production mitochondria play several other cellular activities. It helps to regulate the **self-destruction of cells (aptosis),** necessary for production of substances such as cholesterol and heme a component of haemoglobin.
- The mtDNA contains 37 genes, which are essential for normal mitochondrial

Process of MRT

The Process of **Mitochondrial Replacement Therapy** can be done by two methods – **Pronuclear transfer** and **Spindle transfer**.

Pronuclear Transfer –

- In this method, first mother's eggs with abnormal mitochondria and the donated egg with normal mitochondria are fertilised with sperm.
- Then the pronuclei from the normal mitochondria are destroyed and the pronucleus from zygote of the abnormal mitochondria is transferred to the emptied zygote.
- After this procedure the embryo with normal mitochondria and maternal and paternal genome is transferred to the uterus.

Spindle Transfer

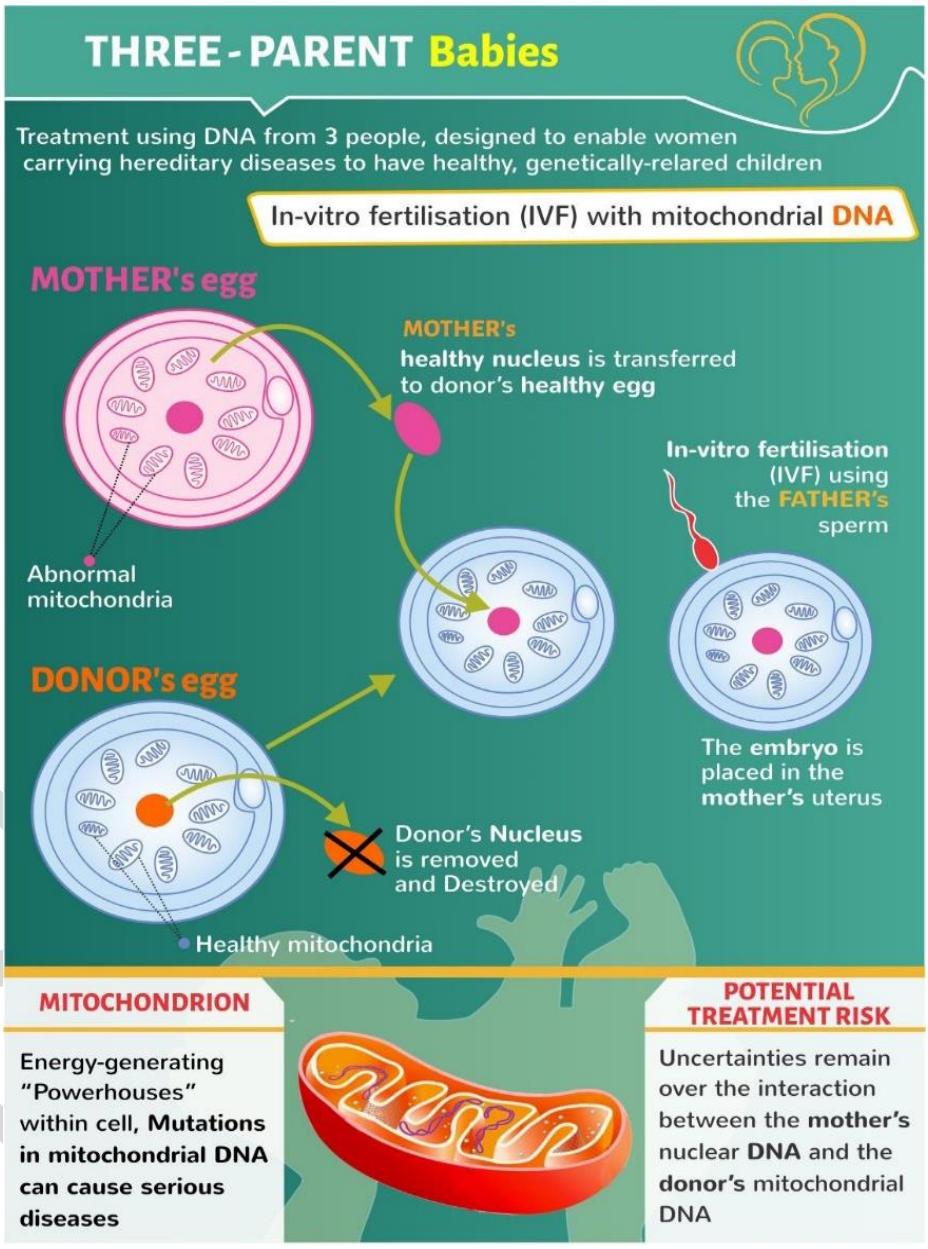
- In this method the spindle and associated chromosomes from the normal mitochondria are removed and destroyed and the spindle and related chromosomes form the mother's eggs/abnormal mitochondria are transferred to the emptied donor egg.
- The reconstituted egg is fertilised with sperm from father and the embryo with normal mitochondria and maternal and paternal genomes is transferred to the uterus.

functioning. This DNA **is inherited from Mother.** It is also useful to trace geographic distribution of **genetic variations**, for investigation of expansions, migration and other pattern of gene flow.

- mtDNA can have mutations that can lead to very serious, debilitating diseases and in some cases infertility for women carrying defective mitochondria.
- Certain disorders caused due to mtDNA dysfunction are diabetes, respiratory disorders, Huntington's disease, Parkinson's disease, Alzheimer's disease etc.

About "three-parent" babies

- **Mitochondrial Replacement therapy (MRT)** is used to **replace mother's faulty Mitochondrial DNA with healthy Mitochondria from a donor woman** during IVF process, thus the name- "three-parent" baby
- The resulting child is still **conceived from two parents** and will have **nuclear DNA from the woman and her partner, and mitochondrial DNA from the donor**.
- The donor's mitochondria contribute **just 37 genes to the child**, compared with more than 20,000 from the parents. That is a **negligible amount** and far less than one would gain from a blood transfusion or organ transplant.
- **No other characteristics** in terms of intelligence, eye colour, hair colour, height etc. are changed.



Issues involved

- **Safety Implications-** Long term evolutionary implications and unintended consequences on the heredity and future generations are unknown.
- **Religious Grounds-** Some groups believe that technologies which manipulate or interfere with human eggs and embryos should not be used. Objections are mostly raised with pro-nuclear transfer technique which involves creating and then destroying a fertilised egg in order to treat another embryo.
- **Ethical Issues**- Parents may misuse the technique to get "genetically modified" or "designer" babies. Thus, it could potentially lead to gender selection and sex discrimination against women in society.
- **Future Health Issues** – It could result in children being at higher risk of cancer and pre-matured ageing and would need to be monitored all their lives.

Way Forward

MRT technique should be developed and administered in a regulated environment such that it can be used to prevent fatal diseases while ensuring that it is not misused and only those who need it get access to it.

1.5. HUMAN GENOME PROJECT-WRITE (HGP-WRITE)

What is HGP?

- It was a large multi-institutional effort that took 13 years (1990-2003) to produce a blueprint of the sequence of genes and spaces between genes that make up a typical human genome.
- The first HGP was called HGP-read while the second was called HGP-write.
- The former aimed to read the human genome while scientists believed that it was necessary to write the DNA sequence in order to understand it and hence HGP-write.

Earth Genome Project (EGP)

- It is an international consortium of scientists which will undertake the project that aims to sequence, catalogue, and characterize the genomes of every eukaryotic biodiversity on Earth over a period of 10 years to sequence 1.5 million species in three phases.
- The EGP project will help to create a detailed genetic sequence and reveal evolutionary connections among genus, orders and families that will make up the Digital Library of life.

Difference between HGP-read & HGP-write

- Human Genome Project-write (HGP-write) is a project in which human genome is synthesized from scratch. It implies that complete set of genes or genetic material present in humans will be written with sophisticated bioengineering tools. The project aims to develop technologies to more efficiently and cheaply write synthetic human genome.
- In the earlier human genome project (HGP-read), certain chemicals and instruments were used to read and decipher human genome. On the other hand, in HGP-write, human genome is built, including making the cell lines. While HGP-read helped scientists and practitioners to understand human gene at fundamental level, HGP-write enables mankind for action at gene level.

Potential Benefits for Indian Healthcare

HGP-write can result into paradigm change in the medical sector. In this context, India's healthcare system can largely benefit from the innovation in the following manner:

- **Communicable disease:** Tools, techniques and technologies that are going to be developed through HGP-write will be universally applicable to all organisms, towards building individual genes and genomes. These will also accelerate vaccine and drug development and provide low cost solutions to diseases like malaria, dengue and chikungunya etc.
- **Non-Communicable diseases:** HGP will help us fight the non-communicable diseases like cancer by constructing specific chromosomes or complex cancer genotypes to more comprehensively model human disease.
- **Organ growth and transplant:** HGP-write has the potential to grow human organs and thus solve the issue of shortage of human donors. It will help in safer organ transplantation as well.
- **Safety and Efficacy:** It will make the treatment less risky. Moreover, it will revolutionize the use of stem cells by using induced pluripotent stem cells (iPSCs) to create an 'Ultra safe' human cell line.

Conclusion

There are ethical (humans playing God) and scientific concerns (concerns about synthetic genes and genomes in the area of intellectual property rights) being raised about the project. However, instead of shying away from this scientific endeavour, India should reap its potential benefits by adopting a transparent regulatory framework and grab opportunities which science does provide.

1.6. ASSISTED REPRODUCTIVE TECHNOLOGY

Why in news?

Recently, Draft Assisted Reproductive Technology (ART) (Regulation) Bill, 2017 was released by Department of Health Research under **Ministry of Health & Family Welfare.**

Assisted Reproduction Technology

ART refers to all techniques that attempt to obtain a pregnancy by **handling the sperm or the egg outside the human body** and transferring the gamete or the embryo into the reproductive tract of a woman.

The technique is used to **treat infertility** and it works by removing eggs from a woman's body. The eggs are then mixed with sperms to make embryo which is then put back into a woman's body. This is called **In Vitro Fertilisation (IVF)** and is most common form of ART.

Surrogacy: Surrogacy is an ART process, where an intending couple commissions a surrogate mother to carry their child.

Need For the Bill

- **Lack of regulation in the ART industry**: Approx. 50% of the IVF cycles performed in India is by unorganized clinics with lack of experience leading to a lot of unethical practices
- **Lack of ART penetration**: Approx. 1% of the total infertile population comes forward for evaluation and less than 40% out of these are prescribed treatment.

About the bill

- **Objective**: The Bill seeks to regulate and supervise the practice of ART services and promote its safe and ethical practice by regulating and supervising ART clinics and ART banks.

Key features of the Draft Bill

- **Setting National and State Board for ART for:**
  - Advising the government on policy matters relating to ART.
  - Reviewing and monitoring the implementation of the Bill.
  - Laying down the code of conduct to be observed by persons working at ART Clinics.
  - Setting the minimum standards of physical infrastructure, laboratories and diagnostic equipment, and expert manpower to be employed by ART clinics and banks
  - Overseeing the performance of various bodies constituted under the bill.

Related Information
Embryo Transfer Technology (ETT)

- It is a technique of **assisted reproduction** in which the **embryo or zygote** is collected from a donor female with **higher genetic merit** and transferred to a recipient who serves as **surrogate** for rest of the pregnancy.
- The technique is being utilised for **development and conservation** of indigenous breeds through following programmes:
  - Rashtriya Gokul Mission;
  - National Mission on Bovine Productivity;
  - National Dairy Plan-I and
  - Breed Improvement Institutes.
- Indigenous Cow Breeds such as **Sahiwal, Gir, Red Sindhi, Ongole, Deoni and Vechur** will be the recipient surrogates under the program.
- **Benefits of ETT**
  - Farmers may get 5-6 times increased number of off springs
  - Calves will be of high genetic merit and born disease free.

- **Setting up a National Registry**:
  - It will be established under the National Board to act as registration authority, central data base of the ART clinics and banks in India
  - The Functions of registry are – registering all the ART Clinics and banks in India and issuing a unique registration of any ART, cancelling registration etc.
- **ART Clinics and banks** established will undertake functions such as obtaining donor gametes, providing professional counselling to commissioning couples about implications of ART procedures etc.
- **Offences and penalties** under the Bill – abandoning or disowning a child born through ART, trading embryo or gametes and using any intermediates to obtain gamete donors.
- Child born will be entitled to all the rights and privileges available to a natural child only from the commissioning couple.
- **Sex selection**: Bill strictly prohibited the pre-determination of child sex.
- Other important provisions include – creation of **Assisted Reproductive Technology of India General Fund,** confidentiality of information etc.

1.7. GM FOODS

Why in news?

FSSAI has issued Draft food Safety and Standards (Labelling and Display) Regulations 2018 wherein it has proposed that all packaged food products containing genetically modified (GM) ingredients must clearly state it on their labels.

Background

- Genetically modified crops are cultivated from seeds that are genetically engineered to increase yields or tolerance to pests. The first GM labelling requirements for food products were introduced by the European Union (EU) in 1997.
- In case of India, a Supreme Court **moratorium** has been in place concerning the cultivation of GM food crops.
- Furthermore, GM food imports require approvals under two laws- the Environment Protection Act of 1986 and the Food Safety and Standards Act of 2006.
- While the EPA, 1986 covers environmental impacts of the food products, the FSSA, 2006 assesses the food's impact on human health.
- There are no regulations in India for GM products till now.

Draft food Safety and Standards (Labelling and Display) Regulations, 2018

- It makes it mandatory to label such food stuffs as "Contains GMO/Ingredients derived from GMO" if such items contain 5% or more GE ingredients.
- It also suggests mandatory declaration by packaged food manufacturers about nutritional information such as calories, total fat, trans fat, sugar and salt per serve on the front of the pack.
- It has also proposed a colour code scheme where food with the high fat, sugar and salt will be coloured 'red' in case the value of energy from total sugar is more than 10% of the total energy provided by the 100 grams or 100 ml of the product. It has similar provisions for trans-fat and sodium content as well.

Food Safety and Standards Authority of India (FSSAI)

- FSSAI, under the **Ministry of Health & Family Welfare**, has been established under Food Safety and Standards Act, 2006.
- It has responsibility of laying down scientific standards for articles of food and to regulate their manufacture, storage, distribution, sale and import to ensure availability of safe and wholesome food for human consumption.

Genetic Engineering Appraisal Committee,

- It functions under the Ministry of Environment, Forest and Climate Change (MoEF&CC)
- It is responsible for appraisal of activities involving large scale use of hazardous microorganisms and recombinants in research and industrial production from the environmental angle.
- It is also responsible for appraisal of proposals relating to release of genetically engineered (GE) organisms and products into the environment including experimental field trials.

Should labelling of GM foods be mandatory?

Arguments in favour	Arguments Against
• Consumers have the **right to know** which products may have GM item as they are already being used in a lot of processed foods. • Labelling is **already mandatory** in 27-member nations of the European Union, Australia, New Zealand, Japan, Korea, Brazil and China. So, India also must follow suit. • GMO technology is **unpredictable, uncontrollable** and may have unforeseeable effects • **Eighty percent of GMOs** are engineered to withstand toxic pesticides and herbicides using neurotoxic chemicals and genes. • GMO crops, with **heavy herbicide use**, destroy the microbiome of the soil, reduce the nutritional content of the food and leave **higher residues of chemicals** on the food.	• The experience in EU and Japan has shown that consumers, retailers and processors shift away from GM ingredients or food products. Thus, mandatory labelling would act as an **import barrier and diverts trade** and may result in GM foods not appearing at retail level at all. • It results in **additional taxpayer costs** due to enforcement and testing. It also amounts to **loss to those consumers** who would otherwise prefer to buy lower-priced GM food products but may not get them due to the shift. • Mandatory labelling makes it is easier for **pressure groups** opposed to genetic modification to **target any product** and launch a negative campaign against the processing firms. • **Voluntary labelling** could achieve less-distorted

• Further GM technology into Indian fields may also lead to the **widespread industrialization of food production.**	results with lower costs and is a superior regulatory solution.

Way Forward

- India needs to establish a **regulatory mechanism for GM foods**. The regulation of GM products may be integrated with other major initiatives undertaken by FSSAI for food safety such as:
  - **Food Safety on Wheels** initiative under which 62 mobile food lab units will be deployed across the country for food testing, public education and awareness and for conducting training and certification programmes.
  - A centralised lab management system called **InFolNet (Indian Food Laboratory Network)** to connect all the government and private food labs.
  - **Food safety index** which will be launched by FSSAI, considering the need for States to have a robust food safety ecosystem**,** to measure their performance on various parameters.
- Along with mandatory labelling of GMOs labels such as **Organic label and Non-GMO label** should also be promoted.

2. NANOTECHNOLOGY

Why in news?

- Recently, a new periodic table for nanomaterials was introduced by the Kyoto University's Institute for integrated Cell-Material Sciences and the Tokyo Institute of Technology.

About Nanotechnology

- Nanotechnology is the development and use of techniques to study physical phenomena and develop new devices and material structures in the physical size range of 1-100 nanometres (nm), where 1 nanometre is equal to one billionth of a meter.
- At this scale the general physical, chemical, electrical, biological and optical properties of a material behave in a different manner and follow the **laws of quantum physics**.
- It is a **multidisciplinary and interdisciplinary area** of enquiry and application. The broad spectrum of the nanotechnology deals with agriculture, energy, electronics, medicines, healthcare, textile etc.

Applications of Nanotechnology

Medical field

- **Disease Diagnosis:** Nano medicine have resulted in formation of Nano scale diagnostic device which are more efficient & able to detect cancer, bacterial and viral infection.
- **Drug Delivery:** Nanotechnology can be used in 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.
- **Cancer Diagnosis and Treatment:** Nanotechnology can locate & eliminate cancer cell using gold Nano cells. Nano cells are targeted to cancer cell by tagging or attaching antibodies to Nano cell surface.
- **Tissue Engineering:** Nanotechnology can help to repair damaged tissue through tissue engineering. It makes use of biodegradable polymer such as polycaprolactone coated with collagen to promote the wound healing process.
- **Medical Nanorobot:** Nanorobotics is a technique of creating machine or robot close to microscopic scale, nanometre. 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.

Defence

- Use in intelligence gathering through difficult to detect sensors/cameras/recording devices.
- Possible supplement to traditional weaponry for close combat situations.
- Precision guiding tools for snipers/others who use fire motor shells.

Agriculture

- 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.
    - Anti-bacterial products such as **nano silver** when used as a materials preserver maintain its ability to reduce odour-causing bacteria longer and require smaller quantities than other silver preservatives.

Issues of Nanotechnology

- **Governance issues** - As nanotechnology is multidisciplinary and interdisciplinary, it has given rise to various issues. Thus, the question here is how particular countries, groups, or actors can facilitate the responsible development of nanotechnology.
- **Health and environmental issues** - Another major challenge that nanotechnology has raised across the world is the potential risk of nanotechnology to human health and the environment due to the size of the nano particles.
- **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.
- **Human Resource issues** - A developing country such as India may struggle to find quality human resource, specially in an emerging field which requires cutting edge research.

- Soil health can be maintained by neutralizing harmful chemical or biological agents. Bio indicators can be used to detect the bio magnification of pesticides and fertilizers.
- Enhancement of agricultural productivity using bio-conjugated nanoparticles (encapsulation) for slow release of nutrients and water
- Use of nanomaterials for preparation of different kind of biosensors, which would be useful in remote sensing devices required for precision farming.
- For controlling pests state-of-the-art nanotechnology has evolved to hassle-free gel-based carriers for pheromones called **nanogels.**

Water treatment and remediation

- Nanomembranes for water purification, desalination and detoxification
- Nanosensors for the detection of contaminants and pathogens
- Nanoporous zeolites, nanoporous polymers, and attapulgite clays for water purification
- Magnetic nanoparticles for water treatment and remediation

Construction

- Nanomolecular structures to make asphalt and concrete more robust to water seepage.
- Heat-resistant nanomaterials to block ultraviolet and infrared radiation.
- Self-cleaning surfaces (e.g., windows, mirrors, toilets) with bioactive coatings.

Energy

- Novel hydrogen storage systems based on carbon nanotubes and other lightweight nanomaterials
- Photovoltaic cells and organic light-emitting devices based on quantum dots.
- Carbon nanotubes in composite film coatings for solar cells.
- Nanocatalysts for hydrogen generation.

Current Status of Nanotechnology in India and its evolution

- India **ranks third** in the number of researches in the field of nanotechnology after China and USA.
- 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.**
- 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.

Nation Mission on Nano Science and Technology (Nano Mission)

- It is an **umbrella programme for capacity building** which envisages the overall development of this field of research in the country and to tap some of its applied potential for nation's development. In brief, the **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 for pursuing studies leading to fundamental understanding of matter that enables control and manipulation at the nanoscale.
  - **Infrastructure Development for Nano Science & Technology Research** – Investigations on the nano scale require expensive equipments. For optimal use of expensive and sophisticated facilities, it is proposed to establish a chain of shared facilities across the country.
  - **Nano Applications and Technology Development Programmes**- To catalyze Applications and Technology Development Programmes leading to products and devices, the Mission proposes to promote application-oriented R&D Projects, establish Nano Applications and Technology Development Centres, Nano-Technology Business Incubators etc. Special effort will be made to involve the industrial sector into nanotechnology R&D directly or through Public Private Partnership (PPP) ventures.
  - **Human Resource Development** – The Mission shall 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. It is planned to launch M.Sc./M.Tech. programmes, create national and overseas post-doctoral fellowships, chairs in universities, etc.

- **International Collaborations** – Apart from exploratory visits of scientists, organization of joint workshops and conferences and joint research projects, it is also 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.

- The Department of Science and Technology is the nodal agency for implementing the Nano Mission.

Draft Guidelines for Safe Handling of Nanomaterials

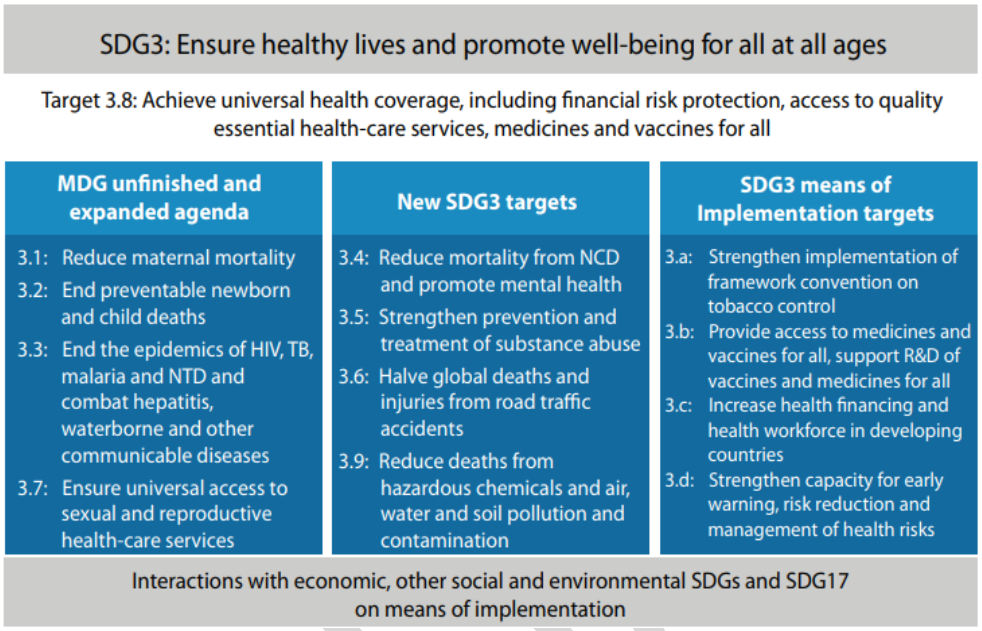
- **Need of the guidelines:** Nanomaterials are promising candidates for a variety of structural and functional applications. However, due to their extremely small dimensions, large surface area and high reactivity, they have the potential ability to penetrate living cells quite readily.
  - Their unique nano-features may also make them potentially hazardous for human health and environmental safety.
  - Currently, evidence regarding the toxic effects of nanomaterials on humans in the scientific and technical literature is insufficient and consequently their risk remains unknown.
- **Objectives of these draft guidelines**
  - **Identifying hazards**: Nanomaterials pose hazards of different degrees. The draft policy has separately outlined the involved hazards.
  - **Best practices for handling nano particles:** The guidelines have clearly intended to make the Nano tech lab a safer place. With the provision for locating emergency equipment, hygiene standards, labelling and signage and cleaning procedures and spill, it can be concluded that Nano tech just like other tech has to be dealt with a word of caution.
  - **Safety practices:** Explosion safety, access control, transportation of nano materials is specifically mentioned that again aims at making nano lab a very safe place.

Nano-Biosensors and Microfluidics for Healthcare Mission

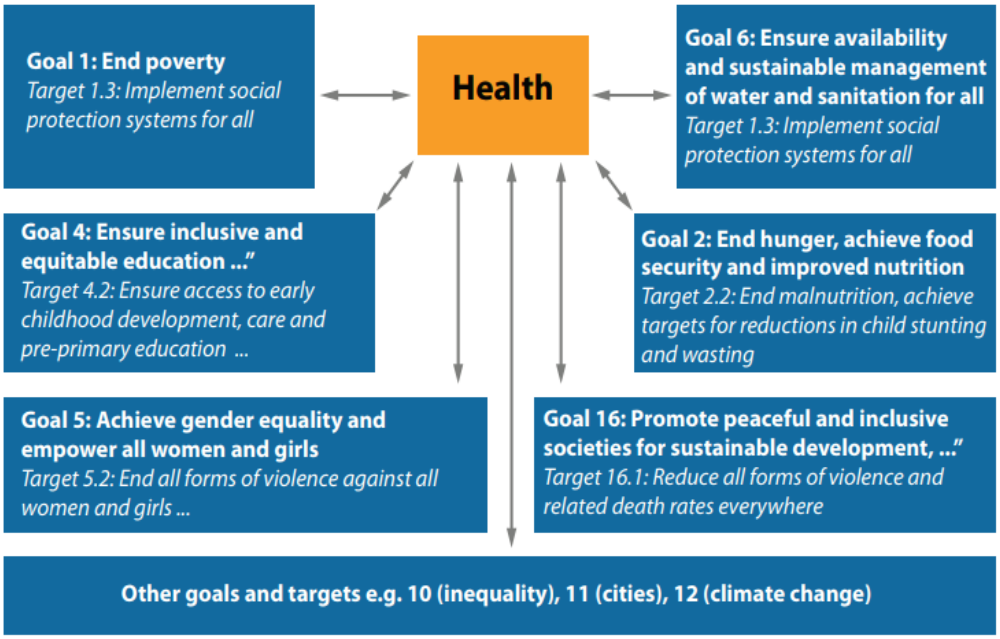
- It aims to use micro/nano-technologies in integration with micro-fluidics for the development of point-of-care, affordable and easy-to-use systems for healthcare applications such as: rapid test card for Typhoid detection, easy-to-use biosensor for detection of dengue virus infections in patient samples, devices for early stage Breast Cancer diagnosis etc.

3. HEALTH

- According to WHO Health refers to a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition.



- Indian Constitution also guarantees free healthcare to all its citizens, however Indian healthcare system suffers from various shortcomings such as high out of pocket expenditure, low government spending in healthcare sector, lack of quality infrastructure and human resources etc.
- The Sustainable Development Goals (SDGs) have also placed health centrally in its 2030 Agenda. The health goal is comprehensive: 'to ensure healthy lives and promote well being for all at all ages.'
- SDGs build up on the success of the Millennium Development Goals.
- SDG3 (on health) includes 13 targets with over 26 indicators covering all major health priorities grouped around the unfinished MDG agenda, new priorities and means of implementation of targets.



- India was ranked 128 in terms achieving Health related SDGs due to low scores on air pollution, sanitation, hepatitis B and child wasting.

Despite the importance accorded to the health sector there are various issues that the country faces in terms of various aspects related to health like-

3.1. ANTIMICROBIAL RESISTANCE

Why in News?

Recently, Ministry of Science and Technology have released the **Scoping Report on Antimicrobial Resistance in India.**

SCOPING REPORT ON ANTIMICROBIAL RESISTANCE IN INDIA – Highlights

- In 2014, India was the highest consumer of antibiotics, followed by China and the United States. However, the per capita consumption of antibiotics in India is much lower than in several other high income countries.
- India has some of the highest antibiotic resistance rates among bacteria that commonly cause infections in the community and healthcare facilities.
- It has also pointed that the resistance to carbapenem class of antibiotics (one of the last-resort antibiotics to treat serious bacterial infections in humans) among various bacteria was extremely high.
- Antibiotic-resistant bacterial infections are also increasingly reported among neonates.

What is Antimicrobial Resistance?

- Antimicrobial resistance is the broader term for resistance in different types of microorganisms which encompasses resistance from antibacterial, antiviral, ant-parasitic and antifungal drugs.
- An antibiotic is a type of drug that kills **or stops the growth of bacteria** such as penicillin and ciprofloxacin. Antibacterial resistance is the **ability of the bacteria to resist the effects of an antibiotic** – that is the bacteria are not killed, and their growth is not stopped. Resistant bacteria **survive exposure** to the antibiotic and **continue to multiply in the body**, potentially causing more harm and spreading to other animals or people.
- Antibiotic resistance occurs naturally, but misuse of antibiotics in humans and animals is accelerating the process. When the microorganisms become resistant to most antimicrobials they are often referred to as "superbugs".
- Some resistant infections may cause severe illness and people with infections may require longer time to recover, tend to incur increased medical expenses and may die from infection.
- It also affects the, medical procedures such as organ transplantation, cancer chemotherapy, major surgeries etc. making them very risky.
- On resistance the physicians have to recommend second or third choice drugs for treatment. But the alternative drugs might be less effective, more toxic, and more expensive. **Preserving the effectiveness of antibiotics** is vital to protecting human and animal health.
- Resistant bacteria also ends up in our food through the animals which are treated with antibiotics.
- Giving antibiotics kills many bacteria but resistant bacteria can survive and multiply. So, when the food animals are slaughtered and processed and these resistant bacteria can contaminate the meat or other animal products. The bacteria can also enter environment through animal excreta.

Superbugs

- They are microorganisms that have be**come resistant to battery of antibiotic drugs** after their prolonged exposure to antibiotics.
- Hence, the **medicines become ineffective** and infections persist in the body, increasing the risk of spread to others.
- **Overuse** (consuming more antibiotic than prescribed) and **Misuse** (taking prescribed antibiotic incorrectly or taking antibiotic to treat viral infection) of antibiotics are the major reason for formation of Superbugs. Human consumption of antibiotic-treated chicken and livestock further increasing resistance.
- Few prominent superbugs highlighted by WHO are MRSA (methicillin-resistant Staphylococcus aureus), Neisseria gonorrhoeae, Klebsiella, E. coli.
- Klebsiella Bacteria has recently developed resistance to a powerful class of antibiotics called carbapenems.
- World Health Organization (WHO) has recently provided a list of twelve "Superbugs" which pose an enormous threat to human health.

Antimicrobial Resistance (AMR) in India

- AMR is a global public health threat but it is nowhere as stark as in India. India has some of the highest antibiotic resistance rate among bacteria that commonly cause infections in the community and healthcare facilities.
- India faces a twin challenge of overconsumption as well as poor and vulnerable access to quality drugs. Another challenge is the lack of knowledge among medical practitioners as well as general public on rational use of antibiotic which aggravates the situation.
- According to WHO, anti-biotic resistance may cause rise in death of Indians to 20 lakhs per year by 2050.

Factors responsible for antibiotic resistance in India

- **Antibiotic Consumption:** Inappropriate consumption of broad spectrum (last resort) of antibiotics is high because of changing prescription practice in healthcare system due to non-availability of narrow spectrum of antibiotics.
- **Social Factor:** such as inappropriate antibiotic use among the general public and formal healthcare providers.
  - **Public:** such as self-medication (to avoid financial burden), access to antibiotics without prescription (left over medicine of any family member), use of pharmacies and informal healthcare providers as sources of healthcare.
  - **Health care providers:** several factors are associated with inappropriate antibiotic prescribing such as:
    - ✓ Doctors may perceive that they are compelled to give antibiotics as patients come with preconceived idea of quick relief.
    - ✓ Pharmaceutical companies put pressure on doctors and pharmacists to prescribe new antibiotics, and in return they receive incentives.
    - ✓ Public sector does not have adequate microbiology diagnostic laboratory services. Unaffordability of private labs and diagnostic uncertainty compels the physicians to prescribe antibiotics.

Global Action Plan on Anti-Microbial Resistance, 2015

- The WHO released it Global Action Plan on Anti-microbial Resistance, 2015. It has the following five objectives:
  - To improve awareness and understanding of antimicrobial resistance.
  - To strengthen surveillance and research.
  - To reduce the incidence of infection.
  - To optimize the use of antimicrobial medicines.
  - To ensure sustainable investment in countering antimicrobial resistance
- WHO has **revised antibiotics protocol** to curb antibiotic resistance. This is the biggest revision of the antibiotics section in the essential medicines list (EML). The new list will help health system planners and doctors ensure that people who need antibiotics have access to them, and they get the right one, so that the problem of resistance doesn't get worse.
- WHO has divided the **drugs into three categories** — access, watch and reserve.
  - The 'access' category includes commonly used antibiotics. They will be available at all times as treatment for a wide range of common infections.
  - The 'watch' group covers antibiotics that are recommended as first or second choice treatment for a small number of infections. Prescription of these drugs should be reduced to avoid further development of resistance.
  - The 'reserve' category includes antibiotics that are considered last-resort options, and used only in the most severe circumstances such as for life-threatening infections due to multidrug-resistant bacteria.

- **Cultural Activities:** The report has highlighted that mass bathing in rivers as part of religious mass gathering occasions associated with potential acquisition and spread of antibiotic-resistant bacteria. For e.g. blaNDM-1 (gene that confers resistance to the carbapenem class of antimicrobial drugs) was found to be over 20 times greater in the Ganges River during pilgrimage season than at other times of year
- **Antibiotics Consumption in Food-Animals:** Use of antibiotics as growth promoters in food animals and poultry is a common practice. With rising incomes and changing dietary patterns leading to an increase in the demand for animal protein, antibiotic use is projected to rise quickly making India the fourth-largest consumer of antibiotics in food animals by 2030.
- **Pharmaceutical industry pollution:** It is estimated that 80% of the antibiotics sold worldwide are manufactured in India and China. The effluents from the antibiotic manufacturing units contain a substantial amount of antibiotics, leading to contamination of rivers and lakes in India.
- **Poor Sanitation:** The large proportion of sewage is disposed untreated into receiving water bodies, leading to gross contamination of rivers with antibiotic residues, antibiotic-resistant organisms.
- **Infection Control Facilities in healthcare:** The prevalence of various healthcare associated infections (HAIs) among Indian hospitals ranges from 11% to 83%, in contrast to the global HAI burden of 7% to 12%.

Policy/Initiatives of Government

- **National Policy for Containment of AMR 2011** envisaged enforcement of regulatory provisions for use of antibiotics for humans as also for veterinary use along with a hospital based surveillance system for monitoring antibiotic resistance.
- The **Drugs and Cosmetic Rule,** 1945 were amended in 2013 to incorporate **a new Schedule H1** for having strict control over the sale of these drugs.

- **FSSAI** has set certain guidelines limiting the antibiotics in food products such as fish and honey.
- **Red Line Campaign on Antibiotics** 2016, was launched to create awareness regarding rational usage and limiting the practice of self-medication of antibiotics among the general public.
- **National Health Policy 2017** envisions a holistic framework against AMR.
- **The National Action Plan on Antimicrobial Resistance (NAP-AMR)** 2017 has assigned coordinated tasks to multiple government agencies involving health, education, environment, and livestock to change prescription practices and consumer behavior and to scale up infection control and antimicrobial surveillance.
    - The strategic objectives of NAP-AMR are aligned with the WHO's Global Action Plan on AMR (GAP-AMR).
    - Six strategic priorities have been identified under the NAP-AMR:

Improve awareness	Strengthen knowledge and evidence through surveillance	Optimize the use of anti-microbial agents
Promote investments, research, and innovations	Reduce the incidence,	Strengthen leadership on AMR through international collaborations

Way forward

- Fragmented approach by various government agencies such as policy action of FSSAI, Ministry of Environment Forest and Climate Change and ministry of health and family welfare need to be aligned and integrated.
- AMR involves multiple stakeholders such as Pharmaceutical Companies, Medical practitioner, patient, etc. One size fit all policy to tackle AMR will not provide intended results in the absence of collective efforts.

3.2. TOBACCO CONSUMPTION

Why in news?

Supreme Court has stayed the Karnataka High Court decision on reducing the size of Pictorial warning on Tobacco products from 85% to 40%.

Tobacco consumption in India

- India is the **second largest consumer** and producer of tobacco-based products.
- Nearly one million tobacco-related deaths take place in India every year. The tobacco related health burden amounts to about one lakh crore rupees and government's earning from tobacco excise duty is only 17 % of health burden.
- High percentage of chewable tobacco used by economically weaker section.
- According to Global Youth Tobacco Survey, in 2009, nearly 15% Children in India in the 13-15 age group used some form of tobacco.
- According to the Global Adult Tobacco Survey 2016-17 62% of cigarette smokers and 54% of bidi smokers had thought of quitting because of the 85% warnings on the packets.
- The health warnings health knowledge about the harms of tobacco, prevent relapse in former smokers and deter youth and adults from initiating use and experimentation.
- Recently the government also asked the Supreme court to classify tobacco as "*res extra commercium*", which is a Latin phrase for "outside commerce"

Tobacco Farming in India

- In India, Tobacco crop is grown in an area of 0.45 M ha (0.27% of the net cultivated area) producing ~ 750 M kg of tobacco leaf. India is the 2nd largest producer and exporter after China and Brazil respectively.
- In the global scenario, Indian tobacco accounts for 10% of the area and 9% of the total production.
- It is grown largely in semi-arid and rain-fed areas where the cultivation of alternative crops is economically unviable.
- The distinctive and positive features of Indian tobacco include the lower levels of heavy metals, very low levels of Tobacco Specific Nitrosamines (TSNAs) and pesticide residues compared to the other tobacco producing countries in the world.
- Further, endowed with varied agro-climatic conditions, India has the capacity to produce different styles of tobacco ranging from coloury neutral filler to flavourful leaf catering to the needs of a wide variety of customers globally. In addition, production and processing costs of tobacco are also quite low in India, thus making the Indian tobacco price-competitive and value for money.

- **Tobacco labelling rules** have been consistently challenged by industry. This move is part of the government's effort to regulate the tobacco companies looking to challenge tough regulations pertaining to the industry.

Impact of Tobacco

- **On Health: Biological-** It causes Non-communicable diseases (NCDs) like ischemic heart diseases, cancers, diabetes, and chronic respiratory diseases.
  - **Psychological:** Low emotional stability and risk taking behavior are more common in tobacco users. Existence of some mental disorders also increases the risk of tobacco use.
- **Effects on New born:** Maternal tobacco use during pregnancy and exposure of child to second hand smoke in childhood is known to be a risk factor for various conditions like increased risk of allergies, high BP in childhood, increased likelihood of obesity, stunted growth, poor lung function, etc.
- **Social and Environmental:** Parental influence, lower education status, attraction towards role models, cultural practices, etc.
- **On Wealth:** The total costs attributable to tobacco use as on 2011 was estimated to be 12% more than the combined state and central government expenditure on healthcare in that year, and 1.16% of India's GDP.

Measures to control tobacco consumption

- **Cigarettes and other Tobacco Products (Packaging and Labelling Rules) amendment rule 2017.**
  - It was mandated that "the specified health warning shall cover at least eighty-five per cent (85%) of the principal display area of the package.
  - Sixty per cent (60%) shall cover pictorial health warning and twenty-five per cent (25%) shall cover textual health warning.
- India had ratified WHO the **Framework Convention on Tobacco Control (WHO FCTC) in** 2004.
- MPOWER- (**a policy package intended to reduce the demand of Tobacco)** initiative of WHO is being implemented in India.
- **National Tobacco Control Programme -** for greater awareness about the harmful effects of tobacco use and tobacco control law.
- **National Tobacco Control Cell (NTCC)** nodal agency for overall policy formulation, planning, monitoring and evaluation of the different activities.
- **The Cable Television Networks (Amendment) Act 2000:** prohibited tobacco advertising in state controlled electronic media and publications including cable television.
- **Cigarettes and Other Tobacco Products (Production Supply and distribution) act 2003**: prohibition of smoking in public places, selling to minors, and ban on sale of tobacco products within 100 yards of all educational institutions.
- Prevention of Food Adulteration Act mandates statutory warnings regarding harmful health effects for paan masala and chewing tobacco.
- **Higher Tax:** Under GST, there will be an additional cess charged on the tobacco-related products, over and above the GST charged at the rate of 28%.

3.2.1. E-CIGARETTES

Why in news?

The government recently quoted a WHO report to state that there is **sufficient evidence** to warn children, adolescents, pregnant women, and women of reproductive age against use of e-cigarettes.

About E-Cigarettes

- E-cigarettes are a type of **Electronic Nicotine Delivery Systems (ENDS)** which **claims to emit nicotine without other harmful chemicals that are present** in normal cigarettes.
- They aim to provide a **similar sensation to inhaling tobacco smoke**, without the smoke and are **sold as aids to reduce or quit smoking**.
- They produce an **aerosol by heating a fluid** that usually **contains nicotine, flavorings, and other chemicals** which is then **inhaled by users of e-cigarettes**.

WHO Report on the Regulation on ENDS recommends to-

- ban the use of ENDS indoors and in public places.
- bring regulations to stop ENDS promotion to non-smokers and protect existing tobacco control efforts.
- Restrict its advertising, promotion and sponsoring.

- Smoking e-cigarettes is also called **vaping.**
- However, **some serious concerns regarding their use** have been highlighted by **WHO**-
  - vaping can **get teens addicted to nicotine** and they can go on to **use other tobacco products.**
  - Nicotine is considered to promote cardiovascular diseases and may also affect the brain development in foetus.
  - No **convincing evidence** proving that e-cigarettes help quit smoking.
  - Smoking e-cigarettes **delivers cancer-causing chemicals** into the body such as formaldehyde.
  - It may function as a **"tumour promoter"** and seems to be involved in the **neuro-degeneration**.
  - May also contribute to **cardiovascular disease**.
  - **Foetal and adolescent nicotine exposure** may have l**ong-term consequences for brain development**, potentially leading to **learning and anxiety disorders.**
- It is **because of above concerns** that **worldwide a need is being felt to regulate the e-cigarettes** just as traditional tobacco products are regulated.

Cigarettes and other Tobacco Products Act 2003

- Section 5 prohibits all forms of advertisements (both direct and indirect) of tobacco products.
- This Act mandates health warnings on the packaging and advertisements of tobacco products.

India's Position

- WHO Global Report 2015 says that number of smokers in India is on the decline.
- As e-cigarettes contain nicotine and not tobacco, these do not fall within the ambit of the COTPA Act 2003.
- Most e-commerce websites sell e-cigarettes as therapeutic products thus increasing appeal.
- A committee in 2014 recommended to ban e-cigarettes having nicotine. Only few states banned it.
- Lack of a uniform approach enables the sellers to exploit loopholes. E.g. Punjab has classified nicotine as a poison, while Maharashtra treats it as an unapproved drug.

3.3. NON-COMMUNICABLE DISEASES

Why in news?

Recently **Report of World Health Organization's (WHO) Independent High-Level Commission on non-communicable diseases (NCD) titled "Time to deliver"** has been released.

Findings of the report

- NCDs and mental disorders currently pose one of the biggest threats to health and development globally, particularly in the developing world. The risk of dying prematurely from an NCD in **a low or lower-middle income country is almost double that in high-income country.**
- NCDs affect the people around the world **at all stages of the life course, from childhood to old age**. Obesity, including in children, is increasing in all countries, with the most rapid rises occurring in low- and middle-income countries.

Steps taken globally

- **The Moscow Declaration** adopted during the First Global Ministerial Conference on Healthy Lifestyles and Non-communicable Disease Control in 2011 stressed on the need of a multi-sectoral approach.
- Member States of WHO have adopted and taken action on a number of interventions such as Global Action Plan for Prevention and Control of NCDs (2013-2020), the WHO Framework Convention on Tobacco Control, the Global Strategy on Diet Physical Activity and Health etc.
- **WHO's Comprehensive Mental Health Action Plan 2013-2020** to strengthen and integrate mental health prevention and prevention services.
- The **WHO Mental Health Atlas** to provide a comprehensive, longitudinal, monitoring of the mental health system performance.
- Adoption of an **Outcome Document at the UN General Assembly** in 2014, which included four time-bound commitments for implementation in 2015 and 2016. The commitments include setting national NCD targets, developing a national plan, reducing risk factors for NCDs and strengthening health systems to respond to NCDs.
- In 2015, a specific NCD target within **SDG target 3.4** was adopted which is a **one-third reduction of premature NCD mortality by 2030** through prevention and treatment of NCDs and the promotion of mental health and well-being.
- In 2017, **the Montevideo Roadmap 2018–2030 on NCDs** as a Sustainable Development Priority was adopted by Member States at the WHO Global Conference on NCDs.
- **25x25 strategy** where Member States agreed to a **25% reduction in premature NCD mortality by 2025.**

- **Most of the premature death is due to four NCDs** —cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes**.** Many other NCDs, such as neurological, skin, genetic disorders, disabilities etc., are closely associated with these four major NCDs.
- Although **the number of premature deaths has risen** in the years 2000 to 2015, **the probability of dying from any one of the four major NCDs is declining** due to
  - A growing younger population **aged 30 to 70 years.**
  - Falling mortality in two categories, **cardiovascular and chronic respiratory diseases**.
- The global rate of decline in NCDs death was 17% between 2000 and 2015. However it is **still not enough to meet the target of a one-third reduction in premature mortality from NCDs by 2030, as specified in SDG target 3.4.**
- There is increasing evidence about **the role of indoor and outdoor air pollution**, with its links to urbanization, in the development of NCDs.
- **Mental disorders:** Depression alone affects 300 million people globally and is the leading cause of disability worldwide. Nearly 800,000 people die from suicide every year. People with severe mental disorders have **a reduced life expectancy of 10 to 20 years**, largely owing to lack of treatment.

Challenges

- **Failure in converting their Commitments:** into legislative and regulatory measures sustained investments, or in financing for NCD programmes consistently. This will have enormous **health, economic, and societal consequences** in all countries.
- **Capacity building:** Many countries do not have the requisite technical expertise, resources, research capacity**,** and data to address NCD challenges
- **Mental disorders are too often not included in basic UHC packages**: It leads to an exceptionally large gap in treatment.
- **Ageing population:** The growing trend of population ageing has enormous ramifications for the prevention and management of NCDs.
- **Vicious cycle of poverty and NCDs:** NCDs and their risk factors worsen poverty, while poverty, isolation, marginalization, and discrimination contribute to rising rates of NCDs, poses a threat to public health and socio-economic development.
- **Other challenges:** Weak health systems, inadequate access, and lack of prevention and health promotion services and evidence-based interventions and medicines are other challenges to each country's path towards UHC in line with its national context and priorities.

Recommendations

- **Leadership and responsibility**: Heads of state and government and not just Ministers of Health should be involved in overseeing while political leaders at all levels should take responsibility for comprehensive local actions.
- **Prioritizing interventions**: within the overall NCD and mental health agenda, based on public health needs. **For e.g. comprehensive tobacco contro**l, comprehensive cardiovascular prevention and treatment programmes etc.
- **Re-orienting health systems**: to ensure that the national UHC public benefit package includes NCD and mental health services, strengthen primary health services to ensure suitable coverage and synergise existing chronic-care platforms to jumpstart NCD and mental health care.
- **Collaborate and regulate:** Governments should increase engagement with the private sector, academia, civil society, and communities, building on a whole-of-society approach to NCDs, and share experiences and challenges, including policy models that work.
- **Finance**: Governments and the international community should develop a new economic paradigm for funding action on NCDs and mental health. The percentage of national budgets allocated to health, health promotion, and essential public health functions should be increased.
- **Strengthen accountability of government to their citizens:** for action on NCDs. Also, WHO should simplify the existing NCD accountability mechanism and establish clear tracking for the highest impact programmes that can lead to achievement of SDG target 3.4.

3.3.1. TRANS FAT

Why in News?

World Health Organization has urged developing nations to eliminate man-made trans fatty acids from their food supplies.

"REPLACE" by WHO

- WHO has released a step by step guide for the industry to eliminate trans fats from the food by 2023.
- The guide, called REPLACE, has **six actions**, which include
  - A review of dietary sources of trans fats,
  - Promoting replacement with healthier fats,
  - Setting up a regulatory framework,
  - Assessing and monitoring trans fats content in food,
  - Creating awareness and
  - Enforcing regulation.

About Trans-Fat

- Also known as Trans Fatty Acids (TFA), they are of 2 types-
  - **Natural Trans-Fat**- Occur naturally in the dairy and some meat products.
  - **Artificial Trans-Fat**- They are created when the oil goes through hydrogenation, which involves adding hydrogen to the liquid oil to make it more solid.
- They help to increase the shelf life of oils and foods and stabilise their flavours.
- In India, Vanaspati, desi ghee, butter and margarine are the main sources of trans fat. Vanaspati is favoured by the industry as it prolongs a food product's shelf life and is cheap.

Perceptible Progress in Developed Countries

- Many developed countries have already eliminated Trans-fat.
- **Denmark was the first country** to restrict industrially-produced trans fats in food and it has witnessed a sharp decline in deaths due to cardiovascular diseases.

Health Hazards due to Trans-Fat

- According to various studies, a 2% increase in energy intake from trans-fat has been associated with a 23 % increase in the **risk of heart disease** and according to another estimate by WHO.
  - Its consumption increases the risk of heart disease by raising the level of **low-density lipoprotein (LDL)**, also known as the "bad" cholesterol and at the same time it reduces the level of **high-density lipoprotein (HDL)** which is the "good" cholesterol.
- They are supposed to be the **main cause of Type-2 Diabetes** and linked to insulin resistance, that is why WHO recommends that no more than one per cent of a person's calories come from trans fats.

FSSAI Recommendation

- The current **permitted level of trans fat** is 5 per cent (by weight) in India. FSSAI has further proposed to limit the maximum amount of trans fat in vegetable oils, vegetable fat and hydrogenated vegetable oil to 2 per cent to make India **trans-fat free by 2022.**
- It had also notified standards on **re-use or reheating of cooking oil** last year, according to which, vegetable oils that have accumulated the total polar compounds (Polar compounds are formed due to oxidation, hydrolysis and some other chemical reactions of oils during frying) of **more than 25 per cent cannot be used**.

3.4. HOSPITAL ACQUIRED INFECTIONS

Why in news?

The **Gorakhpur Tragedy** of 84 children dying in **BRD medical college** followed by various similar incidents has raised serious concerns regarding India's healthcare infrastructure and **hospital acquired infections (HAI).**

International Nosocomial Infection Control Consortium is an international scientific organisation that works to fight against healthcare associated infections.

What are Hospital Acquired Infections?

- Also called **nosocomial infections,** HAI are passed onto the patients after being admitted at the hospital facility.
- It usually goes by unacknowledged unless an epidemic situation such as Gorakhpur tragedy happens.

Current Status in India

- Despite being unacknowledged by the healthcare system in India, it is very much a reality according to a report published by the **International Nosocomial Infection Control Consortium** in 2015.

- Another study published in the **British Medical Journal** indicates that that the burden of healthcare associated infections in countries like India is high, with an estimated pooled prevalence of 15.5 per 100 patients, more than double the prevalence in Europe and the US**.**
- **Inability to improve health outcomes** is one of the reasons that India was not able to achieve the millennium development goal of "Good well being and Health".
- **India does have guidelines for** patient safety, waste disposal or other standard hospitals procedures. However, they are seldom followed.

Causes of HAI

- **Lack of proper Equipment**: This includes both **clinical and non-clinical equipments** such as oxygen cylinders in the case of Gorakhpur Tragedy. This **leads to inappropriate methods of treatments** such as putting two infants in the same incubators. According to **a CAG (Comptroller and Auditor General)**, there is 27.21% shortage for clinical equipment and 56.33% for non-clinical equipment,.
- **Poor knowledge and application of basic infection control measures:** This includes absence of sanitisation of the hospital premises such as visitor chair as well as strict rules regarding visitation especially in intensive care units (ICUs).
- **Poor Infrastructure**: Poor infrastructure in general includes proper beddings for patients, separate and disinfected lavatories for visitors and patients.
- **Understaffing and Overcrowding:** This is one of the root causes of non-compliance of the most basic hygiene standards by hospitals.
- **Lack of Procedure:** Lack of standard procedure for dealing with communicable disease patients increases the risk of HAI exponentially.
- **Lack of knowledge of injection and blood transfusion safety:** Lack of proper training for such procedures increases risk of contracting infection such as HIV and Hepatitis B. Moreover, with quackery highly prevalent in India (especially in rural areas), this becomes all the more relevant.
- **Inadequate environmental hygienic and waste disposal mechanisms:** There have been numerous cases of aborted fetuses and hospitals waste being thrown in nearby water bodies. Inadequate waste disposal not only increases chances of HAI but also puts the environment at risk.
- **Absence of local and national guidelines**: Absence of proper guidelines for hospital maintenance, accreditation and laws puts patients at risk.
- **Prolonged and inappropriate use of invasive devices and antibiotics:** Resistant strains have been found in India even for third- and fourth-generation antibiotics like cephalosporin and carbapenem making it difficult to treat patients.
- **Immune-suppression and other severe underlying patient conditions**
- **Insufficient application of standard and isolation procedures**

Implications

- Creates **additional suffering for patients** and comes at a high cost for their families.
- It **increases hospital stays and creates long-term disability**
- **Increases resistance to antimicrobials**
- Increases cost burden for healthcare systems and causes unnecessary deaths.

Way Forward

- **Identification of local determinants –** Hospitals should have a set protocol in order to identify HAI and curb them.
- **Improving reporting and surveillance systems:** Health is a state subject but the government must come forward with a national surveillance plan for HAI.
- **Standard procedures for infection control** must be adhered at both private and public health care centres. Although **ICMR (Indian Council for Medical Research)** does holds workshops for the same but the lack of standardization creates practical difficulties.
- Strict Adherence to standard precautions such as **hand hygiene** by hospital staff
- **Improving staff education and accountability:** Training for dealing with critical care patients must be provided for all hospital staff especially informal healthcare providers such as nurses as quacks. This can help improve case management.

- Quacks must be surveyed and laws must be put in place to avert them from providing treatment that they are not trained for.
- **Awareness campaigns** must be held for patients and their families for **timely reportage of HAIs.**
- **Immunization and vaccination of staff** must be made mandatory for influenza and other communicable diseases.
- Antibiotics must be sold as **prescription drugs only.** India's **Red Line campaign** is a step in this direction
- India has done ample work on the policy front when it comes to tackle antimicrobial resistance. However, what we need to do is to buck up the administrative setup to implement those policies.
- This could be done **through public-private partnerships.** This will also solve the problem of insufficient funding and human resources.
- Hospitals not following standard treatment procedures, waste disposal methods and other protocols must be held accountable and duly fined.
- The **Indian Medical Association** has proposed that all government hospitals too must be accredited from NABH in line with the private hospitals.
- All blood samples collected for blood transfusion must be tested. **Nucleic Acid Test (NAT)** must be mandatory in order to reduce HIV infections. NAT detects HIV infections of 11 days to two weeks while the currently prevalent ELISA detects the infections of 30 to 40 days of six weeks.

3.5. ZOONOTIC DISEASES

Why in news?

Recently, there were several cases of deaths due to 'Nipah' (NiV) virus in Kerala.

Nipah virus

- Nipah virus was first identified in Kampung Sungai **Nipah**, Malaysia in 1998 from where it derives its name.
- The first outbreak in India was reported from Siliguri, West Bengal in 2001.
- The natural host of the virus is the fruit bat but it can also infect pigs or **any domesticated animals.**
- The virus is present in bat urine, faeces, saliva, and birthing fluids which then transmits it to Humans climbing trees or drinking raw palm sap covered in it.
- Transmission of Nipah virus also takes place through **direct contact** with other NiV-infected people.

What are Zoonotic diseases?

- A zoonotic disease is a disease that spreads between animals and people.
- They can be caused by **viruses, bacteria, parasites, and fungi**.
- Important Zoonotic diseases in India are: Nipah virus, avian influenza, rabies, Japanese encephalitis, leptospirosis, Hanta virus, SARS, cysticercosis, anthrax, plague, echinococcosis and schistosomosis, Kyasanur forest disease (KFD) etc.

Why are zoonotic diseases a concern?

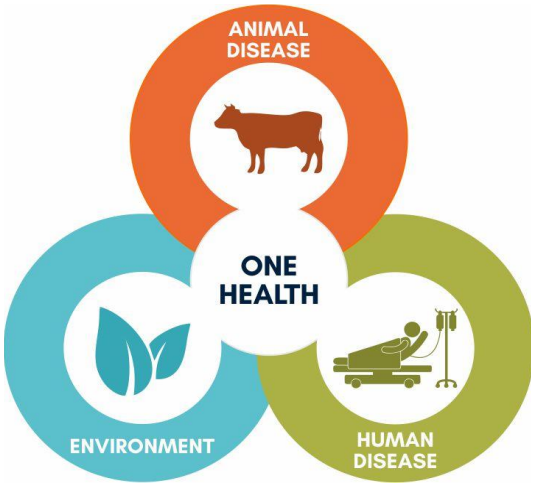
- Over the past 70 years, more than 300 zoonotic diseases have been reported, they result in 75 per cent of all emerging infectious diseases (EIDs) among humans.
- In a globalized world, the mobility of diseases has greatly increased, for example the SARS virus originated in wild animals in China quickly spreading globally.
- Some EIDs have adapted to a human-sustained cycle independent of animals for example, Human immunodeficiency virus (HIV) virus.
- Some carriers of diseases like birds can help in transmitting the diseases across vast distances.
- More than 220 million people in India depend on forestry and are vulnerable due to contact with wild animals but have less economic capacity to fight disease outbreaks like Kyasanur forest disease (KFD).

Why is there an increase in Zoonotic diseases?

- The recent upsurge has often been attributed to the dramatic **increase in population, mobility** and the associated social and environmental changes in the past 70 years.

- **Habitat destruction** forces many species to move towards human settlements for example, In the first outbreak of encephalitis in Malaysia in 1998, fruit bats were displaced from their natural forested habitat due to severe deforestation and fires.
- **Extinction of one species** leads to a cascading effect that may increase the population of reservoir species.
- Forest clearing for **agriculture** leads to expansion of ecotones (transition zones between adjacent ecological systems) and overlapping environment for wild and domesticated animals increasing chances of transmission of diseases.
- The geographic range of many diseases like chikungunya virus (CHIKV) and dengue virus are increasing due to effects of **climate change.**

The One Health Initiative defines One Health as 'the collaborative efforts of **multiple disciplines** working locally, nationally and globally to attain optimal health for **people, animals, plants and our environment'.**



Way forward

- Since, there are no vaccine available for many zoonotic diseases, there needs to be adoption and awareness generation of preventive measures.
- Habitat conservation should be given priority to prevent deforestation and fragmentation of forests.
- Intensification of agriculture and livestock farming near wild animals should be regulated.
- We need to adopt **"one health"** approach particularly to fight zoonotic diseases.

3.6. NEGLECTED TROPICAL DISEASES

About Neglected Tropical Diseases

- Neglected tropical diseases (NTDs)– a diverse group of communicable diseases that prevail in tropical and subtropical conditions in 149 countries – affect more than one billion people and cost developing economies billions of dollars every year.
- Populations living in poverty, without adequate sanitation and in close contact with infectious vectors and domestic animals and livestock are those worst affected. Thus, it prevention and control is a major task.

Issues in fighting NTDs

- **Procurement and supply of anthelminthic medicines-** Anti-NTD medicines fail to satisfy a traditional market mechanism. As a result, there is a huge gap between demand and supply in terms of the quantity and variety of medicines.
  - Investment in research and development should continue in order to identify new anthelminthic medicines that may be used to prevent the possible emergence of drug resistance.
- **Quantification of the burden of neglected tropical diseases among neglected populations**- Within developing countries, NTDs are often restricted to marginalized sections of the population who cannot access formal health services for geographical, social or cultural reasons.
  - The burden of disease among these groups must be quantified and control programmes developed that are culturally appropriate to address their particular needs.
- **Providing treatment and other interventions free of charge to communities in need**- Although the treatment costs per patient for some diseases may be minimal, they are still unaffordable to the poor communities affected by NTDs. Moreover, the total costs of successful delivery can be significant given the large numbers affected by NTDs
  - External support and advocacy are needed to provide the required interventions in a package to communities at risk at no cost, along the lines of childhood immunization.
- **Medicine delivery system for covering the entire at-risk population**- The interruption of transmission through MDA requires high coverage. Often, however, populations at risk are not reached as they live in remote areas or their children do not attend schools.
  - Therefore, in addition to school-based campaigns, specific strategies need to be developed to cover the hard-to-reach populations at risk.

- **Multi-intervention packages**- Due to high distribution cost of the medicines, there is a need to move from a purely disease centred approach to an integrated one, with NTDs grouped together based on similar intervention strategies.
- **Urgent need for diagnostic tools, medicines and pesticides**- Current control strategies for some NTDs that belong to the tool-deficient category rely on imperfect tools. Diagnostic tools, medicines and pesticides are costly and difficult to manage.
    - There is an urgent need to develop simple and safe control tools that can be integrated into health systems in resource-limited settings.
- **Development of more effective medicines and insecticides**- For many vector-borne diseases there are no vaccines, and regular Mass Drug Administration programmes alone may not be sufficient to curb transmission. In such circumstances, vector control often plays a vital role.
    - However, the increasing problem of insecticide resistance with the environmental and health concerns over persistent organic pollutants emphasizes the need for safe insecticides and more effective medicines.
- **Post-implementation surveillance and monitoring**- Surveillance and monitoring of diseases are fundamental for preserving hard-won successes against NTDs. Post-implementation surveillance and constant monitoring activities should be carried out. Interventions need to be sustained over an extended period of time to produce a significant long-term impact and protect new generations from infection.

WASH (water, sanitation and hygiene) & related Issues

Worldwide, at least one billion people are infected with one or more of the 17 NTDs—and two billion more may be at risk of infection. As diseases of poverty, many NTDs occur in areas with limited access to water and sanitation, and where hygiene practices, household infrastructure and health services are limited. Various issues related to WASH are-

- The lack of sustainability of water, sanitation and hygiene interventions is a major obstacle to universal access to WASH.
- Access to clean water, safe sanitation, and effective hygiene remains a persistent challenge with devastating consequences for individuals, economies and the environment.
- Also, we know that a significant portion of existing WASH projects are not managed or implemented in way that guarantees their sustainability and avoids retrogression.
- There are various steps that need to be taken like-
    - Making the achievements of WASH programmes and services sustainable requires a focus on water governance.
    - Accountability is an effective entry point to work with water governance.
    - To achieve an effective governance of water resources and services, decision-makers and service providers need to take responsibility for their decisions and services.

The WASH sector can significantly impact health and development of people living in these areas by targeting WASH activities where these diseases occur at the highest rates and by incorporating into existing hygiene promotion efforts behavior change messages relevant to specific NTDs.

WHO Strategies

To face the issues WHO has formulated following strategies for the prevention, control, elimination and eradication of NTDs-

- **Preventive chemotherapy-** It aims at optimizing the large-scale use of safe, single-dose medicines, currently against four helminthiases/worm infection (lymphatic filariasis, onchocerciasis, schistosomiasis and soiltransmitted helminthiases). Additionally, a key component of the SAFE (Surgery, Antibiotics, Facial cleanliness and Environmental improvement) strategy against trachoma – the large-scale administration of azithromycin – is amenable to close coordination with interventions targeted at helminthiases.
- **Intensified disease management-** This intervention targets complex protozoan and bacterial diseases, such as human African trypanosomiasis, leishmaniasis, Chagas disease and Buruli ulcer.
- **Vector and intermediate host control-** Vector control serves as an important cross-cutting activity aimed at enhancing the impact of preventive chemotherapy and intensified disease management.
- **Veterinary public health at the human–animal interface-** Several of the important neglected tropical diseases are caused by agents originating from or involving vertebrate animals in their life-cycles. An integrated human and animal health approach will improve the prevention and control of neglected zoonotic diseases.
- **Provision of safe water, sanitation and hygiene** – Statistics compiled by the United Nations show that 900 million people lack access to safe drinking-water, and 2500 million live without appropriate

sanitation. There needs to be acceleration of efforts in this direction through concepts like WASH (water, sanitation and hygiene).

India and NTDs

- India experiences the **world's largest absolute burden** of at least 11 major NTDs. Excluding NTDs that are spatially bound by their requirement for unique insect vectors or snail hosts (e.g., schistosomiasis, onchcocerciasis, human African trypanosomiasis, and Chagas disease), India leads the world in terms of the **total number of cases for each** of the major NTDs, as defined by the World Health Organization (WHO).
- Moreover, the high-disease-burden NTDs in India are not evenly distributed, but instead focused in areas of urban and rural poverty.
- Because of the ability of NTDs to reduce worker productivity and child intellectual growth—and ultimately impair India's economy—these diseases deserve further more attention.
- Various steps taken to fight the NTDs in India include-
  - WHO estimates that in 2015, approximately three-quarters of the more than 200 million Indian children that require deworming for their intestinal helminth infections received mass treatment. India also celebrates National Deworming day.
  - India is also achieving a similar level of mass treatment coverage for almost 400 million people who are at risk for lymphatic filariasis (LF), while for years the nation has been committed to multidrug therapy for leprosy (together with rifampicin post-exposure prophylaxis).
  - Through programmes like Swatchh Bharat, Swatchh Vidhyalay government has been trying to implement the ideals of WASH.

Additional opportunities exist to aid India's progress against many other NTDs, especially vector-borne diseases such as leishmaniasis, dengue, and other arbovirus infections. For example, India hosts a sophisticated and extensive network of biotechnology organizations and private companies capable of developing next-generation vaccines, drugs, and diagnostics. Together with increased access to these new technologies, a new vision for public–private partnerships would further reduce its NTD burden and indirectly promote economic development.

3.7. HIV AIDS

- HIV stands for **Human Immunodeficiency Virus**. It is the virus that can lead to acquired immunodeficiency syndrome, or AIDS, if not treated. HIV attacks the body's immune system, specifically the CD4 cells (T cells), which help the immune system fight off infections.
- Untreated, HIV reduces the number of CD4 cells (T cells) in the body, making the person more likely to get other infections or infection-related cancers.
- No effective cure currently exists, but with proper medical care, HIV can be controlled. The medicine used to treat HIV is called **antiretroviral therapy** or ART.
- Without treatment, HIV advances in stages, overwhelming the immune system and getting worse over time. The three stages of HIV infection are: (1) acute HIV infection, (2) clinical latency, and (3) AIDS (acquired immunodeficiency syndrome).

The **National AIDS Control Programme (NACP)**, launched in 1992, is being implemented as a comprehensive programme for prevention and control of HIV/AIDS in India.

NACP-IV Components

Component 1: Intensifying and Consolidating Prevention services with a focus on High-Risk Group (HRG) and vulnerable populations.

Component 2: Expanding IEC services for (a) general population and (b) high risk groups with a focus on behaviour change and demand generation.

Component 3: Comprehensive Care, Support and Treatment.

Component 4: Strengthening institutional capacities.

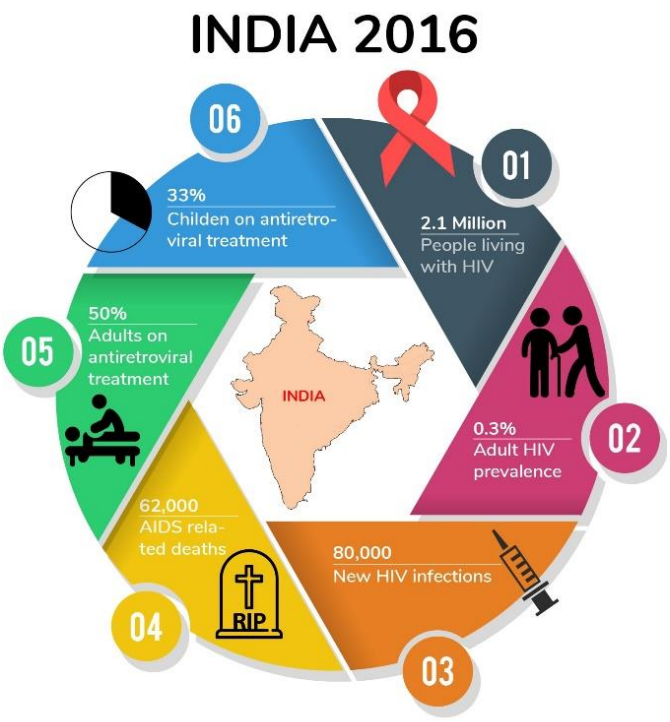
Component 5: Strategic Information Management Systems (SIMS).

HIV AIDS in India

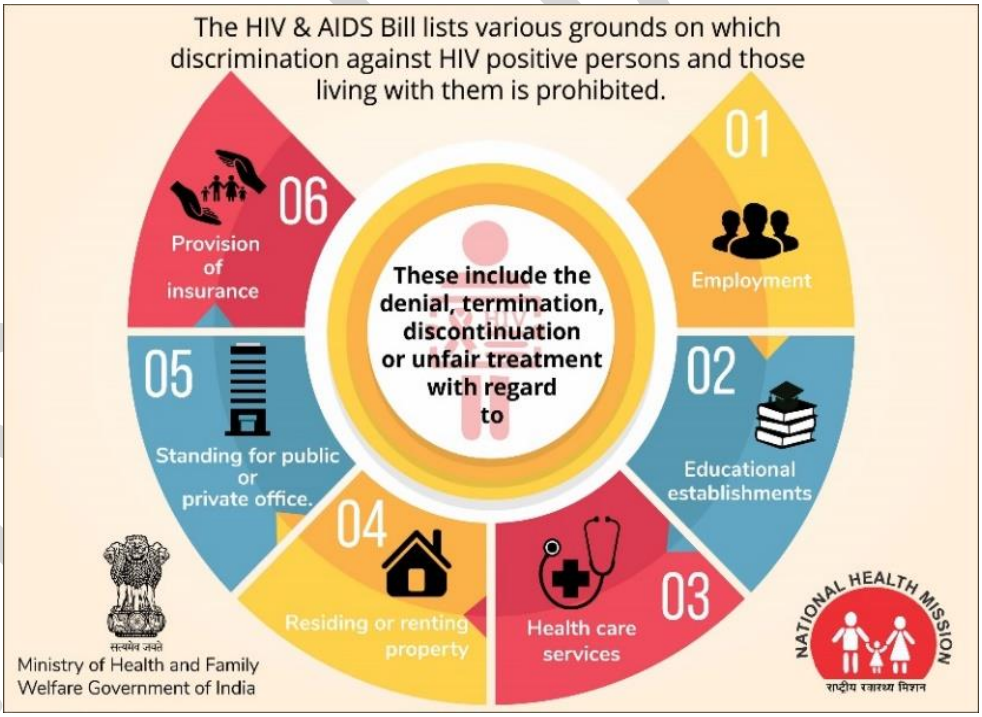
- The first HIV infection in India was detected in India in 1986 while the first AIDS case was identified soon after.
- With HIV prevalence of 0.26% in the adult population, India has an estimated 201 million people living with HIV (2015).
- HIV prevalence is high or 'concentrated' among 'key populations' (KPs) who have unprotected sexual contacts with multiple partners or who engage in injecting drug use. These populations include female

sex workers (FSW), men who have sex with men (MSM), hijra/transgender (TG), people who inject drugs (PWID), long-distance truck drivers and migrants.

- The occurrence of HIV infections also varies across the State/UTs as well as the urban-rural divide.
- In addition, young women at childbearing age are also at higher risk of infection and the source of onward transmission to their infants, during birth, labour and through breast feeding.
- Although there was a 66% decline in new infections from 2000 to 2015, this trend has largely flat-lined between 2010 and 2015.
- There has also been a fall in estimated number of AIDS-related deaths by 54% largely due to increasing coverage of ART, and this together with reductions in new HIV infections, has contributed to stabilising the number of people living with HIV.



Provisions for protection of AIDS patients in India



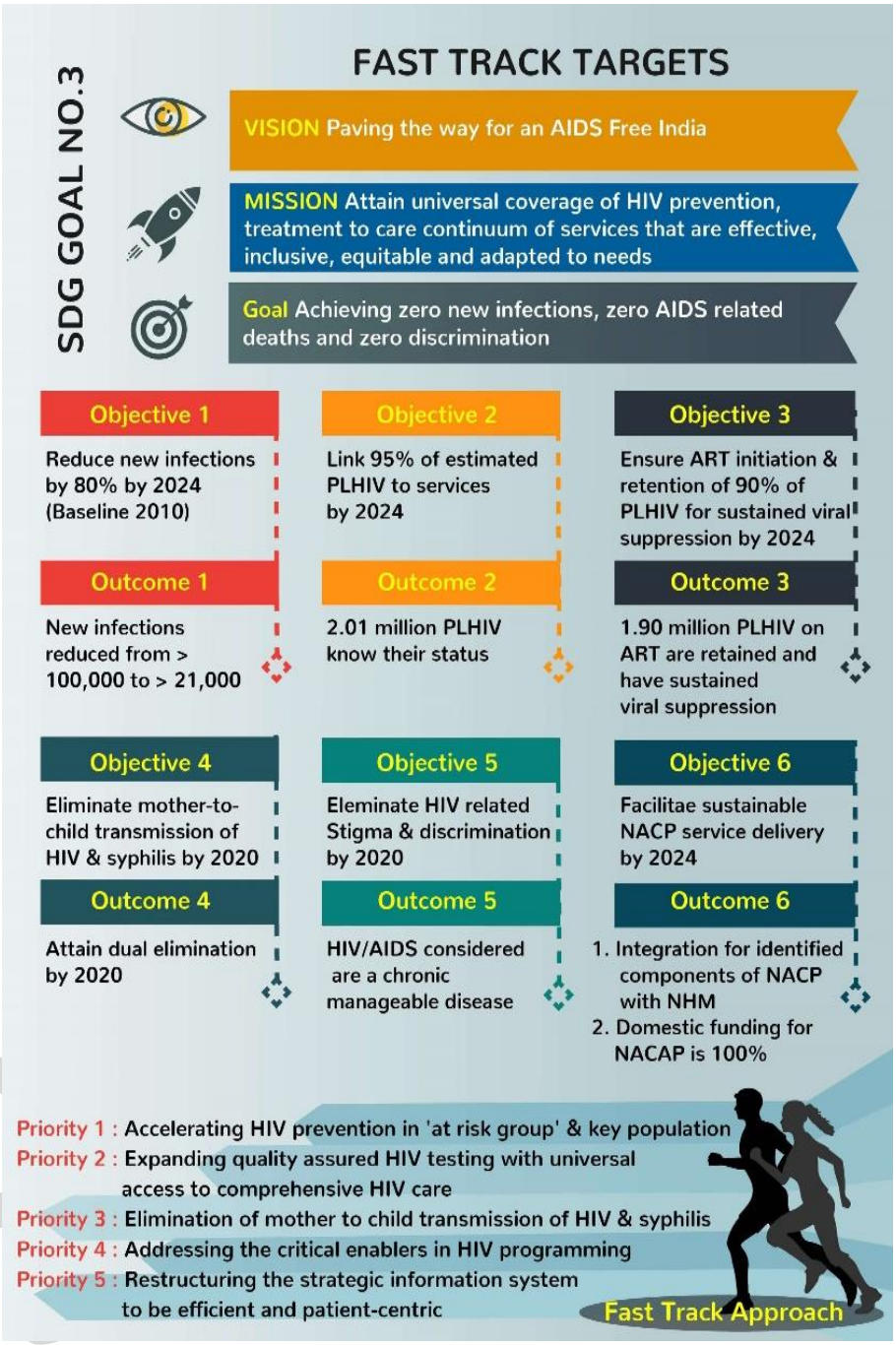
- India is currently in the fourth (since 2012) phase of **National AIDS Control Programme**, launched with two principal objectives-
  - 50% reduction in new infections (using 2007 as baseline)
  - Provision of comprehensive care and support to people living with HIV
- **National AIDS Prevention and Control Policy** (2002, adopted under NACP II)- The main purpose of this policy was to bring in a legal sanction to prevent discrimination of people living with HIV in work and social, medical and financial settings.
- **Indian Medical Council Act, 1956** (Professional Conduct, & Ethics) Regulations, 2002)- It lays down certain duties on the part of doctors towards the HIV/AIDS patients.
- **Immoral Trafficking Prevention Act, 1986**- It provides for conducting compulsory medical examination for detection of HIV/AIDS among the victims of trafficking.
- **HIV/AIDS Prevention and Control Act, 2017-** It criminalises discrimination against people living with HIV/AIDS. Some of its important features are-
  - Provision for appointment of an ombudsman by State/UT Governments to address grievances related to violation of the Act and penal action in case of non-compliance

- Provides an environment for enhancing access to health care services by ensuring informed consent and confidentiality for HIV-related testing, treatment, and clinical research. It also provides ground for penal action for any health care provider, except a physician or a counsellor to disclose the HIV positive status of a person to his or her partner.

- Government has also launched National Strategic Plan 2017-2024 and Mission SAMPARK.

Mother-to-child-transmission

- HIV transmitted from a HIV positive mother to her child during pregnancy, delivery or breast feeding is called mother-to-child transmission (MTCT).
  - **Antiretroviral treatment** for the mother and a short course of antiretroviral drug for the baby.
  - **Counselling and psychological support** to help mothers safeguard their children against the infections.



- The current **WHO comprehensive approach to** prevention of mother to child transmission (PMTCT):
  - Providing lifelong Assistive reproductive technologies (ART) to all pregnant and breast feeding mothers
  - Providing ART to those women during MTCT risk period and the continuing it for lifelong.
  - Preventing new HIV infection among women during childbearing age.
  - Preventing unintended pregnancy among women living with HIV.
- **Steps being taken in India:**
  - Earlier in India, **'Single dose therapy'** was being practised wherein the ART was administered 72 hrs before birth. However, in 2014 WHO recommended 'multidrug therapy' was adopted.
  - **Multidrug Therapy** is a combination of three drugs — tenofovir, lamivudine and efavirenz (TLE) which the infected mother is required to take throughout their lives except nevirapine which is supposed to be taken by new born only for six weeks.
  - In 2002, Prevention of Parent to Child Transmission of HIV/AIDS (PPTCT) program was launched. So far, 20,756 integrated counselling and testing centres have been established under the program.
  - PPTCT program also administers Multidrug Therapy.

3.8. NATIONAL POLICY FOR TREATMENT OF RARE DISEASES

Why in News?

The Ministry of Health and Family Welfare has come up with a "National Policy for treatment of Rare Diseases".

About Rare Diseases

- There is no universally accepted definition of rare diseases and the definitions usually vary across different countries. However, generally rare diseases are defined as a health condition of low prevalence that affects a small number of people compared with 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 population. **80% of rare diseases are genetic in origin** and hence disproportionately impact children.
- These are also called **'orphan diseases'** because drug companies are not interested in adopting them to develop treatments due to low profitability. They usually affect 6%- 8% of the total population in a country.
- The most common rare diseases include Haemophilia, Thalassemia, Sickle-cell Anaemia and Primary Immuno Deficiency in children, auto-immune diseases, Lysosomal storage disorders such as Pompe disease, Hirschsprung disease, Gaucher's disease, Cystic Fibrosis, Hemangiomas and certain forms of muscular dystrophies.
- So far about 450 rare diseases have been recorded in India. **Karnataka** is the first state to release a **Rare Diseases and Orphan Drugs Policy**.

Need for A policy

There is a need for a set policy framework to deal with various aspects related to rare diseases because-

- **National Health Policy**- The National Health Policy 2017 also took cognizance of the situation and talked about the need for management of rare/orphan diseases.
- In India approximately 72 to 96 million people affected by rare diseases. This part of population too has **fundamental right to quality health care**-that is affordable, accessible and compassionate.
- **Not covered under Health Insurance**- Private insurance companies treat genetic disorders as pre-existing conditions and, on that ground, exclude them from coverage. Since most rare diseases are genetic, patients are routinely denied insurance cover.
- **Need a longer time to cure**- Rare diseases are serious, chronic and life-threatening illnesses, often requiring long-term and specialised treatments/management. It's impact on families is often catastrophic in terms of emotional as well as financial burden.

Challenges in fighting Rare Diseases

- Lack of epidemiological data is a major concern.
- Varying definitions and prevalence thresholds across different countries.
- Diagnosis of a rare disease may take many years→ A fundamental challenge in research and development for the majority of rare diseases is that there is relatively little known about the pathophysiology or the natural history of these diseases.
- Rare diseases are difficult to research upon as the patient pool is very small and it often results in inadequate clinical experience.
- Challenges of treatment unavailability also exist:
  - About 95% rare diseases have no approved treatment.
  - Very high cost of treatment.
  - The number of persons suffering from individual rare diseases do not constitute a significant market for drug manufacturers leading to their neglect.
- There is a need to balance priorities of public health as there is a tension between rare and common diseases with regard to budget allocations.

Features of the policy

Government of India had constituted several committees (V. K. Paul Committee, I.C. Verma Committee and Deepak K. Tempe Committee) with the objective to make suggestions towards framing of a 'national policy on treatment of rare diseases'. Based on their suggestions the policy provides immediate and long-term suggestions:

- **Immediate Measures**
  - It calls for arriving at a **definition** of rare diseases suited to India and recommends an **Inter-ministerial Consultative Committee** to coordinate and steer the initiatives of different ministries.
  - It calls for creating a **corpus fund** at Central (an initial amount of Rs. 100 crore towards funding treatment of rare genetic diseases) and State Level (GOI will contribute funds towards the State corpus to the ratio of 60:40). The corpus fund will be dedicated for rare disorders. However, it will not fund treatment for blood disorders (hemophilia, thalassemia and sickle cell anemia) as separate government programs for them are in place.
  - The **Public Sector Undertakings (PSUs) and corporate houses** should be encouraged to make contributions to the corpus via CSR.
  - A **Technical cum Administrative Committee** at Central as well as State levels, for management of corpus funds and developing technical guideline/criteria for - which rare diseases to focus on. Further a **Web-based application** for online application process to access the corpus funds be also created.
  - It calls for creating a patient registry for rare diseases in ICMR.
  - It recommends creating a **Rare Diseases Cell within MoHFW**, Indian Council for Medical Research (ICMR) and Department of Pharmaceuticals in the Ministry of Chemicals and Fertilizers to be the **nodal for the activities** related to rare diseases
  - For patients in the **BPL category** who get diagnosed with rare diseases, it suggests free supportive services available in private and government hospital.
- **Long term measures**
  - Along with systems for **reporting and data collection** it suggests taking measures to **improve research and development**, diagnosis, drug development, etc.
  - In terms of finances, it calls for measures to **control the prices of drugs** for rare diseases and recommends **ensuring insurance coverage** for rare genetic disorders. It seeks **funding support from Public Sector Undertakings** (PSUs) and corporate sector and exploring other options.
  - It suggests allowing import of **Enzyme Replacement Therapies (ERTs)** and remove import duty on them as well as on assistive devices.
  - For **early diagnosis** of rare diseases, it suggests formulating a plan for piloting, and rolling out testing for rare genetic diseases in newborns.
  - It seeks to accredit centres for diagnosis and treatment of rare diseases which can be developed as Centres of Excellence (CoE) over a period of time.
  - As a preventive strategy, it suggests-
    - ✓ To explore a plan for providing pre-conception and antenatal genetic counselling.
    - ✓ Else provide option to parents to prevent conception or birth of a child with a rare genetic-diseases.
  - It calls upon Drug Controller General of India (DCGI) to consider amending Drugs and Cosmetics Act or taking measures for provisioning drugs for rare diseases and facilitating clinical trials and import of ERTs.
- The Policy **segregates the role** of various Ministries and departments with respect to Rare Diseases.

3.9. ACTIVE PHARMACEUTICAL INGREDIENTS

Why in News?

Department of Pharmaceuticals (DoP) seeks support from other government departments to reduce India's dependence on **Active Pharmaceutical Ingredients** (APIs).

Background

- **Bulk drugs or APIs** are the active raw materials used in a drug that give it the therapeutic effect.
- **India's API imports** from top five countries stood at Rs 18,372 crore in 2016-17 with China accounting for 66%.
- **V.M. Katoch committee** was formed to formulate a long-term policy and strategy for promoting domestic manufacture of APIs/bulk drugs in India.

Challenges to API Industry

- **Low profitability** in API business is one of the major reasons for Indian companies to shift their focus to formulation industry.

- **Monetary Policy:** High Interest rates in country at 12% in compare to China where, the interest rate on loan is 5%
- **Stepmotherly Treatment by the Government:** Finished drugs industry are provided with tax-free zones and other concessions while API manufacturers are exposed to **Inverted duty structure**
- **Regulatory bottleneck:** Pharmaceutical firms currently need a lot of clearances to set up a manufacturing plant which has affected country's competitiveness and capability in manufacturing some of APIs.
- **Quality of Imported API:** India's drug regulator **Drug Controller General of India (DCGI)** in January 2018, has banned the import of ingredients of drugs from six major Chinese pharmaceutical firms on quality concern.

Salient features of the recommendations of the Katoch committee:

- Establishment of **Large Manufacturing Zones (LMZs)/ Mega Parks** for APIs.
- Mega Parks need to be provided with common facilities such common Effluent Treatment Plants (ETPs), Testing facilities, Assured power supply, Common Utilities/Services such as storage, testing laboratories, IPR management etc.
- Large manufacturing zones could be set up in National Manufacturing Investment Zones/ petroleum, Chemicals and Petrochemical Investment Regions (**PCPIRs)** in states that have the requisite facilities/system in place.
- The bulk drug industry is one of the **major polluting industries** so it is necessary to have proper rules and regulations to check on the pollution level and the quality of output.
- There is an urgent need to start few large **API intermediate clusters** to transform the nation as one such cluster can bring around one billion dollar per year.
- **Single window clearance** and fiscal and Financial incentives such as tax breaks, soft loans etc. should be made available.

Government effort to promote API in India

- Government has designated 2015 as the **Year of Active Pharmaceutical Ingredients** to make India becomes self-sufficient in the Bulk Drugs.
- It had withdrawal exemption in customs duties which were earlier given to certain categories of drugs and bulk drugs to provide a boost to the domestic manufacturers.
- It has proposed "peak customs duty" for all APIs that can be indigenously manufactured.
- **Department of Commerce** has been asked to check unhindered import of APIs and to put up a system of 'canalisation'.
- **Ministry of Power** has been asked to ensure availability of power at cheaper rates for domestic API manufacturing plants
- **Health Ministry** has been asked to impose higher registration fees on imports and stipulate time-bound requirements for foreign companies, which are exporting active pharmaceutical ingredients to India, to establish their Indian production facilities.

3.10. DIGITAL THERAPEUTICS OR DIGICEUTICALS

Why in news?

America's Food and Drug Administration (FDA) has given its approval to some digital therapeutics.

More about Digital therapeutics

- It can broadly be defined as a treatment or therapy that **utilizes digital and often Internet-based health technologies** to spur changes in patient behavior to treat a medical or psychological condition. It uses methods rooted in **cognitive behavioral therapy** to spur patients to make lifestyle changes.
- It uses methods **rooted in cognitive behavioral therapy** to spur patients to make lifestyle changes. It may compliment or even substitute conventional drugs for treating many conditions ranging from substance abuse to attention deficit hyperactivity syndrome.
- It is often used as a **preventive measure** for patients who are at risk of developing more serious conditions. For instance, a patient with pre-diabetes may be prescribed digital therapeutics as a method to change their diet and behavior.
- It can also be used to treat patients with psychological and neurological disorders. For example, those with Alzheimer's disease or dementia can also receive cognitive behavioral therapy along with reminiscence therapy as a method for reducing confusion and anxiety.

According to WHO, over 61 per cent of all deaths in India are due to lifestyle or non-communicable diseases (NCDs), As a result, this method can be used to manage and prevent numerous conditions such as Type II diabetes, congestive heart failure, obesity, depression etc.

Opportunities offered by digital therapeutics

- It can both **complement the prevalent general treatment methodologies** as well as entirely replace **medication.**
- It can lower the **future medical costs** and become "the third phase" of medicine, i.e. successor to the chemical and protein drugs.
- It would prove more effective in controlling lifestyle diseases, as they **focus on preventive measures**.
- It can also be used to treat patients with psychological and neurological disorders. For example, using **cognitive behavioral therapy** along with reminiscence therapy for treating Alzheimer's disease.
- It is a budding sector that offers **huge return on investment opportunities**.
- It can offer **huge amount of data** vis-à-vis traditional drug companies that do not always track the real world benefits of their drugs post clinical trials. This can provide unprecedented insights into patient behaviour and help invent new effective drugs.

Challenges faced by digital therapeutics

- **Viable business models:** Digital therapeutics are yet to settle upon well-defined business models.
- **Regulatory approval:** Efficacy of these drugs would require evaluation through data from randomised clinical trials. This will require robust governance norms, and may increase cost & hamper speed of innovation.
- **Fast evolution:** They have unprecedented short lifecycle with new version of the same product being launched every year, thus necessitating agile frameworks for regulations as well as payment.
- **Awareness:** Many medical practitioners and patients are unaware of this field.
- **Consumer Adoption:** Consumers haven't yet adopted the habit of considering a digital application as a 'prospective medicine'.

Emerging economy like India, which is said to be pharmacy of the world, can acquire a leadership position in this field. Government should establish a robust, transparent and quick regulatory approval mechanism which should contain clear guidelines on clinical trials of digital therapeutics and smooth certification process.

4. INTELLECTUAL PROPERTY RIGHTS

Why in news?

Recently, Global Innovation Policy Centre (GIPC) of US Chambers of Commerce had released the International Intellectual Property Index (IIPI).

What is Intellectual Property?

- Intellectual Property (IP) 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.

Types of IPR

- **Patent**
  - A patent is granted for an **invention** which is a **new product or process** that meets conditions of **novelty, non-obviousness** 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, ratinalised 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**".

Initiatives taken to promote Intellectual Property Rights

- 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.
- ✓ The National IPR Policy 2016 is completely compliant with the World Trade Organisation's agreement on Trade Related aspects of IPRs (TRIPS).
- ✓ **Department of industrial policy and promotion (DIPP)** will be the nodal agency for all IPR issues and the policy will be renewed every five years in consultation with all the stakeholders.
- ✓ The policy has a special thrust on
  - Awareness generation at school/college level,
  - Effective enforcement of IPRs and
  - Encouragement of IP commercialisation through various incentives
- ✓ 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.
- ✓ According to Section 3(d), besides novelty and inventive step, improvement in therapeutic efficacy is a must for grant of patents when it comes to incremental inventions.
- ✓ The policy will also suggest incentives such as tax benefits and fee waivers to encourage R&D and IP creation to strengthen the

Major Findings of the IIPI 2018

- According to the report USA topped the list with 37.98 points with UK right behind at 37.97 and Sweden at 37.03 points.
- It has been noted in the IIPR index 2018, economies which implement moderate improvement in the IP environment see positive economic and societal outcomes ranging from access to financing and foreign direct investment to higher levels of economic value generation

International Intellectual Property Rights Index on India

- India has been ranked 44 out of 50 countries up from 43 out of 45 in 5th edition.
- India's score has improved from 25% (8.75 out of 35) of total score in 5th edition to 30% (12.03 out of 40) in the sixth edition which is the highest improvement of any country measured.

Cell for IPR Promotion and Management (CIPAM)

- It is a professional body under the aegis of DIPP to ensure focused action on issues related to IPRs to ensure effective implementation of the National IPR Policy.
- It will assist in simplifying and streamlining of IP processes, apart from undertaking steps for furthering IPR awareness, commercialization and enforcement.
- CIPAM is working towards creating public awareness about IPRs in the country, promoting the filing of IPRs through facilitation, providing inventors with a platform to commercialize their IP assets and coordinating the implementation of the National IPR Policy in collaboration with Government Ministries/Departments and other stakeholders.

Scheme for IPR Awareness

- **CIPAM** has launched **'Scheme for IPR Awareness – Creative India; Innovative India'** under the aegis of **DIPP**.
- 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 ecosystem focused on technology and innovation

- Filing of Patents and Trademarks applications has been made online.
- Almost all old Intellectual Property (IP) records have been digitized and new records are digitized immediately.
- 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.
- To encourage for innovation and seek protection for their inventions, a 50 per cent fee reduction has been provided.

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.
- ✓ **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.

- **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.

Conclusion and way forward

- The Policy aims to push IPRs as a marketable financial asset, promote innovation and entrepreneurship, while protecting public interest including ensuring the availability of essential and life-saving drugs at affordable prices.
- The new IPR policy introduced with a slogan of "Creative India, Innovative India" is largely a step in the right direction. However, to obtain the best outcome the challenges and limitations needs to be suitable addressed.

4.1. SECONDARY PATENTS

Why in news?

About 1,700 rejections for pharmaceutical patents at the Indian Patent Office, were applications that sought protection in the form of secondary patents for blockbuster medicines.

About secondary patents

- Secondary Patent refers to the various ways wherein the patent holders attempts to exploit the loopholes in patent laws and related regulatory processes in order to maximize their monopoly especially over bestseller drugs by filing disguised or artful patents on previously patented invention just before the end of the term of parent patents.
- This strategy is most lucrative when employed in the context of so-called **blockbuster medicines**, which reap annual revenues exceeding $1 billion.
- Patent Evergreening promotes **development of unfair means of competition** and related abuse.
- Enhanced IP security may remove the curse of these unfair practices which are widely followed by the innovator companies to create a roadblock for generic companies that are trying hard to provide safe and efficacious medicines to the masses at cost efficient prices.

Innovations in Indian patent law to stop secondary patents/evergreening of patents

- **Section 2(1)(ja) of the Patents Act**, the product in question must feature a technical advance over what came before that's not obvious to a skilled person. Because secondary patents for pharmaceuticals are often sought for trivial variants, they typically fail to qualify as an invention.
- **Section 3(d):** when a medicine is merely a variant of a known substance, Section 3(d) necessitates a demonstration of improvement in its therapeutic efficacy. The provision also bars patents for new uses and new properties of known substances.
- **Section 3(e)** ensures that patents for combinations of known substances are allowed only if there is synergistic effect.
- **Section 3(i)** ensures that no exclusivity can be claimed over methods of treatment.
- These provisions also extend to **biologics**, the new big players in the therapeutics marketplace. Biologics due to their complex structure offers more opportunity in secondary patenting for extending patent terms.
- Together, Sections 3(d), 3(e) and 3(i) have been instrumental in rejecting close to 1,000 secondary patents for pharmaceuticals according to a study.

4.2. TRIPS PLUS

Why in news?

Various developed countries have been advocating for TRIPS Plus provisions in various multilateral platforms.

What is TRIPS Plus?

- Agreement on Trade-Related Aspects of Intellectual Property Rights (or TRIPS Agreement) set the standards for intellectual property protection in the world today. Building upon it, TRIPS-Plus provisions refer to the **stricter and tighter IPR legislations/standards** of protection in their patent laws than are required by the TRIPS Agreement. They extend protection to a **broader array of intangible property** and reduce flexibilities established in TRIPS.
- Since the developed countries own most of the new upcoming technologies, they advocate TRIPS-Plus provisions in order to achieve the following objectives:
  - Stricter patent enforcement and restrictions on compulsory licenses.
  - Anti-circumvention laws to strengthen Digital Rights Management systems.
  - Stronger rights for broadcasters/webcasters.
- The need for TRIPS plus provisions presents justification on the following grounds:
  - Better Research & Development ecosystem as there is a positive correlation between high protection and **R&D**.
  - Stronger IPR's in trade agreements benefits developing countries by creating a favourable business environment that encourages **foreign direct investment** and **technology transfers.**
  - **Protection of traditional knowledge** to further specific development needs.
  - Stricter enforcement of **anti-circumvention and anti-counterfeiting trade laws** for the purpose of establishing international standards for IPRs enforcement.

Analysis

- There is a strong case for developing countries such as India, to **resist moving beyond TRIPS Agreement** as the stronger TRIPS-Plus provisions would:
  - **Increase prices** of medicines, agricultural inputs etc., thus impacting social development.
  - **Reduce competition** by favouring creation of monopolies among generic players impacting industrial growth and exports.
  - **Compromise safety, quality and efficacy** of products, as **data exclusivity** provisions would hamper data usage by the generic manufacturers.
  - **Hinder public access** of technology at affordable prices.
  - **Restrict the application** of compulsory licenses to emergency situations, antitrust remedies, and cases of public non-commercial use.

- Going beyond TRIPS could have a broader impact on IP protection internationally and would result in distortion of trade. Further, to protect its domestic manufactures and pharma-exports, India has tried to stick to TRIPS provisions so far.
- Nowadays, data exclusivity and other TRIPS plus provisions are frequently pushed as a part of free trade agreements between developed and developing countries. For developing countries like India, the best mitigating strategy lies in the combination of multilateralism and networking along the lines of a rights-based approach.

Conclusion

In this context, India should adopt a two-pronged approach. On one hand, it should build consensus for review of TRIPS Agreement under WTO-agenda with a country-specific and context-sensitive approach. On the other hand, it should update the standards of domestic players with a long-term perspective of IPR regimes that are only going to get stricter.

4.3. GEOGRAPHICAL INDICATION

About Geographical Indication

It is a sign used on products that have a specific geographical origin and possess qualities or a reputation that are due to that origin. In order to function as a GI, a sign must identify a product as originating in a given place. In addition, the qualities, characteristics or reputation of the product should be essentially due to the place of origin. Since the qualities depend on the geographical place of production, there is a clear **link between the product and its original place** of production.

How are GI protected

- **Sui Generis Systems** (i.e. special regimes of protection)
- Using Collective Or Certification; and
- Methods focusing on business practices, including administrative product approval schemes.

GI is a **collective right.** Producers can use the collective GI mark to commercially exploit the products.

Geographical Indications of Goods (Registration and Protection) Act, 1999

- As a member of the World Trade Organization (WTO), India enacted the Act to comply with the Agreement on Trade-Related Aspects of Intellectual Property Rights **(TRIPS).**
- GI is covered as element of intellectual property rights (IPRs) under **Paris Convention for Protection of Industrial Property.**
- The Act is administered by the **Controller General of Patents, Designs and Trade Mark**s, who is also the Registrar of Geographical Indications.

Issue with GI provision in India

- **It leans heavily on Document proof:** Proof of origin is a mandatory criterion for registering GIs in India whereas in many parts of India (especially tribal), provision regarding the origin are not written rather they are recited, therefore making it extremely difficult in gathering documentary evidence as proof of origin to get GI tag.
- **It only protects the name or indication**: GI act does not protect knowledge or technology of production, which means that same product can be produced and marketed with other name, defeating the whole purpose of the act.
- **Ambiguity in the definition**: Act does not distinguish between real producer, retailer or dealer. As a result the benefits of the registration may not reach to the real producer.
- **Lack of assessment by group applying for GI** about the commercial prospect of a GI product in the domestic and international markets or the potential of such registration in contributing towards the future growth of the product as well as the socio-economic implication for the communities involved in the supply chain.
- **Other** issues include-
  - **Lack of marketing and branding strategies** has kept the GI products from reaping their true potential in both domestic and export markets.
  - **Lack of academic research** and systematic assessment has hindered benefits accruing from GI protection.
  - **Lack of focus on GI in Make in India campaign** has undermined its scope in soft power expansion.

- **Quality** associated with geographical origin is the hallmark of a GI and the current legal framework lacks teeth to ensure it.

Way Forward

- **Flexibility in rules:** In a particular instance, the GI Registry might consider etymology in establishing proof of origin.
- **Amendment in GI rules** as TRIPS only provides a minimum standard of protection and does not mandate a sui generis mode of protection for GI.
- **Defining clear geographical boundaries** to establish legitimacy of the product.

5. SPACE TECHNOLOGY

5.1. ISRO'S ACHIEVEMENTS

- India's space program has evolved through years with focus on national imperatives, and social and economic well-being of the people.
- **Indian Space Research Organization** aims to harness space technology for national development, while pursuing space science research and planetary exploration.
- ISRO has achieved many accolades for its achievements in space technology as a result of which India today is listed as one of the world leaders in Space Technology.

5.1.1. LAUNCH VEHICLES IN INDIA

- Launchers or launch vehicles are used to carry spacecrafts to space. India has two operational launchers – **Polar Satellite Launch Vehicle (PSLV)** and **Geosynchronous Satellite Launch Vehicles (GSLV)**.
- India's launch vehicles development program began as early as 1970s. The first experimental vehicle being Satellite Launch Vehicle (SLV) which later on was followed by ASLV and others.
- So far, India has made tremendous progress in the field of development of launch vehicles and is elite in the commercial launches across the globe.

PSLV C40

- Recently **PSLV C40** placed 31 satellites including main payload Cartosat-2s series and 28 foreign satellites in two different orbits the "multiple burn technology" under which the rocket's engine is switched off and then switched on to control its height.
- This launch marked the roll out of the 100th satellite by ISRO.
- Earlier in 2017, ISRO launched a record 104 satellite in a single mission using PSLV C-37.

- **Polar Satellite Launch Vehicles (PSLV)**
  - Polar Satellite Launch Vehicle (PSLV) is the third generation launch vehicle of India. It is the first Indian launch vehicle to be equipped with liquid stages.
  - It is capable of launching 1750kg satellite in 620km sun-synchronous transfer orbit (Low-Earth Orbit) and 1050 kg satellite in geosynchronous transfer orbit.
  - PSLV has four stages using solid and liquid propulsion systems alternately. It uses solid rocket motors in the first and third stage and uses liquid rocket engines in second and fourth stage.
  - PSLV has emerged as the reliable and versatile workhorse launch vehicle of India with 39 consecutively successful missions by June 2017. It was also used to launch IRNSS constellations, Chandrayan-1 in 2008 and Mars Orbiter Spacecraft in 2013.
- **Geosynchronous Satellite Launch Vehicle (GSLV)**
  - It is the largest launch vehicle developed in India which is currently being used in India and is the primary payload for communication satellite of around 2500kg mass into the Geostationary Orbit (around 36000km) and geosynchronous transfer orbit (GTO).
  - It is the fourth-generation vehicle which is a three stage vehicle with four liquid strap-on.
  - The first stage comprises of solid booster with four liquid strap-ons, second stage is liquid engine and the third stage is a cryo-stage.
  - **Variants of GSLV –**
    - ✓ GSLV MkI – It was developed for launching around 1500kg into geostationary transfer orbit. The chamber pressure in all liquid engines were enhanced which enabled a higher propellant mass and burn time. This allowed GSLV to carry an additional mass of 300kg of payload.
    - ✓ GSLV MkII – This variant uses an Indian cryogenic engine, CE- 7.5 and is capable of launching 2500kg into geostationary transfer orbit.
    - ✓ **GSLV Mk III**

GSAT – 6A

- Recently, GSAT-6A was launched on board the GSLV F08. Launch marked the **12th flight of Geosynchronous Satellite Launch Vehicle GSLV-F08** and sixth flight with the **indigenous Cryogenic upper stage**.
- GSAT-6A, similar to GSAT-6, is a high-powered **S-band communication** satellite which would help improve mobile communications to handheld devices, as well as network management techniques useful in satellite-based mobile communication applications.
- ISRO **lost contact with its communication satellite** GSAT-6A.
- ISRO will launch GSAT-32 satellite in October 2019 to replace GSAT-6A.

- It is the **heaviest rocket** to be launched from India till now. It can lift payloads of up to 4000 kg to Geosynchronous Transfer Orbit and 10000 kg into the Low Earth Orbit which is about twice the capability of GSLV Mk II.
- It is a three-stage vehicle with an **indigenous cryogenic upper stage engine (C25)**. It has been designed to carry heavier communication satellites into the Geosynchronous Transfer Orbit. A Cryogenic rocket stage is more efficient and provides more thrust for every kilogram of propellant it burns compared to solid and earth-storable liquid propellant rocket stages. It uses liquid oxygen and liquid hydrogen as propellants.
- Apart from the upper cryogenic stage, the vehicle has **two solid strap-on motors (S200) and a core liquid booster (L110)**.
- The first experimental flight of LVM3, the LVM3-X/CARE mission using GSLV MkIII lifted off from Sriharikota on December 18, 2014 and successfully tested the atmospheric phase of flight. Crew module Atmospheric Re-entry Experiment was also carried out in this flight.
- The first development flight of GSLV Mk III, the GSLV D1 successfully placed GSAT-19 satellite to a Geosynchronous Transfer Orbit (GTO) in 2017.

LVM3-X/CARE Mission

- It is the first experimental suborbital flight of India's latest generation Launch Vehicle- LVM3, which lifted off from Satish Dhawan Space Centre SHAR and injected the Crew Module CARE at an altitude of 126km.
- The CARE module will test the ability of the module to re-enter the Earth's atmosphere with thermal resistance, parachute deployment in cluster formation, aero braking system and apex cover separation procedures.
- It will help ISRO design the life-support systems to actually fly the astronauts into space.

✓ **Significance GSLV Mk III**

- It would **save foreign exchange reserves** of the government as presently the heavier Indian communication satellites are launched from the French Guinea.
- It would also be a foreign exchange earner with foreign customers using the services of GSLV MK III provided by ISRO.
- It would also act as a carrier to **travel people/astronauts into space**.
- **It would boost India's communication resources** given the fact that there has been a boom of the communication industry in India and there is a high demand for transponders in space related to it.
- The indigenous components of the rocket would help India to become **self-reliant** in terms of technology. The indigenous batteries developed can also be used to **power electric vehicles in India**.
- The cost of launches would also be reduced because of introduction of the cryogenic engine.

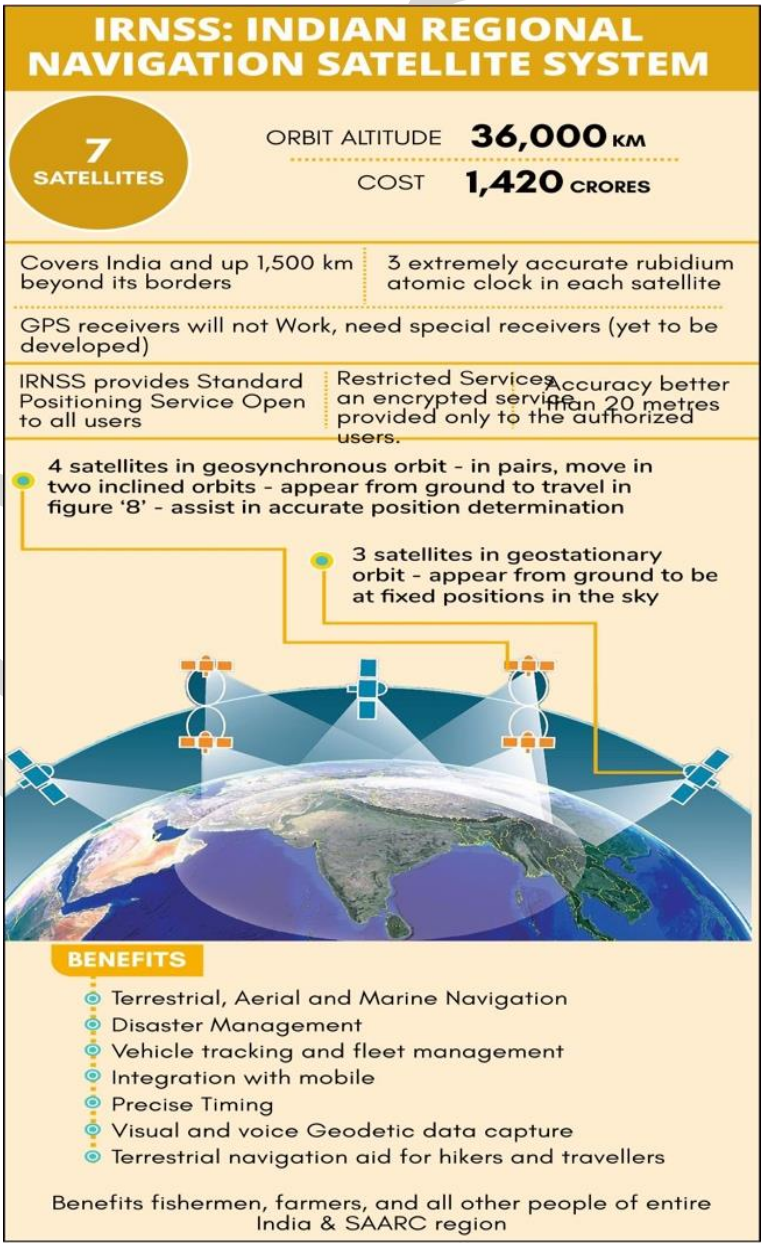
- **Reusable Launch Vehicle – Technology Demonstrator (RLV-TD)**
  - RLV-TD was successfully flight tested in 2016 validating the critical technologies such as autonomous navigation, guidance & control, reusable thermal protection system and re-entry mission management.
  - The launching of 2 ton class of communication satellite by Geosynchronous Satellite Launch Vehicle (GSLV) to Geosynchronous Transfer Orbit (GTO) costs Rs 173 crore. This cost could be significantly reduced if a completely reusable launch vehicle is built.
- **Scramjet Engine – TD**
  - The first experimental mission of ISRO's Scramjet Engine towards the realisation of an Air Breathing Propulsion System was successfully conducted in 2016.
  - It uses Hydrogen as fuel and the Oxygen from the atmospheric air as the oxidiser. Scramjets are efficient only at supersonic speed.
  - Other countries such as USA, Russia, India and China have successfully developed scramjet technologies.
  - **Significance** –
    - The fact that scramjet uses **atmospheric oxygen** to burn the fuel in the first phase will considerably reduce the amount of oxidiser to be carried aboard.
    - This in turn will **reduce cost-to payload ratio**.
    - Scramjet also has many other applications in cruise and other missiles.

- **Sounding Rockets**
  - They are one or two stage solid propellant rockets with a payload of 60kg and altitude capacity of 160 km, used for probing the upper atmospheric regions and for space research.
  - They take their name from the nautical term "to sound," which means to take measurements.
  - They also serve as easily affordable platforms to test or prove prototypes of new components or subsystems intended for use in launch vehicles and satellites.
  - Recently, Vikram Sarabhai Space Centre (IRSO) successfully launched RH-300 MKII Sounding Rocket from Thumba Equatorial Rocket Launch.
  - Objective - is to measure neutral wind in the dynamo region (80-120 km) of equatorial ionosphere using the indigenously developed Electron Density and Neutral Wind Probe (ENWi) and perform cross-validation using an independent Tri Methyl Aluminium (TMA) release technique.

5.1.2. Indian Regional Navigation Satellite System (NavIC)

Why in news?

ISRO launched the IRNSS-1I satellite from Satish Dhawan Space Centre, Sriharikota, through its PSLV-C41.



Benefits of NavIC:

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

Significance

- NAVIC's operational launch can result in healthy competition between various navigation services, and potentially significant revenues for the country.
- India can combine NAVIC with GAGAN—its indigenous augmentation system—to service users on differential rates depending on the navigational precision they seek.
- Global navigation system bolsters the ability of a nation to serve as a net security provider, especially through the guarantee of such assurance policies. The US equivalent, Global Positioning System (GPS), played a significant role in relief efforts post disasters such as the tsunami in the Indian Ocean region in 2004 and the Pakistan-India earthquake in 2005.
- Through land-area mapping, yield monitoring and precision-planting of crops, NAVIC allows for the development of civic capabilities in food and livelihood security.
- NAVIC should also propel technological innovations and spin-offs that render India progressively less reliant on technological imports from the West and elsewhere.

GPS Aided Geo Augmentation System (GAGAN)

- It is a step taken towards Satellite based Navigation Services in India. It is a system to improve the accuracy of a global navigation satellite system (GNSS) receiver by providing reference signals.
- **ISRO** and **Airports Authority of India (AAI)** have implemented GAGAN project as a **Satellite Based Augmentation System (SBAS)** for the Indian Airspace.
- The objective of GAGAN to establish, deploy and certify satellite based augmentation system for safety-of-life civil aviation applications in India has been successfully completed.
- The system is inter-operable with other international SBAS systems like US-WAAS, European EGNOS, and Japanese MSAS etc. GAGAN GEO footprint extends from Africa to Australia and has expansion capability for seamless navigation services across the region.
- GAGAN provides the additional accuracy, availability, and integrity necessary for all phases of flight, from en-route through approach for all qualified airports within the GAGAN service volume.
- GAGAN Payload is already operational through GSAT-**8, GSAT-10 and GSAT-15** satellites.
- GAGAN though primarily meant for aviation, will provide benefits beyond aviation to many other user segments such as intelligent transportation, maritime, highways, railways, surveying, geodesy, security agencies, telecom industry, personal users of position location applications etc.

5.1.3. EXTRATERRESTRIAL MISSIONS

5.1.3.1. CHANDRAYAAN-1

Why in news?

Scientists from Brown University, USA have created the first map of water trapped in the uppermost layer of Moon's soil using the data captured by instrument on Chandrayan-1.

More on news

- Scientists have stated that the water thus detected by the Chandrayan-1 lunar mission mostly concentrated around the polar region is present everywhere and not just polar region.
- It was also found that the concentration of water changes over the course of Lunar Day at latitudes lower than 60 degrees i.e. wetter in morning and evening and dry during lunar noon with fluctuations up-to 200ppm.

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 using HySi and TMC.
- **Evidences of landing site of Apollo 15 and 17** – TMC found the anomalies in Lunar surface about the landing of USA's Apollo-15 and 17.
- **New Spinel-rich Rock –** Data from TMC, HySI, M3 and SIR2 have led to detection of new spinel-rich rock type on lunar far-side.
- **X-Ray signals detected–** C1XS have detected x-ray signals during weak solar flares thus indicating presence of **magnesium, aluminium, silicon and calcium on lunar surface.**

About Chandrayan-1

- **Chandrayan-1** was launched by India in October, 2009 using **PSLV-C11.**
- The primary objective of the mission was to prepare a three-dimensional atlas of both near and far side of the moon and chemical, mineralogical and photo-geological mapping of moon.
- It had made almost 3400orbits around the moon before it lost contact with Earth in 2009.
- Chandrayaan-1 had payloads from India namely:
  - Terrain Mapping Camera (TMC)
  - Hyper Spectral Imager (HySI)
  - Lunar Laser Ranging Instrument (LLRI)
  - High Energy X-Ray Spectrometer (HEX)
  - Moon Impact Probe (MIP)

Chandrayaan 2

- It is India's second mission to the Moon and is a totally indigenous mission comprising of an Orbiter, Lander and Rover.

- The mission will carry a six-wheeled Rover which will move around the landing site in semi-autonomous mode as decided by the ground commands. The instruments on the rover will observe the lunar surface and send back data, which will be useful for analysis of the lunar soil.
- The Chandrayaan-2 weighing around 3290 kg and would orbit around the moon and perform the objectives of remote sensing the moon. The payloads will collect scientific information on lunar topography, mineralogy, elemental abundance, lunar exosphere and signatures of hydroxyl and water-ice.
- **GSLV-F10/Chandrayaan-2 Mission** is planned during second half of 2018. The lander on the Chandrayaan-2 mission, will be named 'Vikram' after **Vikram Sarabhai.**

Contribution of Vikram Sarabhai

- Vikram Sarabhai was considered as the **Father of Indian space programme**.
- He was the **first chairman of the Indian National Committee for Space Research** (INCOSPAR) setup in 1962, which was restructured and renamed as Indian Space Research Organisation (ISRO) in 1969.
- He **founded the Physical Research Laboratory** in Ahmedabad in the year 1947. Its first topic of research was cosmic rays.
- He also **set up India's first rocket launch site** in Thumba, a small village near the Thiruvananthapuram airport in Kerala.
- He was also **responsible for bringing cable television to India**. His constant contact with NASA paved a way for the establishment of Satellite Instructional Television Experiment (SITE) in 1975.
- He was the mastermind behind **building India's first satellite, Aryabhata**.
- He was appointed as chairman of the Atomic Energy Commission of India. He laid the foundations for the indigenous development of nuclear technology for defense purposes.
- He initiated programs to take education to remote villages through satellite communication and called for the development of satellite-based remote sensing of natural resources.
- He was **one of the founding members of the Indian Institute of Management, Ahmedabad (IIMA)**.

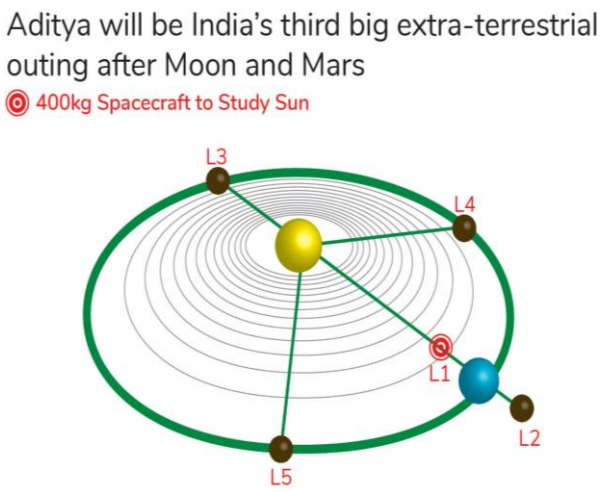
5.1.3.2. ADITYA L1

Why in News?

- India is set to launch its first solar mission Aditya-L1 in 2019.

More on news

- The Aditya L1 will be placed **in a halo orbit around a vantage point in space known as L1 Lagrange point.**
  - Lagrange point is a point where combined gravitational forces of two bodies, say Earth and sun or Earth and moon, equal the centrifugal force felt by much smaller body. Such interaction of forces creates equilibrium where spacecraft can be positioned to make observations.
  - The point L1 has the major advantage of viewing the sun without any occultation/ eclipses.



- The mission will carry seven payloads including the main payload the **Visible Emission Line Coronagraph (VLEC).**
- Aditya L1 is to be the first satellite to study the magnetic field of the sun's corona.
- The Aditya L1 is expected to help study that why the photosphere, the deeper layer of the sun is at much lower temperature than the corona.
- It will also study aspects that affect space weather, the origin of solar wind ions, their reaction to coronal mass ejections, the distribution of these in the heliosphere- the space around the sun that extends up to Pluto.

5.1.4. SPACE COMMERCE

Current Status

- The global space industry is valued at $335.5 billion presenting a huge opportunity for India to foray into the space market.
- Antrix is the commercial and marketing arm of ISRO and is engaged in providing Space products and services to international customers worldwide.
- Antrix has achieved commendable growth since its inception and has grown its turnover from half a crore in 1992 to 2000 crore at present.
- At present Antrix focusses on
  - Provisioning of communication satellite transponders to various users
  - Providing launch services for customer satellites
  - Marketing of data from Indian and foreign remote sensing satellites
  - Building and marketing of satellites as well as satellite sub-systems
  - Establishing ground infrastructure for space applications
  - Mission support services for satellites
- India's cost-effective space programme has launched 51 satellites for 20 countries to date and has the potential to serve as the world's launchpad. With successful launches such as launching 104 satellites in a single mission, India is emerging as a reliable player in the space market.

The rise of the space industry in India can help in the following ways:

- Adding an edge to India's foreign policy as our space capabilities can be a part of our initiatives to foster new relationships,
- Avoiding the outflow of tax-payer's money to foreign hands from where we procure turnkey products and services,
- Creating more opportunities for foreign direct investments (FDI), as well as new jobs for highly-skilled labour market,
- Empowering India's defence system by equipping it with space technology, and allowing armed forces to procure defence products and services indigenously, and
- Reversing the brain-drain from India.

Indian Space Industry: Opportunities & Policy Needs

OPPORTUNITIES	POLICY NEEDS	STRATEGY
•Demand for capacity increase •Moving up the value chain •Architecture-consortia •Market for services •International services •Space asset ownership •Co-development	•Risk management •Competition •Foreign collaboration •Licensing & authorisation •Use of government facilities •Government procurement •Innovation & entrepreneurship •Infrastructure development •Safety and technology safeguards	•Privatising identified segments •Cost minimisation strategies •Public Private partnership models •International cooperation & assistance •Application driven strategies - differentiated products & services •Make in India •Financing risk •Regulations transparent

Challenges

- In 2015-16, Antrix earned a revenue of approximately ₹230 crore through such commercial launch services. But this is a mere 0.6 per cent of the global launch services market.
- Despite launching over 175 commercial satellites till date India's share is low because while nano and micro satellites are becoming increasingly popular, the market lies in carrying heavier satellites. **Roughly 80% of the** revenue has historically come from the **launch of heavy satellites** ISRO needs to develop more missions to carry heavier satellites.
- Despite the success of the GSLV Mark III, India still does not have a rocket powerful enough to do that. **ISRO is still only a master at launching PSLV, which can carry only 2,000 kg or less into a Low Earth Orbit (between 300 km and 800 km).**
- Space market at present is facing **intense competition from private players** who are already to take risks. Even though Antrix has a huge turnover, it is barely 0.123% of the 260 billion USD space market.
- As a national space agency, **the priority for ISRO is not business**, but national missions, and commercial launches are accommodated only when some spare capacity opens up. This becomes a major barrier before Antrix in properly exploiting ISRO's launch capabilities.

- Space is still an entirely **government-controlled entity** in India, unlike in the US or in Europe, where it has been increasingly privatized since the 1980s, turning their national space agencies into managing and contracting organizations.

Way forward

- To thrive in this competitive market Antrix should try to atleast grab at least 1% of the global market by 2030 therefore it should encourage and enable SMEs as well as new space entreprenuers to take the next leap forward in the country to develop end-to-end products and services that are globally scalable.
- ISRO should also step up to guide the first movers towards sustainable growth of commercial space market and mechanisms should also be developed to evolve and engage with start-up entreprenuers.
- In order to build a sustainable private capital investment scenario, transparent and timeline-oriented policies must be brought forth for both upstream and downstream products and services in the well-established areas of communications and broadcasting, remote sensing, navigation and timing.

5.1.5. VILLAGE RESOURCE CENTRES

Why in news?

ISRO has established around 473 Village Resource Centres (VRCs) on a pilot basis, in association with selected NGOs, Trusts and State Government Departments.

What is Village Resource Centres (VRC)?

This is one of the unique initiatives that use Satellite Communication (SATCOM) network and Earth Observation (EO) satellite data to reach out to the villages to address the needs of the local people in villages itself.

Applications: VRCs provide wide varieties of services in rural areas:

- **Tele-medicine** concept connects the sick people in villages, through VSAT network, to the doctors, who located in cities/urban areas or the Super-specialty hospitals, for providing health services.
- The **Tele-education** uses SATCOM to provide a virtual classroom facility to far-flung villages or remote areas in the country and helps in imparting education to the needy.
- Advisories related to agriculture like crop pest and diseases, fertilizer/pesticides, organic farming, crop insurance etc.; livestock/poultry, career guidance to rural students,
- Skill development and vocational training etc., to the rural population.
- Other areas of application include Panchayat planning, Weather information, Marketing information, Watershed Development, Drinking water etc.

Conclusion

There is need to upscale the VRCs and link all the village Panchayats. This will help in efficient use of available resources at the villages and also reduce distress migration from villages due to lack of basic health, education and information asymmetry.

5.2. SPACE ACTIVITIES BILL, 2017

Why in news?

- The government of India has come up with **Space Activities Bill 2017**, a draft law meant to regulate the space sector.

Background

- **Department of Space (DoS)** is the **nodal agency for space activities in India** which include:
  - **Space Infrastructure**: spacecraft for various applications and associated ground infrastructure
  - **Space Transportation systems**: various class of launch vehicles and associated ground infrastructure **Space applications:** for various national requirements through establishment of necessary ground infrastructure and coordination mechanisms.
- Space activities in India till now have been governed by **Satellite Communication Policy, 2000** (which enacted a framework to provide licenses to private sector players to operate communication satellites over India) **and the Remote Sensing Data Policy, 2011.**

- However apart from these two policies, there has been no formal law in the country that provided any framework for creating a private space venture.
- Internationally, the outer space activities are governed by **relevant chapters of international law in general** and by **United Nations' (UN) Treaties and principles evolved under UN Committee on Peaceful Uses of Outer Space (UNCOPUOS)** in particular.

Need to strengthen and encourage private participation due to following reasons:

- It helps overcome budgetary and manpower limitations faced by ISRO.
- It will augment ISRO's efforts in terms of launch vehicles, satellites and ground applications.
- Collaboration with private players is vital for capacity building, cost reduction and getting cutting-edge technology.
- It will allow ISRO's time and resources to explore other research-related opportunity areas and global opportunities.
- Private sector brings advantages of speed and agility by focusing on specific solutions and delivering them in a time-bound manner.
- There is a need to make investments in space technology by private players a lucrative proposition.
- By transfer and indigenization of technology, it will give a boost to core technology and research firms as well as MSMEs involved in production of parts.
- Throughout the globe, space sector is no longer the reserve of the government.

Need for a Space Law

- **Crucial Manpower** - There has been a growing interest of private sector in the space activities which also highlights the increasing demand of crucial manpower ISRO which is insufficient to meet the requirements.
- **Private Sector involvement** - ISRO has been trying to build the private industrial capabilities in the country to support its activities. Recently, it invited single or combined bids from private players to build up to 18 spacecraft a year.
- **No formal Law** - But apart from **Satellite communication and Remote Sensing Policy**, there has been no formal law in the country that provided any framework for creating a private space venture.
- There is no law to provide for alternative launch vehicles, heavy rocket launchers, more launch facilities and address bureaucratic delays.
- There should also be some guidelines to outline an all-encompassing role of ISRO in both civilian and national security domain. While using space assets for economic and developmental applications, security-related needs cannot be ignored against the backdrop of regional and global developments.
- Currently, there is no concrete space policy or law and clarity regarding India's long-term projects. In the absence of clarity, the scientific and technical bureaucracy will develop a perspective that is almost entirely technology-driven, minus a strategic interface.
- Also, outer space has been the domain of scientific bureaucracy and due to this a strategic national perspective is not prioritized.
- The outer space activities are pushing states to write new rules and develop global norms. As India contemplates its space policy and space law, it needs to consider them and, being an established space player, should play an active role in shaping these.
- Lastly, there should be parity between research and development on remote sensing, meteorological satellites, navigation satellites and telecommunications satellites and not just commercial space projects. This is vital as ISRO has emerged as one of the pillars of development in India and the mentioned satellites have applications in various fields such as agriculture, national security, communications etc.

Salient Features of the Draft Law

- The provisions of this Act shall apply to every citizen of India and **to all sectors engaged in any space activity** in India or outside India.
- A non-transferable licence shall be provided to any person carrying out commercial space activity through an appropriate mechanism.
- The government will maintain a register of all space objects (any object launched or intended to be launched around the earth).
- It will provide professional and technical support for commercial space activity and regulate the procedures for conduct and operation of space activity through a regulatory body.
- If any person undertakes any commercial space activity without authorisation they shall be punished with imprisonment up to 3 years or fined more than ₹1 crore or both.

Criticisms

- **Erroneous Definition of Space Activity** - As per the definition of space activity in the bill even data companies handling satellite imagery or universities operating ground facilities for their microsatellites may also need a licence. This might adversely affect the operations of hardware and internet companies.
- **Non-specification of Regulator** - As the bill hasn't specified an independent regulator for the space sector, making DoS the regulator will amount to conflict of interest because DoS is also a service provider through ISRO as well as a commercial operator through Antrix.
- **One Blanket Law for All Space Activities** - Space activities have not been segregated and putting them all under one blanket licence can hinder their efficient functioning.
- **Non-differentiation of Liabilities** - The liabilities of upstream activities such as spaced operations and launch and those of downstream activities such as space-based products/services on the ground are different. However, it hasn't been defined separately and has been passed on to the players involved.
- **Non-clarity on Pollution** - Pollution to the environment of outer space including celestial bodies has not been defined clearly.

5.3. SPACE DEBRIS

Why in News?

- A space mission named **RemoveDebris** was launched to demonstrate various space debris removal technologies.

Details

- 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.
- The term **Kessler syndrome** is associated with Space Debris, which is used to describe a self-sustaining cascading collision of space debris in LEO (Low Earth Orbit).
- 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.
- 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.
- Moreover, space-scientists concern about the inexpensive, tiny satellites called CubeSats which are going to add space junk around 15% in next 10 years.
- Japan earlier launched a cargo ship which will use a half mile 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.
- International guidelines suggest **removing space crafts from low-Earth orbit within 25 years** of the end of their mission. However, only 60 percent of missions follows the guidelines.

Remove debris Mission

- The Remove Debris satellite platform will showcase four methods for release, capture and deorbit two space debris targets, called DebriSATs:
  - **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.

The mission will demonstrate key Active Debris Removal (ADR) technologies in orbit which will have significance for future missions as well.

Committee on the peaceful uses of Outer space

- It is **an ad-hoc committee under United Nation** set up by the General Assembly in 1959 to govern the exploration and use of space for the benefit of all humanity: for peace, security and development.
- The committee encouraging space research programmes, and studying legal problems arising from the exploration of outer space.

International Space debris Committee.

- It is an international governmental forum for the worldwide coordination of activities related to the issues of man-made and natural debris in space to facilitate opportunities for cooperation in space debris research, to review the progress of ongoing cooperative activities, and to identify debris mitigation options.

- **Committee on the Peaceful Uses of Outer Space**, and Inter-Agency Space Debris Coordination Committee (IADC) advocates Global mitigation measures takes many forms ; 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 by the committee are only voluntary in nature and there is no international treaty on space debris currently.**

5.4. Other Developments in Space Technology

5.4.1. LASER INTERFEROMETER GRAVITATIONAL-WAVE OBSERVATORY

Why in news?

- India is planning to build a new gravitational wave detector by 2025 to measure the ripples in the fabric of space and time.

More on news

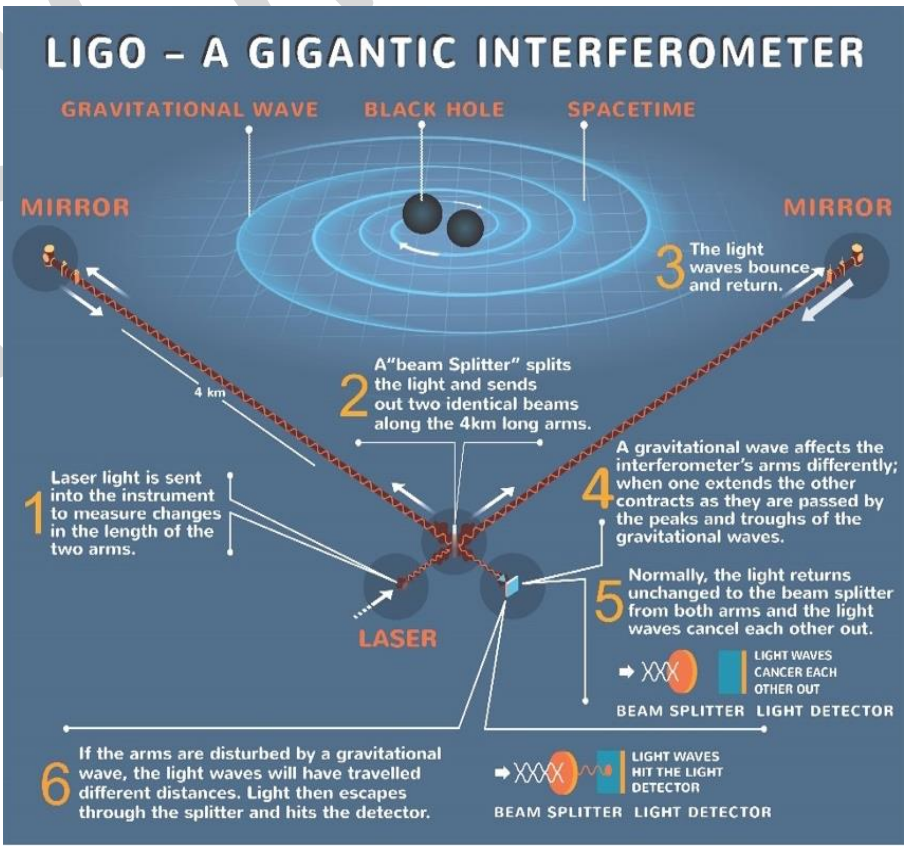
- LIGO-India is a planned advanced gravitational-wave observatory to be located in India as part of the worldwide network.
- It is planned as a collaborative project between a consortium of Indian research institutions and the LIGO Laboratory in the USA, along with its international partners Australia, Germany and the UK.
- The Laser Interferometer Gravitational-wave Observatory (LIGO) project operates three gravitational-wave (GW) detectors. Two are at Hanford in the state of Washington, north-western USA, and one is at Livingston in Louisiana, south-eastern USA.
- The proposed LIGO-India project aims to move one Advanced LIGO detector from Hanford to India.

Significance of LIGO

- As Universe is nearly transparent to gravitational waves, the intervening matter and gravitational fields neither absorb nor reflect the gravitational waves to any significant degree.

What are gravitational waves?

- Gravitational waves are distortions or 'ripples' in the fabric of space-time caused by some of the most violent and energetic processes in the Universe.
- Albert Einstein predicted the existence of gravitational waves in 1916 in his general theory of relativity.
- The effect is very weak, however, and only the biggest masses, moving under the greatest accelerations, are expected to warp their surroundings to any appreciable degree.
- Events such as the explosion of giant stars, the collision of ultra-dense dead ones, and the coming together of black holes should radiate gravitational energy at the speed of light.
- The LIGO detectors discovered the first gravitational waves produced by two giant merging blackholes last year.
- **Nobel Prize for Physics** has been awarded to Scientists Rainer Weiss, Barry Barish and Kip Thorne for contributions to the **LIGO detector** and the **observation of gravitational waves.**
- Recently there was first ever direct observation of gravitational waves emerging from the merger of two neutron stars.



Therefore with the help of the LIGO, humans will be able to observe the astrophysical objects that would be otherwise obscured.

- The detections by LIGO has helped to gain unexpected insights into the cosmos. The event which leaves little or no observable light like black hole collisions could also be detected now.
- With these detections, astronomers will be able to combine gravitational waves with more traditional ways of seeing the universe which will help to untangle mysteries about the dense, dead objects known as neutron stars.
- The physics that went into creation of gravitational waves is encoded in the waves itself. Thus the Gravitational waves detectors will act like radios to infer the information about their creation and decode them.
- LIGO also has an advantage over other observatories such as Telescopes i.e. it can go back in time through the data and search for gravitational waves around the start time of the supernova.

Impact of LIGO India

- **Impact on Indian science:** The proposed LIGO-India project will help Indian scientific community to be a major player in the emerging research frontier of Gravitational Wave astronomy. A major initiative like LIGO-India will further inspire frontier research and development projects in India.
- **Impact on industry:** The high-end engineering requirements of the project (such as the world's largest ultra-high vacuum facility) will provide unprecedented opportunities for Indian industries in collaboration with academic research institutions. LIGO project has facilitated major industry-academic research partnerships in USA and Europe, and has produced several important technological spin offs . LIGO-India will provide similar opportunities to Indian industry.
- **Education and public outreach:** A cutting edge project in India can serve as a local focus to interest and inspire students and young scientists. The LIGO-India project involves high technology instrumentation and its dramatic scale will spur interest and provide motivation to young students for choosing experimental physics and engineering physics as career options.

5.4.2. COSMIC MICROWAVE BACKGROUND RADIATION (CMBR)

Why in news?

Scientists from the **Raman Research Institute (RRI)** in **Bengaluru** have conducted an experiment for detection of Cosmic Microwave back ground radiation in a place called **Timbaktu in Andhra Pradesh**.

Important Scientific Inferences derived from CMBR:

- Most cosmologists consider this radiation to be **the best evidence for the hot big bang model of the universe.**
- The early universe was filled with **hot, dense and extremely uniform gas**, mostly hydrogen.
- The first stars were formed when these blobs of gas got together under the influence of gravity. **That is when visible light also made its first appearance** in the universe. Scientists refer to this phase **as cosmic dawn**.

More about news

- The experiment by RRI can profoundly change our understanding of the early universe, specifically of events leading up to the formation of the first stars.
- Similar experiment conducted by Arizona State University (ASU) at a similarly quiet place in Australia in February this year has observed unusual and unexplained shapes in the spectrum of CMBR.
- Timbaktu is chosen as it is described as **Radio Quiet** — an area where there is virtually no interference from signals produced by modern technology like mobile, TV etc. which makes it most suitable place to detect even faint electromagnetic signals from the sky.

Cosmic Microwave Background Radiation (CMBR)

- It was first discovered in **1964**.
- It is **an all-pervasive, but weak, electromagnetic radiation** from the early universe**, about 3,80,000 years after the Big Bang when matter was still to be formed.**
- This radiation **does not come from any of the objects that we see in the universe, like stars or galaxies** but from a time **when matter and radiation were in thermodynamic equilibrium**.
- The spectrum produced by **CMBR is very smooth**. It does, however, contain **small wiggles, or deformities,** in its shape.

- **Each of these wiggles has valuable encoded information** about specific events that took place as the first stars were born.
- CMB signals are so **faint**, and so pervasive is the **interference** from modern technology that there is a proposal to set up CMB observation experiments on the other side of the moon.

5.4.3. ASTEROID MINING

Why in news?

Several privately funded space companies are locked in a race to claim the trillions of pounds worth of precious metals thought to exist in asteroids.

NASA has released a document, titled "National Near-Earth Object (NEO) Preparedness Strategy and Action Plan".

- It is a 10-year plan which will enhance NEO Detection, Tracking, and Characterization Capabilities and develop Technologies for NEO Deflection and Disruption Missions.
- It also calls for increased international cooperation to prepare for potential global impact threats.
- NASA's catalogue contains over 18000 NEOs with 8000 NEOs as **>140m wide**, the size at which mass casualties would occur. NASA has documented roughly 96% of the objects large enough to cause a global catastrophe.
- An asteroid or comet collision is a "**low probability but high consequence**" event as larger objects offer the world years of notice about when an orbit would intercept Earth. 40 m is about the average size an object must be to make it through the atmosphere without burning up.
- Double Asteroid Redirection Test **(DART) mission** will be the most prominent demonstration of the kinetic impact technique to change the motion of an asteroid in space. Its primary objective is to demonstrate it on small binary near-Earth asteroid (65803) called Didymos
- NASA is a key member in both the International Asteroid Warning Network (**IAWN**) and the asteroid Space Mission Planning and Advisory Group, endorsed by the UN Committee on the Peaceful Uses of Outer Space **(UN-COPUOS**) as the combined response for all space-capable nations to address the NEO impact hazard.

Asteroid mining

- According to a report, **a single asteroid could contain 30 million tons of nickel**, 1.5 million tons of metal cobalt and 7,500 tons of platinum. The platinum alone would have a value of more than $150 billion.
- The first step in an asteroid mining operation involves cataloging and selecting an appropriate target. Using telescopes, mining firms will scout the skies looking for near Earth asteroids with a relatively low velocity.
- Asteroids can be categorised as being made of **carbon (C-type), silicon (S-type) or metal (M-type).** Mining companies are particularly interested in metallic asteroids.
- C-type asteroids contain an abundance of water, carbon and phosphorous that could be used to support colonies or larger mining operations.
  - **One water rich asteroid could provide enough fuel for every rocket launched in history.**
- S-type asteroids distinguish themselves by having an abundance of precious metals. M-type asteroids are also heavy with metals, but they contain about 10 times more elemental pay dirt than S-type.
- By certain estimates, off-planet energy generations like asteroids could eliminate one-quarter of the human industrial footprint by 2100.
- Asteroid mining **will open up a trillion-dollar industry** and could provide a sustainable supply of natural resources and fuels.
- However, **no asteroid has yet been directly sampled.** Telescope observations have been carried out along with analyses of meteorites – fragments of asteroids that have fallen to Earth – and the data suggests that a small percentage of asteroids contain high concentrations of valuable metals such as platinum and gold.
- Landing a mining craft on the surface of the target and extract precious metals in situ would require huge technological advancements.

5.4.4. INDIA'S FIRST ROBOTIC TELESCOPE

Why in news?

Recently, India's first robotic telescope – Global Relay of Observatories Watching Transients Happen (GROWTH)-India, began its operation at the Indian Astronomical Observatory (IAO) in Hanule in Ladakh.

GROWTH-India

- It is a **fully robotic telescope** which has been funded by the Science and Engineering Board (SERB) of the Department of Science and Technology.
- It is a 70cm telescope and the primary objective of the project is the **time domain astronomy**.
- It is mostly an **imaging telescope** and the **spectroscopy** (analysis) will happen at Himalayan Chandra Telescope (HCT).
- It will be **remotely operated** from IIA's Centre for Research and Education in Science and Technology near Bangalore. The facility also houses the control room for remote operations of the Himalayan Chandra Telescope and is the data hub of the telescope.
- The first targets for the telescope were chosen from the **Messier catalogue** (a catalogue of nearby, bright astronomical sources accessible from the northern hemisphere) which allowed various image quality tests.

What are transient events?

- These are short lived burst of energy in a system caused by a sudden change of state.
- The events are caused due to several factors such as relatively benign flares of stars, accretion of matter on compact objects, stellar merger and explosions.
- All these result in a flash in the sky for a period and then slowly fade away.
- Through these electromagnetic signatures, astronomers try to gain an insight into the cosmic objects as well as physical processes that govern their evolution.

What is Time Domain Astronomy?

It is the study of how astronomical objects change with time. Changes may be due to movement or physical changes in the object itself. Examples include pulsar variability, and the variability of accreting black holes, variable stars, and the Sun.

About GROWTH Initiative

- It is a part of **multi-country collaborative** initiative known as Global Relay Observatories Watching Transients Happen (GROWTH) to observe transient events in the universe.
- The initiative will focus on **three scientific themes** in the field of time-domain astronomy – cosmic explosions (supernova), small near-earth asteroids and the electromagnetic identification of gravitational wave sources.
- It is a fully robotic optical research telescope which has been designed to capture cosmic events occurring in timescales much shorter than light years like years, days and even hours.
- United States of America, United Kingdom, Japan, Germany, India, Taiwan and Israel are part of the initiatives.

Himalayan Chandra Telescope

- It is a 2-m Telescope at IAO, Hanule, Ladakh.
- It is remotely operated using dedicated satellite communication link from the Centre of Research & Education in Science and Technology.

6. IT & COMPUTERS

6.1. ARTIFICIAL INTELLIGENCE

Why in news?

The task force on Artificial Intelligence (AI) constituted under the Department of Industrial Policy and Promotion in August 2017 submitted its report recently.

Machine Learning and Deep Learning

- Machine Learning, a term coined by **Artur Samuel in 1959**, based on the idea that **systems can learn from data, identify patterns** and make decisions with minimal human intervention.
- Deep Learning is **a technique for implementing Machine Learning**. It is inspired by the structure and function of the brain called artificial neural networks.

What is Artificial Intelligence?

- It refers to the ability of machines to perform cognitive tasks like thinking, perceiving, learning, problem solving and decision making.
- It enables computer system to carry out task on their own that otherwise requires human intelligence.

Enablers for AI promotion

- Positive social attitudes towards machines and trust in autonomous systems
- Data literacy to create awareness about value of their own data
- An ecosystem (digital data marketplaces, exchanges, infrastructure) which encourages free flow of data & information
- Enabling policy & regulatory framework
- Skill sets available with workforce
- Establishment of standards for data exchange and safety
- Synergy between government, civil society, industry, academia and R&D.

Importance of 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. For e.g.: A recent study found that a Google neural network correctly identified cancerous skin lesions more often than expert dermatologists did.
  - **Labour and capital augmentation:** i.e. enabling humans to focus on parts of their role that add the most value, complementing human capabilities and improving capital efficiency.
  - **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 and infrastructure to meet the demands of rapidly urbanising population are some of the examples that can be effectively solved through AI.

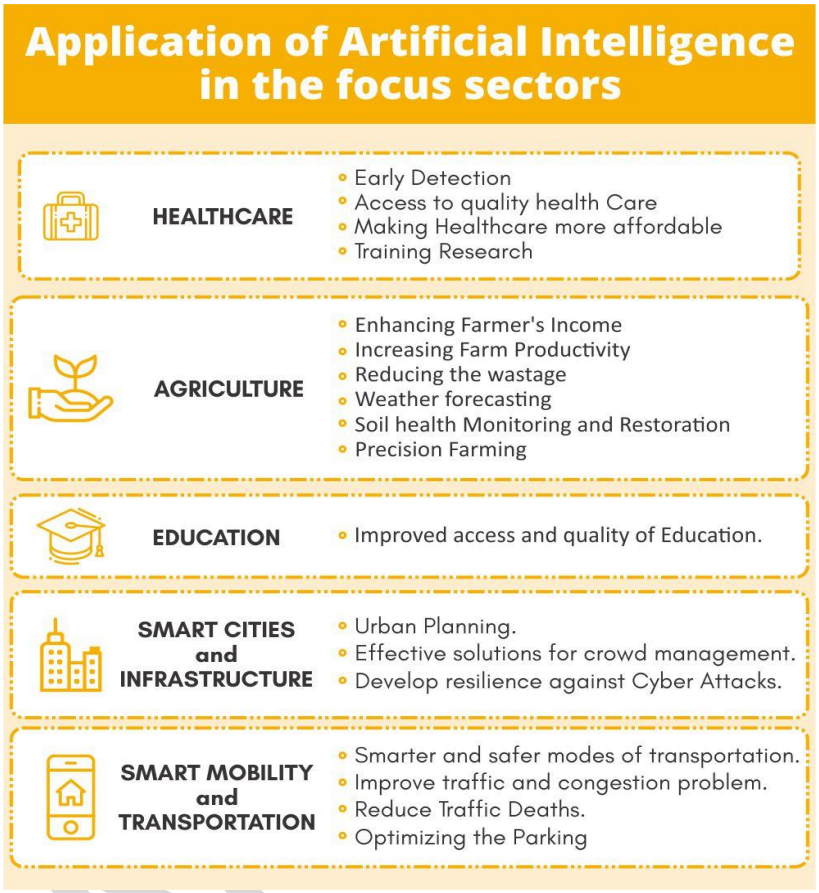
Findings of the report of task force:

- It identifies **10 specific domains** for rapid AI incorporation such as: manufacturing, fintech, healthcare, agriculture/food processing, education, retail/customer engagement, aid for differently abled/accessibility technology, **environment, public utility services and national security.**
- Within these domains too, the report identifies four "**grand challenges**" for AI incorporation:
  - Improving manufacturing to increase profitability and increase manufacturing jobs, especially in the SME (small and medium-sized enterprises) sector
  - Improving healthcare quality, reach and cost;
  - Improving agriculture yields and profitability; and,
  - Improving delivery of public services
- The report has argued that AI will in all likelihood create more jobs than it will destroy. It has potential to assist in various sectors which would in turn create new jobs.

AI in India

- India is the fastest growing economy with second largest population in the world and has a significant share in the AI revolution.
- To harness the potential of AI, NITI Aayog will also establish National Program on AI with a view to guide the research and development in new and emerging technologies.
- NITI Aayog paper highlights the **potential for India to become an AI 'garage'**, or solutions provider, for 40% of the world.

- **Focus Areas for AI Intervention:** NITI Aayog has identified **five focus sectors** that are envisioned to benefit the most from AI in solving societal needs.



Key Challenges to the Adoption of AI in India

- **Lack of broad based expertise in research and application of AI:** Global AI Talent Report 2018 presents a gloomy picture of India in terms of PhD educated researchers in AI.
- Ensuring data security, protection, privacy, and **ethical use** via enabling both **regulatory** and technological frameworks.
- **Absence of collaborative approach** to adoption and application of AI.
- **Lack of Trained professionals:** only around 4% of Indian AI professionals are trained in emerging technologies such as deep learning.
- **Absence of enabling data ecosystems** such as access to intelligent data, data collection, archiving and encouraging **data availability** with adequate safeguards, possibly via data marketplaces / exchanges.
- **High resource cost** and low awareness for adoption of AI.
- Digitization of systems and processes with Internet of Things (IoT) systems along with Channel impediments in technology delivery like poor Internet access.
- Socially disruptive impact of AI in areas such as Employment generation, Wealth generation, changing preference of an AI empowered middle class.
- Rigorous auditing to ensure non-contamination by human biases & prejudices.

Way Forward

- Achieving the goal of #AIforAll requires **long term and engaged institutional collaboration** between all the stakeholders including the citizens.
- **Allocation of Resources in STEM** (Science, Technology, Engineering and Mathematics) need to be increased.

What India can learn from other countries?

- **US, the global leader in AI** is heavily investing on AI based research and US leadership has largely been **driven by the private sector.**
- **China** has ambition of becoming **world leader in AI by 2030.** The top 9 universities of China have received **government funding** to establish AI schools.
- **EU's Robotics Public Private Partnership,** launched in 2013, is believed to be the biggest civilian research programme in AI in the world.

- **Robust Intellectual Property Framework** – is required to ride the AI innovation wave.
- **More funding should be deployed in AI** and incentives should be provided for researchers.
- **Early Adoption of AI**- Be it the research in technology infrastructure, the start-up community developing applications and corporations deploying solutions for their business needs, early adoption will be the key determinants in ensuring leadership in AI.
- **AIRAWAT (AI Research, Analytics and knowledge Assimilation platform)** should be utilised effectively to support advancement of AI-based developments.

- **Digital data banks**: Digital data banks, marketplaces and exchanges should be set up to ensure availability of data and information across industries, with requisite sharing regulations.
- **National Artificial Intelligence Mission (N-AIM)**: An Inter-Ministerial N-AIM with funds allocated under Union Budget should be established with an allocation of Rs1,200 crore for a period of five years.
- Ministry of Commerce & Industry needs to create and functionalise a **data-ombudsman** to quickly address data-related issues & grievances

Key features of N-AIM

- Fund establishment of a network of **alliances** among Academia Services Industry, Product Industry, Start-ups and Government Ministries;
- Establishing & administering **National AI Challenge funds**;
- Increasing **awareness** of AI through AI-yatras;
- **Coordination of projects of national importance:** to accelerate development and commercialisation of AI based products and technology through PPP models and start-ups
- **Establishing Centres of Excellence** for promoting interdisciplinary research
- Setting up of a **generic AI test bed** for verification & validation of AI based products
- Funding an inter-disciplinary & dedicated large **data integration center.**

- **Standard setting:** by the central government for the design, development and deployment of AI based systems. For example, data storage and privacy standards, and communication standards for autonomous systems such as cars.
- **Enabling policies:** need to be developed by the central government. Two major recommendations in this regard are: (i) developing a data policy including ownership, sharing rights, and usage policies, and (ii) providing tax incentives for income generated due to the adoption of AI technologies and applications for socially relevant projects.
- **Human Resource Development:** through developing an AI Education strategy and recommending AI-based curriculums. This also includes reskilling via identification of skill sets required for AI as well as creating an AI Readiness Index for states.
- **International rule-making:** Participate actively in shaping international policy discussions on governance of AI related technologies. This also includes enhanced bilateral cooperation.

2-Tier Research Architecture proposed by NITI Aayog to address India's AI Aspirations	
Centre of Research Excellence (CORE)	**International Centers of Transformational AI (ICTAI)**
It is focused on developing better understanding of existing core research and pushing technology frontiers through **creation of new knowledge.**	It is entrusted with a mandate of developing and deploying **application-based research. Private sector collaboration** is envisioned to be a key aspect of ICTAIs.

6.1.1. AI AND ETHICS

Ethical Issues involved in AI

- **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.
- **Predictability:** The algorithms taking over social functions must be predictable to those they govern. The local, specific behavior of the AI may not be predictable apart from its safety, even if the programmers do everything right.
- **Accountability:** If an AI system fails at its assigned task, who should be made responsible for it?
- **Safety Issues:** AI machines can use their intelligence in specific domains for which they are designed. They might not work in a situation which has never been envisioned. This can create safety issues for others.
- **Maneuverability:** The AI algorithms can be manipulated by people who want to take advantage e.g. criminals willing to carry a gun in airplane can find a loophole in machine vision system and can exploit the flaws in it compromising lives of others.

- **Moral Status:** Currently AI systems have not been given any moral status. Therefore, they can be copied, deleted, changed or terminated as the programmers are pleased. But, future AI systems can have both sentience and sapience. Discriminating them will tantamount to racism.
- **Lack of consciousness:** There is possibility that a future AI system is sapient but does not have sentience or consciousness in it.
- **Transparency:** When AI is involved in cognitive works with social dimensions, such as decision of an AI enabled car during an accident (resolving famous Trolley Problem of ethics), it is important that the AI algorithm developed for it is transparent.
- **Super-intelligence:** A sufficiently intelligent AI system can redesign itself or can create a better successor system and so on leading to intelligence explosion. Whether this super-intelligence will be good or evil to human kind will depend upon its technological capabilities and ethicality. Though the probability of creating technologically advanced being is high, how can one create an AI system which when executes becomes more ethical than the original programmer?

Trolley Problem

This is a well-known thought experiment in ethics which raises a number of important ethical issues related to AI.

It says that if a runaway trolley is going down the railway lines and five people are tied to the track ahead. You are in front of a lever which can switch the trolley to a different set of track. However, there is another person tied to that track. will you pull the lever or not?

Sapience: a set of capacities associated with higher intelligence, such as self-awareness and being a reason-responsive agent.

Sentience: the capacity for phenomenal experience or qualia, such as the capacity to feel pain and suffer.

Way-forward for AI

- Although current AI systems offer few ethical issues, they need to be more predictable and transparent when social roles are involved.
- The French strategy can be adopted which proposes to develop transparent algorithms that can be tested and verified, determining the ethical responsibility of those working in artificial intelligence, creating an ethics advisory committee, etc.
- Resolutions can be brought to regulate Robotics, and code of ethical conducts can be brought for Robotic engineers, as well as Research ethics committees.
- Four ethical principles can be followed in Robotics Engineering such as:
  - **Beneficence:** robots should act in the best interests of humans
  - **Non-maleficence:** robots should not harm humans
  - **Autonomy:** human interaction with robots should be voluntary
  - **Justice:** the benefits of robotics should be distributed fairly

Conclusion

AI systems should be made legally liable for their actions through making their programmers and users accountable. But, this may hamper innovation. Therefore, a balanced approach is needed and for that we must know what goals we are pursuing in the development of artificial intelligence and how effective will it be.

6.2. BIG DATA

Introduction

In the recent past, the topic 'Big data' have gained significant popularity globally because of its capability to revolutionize the businesses and services. In fact, Big data has an impact on every aspect of our daily life. The emerging technology areas like Internet of Things (IoT), Artificial intelligence, machine learning are fuelled by Big data and analytics only.

What is Big Data?

- Big data is high-volume, and high-velocity and/or high-variety information assets that demands cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation.
- Big Data analytics helps organizations to harness their data and use it to identify new opportunities, enabling them to develop smarter strategies, efficient operations, and increase returns and customer centricity.

- According to **UN Economic Commission for Europe's in 2013,** large volume of data can be classified into three categories:
  - **Human-Sourced Information** - loosely structured and often ungoverned data stored everywhere from personal computers to social networks.
  - **Process-Mediated Data** - structured data stored in relational database systems like the traditional business and administrative data.
  - **Machine-Generated Data** - large volume of well-structured data derived from sensors and machines used to measure and record the events and situations in the physical world.

Application of big data

Data is important to ensure efficient strategic planning, policy decisions, governance, and empowering communities. Availability and accessibility of data has helped increase the efficacy in human intuition (decision-making) in every field of science, medicine and technology.

- **In governance**: Data driven governance aims to improve the last-mile linkage of individuals to schemes and empower communities and service providers through data collection, analysis, and improvisation. The Digital India and Smart Cities initiatives of the government also include efforts to utilise data to design, plan, implement, manage, and govern programmes.
- Companies use big data to better understand and target customers by bringing together data from their own transactions as well as social media data and even weather predictions.
- Big Data is **used in healthcare** to find new cures for cancer, to optimize treatment and even predict diseases before any physical symptoms appear.
- Big Data is used to analyze and improve the **performance of individuals** (at sports, at home or work) where data from sensors in equipment and wearable devices can be combined with video analytics to get insights that traditionally were impossible to see.
- **Police forces and security agencies** use big data to prevent cyber-attacks, detect credit card fraud, foil terrorism and even predict criminal activity.
- **Intelligence and Surveillance:** Seamless Integration of Strategic Intelligence with Operational and Tactical Intelligence across Defence Services and other Agencies can be made feasible using Big Data analytics.

According to UN, Big data analytics can facilitate:

- Real-time situational awareness;
- The ability to "shine a light on the invisible," by improving information on the lives of women and girls;
- New information on mobility, social interactions; sentiment and cultural beliefs, and economic activity;
- Early warning of emerging issues and crises;
- Improved understanding of community well-being;
- Understanding of both local impacts and larger geographic patterns;
- Identification of trends and correlations within and across large datasets that would otherwise be unknown;
- Data visualization for more nuanced and accessible insights;
- Opportunities for participatory monitoring, realtime feedback, and learning loops;
- The ability to recalibrate and iterate within the implementation of a programme; and
- Improvements in accountability and transparency

International Efforts

- **Sustainable Development Goals**: The 2030 Agenda explicitly calls for a data revolution for sustainable development
- **Cape Town Global Action Plan for Sustainable Development Data**: It calls for a commitment by governments, policy leaders, and the international community to undertake key actions under **six strategic areas** of data for sustainable development:
  - Its dissemination and use.
  - Coordination and strategic leadership.
  - Innovation and modernization of national statistical systems.
  - Strengthening of basic statistical activities and programmes.
  - Multi-stakeholder partnerships.
  - Mobilizing resources and coordinating efforts for capacity building.

- **Disaster Management:** Big Data Applications for Disaster Management will enable predictive modelling and preventive prescription. Post disaster, damage assessment in scale and financial terms, and rescue cum movement of relief can be analysed from big data.
- **Logistics Management:** It will revolutionise the Supply Chain Management system by creating diagnostic tools.
- **Future Technologies:** Future of cyber and unmanned system will put data strain on the existing system, hence data analytic tools need to be based on future technologies for better absorption in the administration.
- **Analysis of Archival Data:** Historical data can give insights into the future hence analytics should be applied into the huge archive with the Government.
- **Social Benefits**: It can also be used to improve our homes, cities and countries for e.g. optimizing the heating or lighting in our homes, the traffic flow in our cities, or the energy grid across the country.

Big Data and India

- India has been making exponential growth with big data analytics being employed by government agencies and private companies, and it is slowly being imbibed by not-for-profits organization.
- Recent Usage of Big Data in India
    - Use of preliminary data from the **Goods And Services Tax Network** (GSTN) to understand the patterns of trade between states and extract employment data for all enterprises covered by the new tax.
    - Use of railway system to understand migration patterns in a country on the move.
    - The Aarogyashri Healthcare trust by Telangana government uses data analytics to identify disease trends and fund management.
    - Bangalore and Kerala use data analytics for better water management and distribution.
    - Project Insight will use Big Data to identify tax evaders.
    - Use of payroll data from the **Employees' Provident Fund Organisation** to capture the state of job creation in formal enterprises.
    - Use of satellite images to show that India is far more urbanized than the census suggests and to show growing regional inequality through the use of night-light images.
- NASSCOM has anticipated India's big data industry will capture 32% of the global market to reach $16 billion by 2025 from the current level of $2 billion.

Challenges

- **Absence of good quality of datasets**: In most cases, available dataset are found to be outdated, duplicated, incomplete, lacking in semantic interoperability, and inadequately referenced.
- **Logistic Issues**: Use of big data technology is facing new challenges like storage, applicability, security, and scope.
- **Lack of competent Professional:** According to NASSCOM, there is an employee deficit of around 1.4 lakh jobs in the Artificial Intelligence (AI) and Big Data Analytics segment across various sectors in India, which is expected to increase to 2.3 lakh by 2021.
- **Privacy Concern**: There are concerns about the misuse of Big Data by intruding in personal sphere of an individuals.
- **Lack of Coordination and Cooperation**: According to the Ministry of Industry and Information Technology, the full potential of big data remains unrealised due to "low-level sharing of resources".

Indian Government Initiative for Big Data

Digital India Programme:

- It was launched to transform India into a digitally empowered society and knowledge economy.
- It aims at seamless integration across departments/jurisdictions, and ensuring availability of facilities in real time from online and mobile platforms

National Data Sharing and Accessibility Policy (NDSAP), 2012

- It aims to provide an enabling provision and platform for proactive and open access to the data generated by various Government of India entities.
- **Objective:** To facilitate access to Government of India owned shareable data (along with its usage information) in machine readable form through a wide area network all over the country in a periodically

updatable manner, within the framework of various related policies, acts and rules of Government of India, thereby permitting a wider accessibility and usage by public.

- **Open Government Data (OGD) Platform India - data.gov.in** - is a platform for supporting Open Data initiative of Government of India.
  - It intends to increase transparency in the functioning of Government and also open avenues for many more innovative uses of Government Data to give different perspective.

Big Data Management Policy, 2016

- It was launched by **Comptroller and Auditor General**. It paved the way for Data Analytics Centre (first of its kind in the country) and aims to exploit the data-rich environment in the union and state governments to build capacity in the Indian audit and accounts department.

National Data and Analytics Platform, 2018

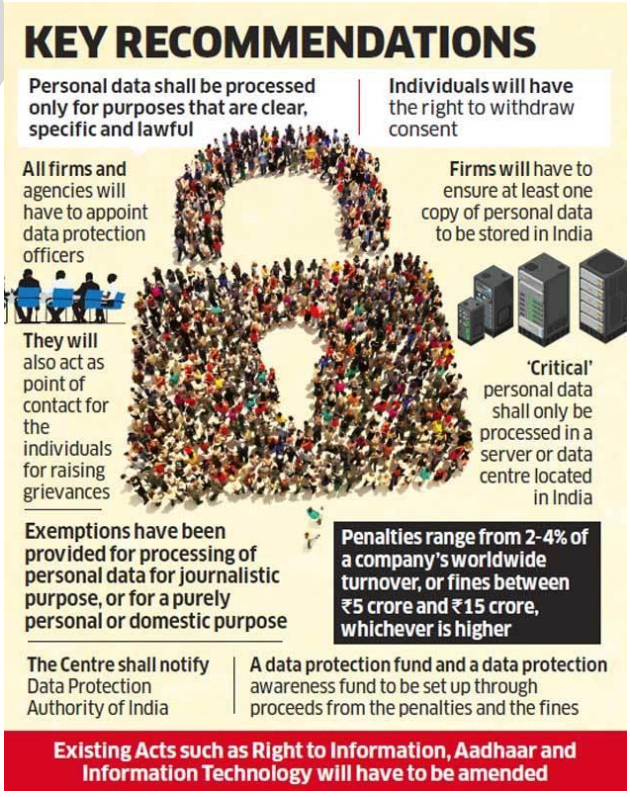
- NITI Aayog is planning to develop it in collaboration of private tech players.
- It will collect data from central ministries and state governments to aid more informed policymaking and become a single source of sectoral data for the stakeholders such as citizens, policymaker, and researchers.
- Government of India is also working towards an **Open Data Policy**, to encourage sharing information between departments and across ministries.

Future Skills programme by NASSCOM: To reskill one million professionals along with skilling one million potential employees and students in eight emerging technologies that could drive IT jobs in the future.

Recently, **Justice BN Srikrishna committee** submitted its report on **The Data Protection Law** which talks about implications on data handling and processing practices by both Indian as well as foreign companies along with government departments.

Way Forward

- Data Management should address the ethical issues regarding big data analytics and formulate a policy regarding data privacy.
- NASSCOM has proposed a curriculum upgradation to include big data and data analytics in engineering colleges.
- Government reforms must aim to work with data to assess the impact of services, make informed decisions, improve monitoring programmes, and improve systemic efficiencies.
- **Capacity Augmentation of Data Centres**: Data, if harnessed better, would ease the load of government, while creating greater accountability. Actively engaging policy makers and researchers with the processed data is crucial to bring in cross-sectoral transformation.
- **Adhering to the Principle of 'data minimisation'** for ensuring that the data collected is limited to the minimum necessary.
- **Adhering to the Guideline formulated by Justice BN Srikrishna committee on data protection (refer infographic).**



Conclusion

Standardization in Big data is going to play a major role in facilitating the exchange and sharing huge volume of data across multiple platforms, multiple applications and multiple sectors. With proper standardization in place, huge volume of data generated within a system can be effectively utilized by other systems/services and applications for greater welfare of individuals and society as a whole.

Data Protection will be covered in detail in the updation material for Mains 365 Security.

6.3. CYBER PHYSICAL SYSTEMS

Why in news?

The government plans to set up 25 Cyber Physical Systems (CPS) across the country over the next seven years.

What are Cyber Physical Systems?

- Cyber-Physical Systems are the integrations of computation, networking, and physical processes. It has seamless integration of algorithms and physical components.
- In these systems, embedded computers monitor and control the physical processes such as natural and man-made systems governed by laws of physics.
- The CPSs have feedback loops where physical processes affect computations and vice versa.

Fields of applications: Medical devices and systems, aerospace systems, transportation vehicles and intelligent highways, defence system, robotics system, process control, factory automation, building and environmental control and smart spaces like Smart Cities, Smart Grids, Smart Factories, Smart Buildings, Smart Houses and Smart Cars where every object is connected to every other object.

Relevance for India: Being a developing country, India can be one of the best laboratory for research in CPS. By ensuring that future workforce is skilled in robotics, artificial intelligence, digital manufacturing, big data analysis, deep learning, quantum communication and Internet-of-Things, CPS could be turned into a huge opportunity.

Some of the areas of research in CPS that are specifically relevant to India are:

- **Smart city:** CPS will integrate all physical systems with each other and connected to network.
- **Agriculture:** Will increase efficiency throughout value chain, improving environmental footprint and creating employment opportunities.
- **Infrastructure Management:** To provide technology for condition monitoring and predictive maintenance of infrastructure.
- **Internal & External security:** Expedite design and delivery of trustworthy, adaptable and affordable systems in cyberspace and autonomous systems to augment security operations.
- **Disaster Management:** by including CPS technologies for next generation public safety communications, sensor networks, and response robotics which can increase situational awareness of emergency responders.
- **Energy:** Integration of intermittent and uncertain wind and solar sources and plug-in devices necessitates not only new sensors, switches and meters, but also a smart infrastructure for realizing a smart grid.
- **Healthcare:** Ever growing population combined with opportunities provided by inexpensive sensing, communication and computation and demand for 24/7 care needs CPS.
- **Manufacturing and Industry:** It can enable predictive maintenance models, help in convergence of global industrial system with power of advanced computing, analytics and new levels of connectivity and new paradigm called the Industrial Internet.
- **Transportation:** Eliminate accidents caused by human error, congestion control, traffic based grid jams including road, air and highway networks.

Steps taken

- DST has recently launched a new programme "Interdisciplinary Cyber Physical Systems (ICPS)" to foster and promote R&D in this emerging field of research.
- A mission on cyber physical systems has been announced in the Union budget with an outlay of 100 crore rupees.

6.4. CRYPTOCURRENCY

Why in news?

- The Reserve Bank of India released a statement directing all regulated entities, including banks, to stop dealing with individuals and businesses involved in virtual currencies **within three months.**

What is cryptocurrency?

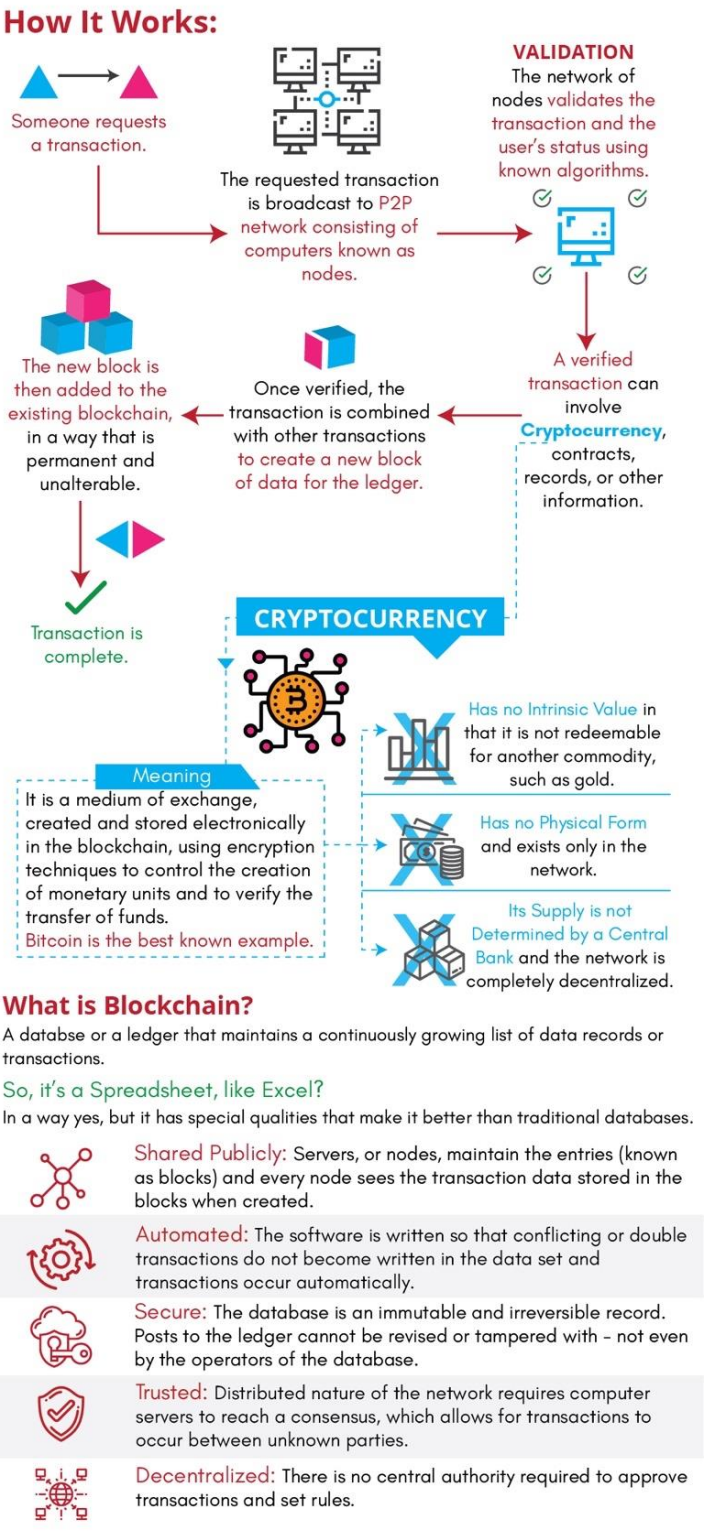
- A cryptocurrency is a digital or virtual currency (computer generated currency) and is based on the principle of cryptography. It allows transacting parties to remain anonymous while confirming the transaction is valid.
- The first cryptocurrency to capture the public imagination was Bitcoin, which was launched in 2009 by an individual or group known under the pseudonym Satoshi Nakamoto.
- Bitcoin's success has spawned a number of competing cryptocurrencies, such as Litecoin, Namecoin and PPCoin.

Factors responsible for growth of cryptocurrencies

- The rise of computational power that allows algorithms to programmatically issue currencies.
- Distrust towards governments that can idiosyncratically debase currency or demonetise at will.
- Scarcity of safe assets to store wealth over the long term.

Benefits of cryptocurrency

- **Privacy Protection:** The use of pseudonyms conceals the identities, information and details of the parties to the transaction.
- They are **difficult to counterfeit** as compared to physical currency.
- **Cost-effectiveness:** Electronic transactions attract fees and charges, which is on the higher side when the transactions are transnational and undergo currency conversion, or attract processing fee levied by the banks, third party clearing houses or gateways. Cryptocurrencies solve this problem, as they have single valuation globally, and the **transaction fee is extremely low**, being as low as 1% of the transaction amount. Cryptocurrencies eliminate third party clearing houses or gateways, cutting down the costs and time delay.
- **Lower Entry Barriers:** Possessing a bank account or a debit/credit card for international usage requires documented proofs for income, address or identification. Cryptocurrencies lower these entry barriers, they are free to join, high on usability and the users do not require any disclosure or proof for income, address or identity.
- **Alternative to Banking Systems and Fiat Currencies:** Governments have a tight control and regulation over banking systems, international money transfers and their national currencies or monetary policies. Cryptocurrencies offer the user a reliable and secure means of exchange of money outside the direct control of national or private banking systems.



- **Open Source Methodology and Public Participation:** They have their own consensus based decision making, built-in quality control and self-policing mechanisms for building frameworks, practices, protocols and processes.
- **Benefits for customers:** The rise of cryptocurrencies offers ordinary people the rare opportunity to choose among multiple currencies in the marketplace. It also may help people gather funds for a cause.

Use of blockchain beyond cryptocurrency

It has the power to transform business processes and applications across sectors — from financial services to agriculture, from healthcare to education, among others. Some examples include:

- **Blockchain-powered smart contracts** where every piece of information is recorded in a traceable and irreversible manner would enhance ease of doing business, augment the credibility, accuracy and efficiency of a contract and reduce the risk of frauds substantially.
- **Property deals** which are still carried out on paper making them prone to disputes, can be benefitted through in-built transparency, traceability and efficiency in this system
- **Financial services:** For example, Yes Bank adopted this technology to fully digitise vendor financing for one of its clients which enables timely processing of vendor payments without physical documents and manual intervention while tracking the status of transactions in real time. Even NITI Aayog is reportedly building a platform called **'IndiaChain'** — a shared, India-specific blockchain infrastructure to leverage the trinity of Jan-Dhan-Yojana, Aadhaar and the mobile.
  - RBI praised the intrinsic potential of blockchain technology to help check counterfeiting and bring a major transformation in financial infrastructure, collateral identification and payments system.
  - RBI's research wing, Institute for Development and Research in Banking Technology (IDRBT) completed the first ever end-to- end test of the blockchain technology. The project was tested in a trade finance with banks and National Payments Corporation of India (NPCI).
- **Healthcare and pharmaceuticals.** It involves a lot of sensitive clinical data which demands a secure and reliable system.
- **Insurance sector:** It may play a crucial part in health or agriculture insurance claims management by reducing the risk of insurance claim frauds.
- **Education sector** to ensure time-stamped repository of pass-outs and job records of students to enable easier verification of candidates by the employees.

Risks involved in cryptocurrencies

- **Security risks:** In the entire chain of security, wallets and exchanges are found to be the weakest link, and that is where the cyber attacks are commonly aimed at. Theft of cryptocurrencies from exchanges soared in the first half of this year to three times the level seen for the whole of 2017.
  - In February 2018, a Spanish cybersecurity firm, Panda, wrote that a cyrptojacking scrypt known as WannaMine had spread to "computers around the world." Cryptojacking is a form of cyber attack in which a hacker hijacks a target's processing power in order to mine cryptocurrency on the hacker's behalf.
- **Uncertain Regulatory Environment:** The future and further success of cryptocurrencies depends upon the way regulatory frameworks are devised. Different countries have approached this innovation in different ways, and therefore the regulatory environment remains uncertain.
- **Lack of Liquidity and Lower Acceptability:** Cryptocurrencies function outside banking systems, beyond the regulations or controls of the regulatory agencies. Although online exchanges facilitate exchange of cryptocurrencies with fiat currencies, but generally, this is restricted to the more popular cryptocurrencies only.
  - If they grow beyond a critical size, they can endanger financial stability as they raise concerns regarding consumer protection, market integrity and their use for speculation.
- **Price Volatility:** Cryptocurrencies are known to be extremely prone to price fluctuations. Cryptocurrencies do not yet have an accepted vulnerability index, which other financial instruments such as fiat currencies and gold have.
- **Uncertainty over Consumer Protection and Dispute Settlement Mechanisms:** Cryptocurrencies are decentralised, that means, there is no single authority for mediation or dispute redressal. The miners are not responsible for any arbitration of disputes between the parties. The transactions are also irreversible.
- **Investor protection:** Since cryptocurrencies are virtual and do not have a central repository, a digital cryptocurrency balance can be wiped out by a computer crash if a backup copy of the holdings does not exist.
- **Potential use for Illicit Trade and Criminal Activities**: Between 2011 and 2013, the value of Bitcoins surged as criminals were purchasing Bitcoins in large volumes. In late 2015 and early 2016, Dutch police

unearthed two small groups that indulged in Bitcoin-related money laundering. Cryptocurrencies are also emerging as a new funding stream for terrorist outfits. Islamic State of Iraq and Syria (ISIS) had proposed using Bitcoins to raise funds.

- **Potential for Tax Evasion**: Cryptocurrencies are not regulated or controlled by governments, making them a lucrative option for tax evasion. Sales made or salaries paid in the form of cryptocurrencies could be used to avoid income tax liability.

Conclusion

In this age of digitisation, it is difficult to ban cryptocurrencies. For example, cryptocurrency exchanges have found a way around the ban by introducing currency-to-currency trading platforms, which essentially bypass the regulators. A ban could lead to millions of dollars leaving the country to carry on trade in these currencies outside India.

Hence, it's important we regulate instead of banning. Also, some more steps can be taken in this regard:

- **Upgrading the technology platforms** to be secure against fraud and data leak.
- Setting up some kind of **a global oversight** to guard against misuse of the new currency by anti-social elements, terrorists and enemy countries.
- **Educating the users** and greater interface with the tax authorities for introducing these currencies in future.
- **Promoting stability** in the sector, for eg – IBM is backing a new cryptocurrency pegged to the US dollar, in a partnership with US-based financial services provider which provides stability in this sector.

6.5. 5G

Why in news?

- The government has set up a high-level forum to evaluate roadmaps and formulate a strategy to adopt 5G in the country by 2020.

Significance of the high level forum

- This move to usher in 5G will help companies design and manufacture 5G technologies, products and solutions in India, thus developing some essential IPR (intellectual property rights) in the 5G standard.
- Using the deployment of 5G technology, the government aims to have 100 per cent coverage of 10 Gbps broadband across urban India and 1Gbps across the rural India.
- By strengthening the domestic telecommunication manufacture market, it will enable local manufacture to capture 50 percent of the domestic market and 10 percent of the global market.

Background

- Mobile wireless generation generally refers to a change in the nature of the system, speed, technology, frequency, data capacity, latency etc.
- Each generation has certain standards, different capacities, new techniques and new features which differentiate it from the previous technology.
- **First Generation (1G)** mobile wireless communication network was analog and was used for voice calls only. Its basic features were – speed of 2.4kbps, voice calls in one country only, use analog signal, poor voice quality etc.
- **Second Generation (2G)** is a digital technology and supports text messaging. Next to 2G. 2.5G system uses packet switched and circuit switched domain and provide data rate upto 144kbps e.g. GPRS, CDMA etc.
- **Third Generation (3G)** mobile technology provided high data transmission rate, increased capacity and provided multimedia support. The aim of this technology was to provide high speed data and offers data services, access to television/videos, new services like Global Roaming etc. It used Wide Band Wireless Network with which clarity is increased.
- **Fourth Generation (4G)** integrates 3G with fixed internet to support wireless mobile internet which is an evolution to mobile technology and it overcomes the limitations of 3G. Long Term Evolution (LTE) is considered 4G technology.

What is 5G?

- 5G is a wireless communication technology. It is the next generation mobile networks technology after 4G LTE networks.
- The final standard for 5G will be set up by the **International Telecommunications Union (ITU).**
- Technical specification for 5G –

- high data rates (1 Gbps for hotspots, 100 Mbps download and 50 Mbps upload for wide-area coverage)
- massive connectivity (1 million connections per square kilometre)
- ultra-low latency (1 millisecond)
- high reliability (99.999% for mission critical 'ultra-reliable' communications), and
- Mobility at high speeds (up to 500 km/h i.e. high-speed trains).

- The technology is still a long way from becoming a reality but it has the potential to completely change the way we interact with wireless devices.

Advantages of 5G

- **Faster Data Speed** – Currently 4G networks are capable of achieving the peak download speed of one gigabit per second. With 5G the speed could be increased upto 10Gbps.
- **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.
- **A more Connected World** – 5G will provide the capacity and bandwidth as per the need of the user to accommodate technologies such as **Internet of Things**. Thus, will help to incorporate **Artificial Intelligence** in our lives.
- As per the **OECD (Organization for Economic Cooperation and Development) Committee** on Digital Economic Policy, 5G technologies rollout will help in **increasing GDP, creating employment and digitizing the economy.**

Challenges

- **Integration of various standards** – There are already multiple groups working to come up with standards around interoperability, backward compatibility with older technologies etc. Thus standardisation becomes a major challenge faced by 5G.
- **Common Platform** – There is no common architecture for interconnecting various engineering practices. Therefore, a common governing body should develop a common platform for all engineering practices.
- **Building Infrastructure** - It is a huge task, with issues around spectrum and installing new antennas.
- **Obstacles** – Like buildings, trees and even bad weather can cause interruptions which would require more base stations to be built to ensure better connections.
- India lacks a strong backhaul to transition to 5G. Backhaul is a network that connects cells sites to central exchange. As of now 80% of cell sites are connected through microwave backhaul, while under 20% sites are connected through fibre. The former has bandwidth issues as it uses traditional bands while the latter provides low latency and unlimited capacity (a prerequisite for 5G).
- The Indian market is yet to adapt to 4G completely and has not fully evolved to experience an AI revolution.

Way Forward

- Fiberization of Backhaul must be carried out for the smooth adoption of 5G.
- Regulatory issues must be revisited in order to overhaul the spectrum licensing regime.
- 5G capable technology must be deployed on a large scale in order to prepare for its adoption.

6.6. FREE SPACE OPTICAL COMMUNICATION

Why in news?

- X Development LLC, a subsidiary of Alphabet will supply and deploy two thousand cutting-edge **Free Space Optical Communication (FSOC) links** for Andhra Pradesh (AP) fibre-grid.

What is Free Space Optical Communication?

- It is an optical communication technology in which data is transmitted by propagation of light in free space allowing optical connectivity.
- Working of FSO is similar to **OFC (optical fibre cable)** networks but the only difference is that the optical beams are sent through free air or vacuum instead of glass fibre.
- It is a **Line of Sight (LOS) technology**. It consists of an optical transceiver at both ends to provide full duplex (bidirectional) capability.

- It is capable of sending up to 1.25 Gbps of data, voice, and video communications simultaneously through the air.

Advantages

- It has **low initial investment** and is a flexible network that delivers **better speed** than broadband.
- High data rate can be obtained which is comparable to the optical fibre cable's data rate but **error rate is very low**.
- The extremely narrow laser beam enables having **unlimited number of FSO links** which can be installed in a specific area.
- It is a **secure system** because of line of sight operation. Therefore, no security upgradation is needed.
- There is **no need for spectrum license** or frequency coordination between users as it is required in radio and microwave systems previously. Thereby easy to provide internet services in hinterlands.
- Electromagnetic and radio-magnetic interference cannot affect the transmission in FSO link.

Challenges

- The transmitted optical signal is affected by various limitations before arriving at the receiver such as misalignment errors, geometric losses, background noise, weather attenuation losses and atmospheric turbulence. This system needs high power consumption, which is difficult to provide in rural India.

6.7. QUANTUM COMPUTING

Why in news?

Department of Science and Technology is planning to fund a project to develop quantum computers.

What is quantum computing?

- In a classical computer, information is stored using binary units, or bits. A bit is either a 0 or 1. A quantum computer instead takes advantage of quantum mechanical properties to process information using quantum bits, or qubits.
- A qubit can be both 0 or 1 at the same time, or any range of numbers between 0 and 1.
- They function according to two key principles of quantum physics: **superposition and entanglement.**
- Superposition means that each qubit can represent both a 1 and a 0 at the same time.
- Entanglement means that qubits in a superposition can be correlated with each other; that is, the state of one (whether it is a 1 or a 0) can depend on the state of another.
- Using these two principles, qubits can act as more sophisticated switches, enabling quantum computers to function in ways that allow them to solve difficult problems that are intractable using today's computers.
- The computing power of a quantum computer increases exponentially as the qubits are increased.

Quantum computing in India

- There was no concerted effort to build a quantum computer. India lacks experimental facilities to carry out the work on theoretical research.
  - In terms of R&D India lags behind other countries. In the last 10 years, there have been less than 100 international journal publications from India on quantum computing.

Steps taken

- The DST's Mission-Mode scheme, called "Quantum Science and Technology (QuST)", will fund research for the development and demonstration of quantum computers, quantum communication and cryptography, besides demonstration of quantum teleportation.
- ISRO, in collaboration with Raman Research Institute, has initiated a mega project called "Quantum Experiments Using Satellite Technology (QUEST)".

Uses of Quantum Computing

- **Research in medicine and organic materials –** It would help researchers to test the new materials in a much faster way as compared to classical computers. It has been found that the quantum computers would require 3.5 million fewer steps as compared to a traditional machine.
  - IBM has recently published a research paper in which it has developed a new approach to simulate molecules on a quantum computer.
- **Supply chain and logistics** – It will find better solutions by finding ultra-efficient logistics and efficient delivery mechanism.

- **Financial Services** – It would also help to find better models to process financial data and reduce global risk factor in investment worldwide.
- **Artificial Intelligence** – It will revolutionize AI by creating a faster processing of the complicated data such as images or videos.
- **Faster Communication** – It would help to decode complicated security keys in a very simple manner.

Challenges

- Quantum computing holds the potential to decode and crack world's encrypted data by breaching the security measures easily and very quickly. It will pose threat to data as well as internal security of the national.
- At present the researchers have also pointed out to the **hardware difficulties** in developing a system as qubits such as those made from silicon atoms only work at a very low temperature, near zero degree kelvin.
- The issue with the existing quantum computers is that they produce errors as the size of the molecule being analyzed grows.

Conclusion

Developing quantum computational capacity should be India's "top national priority" as acquiring such technologies from outside the country will be too difficult and expensive. The use of quantum computing can lead to many fundamental scientific breakthroughs and new technologies with wide ranging societal and commercial applications such as data encryption, new drug discovery, and weather prediction. In order to keep track of international developments in quantum computing and to assess and steer India's progress in this area, we need to have an Indian Quantum Computing Roadmap Group consisting of academicians, industry representatives, and end users.

7. DEVELOPMENTS RELATED TO CLEAN ENERGY

7.1. NATIONAL POLICY ON BIOFUELS-2018

Why in news?

The Union Cabinet recently approved National Policy on Biofuels – 2018 to encourage the generation and use of biofuels.

Background

- As per Census 2011, about 65.9 percent of households depend on solid biomass, including firewood, crop residue and cow dung as primary fuel for cooking in India.
- Bio-fuels are expected to contribute 5000 MW to the overall renewable energy target of 175,000 MW by 2022
- The government has also formulated **National Policy on Biofuels** earlier in 2009. The policy included features like:
  - An indicative target of 20% blending of biofuels both for biodiesel and bioethanol by 2017
  - Biodiesel production from non-edible oilseeds on waste, degraded and marginal lands to be encouraged.
  - MSP for non-edible oilseeds to ensure fair price to farmers.
  - Minimum Purchase Price (MPP) for purchase of bio-ethanol and bio-diesel.
  - Major thrust on R&D with focus on plantations, processing and production of bio-fuels, including Second Generation Bio-fuels.
  - Financial incentives for second generation bio-fuels.
  - National Biofuel Coordination Committee, headed by the PM to provide policy guidance and coordination.
  - A Biofuel Steering Committee, chaired by Cabinet Secretary to oversee implementation of the Policy.
  - However, the Biofuels programme in India has been largely impacted due to the sustained and quantum non-

Biofuel is any hydrocarbon fuel that is produced from organic matter in a short period of time. This is in contrast with fossil fuels, which take millions of years to form. Biofuels are considered renewable form of energy as it emits less than fossil fuels. Different generation biofuels:

- **First Generation Biofuels:** It uses the food crops like wheat and sugar for making ethanol and oil seeds for bio diesel by conventional method of fermentation.
- **Second Generation Biofuels:** It uses non-food crops and feedstock such as Wood, grass, seed crops, organic waste are used in fuel preparation.
- **Third Generation Biofuels:** It uses specially engineered Algae whose biomass is used to convert into biofuels. The greenhouse gas emission here will be low in comparison to others.
- **Fourth Generation biofuel:** It aimed at not only producing sustainable energy but also a way of capturing and storing CO_2.

Different types of Bio Fuels:

- **Bio ethanol**: It is an alcohol produced from fermentation of carbohydrate and cellulosic material of crops and other plants and grasses. It is generally used as an additive to increase octane number of fuel.
- **Bio Diesel**: It is a methyl or methyl ester of fatty acids produced by trans esterification of oils and fats obtained from plants and animals. It can be directly used as fuel.
- **Bio gas**: Biogas is methane produced by anaerobic digestion of organic material by anaerobes. It can be produced either from biodegradable waste materials or by the use of energy crops fed into anaerobic digesters to supplement gas yields.

Global Effort to Promote Biofuels

Mission Innovation (MI)

- It is a global initiative of 22 countries and the European Union to dramatically accelerate global clean energy innovation by doubling investments in clean energy innovation over five years

Biofuture Platform

- It is a 20-country effort to promote an advanced low carbon bioeconomy that is sustainable, innovative and scalable.

National Biogas and Manure Management Programme (NBMMP)

- It is a Central Sector Scheme, which aims at setting up of family type biogas plants for providing biogas as **clean cooking fuel** and a **source of lighting in rural and semi-urban areas** of the country.
- The programme is being implemented under ministry of New and Renewable energy by the State Nodal Departments/State Nodal Agencies and Khadi and Village Industries Commission (KVIC), Biogas Development and Training Centers (BDTCs).
- **Ministry of New and Renewable Energy** (MNRE) has fixed a target to set up 65,180 biogas plants in 2018 under the NBMMP.

Gobardhan (Galvanizing Organic Bio Agro Resources Dhan) Scheme

- It aims to convert waste into bio energy, gas and compost which would not only benefit the people but also maintain cleanliness in the village.

availability of domestic feedstock for biofuel production.
    - In India, industrial-scale availability of ethanol so far has been only from sugar factories, which were free to divert it to other users such as alcohol producers, who would pay more.
- The **National Policy on biofuels-2018** tries to address these supply-side issues by encouraging alternative feedstocks with an aim to reduce the cost of producing biofuels and improve affordability for consumers as well as developing biofuel production into a vibrant Rs 1 trillion industry in the next six years.

Salient Features of the National Policy on biofuels, 2018

- **Categorisation of biofuels** to enable extension of appropriate financial and fiscal incentives under each category. The two main categories are:
    - **Basic Biofuels-** First Generation (1G) bioethanol & biodiesel
    - **Advanced Biofuels** - Second Generation (2G) ethanol, Municipal Solid Waste (MSW) to drop-in fuels, third Generation (3G) biofuels, bio-CNG etc.
- **Expands the scope of raw material for ethanol production** by allowing use of Sugarcane Juice, Sugar containing materials like Sugar Beet, Sweet Sorghum, Starch containing materials like Corn, Cassava, Damaged food grains like wheat, broken rice, Rotten Potatoes, unfit for human consumption for ethanol production.
- **Allows use of surplus food grains for production of ethanol** for blending with petrol to ensure appropriate price to farmers during surplus. However, it needs the approval of National Biofuel Coordination Committee.
- **Thrust on Advanced Biofuels**: Viability gap funding scheme for 2G ethanol Bio refineries of Rs.5000 crore in 6 years in addition to additional tax incentives and higher purchase price as compared to 1G biofuels.
- **Encourages setting up of supply chain mechanisms** for biodiesel production from non-edible oilseeds, used Cooking Oil, short gestation crops.
- **Synergising efforts** by capturing the roles and responsibilities of all the concerned Ministries/Departments with respect to biofuels in the policy document itself.

Potential Benefits of the policy

- **Reduce Import Dependency:** The large-scale production of biofuels would reduce import dependency on crude oil and save forex.
- **Economic Benefit**: Annual Saving of LPG via saving on cost of refilling of LPG cylinder, savings on cost of production from reduced need of fertilizers like urea and equivalent etc.
- **Cleaner Environment**: By reducing crop burning & conversion of agricultural residues/wastes to biofuels there will be reduction in GHGs emissions and other particulate matters.
- **Municipal Solid Waste Management**: It is estimated that, annually around 62 MMT of Municipal Solid Waste gets generated in India. The policy promotes conversion of waste/plastic, MSW to drop in fuels (hydrocarbon fuels from solid waste).
- **Infrastructural Investment in Rural Areas**: addition of 2G bio refineries across the Country will spur infrastructural investment in the rural areas.
- **Employment Generation**: the establishment of bio-refineries would create jobs in Plant Operations, Village Level Entrepreneurs and Supply Chain Management.
- **Additional Income to Farmers**: Farmers can capitalize on agricultural residues /waste which otherwise are burnt by them. They can sell their surplus output to ethanol making units when price dump, thus, ensuring appropriate price.
- **Enhancing Productivity**: Slurry produced from biogas plants can be used as an organic bio-manure for enhancing crop yield and maintaining soil health
- **Social benefits** to rural families by reducing drudgery of women involved in collecting fuel wood and mitigating health hazards during cooking in smoky kitchens.
- Sanitation can be improved in villages by linking sanitary toilets with biogas plants.

Challenges and way forward

- **Abuse of policy especially when prices of crude oil soar** as farmers would find it economically more rewarding to convert farm produce into ethanol for doping with petrol.
- **Need of improvement in technological and financial feasibility** with respect to production of biofuels. Thus, industry academic collaboration should be enhanced in an integrated manner.

- **Inadequate supply-chain infrastructure** to deliver biofuels to the final consumer. Hence, improved investment should be done in building robust infrastructure.
- **Limits on private investment**: The government should also take steps to remove policy barriers that have discouraged private investment in building supply chains for tapping India's huge biofuel potential.

7.2. ELECTRIC VEHICLE

Why in news?

Recently, SIAM (Society of Indian Automobile Manufactures) released a White Paper on Electric Vehicles.

Government initiative for Electric Vehicles (EV)

- **India's Electric Vehicle (EV) Mission 2030:** Government plans to have an all-electric fleet of vehicles by 2030.
- **National Electric Mobility Mission:**
  - It aims to achieve **national fuel security** by promoting hybrid and electric vehicles in the country.
  - It targets 6-7 million sales of hybrid and electric vehicles year on year from 2020 onwards .
- **FAME-India (Faster Adoption and Manufacturing of (hybrid &) Electric vehicles in India) scheme:** To support the hybrid/electric vehicles market development and its manufacturing eco-system to achieve self-sustenance by subsidizing electric vehicle purchases on an annual basis.
  - Scheme is proposed to be implemented till 2020
  - The scheme has four focus areas viz. **technology development, demand creation, pilot projects and charging infrastructure.**
- **Automotive Mission Plan 2026:** It aimed at bringing the Indian Automotive Industry among the top three of the world in engineering, manufacture and exports of vehicles & components; growing in value to over 12% of India GDP and generating an additional 65 million jobs.
- **Green Urban Transport Scheme**
  - It focused to reduce the emission of harmful carbon gas from the transportation, especially from government owned transport facilities.
  - Under this scheme, government plans to launch the eco–friendly transportation facilities in urban areas across the nation which run without damaging climatic conditions
- **Other Steps taken by government**
  - EVs are levied with 12% GST and no cess, versus 43% tax for luxury vehicles and hybrid vehicles.
  - It allowed electric vehicles (EVs) for commercial purposes **without any permit.**
  - It directed state-owned power utilities to set up **fast-charging station.**
  - Country's first **multi-modal electric vehicle project** was recently launched in Nagpur for public transport.

Need for promoting EV in India.

- **Boost to Make in India Initiative:** It will make Indian automobile industry a leading global hub for design, manufacture and export of pure electric vehicles.
- **Fighting climate change and achieving INDC target:** India can save 64% of energy demand from the road sector for passenger mobility and 37% of carbon emissions in 2030.
- **Decrease in oil import bill:** Reduction in import of crude oil will roughly save Rs3.9 lakh crore by 2030.
- **Cost effective:** According to **Bloomberg New Energy Finance,** electric cars would become cheaper than conventional cars without government subsidies between 2025 and 2030.

Concern

- **Source of funding:** EV segment requires huge investment initially, whereas Automobile manufacturer are already under pressure due to implementation of Bharat Stage VI norms from 2020 and banks in India are cautious over new lending due to increasing NPA's.
- **High cost of Batteries:** On an average, it costs around 40-50% of a typical mass segment electric vehicle.
- **Affordability:** India's affordability index (population's ability to afford to purchase a particular item) is lower than developed economies due to lower per capita income.
- **Available infrastructure:** Plug in point for charging are necessary before promoting electric vehicle in country.

- **Time consuming:** It still takes longer to charge an electric vehicle than it does to refuel a conventional car at the pump.
- **Sector Suitability:** Heavy-duty truck transportation and aviation, will remain difficult to electrify without drastic advances in battery technology.
- **Chemical pollution:** Lack of eco-friendly disposal facilities of batteries in India to curb pollution.

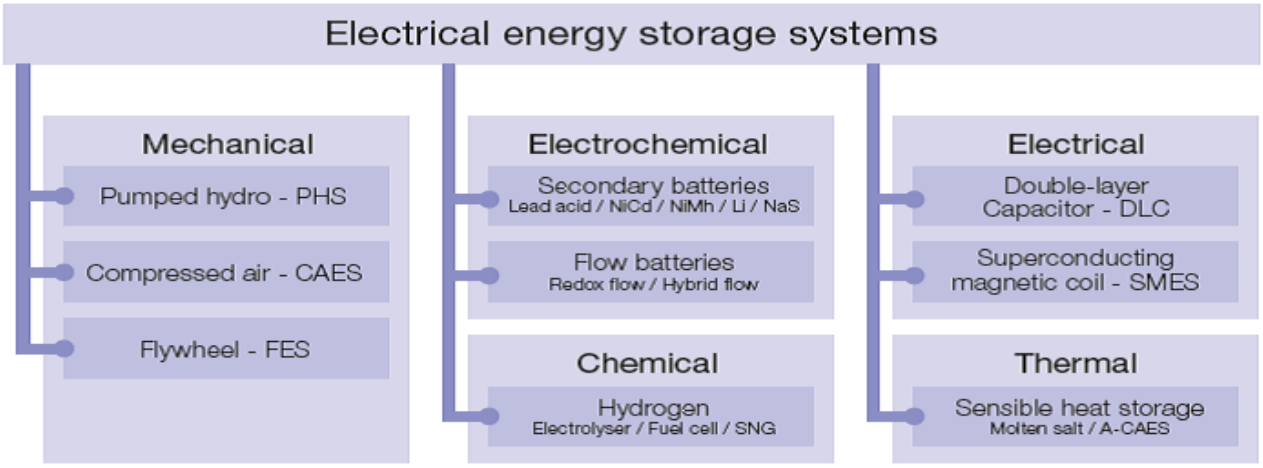
Way forward

- **Tapping green fund:** Many multilateral financial institutions like Soft Bank of Japan provide cheaper loans for eco-friendly projects.
- **Improving infrastructure facility:** Better charging facilities, efficient electric transmission infrastructure and integration of renewable energy into electricity grid would be a sustainable option for addressing infrastructure deficit.
- **Encouraging local manufacturing:** Positive policy environment will encourage Indian automotive industry to become world class manufacturer with a competitive strength in terms of scale, quality, cost and technology for electric vehicles and their critical components.
- **Increasing Public awareness** as there is a direct correlation between knowledge of electric vehicles and its adoption.
- **Battery Swapping:** as recommended by NITI Aayog could significantly reduce the cost of EV and would save the precious charging time.
- **Providing fiscal incentive:** NITI AYOG recommended incentivizing efficient new vehicles by penalizing inefficient ones.
- **Alignment with National Solar Mission:** Batteries in EVs can be a viable option for storing power generated under mission [100 GW solar energy by 2022].
- **Electric public transport:** Implementing the provision of **Green Urban Transport Scheme** would result in Electric feet of transportation across the nation.

7.3. ENERGY STORAGE SYSTEMS

Why in news?

The Ministry of New and Renewable Energy has set up the Energy Storage Expert Committee to propose creation of the National Energy storage Mission for India.



Background

- The committee has been set up in the backdrop of NITI aayog's report **India's Energy Storage Mission: A Make-in-India Opportunity for Globally Competitive Battery Manufacturing and CERC's white paper on Energy storage systems.**
- NITI Aayog has proposed a three-stage solution for promoting battery manufacturing in the country i.e.
  - **Stage One:** Creating an Environment for Battery Manufacturing Growth
  - **Stage Two:** Scaling Supply Chain Strategies
  - **Stage Three:** Scaling of Battery Cell Manufacturing
- It will be achieved by providing incentives such as land grants at discounted prices, Sales and use tax exemptions or tax credits and reduction in number of permits for the same.

- This will allow consistency and easier adoption of the electric vehicles with minimal modifications in charging stations.

Existing Policy/ Regulatory Framework

- **National Electric Mobility Mission (NEMM)**
- **Net Metering Policy:** So far, around 14 States have released net metering policies which give consumer a provision to install Rooftop PV at their premises. Most systems will involve inverters with batteries.
- **Renewable Energy Targets:** of 175 GW of renewable energy with 100 GW coming from solar, 60 GW by wind, 10 GW by biomass and 5 GW by small hydro. Integration of renewable energy will require energy storage technologies.
- **National Smart Grid Mission:** Ministry of Power has approved National Smart Grid Mission (NSGM) which has set aggressive targets for Microgrids which will also require energy storage technologies.

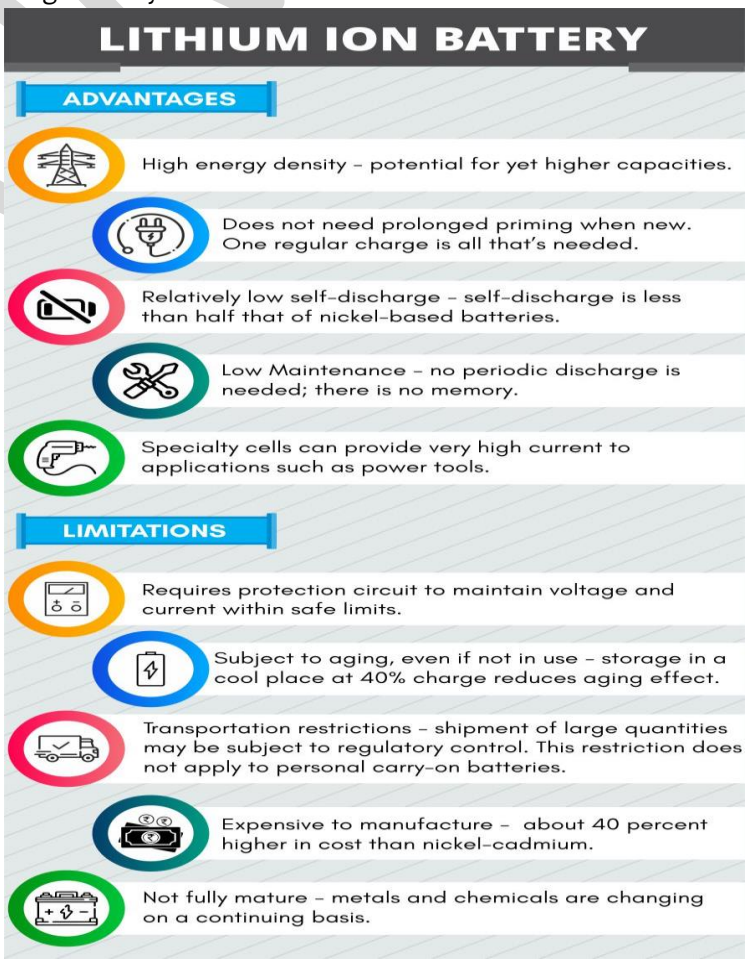
CERC 's White paper on Energy storage

The report envisions various applications of energy storage systems in India:

- Enhance the reliability of delivery of power generated from wind and solar technologies by controlling the intermittent nature of the generation and in effect, increasing the value of renewable power.
- Address peak demand usage by shifting delivery of economical generation output during peak periods.
- Provide spinning reserves or ancillary support services.
- Improve the efficiency of power system by storing excess generation over and above required generation for 50.00 Hz frequency and reduce greenhouse gas emissions caused by wasteful excess capacity.
- Reduce the need for major augmentation of new transmission grids.
- Assist in black start operations during emergency preparedness providing robustness to the power system operation.

Significance

- India's renewable energy targets will see massive amounts of capacity (175 GW renewable energy by 2022) added to the grid over a very short period of time and it will need to **minimise its impact on existing grid system.**
- Energy storage can help in building **new industries** that can create jobs, strengthen energy security, and clean the air. For e.g. Lithium Ion manufacturing industry for electric vehicles.
- India needs a commercially viable plan for storing renewable energy to significantly cut down import of fossil fuels.
- It can help in **accelerating the energy transition towards clean energy economy** in India which is world's third-largest emitter and home to a growing, urbanizing population of more than 1 billion.



7.3.1. INDIA'S FIRST LITHIUM ION (LI-ION) BATTERY PROJECT

Why in News?

- Recently, 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 Lithium Ion (Li-ion) Battery project.

More on News

- Currently, Indian manufacturers source Lithium Ion Battery from China, Japan and South Korea among some other countries.

- India is one of the largest importers and in 2017, it imported nearly 150 Million US Dollar worth Li-Ion batteries.

About lithium Ion Battery

- These are rechargeable batteries having high energy density and commonly used in consumer electronics.
- It uses intercalated lithium compound instead of metallic lithium as its electrode and is able to store 150 watt-hours electricity per kg of battery.
- Rechargeable lithium-ion batteries cycle 5000 times or more compared to just 400-500 cycles in lead acid.

Importance

- They have applications in Energy Storage System – from hearing aid to container sized batteries to power a cluster of villages, Electric Vehicles (2-wheeler, 3-wheeler, 4-wheeler and Bus), Powering Robots in Processing Industry, etc. Lithium-ion batteries can power any electrical application without the need of physical wires-means wireless.
- They have a potential to enable cost reduction, coupled with appropriate supply chain and manufacturing technology for mass production.
- Technology related to Lithium ion battery can assist in National Electric Mobility Mission, make in India and increasing the share of Clean Energy in the energy basket by generating.

About the Graphene Based Supercapacitors

- It is being produced by the waste/discarded lithium ion battery.
- Graphene oxide collected form lithium ion battery showed high specific capacity at low current and it is novel energy storage system that combined high energy and power density.
- The process involves conversion of graphite into graphene oxide by oxidation and subsequent exfoliation which is then further converted into reduced graphene oxide.
- Supercapacitor are now being used explicitly, in wind turbine pitch control, rail, automobile, heavy industry, telecom system and memory backup.

8. OTHER DEVELOPMENTS AND ISSUES IN SCIENCE AND TECHNOLOGY

8.1. SCIENTIFIC RESEARCH IN INDIA

Introduction

- In the past few decades India has taken major strides in science and technology and is today recognized for its achievements in many fields ranging from agriculture, textiles, health-care, and pharmaceuticals to info-tech, space technology, defence technologies and nuclear technology. However, when one compares India's techno-economic performance with some of the advanced countries or even other fast progressing developing countries, one finds that there is much to be desired.

Current status of scientific research in India

- India ranks third among the most attractive investment destinations for technology transactions in the world.
- India is among the topmost countries in the world in the field of scientific research, positioned as one of the top five nations in the field of space exploration.
- India ranks second in terms of contribution to high-quality scientific research. It is among the world's top 10 nations in the number of scientific publications.
- According to WIPO, India is the seventh largest patent filing office in the World.
- According to Zinnov, the engineering R&D market in India is estimated to grow at a compound annual growth rate of 14 percent to reach $42 billion by 2020.

Importance of scientific research

- Research and Development (R & D) is critical for an economy to remain competitive in the era of globalisation. Although India has no dearth of talent, it certainly falls behind other developed nations as far as contributions to quality research are concerned.
- Despite India appearing as a global knowledge superpower, only about three percent of global research output (as of 2010) was from India.

Challenges

- **Funding Issue:** According to Economic Survey (2018), India's R&D funding has been stagnant for two decades at around 0.7% of GDP. Developed countries spend more than 2% of GDP on R&D. Bulk of the spending, especially for basic research, comes from the government and a large section of the country's public research is concentrated in national research centres.
- **Participation of Private sector**: India's private sector spends less than 0.2% of GDP on R&D.
- **Lack of Opportunity**: India has employed only 40 researchers per lakh labour force for the last decade as compared to USA's 790 per lakh of their labour force.
- **A disconnect between labs and academia:** There is limited coordination between colleges and research facilities. Apart from PhD students hardly anyone is seen in labs conducting research.
    - The academic ambience in many universities does not encourage the research pursuits of faculties. Research management is another very serious problem.
- **Less Attractive Option**: Many Indian students prefer to major in engineering rather than science, because of the promise of lucrative industrial career opportunities. According to National Council of Applied Economic Research (NCAER), less than three per cent of school-going children want to pursue a career in science in India.
- Government has not yet come up with a uniform and integrated policy for research and development which could aggregate the efforts of various institutes.

Initiatives to Promote scientific research

- **Ramanujan Fellowship Program:** for Indian scientists and engineers from all over the world, especially those who wish to return to India, to take up scientific research positions at any of the scientific institutions and universities in India.

- **Innovation in Science Pursuit for Inspired Research (INSPIRE) Faculty Scheme:** offers a contractual research positions to Indian citizens and people of Indian origin including NRI/PIO status with PhD (in science, engineering, pharmacy, medicine, and agriculture related subjects) from any recognized university in the world.
- **Ramalingaswami Re-entry Fellowship** for Indian Nationals who are working overseas in various fields of biotechnology and life sciences and are interested in taking up scientific research positions in India.
- **Prime Minister's Fellowship Scheme** - It is a public-private partnership (PPP) between Science & Engineering Research Board (SERB) and Confederation of Indian Industry (CII) which aims to improve the quality of research by attracting the best talents across the country and reduce brain drain.
- The govt. of India recently launched **VAJRA (Visiting Advanced Joint Research)** faculty scheme to enable NRI and overseas scientists community to participate and carry out R&D in the country.
- **Jigyasa: a student- scientist connect programme** which focuses on connecting school students and scientists so as to extend student's classroom learning with that of a very well-planned research laboratory based learning.
- **IMPacting Research INnovation and Technology (IMPRINT):** an IIT and IISc joint initiative to address major engineering challenges that the country must address and champion to empower the nation for inclusive growth and self-reliance.
- **Innovations for Development of Efficient and Affordable Systems (IDEAS):** Government will launch a scheme for students from higher educational institutions to volunteer to offer innovative, original and practical solutions to problems facing the country and win Rs 1 Crore.
- **TARE (Teacher Associates for Research Excellence) Mobility Scheme**: has been formulated and approved by Science and Education Research Board, which aims to activate the latent and unused R&D capacity in our colleges and state universities that lack S&T infrastructure and culture.
- **MANAK (Million Minds Augmenting National Aspiration and Knowledge):** In the context of Start-up India initiative of the Government, implementation of MANAK has been initiated to foster culture of scientific innovation among school children of class VI to class X.
- A five year technology fund with US$ 4 million yearly investment, called Israel India Innovation Initiative Fund (I4F), has been launched.
- Higher Education Funding Agency (HEFA) has approved projects worth US$ 320.89 million, of six institutions, which will be used to improve the research infrastructure in these institutions.

All steps taken seems to be giving positive result as can be find from the reversal of Brain drain, as more scientists are returning home after work stints abroad.

- In the span of 2012-17, 649 Indian scientists have returned to pursue research opportunities.
- However, there is **limited institutional capacity** to absorb all interested Indian origin scientists living abroad. Of the 373 scientists, who got these scholarships between 2014 and 2016, only 125 were absorbed into their host institutions.

Way Forward

- Right set of policies to achieve the right mix of traditional and modern S&T knowledge for the rural India, by fine-tuning the technology policies and implementation methods to optimize our existing technology strengths as well as create new core strengths in critical and enabling technologies.
- Need for a fundamental shift in thinking to create a conducive ecosystem with increased government participation.
- Faculty from the premier institutes of sciences could be freed from routine administrative duties to devote more time for research.
- Encouraging curiosity, and fostering scientific thinking by making systemic changes at the school level to ensure learning is more experience based, and less classroom oriented.
- There is a need to create a flexible environment that allows and incentivizes collaboration between industry and academia.
- According to Economic Survey-2018, there is a need for greater State Government spending by upto 3% of GDP, and appropriate level of public and private collaboration for effective innovation partnerships among companies and with academia.

8.1.1. WOMEN IN STEM CAREERS

Why in news?

According to the 'Revisiting Women in STEM' survey, 45% of those working in STEM (Science, technology, engineering, and medicine) jobs were dissatisfied with their current career choice.

Why is women representation in STEM important?

- Most of the high-tech jobs in STEM field are high-paying, meaning that the lack of women in these roles is contributing to gender salary gap.
- A lack of women in these fields means fewer female role models, both for current female STEM employees, and for girls still forming career choices.
- STEM is the fastest growing field with new technological innovations changing our way of life.
- Science fails to benefit from other points of view.

Why are women not joining STEM?

- Need to upskill constantly
- Long hours
- Male-dominated office environment
- Society and media generally did not encourage women to join STEM
- Pressures of family to conform to traditional gender roles
- Less likely to be paid as much as men
- Perceived gender bias in performance evaluation.

Initiatives in India

- CBSE has launched a scheme **"Udaan"** to provide free online resources to girl students of Class XI and Class XII for preparation of admission test for the premier engineering colleges in the country.
- Scheme to provide assistance for Advancement of Girls participation in Technical Education launched by **All India Council for Technical Education (AICTE)** envisages to grant 4000 scholarships per annum.

What could be done?

- Program and policy focus needs to start at the community level and coordinate inclusively with all actors and stakeholders across sectors and fields of study.
- Girls need to receive the necessary education to become leaders. Women in leadership roles can inform policy and influence exposure and access to STEM careers for girls and women.
- Existing policies and laws designed to expose STEM trainings need to be implemented and enforced.
- Adapt national plans to local levels to ensure a path to STEM careers begins early.

8.2. DIGITIZING RURAL INDIA

Why in news?

Recently, it has been decided to expand Common Service Centres (CSC) to 2.50 lakh gram panchayats and to establish 700 Digital Villages by the end of this year.

More on news

- The CSC model has adopted six villages in the country in the pilot phase to be developed as Digital Villages.
- **DigiGaon or Digital Village** is conceptualized as a connected place in a rural and remote part of the country where citizens can avail various e-Services of the Central Government, state Governments and private players.
- The idea behind this project is to turn these villages into self-sustaining units. It aims at promoting rural entrepreneurship and building rural capacities and livelihoods through community participation and collective action.
- The digital villages have been equipped with solar lighting facility in their community center, LED assembly unit, sanitary napkin unit (with active participation on Asha and Anganwadi workers) and Wi-fi choupal.

Common Service Centres

- Common Service Centres (CSC) scheme is one of the **mission mode projects** under the Digital India Programme.
- CSCs are the access points for delivery of **essential public utility services, social welfare schemes, healthcare, financial, education and agriculture services, apart from host of B2C services** to citizens in rural and remote areas of the country.

Challenges in digitizing rural India

- **High level of digital illiteracy:** As per the 71st NSSO Survey on Education 2014, only 6% of rural households have a computer. This makes adoption of technology driven services delivery very slow.
- **Slow and delayed digital infrastructure development** along with the need of high upfront investment in creating infrastructure.

- **Change in behavioral pattern:** Village community is generally perceived to possess conservative mindset. They are accustomed with years of same of practice and resist changes. The biggest challenge is ensuring that each panchayat point of broadband is functional and in use.
- **Connectivity to remote areas:** The challenge of connectivity is a complex issue because **every state has different laws pertaining to its execution**. Due to this, often the remote areas are neglected under implementation of the several programmes like Bharat net.
- **Promoting Entrepreneurship abilities** as rural youth are needed to be educated about the potential benefits and progress that digitization entails for the village.

Pradhan Mantri Gramin Digital Saksharta Abhiyan' (PMGDISHA)

- It was launched in 2017 to **make 6 crore rural households digitally literate by March 2019.**
- It is expected to be **one of the largest Digital Literacy Programmes** in the world.
- Under the scheme, 25 lakh candidates will be trained in the FY 2016-17; 275 lakh in the FY 2017-18; and 300 lakh in the FY 2018-19.
- To ensure equitable geographical reach, **each of the 250,000 Gram Panchayats would be expected to register an average of 200-300 candidates.**

Other initiatives taken to improve digital connectivity in rural India

- BharatNet project, under which the government is planning to bring internet connectivity via optic fiber to all 2.5 lakh gram panchayats.
- The government has approved Rs 4,909 crore for modernisation of 1.55 lakh post offices including 1.29 lakh post offices in rural areas.

Way Forward

- **PPP models** must be explored for sustainable development of digital infrastructure, as has been the case for civic infrastructure projects **like roads and metro**.
- **PMGDISHA (Prime Minister Gramin Digital Saksharata Abhiyaan)** must be implemented swiftly and coverage should be expanded to all rural households.
- Along with that, **a regular awareness campaign** must be organized in collaboration with civil societies about the benefits of adoption of technology.
- Local authorities should be empowered to fill in the digital gaps in terms of advanced infrastructure, digital skills as well as digital public services and create an environment to facilitate digital innovation in rural areas.

8.3. NOBEL PRIZE IN CHEMISTRY

- Nobel Prize for Chemistry has been awarded to Jacques Dubochet, Joachim Frank and Richard Henderson for the development of high-resolution cryo-electron microscopy.

More on News

- Cryo-electron microscopy is a method for imaging frozen-hydrated specimens at cryogenic temperatures by electron microscopy.
- Specimens that are to be analysed would remain in their native state without the need for dyes or fixatives, which would allow the study of fine cellular structures, viruses and protein complexes at molecular resolution.
- Contrary to earlier electron micro-scoping, cryo-electron miscroscopy can view solutions (as water would not evaporate under microscope's vacuum).
- This method helps in better imaging 3D structures of biomolecules.
- It helps researchers to freeze biomolecules mid-movement and visualise the processes they have never previously seen.
- It has been used to image the elusive Zika virus and its medicine associated research.

8.4. NOBEL PRIZE IN MEDICINE

- Nobel Prize in Physiology or Medicine 2017 was awarded to Jeffrey C. Hall, Michael Rosbash and Michael W. Young for their discoveries of molecular mechanisms controlling the **circadian rhythm**.

Biological clock associated Factors

More on News

- The discoveries explain how plants, animals and humans adapt their biological rhythm so that it is synchronised with the Earth's revolutions.
- The scientist used fruit flies to isolate a gene that controls the normal daily biological rhythm and showed how this gene encoded a protein that accumulates in the cell during the night and degrades during the day.

Significance

- It will assist in further medical research by considering Circadian rhythm as potential factor in health.
- The scientists show why disturbed sleep - like in the case of jet lag, or people with insomnia - can have terrifying knock-on consequences, like an increased risk of various diseases.

Circadian rhythm

- It is a pattern that guides our bodies when to sleep, rise, eat and regulating many physiological processes.
- Biological clocks produce circadian rhythms and regulate their timing.
- It is affected by environmental cues, like sunlight and temperature.
- It regulates the periods of tiredness and wakefulness during the 24-hour cycle.
- The biological clock is generated by about 20,000 neurons that form a structure called the suprachiasmatic nucleus (SCN), which is found in the hypothalamus in the brain.

8.5. STEPHEN HAWKING

Why in news?

Recently, Stephen Hawking passed away at the age of 76.

Contribution of Stephen Hawking

Hawking-Penrose theorem / Big Bang Theory

- **Sir Roger Penrose and Stephen Hawking in 1970** proved in a theorem that Einstein's General Relativity must break down at a certain point in Space-time under certain generic physical conditions. This point is called 'Singularity' which inside a Black Hole indicate towards the beginning of the Universe. Big Bang is now the most widely accepted theory of the origin of the universe.

Information Paradox, or Hawking Paradox,

- By using Quantum Mechanics in the General Relativistic realm, he showed that Black Holes can radiate and has temperature. Emission is similar to something escaping from Black Holes. He also showed that because of the emission of this thermal radiation or **Hawking Radiation**, the black hole would lose energy and eventually disappear or "evaporate".
  - If the paradox is true, it would require some radical revision of physics as it left two pillars of modern physics quantum mechanics and Einstein's general theory of relativity irreconcilable.
  - This could also open a path towards the final unified theory of Physics called 'Quantum Gravity' or more popularly **'The Theory of Everything'**.

Hawking-Hurtle state

- Hawking with colleague James Hurtle developed a Quantum Mechanical model of the Universe that says the Universe is self-contained (like Earth surface which has no starting point) but has No Boundary (We can't fall from the edge of Earth). So Universe is finite but boundary-less (Like Earth surface having finite area but no edge).

Breakthrough Initiative

- It was launched by Russian tech investor **Yuri Milner and Stephen Hawking**, to explore the Universe, seek scientific evidence of life beyond Earth. Various component of initiative are:
  - **Breakthrough Listen Project:** It's a $100 million program of astronomical observations to survey one million stars, the galactic plane and 100 neighbouring galaxies in the search for intelligent life.
  - **Breakthrough Message**: It's a $1 million competition to design a message representing Earth, life and humanity that could potentially be understood by another civilization.
  - **Breakthrough Watch**: It's multi-million dollar astronomical progam to develop Earth- and space-based technologies that can find Earth-like planets in our cosmic neighborhood – and try to establish whether they host life.
  - **Breakthrough Starshot:** It's a $100 million research and engineering program aiming to demonstrate proof of concept for a new technology, enabling ultra-light unmanned space flight at 20% of the speed of light and to lay the foundations for a flyby mission to Alpha Centauri within a generation.

8.6. FOOD IRRADIATION

What is it?

Bhabha Atomic Research Centre (BARC) at Lasalgaon in Nashik district has started radiation process of mangoes.

Need for Food Irradiation

- The **seasonal nature of production**, long distances between production and consumption centres and rising gap between demand and supply increases the odds of post-harvest losses.
- The **hot and humid climate** of a country like India is quite favourable for growth of numerous insects and microorganisms that destroy stored crops and cause spoilage of food every year.
- **Post-harvest losses** in food and food grains in India is around 40-50 per cent, primarily **due to insect infestation, microbiological contamination, physiological changes due to sprouting and ripening, and poor shelf life.**
- Sea-foods, meat and poultry may carry harmful microbes and parasitic organisms that cause illnesses associated with their consumption.

What is Food Irradiation?

Food irradiation means treatment of raw or processed food items with short wave radiation energy to preserve it. The radiant energies include gamma radiation, infrared, microwave radiation etc. The application of irradiation to preserve food is not new as meat, fish, fruits and vegetables have been preserved for centuries by the sun's energy.

Difference between Irradiated food and Radioactive Foods

- **Radiation processed foods** are those that have been exposed to radiation as prescribed above to bring about the desired effect in food.
- **Radioactive foods**, on the other hand, are those that become contaminated with radionuclides. This type of contamination never occurs during food irradiation.

Advantages in Food preservation

- Products of any shape can be sterilized using gamma rays, which penetrate right through the package and products.
- Being a cold process, heat sensitive food materials can also be sterilized safely.
- Since sterilization is affected after final packaging, products sterility is retained indefinitely provided the package is undamaged.
- The treated product can be used immediately.
- No significant alteration in nutrition value, flavor texture and appearance of food.
- It does not leave any harmful or toxic residues on foods as is the case with chemical fumigants.

Food Irradiation in India

- **Bhabha Atomic Research Centre (BARC) – Departmenmt of Atomic Energy** is involved in the research on food preservation through radiation.
- **BARC-DAE** has set up two technology demonstration units, one at Vashi, Navi Mumbai, commissioned in the year 2000 for high dose irradiation and KRUSHAK (Krushi Utpadan Sanrakshan Kendra) facility at Lasalgaon, near Nashik for low dose irradiation established in 2002.
- The **Atomic Energy (Control of Irradiation of Food) Rules 1991**, governs food irradiation in the country. It was amended in 2012.

- Irradiation of food is also governed under the Food Safety and Standards Act, 2006 and the Regulations issued under it. The regulation of this Act has been amended (Food Safety and Standards (Food Products Standards and Food Additives) Sixth Amendment Regulations, 2016) to bring it in harmony with the international regulation.

Relevance for India

- **Food and Nutritional security:** It is very effective in treating agricultural produce to enhance its shelf life. It is essential especially for a hot and humid country like India which is quite favorable for growth of numerous insects and microorganisms that may cause spoilage of food every year.
- **Facilitate distribution from production centers to consumption centers:** During storage and distribution grains worth of thousand of crores of rupees are wasted due to insect infestation and related problems. To preserve it through long distances between production and consumption centres, irradiation is required.
- **Increasing Exports:** Recently, the harmonization of food irradiation rules with the international regulation has taken place in India. This would enable more food exports by overcoming non-tax barriers.
- **Developing new crop varieties:** Department of Atomic Energy (DAE) has developed 42 new varieties of crops using radiation induced mutation (and conventional) breeding. These crops have desirable traits including higher yield, early maturity, resistance to biotic and abiotic stresses etc. Several of these varieties enjoy high patronage among the farming community.
- **Promoting health:** Sea-foods, meat and poultry may carry harmful microbes and parasitic organisms that cause illnesses associated with their consumption.
- **Better returns to farmers and price stabilization:** as farmers would have longer time in hand to bargain a deal at good prices. It also provides economic stability as well as self-reliance to the nation.

8.7. MICRO-LED

Why in news?

Samsung recently demonstrated a prototype MicroLED based TV of 146 inches display.

About MicroLED

- It is an emerging flat panel display technology in which displays consist of arrays of microscopic LEDs forming the individual pixel elements.
- These are simply traditional LEDs shrunk down and placed into an array. The LED technology is not new but manufacturing a panel array using such tiny components is very difficult and currently not commercially viable over OLED.

OLEDs and MicroLEDs

- OLEDs are self-emissive, which means they require no backlight; instead, it lights each individual pixel as needed. Like OLED, Micro LED too don't need backlight.
- OLEDs are made of organic materials that age, resulting in a decrease in luminance over time, with the potential for uneven ageing. MicroLEDs being inorganic (gallium nitride) are not as susceptible to ageing.
- This switch from organic to inorganic also reduces the need for a polarizing and encapsulation layer, making panels thinner.
- The OLED manufacturing process also limits the possible screen shapes and sizes. The MicroLED technology are "modular" in nature which are flexible to configure any size.
- MicroLEDs are more power-efficient than OLEDs.

8.8. ARTIFICIAL LEAF

Why in news?

Indian Institute of Sciences' researchers has developed an **artificial leaf** recently.

About Artificial Leaf or Quantum Leaf

- It will help in reducing carbon footprint as it absorbs carbon dioxide in the atmosphere to generate fuel and oxygen in the process, simulating the process of photosynthesis.

- While most plants **convert less than one per cent o**f the available solar energy into chemical energy, the leaf can **convert about 20 per cent of the incident solar energy into chemical energy. Also,** it is **100 times more efficient than a natural leaf** in absorbing carbon dioxide during the process.
- It is composed of **completely biocompatible, earth abundant, semiconductor nano crystals** called **Quantum dots** which act as catalyst to convert absorbed **CO_2 into bicarbonate and then 'formate'** (derivative of formic acid) that can be used as **bio fuel.**
- It uses copper aluminium sulphate and zinc sulphide as semiconductors.

Quantum Dot:

- It is **a semiconductor nano crystal** which **is made of specific materials**.
- It has a discrete quantized energy spectrum.
- It contains a small finite number of **conduction band electrons, valence band holes, or excitons**.
- They are typically between **10 and 50 nm in size**
- They glow a particular color after being illuminated by light.
- The color they glow depends on the size of the nanoparticle. The smaller the nanoparticle, the higher the energy difference between valence band and conduction band, which results in a deeper blue color. For a larger nanoparticle, the energy difference is lower, which shifts the glow toward red.
- It has many **applications** in several areas such as **solar cells, transistors, LEDs, medical imaging and quantum computing.**

- It can act as a **source of renewable energy**, while **significantly reducing the carbon footprint from the atmosphere, releasing more oxygen in the process.** Hence the development is being viewed as **one of potential solutions in tackling global warming and climate change.**
- The bio fuel generated is not only **100% combustible** but the **carbon dioxide emitted** in the combustion of the fuel can be **recycled by the quantum leaves** too.