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SCIENCE AND TECHNOLOGY

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1. BIOTECHNOLOGY

About Biotechnology

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

Biotechnology industry in India:

- India is among **the top 12 destinations for biotechnology in the world**, with approximately **2% share** in the global Biotechnology industry.
- The **biopharmaceutical sector accounts for the largest share of the biotech industry** in India with a share of 55% of total revenues, followed by bio-agri with 22% market share (2018).
- The high demand for different biotech products has also opened up scope for the foreign companies to set up base in India.
- India has emerged as a leading destination for clinical trials, contract research and manufacturing activities owing to the growth in the bio-services sector.

Government Initiatives: Indian Government seeks to create a US$ 100 billion biotech industry by 2025. It has launched various programs with a view to harness available human and unlimited biodiversity resources.

National Biotechnology Development Strategy 2015-2020 (NBDS)

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

National Biopharma Mission

- It is an **Industry-Academia Collaborative Mission for accelerating discovery research to early development for biopharmaceuticals**.
- The World Bank assisted **INNOVATE IN INDIA (i3)** program under this mission aims to create an enabling ecosystem to promote entrepreneurship and indigenous manufacturing in the sector.
- The **focus of the mission** is to:
  - Develop new vaccines, bio-therapeutics, diagnostics and medical devices to address the rising burden of diseases.
  - Bring isolated centers of excellence (Academia) together, enhance regional capabilities and strengthen the current bio-clusters network in terms of capacities as well as quantity and quality of output.
  - 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.

Promotion of Biotechnology in North Eastern Region of India

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

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

- **Food security:** Biotechnology can help make crops **more productive and tolerant of other stress like pest, insect etc** helping to feed the next billion people.
  - Foods can also **deliver enhanced nutrition,** such as **Golden Rice** with additional vitamin A from the International Rice Research Institute.
  - Making crops resistant to pest attacks (Bt Cotton and Bt Brinjal).
- **Adapting to Climate change:** Biotechnology industry is helping to produce crops that are resistant to the effects of climate change, help farmers convert to no-till practices and develop solutions that decrease carbon-based fertilizers.
- **Tackling diseases:** to threats like Zika virus and the rise of antibiotic-resistant bacteria. Usage of stem cell therapy offers a
- **Bioenergy:** There has been increase in use of **bioethanol and biodiesels** in India. These fuels are derived from living organisms such as plants and their by-products, microbes or animal waste. The growing energy needs of India's rural areas have been increasingly met by biomass fuel.
- **Tackling diseases and advancement in drugs**: Biotechnology offers new solution to various diseases through technologies such as stem cell therapy.
- **Livestock improvement**: Biotechnological techniques such as embryo transfer technology 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.
- **Waste management:** through techniques like bioremediation.

Related news: Golden Rice

- Recently **International Rice Research Institute (IRRI)** along with its partners has successfully **cultivated Golden Rice** in a controlled environment on International Rice Research Institute campus.
- Golden rice is the collective name of **rice varieties that are genetically modified to counter vitamin A deficiency** in developing countries.
- Golden rice differs from standard rice in that it contains **extra genes one from maize and one from bacterial origin** together responsible for the **production of provitamin A (beta-carotene)** in the rice grain.
  - Provitamin A colors the grains yellow-orange, hence the name 'Golden Rice'.
  - Once absorbed into the body, provitamin A is converted into vitamin A.
  - Provitamin A is found in many fruits and vegetables; it is also what makes carrots orange, for example.
- Research has indicated that one cup of Golden Rice can provide up to **50 per cent of the daily requirement of an adult for vitamin A.**
- It **reduces water use** by up to 30 per cent without any yield loss.

Challenges faced in India

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

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

Way forward

- **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.
- **Collaboration between government and industry:** Government needs to come together with the biopharma industry and chalk out a middle ground that recognises the value of innovation and does not hurt its investment attractiveness.
- **Building human capital:** There is a need for development of specialised human resources along with increasing the number and quality of jobs offered by this sector.
- **Funding Mechanism:** Government can build a mechanism where funding can be provided for select innovative ideas based on their national importance.
- **Extending Reach:** There is a need for extending the reach of biotechnology investigations to other fields of study as well such as improving other streams of vaccines and plant varieties.

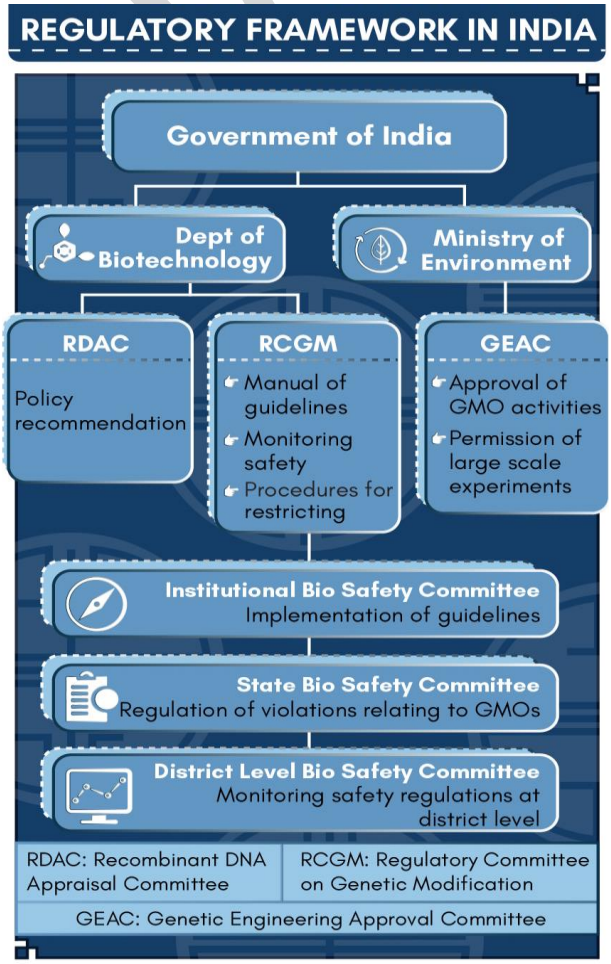
1.1. GM CROPS

Why in news?

Recently, **Genetic Engineering Appraisal Committee (GEAC)** asked Maharashtra Government to initiate action to stop cultivation of illegal **Herbicide-Tolerant variety of Bt Cotton (Ht-bt cotton).**

About GM Crops

- According to **WHO**, Genetically modified organisms (GMOs) are organisms in which the genetic material (DNA) has been altered in a way that does not occur naturally by mating and/or natural recombination. Foods produced from or using GM organisms are referred to as **GM foods**.
- **Indian Scenario**
  - India has **commercialized only one GE crop, the Bt cotton** with the Cry 1 Ac gene.
  - India is at the **4th global position in hectarage under GM crops**.
  - Bt cotton greatly contributed to a **significant increase in farm income** and India's transformation from a cotton importer into an exporter.
  - The **area under Bt cotton seeds is rising**, official data for the 2018 - 19 kharif season reveals that 88.27 per cent of the 122.38 lakh hectares cultivation is under Bt cotton of all varieties
  - GM crops and products are **stringently regulated for their efficacy, biosafety, environmental safety and socio-economic benefits**, through mandatory rules and procedures.



Benefits of GM Crops

- **Increased crop resilience:** Better tolerance to harsh climatic conditons like, heat, drought salinity etc.
  - It also prevents of loss species to endemic disease.

- **Socio- economic benefits:** Improved agricultural performance (yields) with less labour input and less cost input.
  - GM crops provide an opportunity to bring an "evergreen" revolution that benefits **landless, marginal and small farmers in India**.
  - Reduced usage of pesticides and herbicides
- **Reduction in imports:** GM crops can help provide the next great leap by helping to eliminate import of edible oil, Pulses, etc.
- **Food security:** GM crops offer a solution to further enhance the India's food security needs. Food with more desirable traits can be produced.

Other regulations in India

- **Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Microorganisms/Genetically Engineered Organisms or Cells 1989 (known as 'Rules, 1989') under the Environment (Protection) Act, 1986**: These rules and regulations cover the areas of research as well as large scale applications of Genetically Modified Organism (GMOs) and products made there from throughout India. The rules also cover the application of hazardous microorganisms which may not be genetically modified.
- **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 former covers environmental impacts of the food products, the latter assesses the food's impact on human health. Since no regulation has been finalised for GM products, it is still banned in the country.

Codex Alimentarius Commission (Codex):

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

Concern with GM Varieties

- **Monopoly**: Introduction of GM crop is a method by which large seed-producing companies attempt to monopolise the markets. GM seeds contain 'terminator technology' meaning they have been genetically modified so that resulting crops do not produce viable seeds of their own.
- **Outcrossing:** The migration of genes from GM plants into conventional crops or wild species may have an indirect effect on food safety and food security.
- **Decline in yield:** There has been witnessed a decline/stagnation in yield after few years with respect to many GM crops which in turn leads to diminishing returns.
- **Concerns for human health:** Gene transfer from GM foods to humans can be problematic if the transferred genetic material adversely affects human health. This would be particularly relevant if antibiotic resistance genes were to be transferred.
  - **Allergenicity:** Because protein sequences are changed with the addition of new genetic material, there is concern that the engineered or modified organism could produce known or unknown allergens.
- **Resistance developed by Pathogens:** There is always a concern of pathogens becoming resistant to the toxins produced by GM crops. For example the **pink bollworm** has grown resistant to the toxins produced by BT cotton seed of Monsanto.
- **Concerns for the environment:** The susceptibility of non-target organisms (e.g. bees and butterflies) and the **loss of biodiversity** of crop/plant species remains a concern.
  - Toxins produced in GM crops are present in every part of the plant, so when the parts that have not been harvested decompose, a considerable amount of the **toxin may reach the soil/water table**.
- **Regulatory Challenges**
  - **Possibility of data manipulation:** The GEAC does not conduct the closed field trials on their own but are solely dependent on the data provided to them by the technology developer making it susceptible to manipulations and fudging the data.
  - **Concerns regarding GEAC:** Issues such as adhocism in its constitution, criteria adopted for selection of its members, dominance of bureaucrats, no representation from civil society or states where Bt Cotton has been introduced, head not being from field of Biotechnology etc. remain.
  - **Functioning of DLCs:** The presence of District Level Committee (DLC) which regulates GM crop at the ground l evel is hardly felt in any of the States.
- **Negative public perception:** Public attention has focused on the risk side of the risk-benefit equation owing to **lack of transparency and ignorance** about the scientific facts related to GM crops. Moreover, **India has imported edible GM soybean** and canola so the resistance to growing the same is contradictory.

Way Forward

- **National policy on GM crops:** should be brought to define the exact areas where GM is required by the country and where the government will encourage public and private investment in GM technology.
- **Proactive Patent regime:** It must be ensured that proper legislative and judicial safeguards exist to prevent monopolisation of the GM seed market. For example the recent Supreme Court held that US company Monsanto cannot claim patents on its GM cotton seeds.
- **Transparency:** The GEAC reports must be made public and effective discussion should be held with scientific community and civil society to allay their fears.
  - An independent authority, **the Biotechnology Regulatory Authority of India (BRAI)**, to regulate organisms and products of modern biotechnology should be setup.
- **Legal measure**: There should be a liability clause, that is, if something goes wrong the liability should be fixed statutorily like in case of US law, liability is huge in case the GM tech effects the regular varieties of crops. It will ensure that case of non-accountability, in case of pink bollworm pest attack on BT cotton, does not repeat itself in case of other GM crops.
- **Stringent Regulation:** With advances in biotechnology, there is an urgent need for stringent regulation or scrutiny in the sector to ensure cultivation and sale of environmentally-safe agro products.
  - **The Cartagena Protocol on Biosafety** and the **Biological Diversity act, 2002** must be effectively implemented.
  - Mandatory labelling of GMOs should be enforced to provide an option to consumers.
- **Cooperation:** The state governments must be consulted before taking a decision related to GM crops issue as agriculture is a state subject.
- **Analyse Cost-Benefit of New Technology**: It can be argued that while technological changes inevitably have led to some negative externalities, a broader picture should be kept in mind when deciding to include them in our day to day life.

1.2. GENE EDITING

Why in news?

Recently, He Jiankui, an independent Chinese researcher, triggered global controversy over claims that his experiments produced the world's first genetically altered babies using CRISPR/Cas9 gene editing technology.

CRISPR-Cas9

- 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
- CRISPR is the DNA-targeting part of the system which consists of an RNA molecule, or 'guide', designed to bind to specific DNA bases through complementary base-pairing.
- Cas9 is the nuclease part that cuts the DNA.

What is Gene Editing?

- It is a type of **genetic engineering in which DNA is inserted, deleted or replaced in the genome of an organism** using artificially engineered nucleases, or "molecular scissors".
- These nucleases **create site-specific double-strand breaks (DSBs) at desired locations** (e.g. where anomalous gene is present).
- Such breaks are then repaired through recombination or inserting new gene, resulting in targeted mutation.

Benefits of Gene Editing

- Human genome editing can be used to **treat many human diseases & genetic disorders** like HIV/AIDS, haemophilia etc.
- It could substantially **bolster disease resistance in humans & increase life span.**
- It could form the basis of **highly efficient & cost effective next generation antibiotics** (based on bacteriophage viruses).
- Gene editing can be used to **protect endangered species** or bring to life extinct species.
- It can be used to grow **healthier food (via fortification)** and increasing harvest.
- It has the potential to **slow down the spread of diseases by eliminating its means of transmission**. E.g. Gene editing can be used to introduce sterile mosquitoes into the environment.

Issues with Gene editing

- **Balance Risks & Benefits:** Due to the possibility of **off-target effects** (edits in the wrong place creating properties different from those that were intended) and **Mosaicism** (when some cells carry the edit but others do not, leading to presence of two or more populations of cells), safety is of primary concern.
- **Application of the technique to human germline:** Until now, all therapeutic interventions in humans using genome editing have been performed in somatic cells (i.e. only patient gets affected, no chance of inheriting the altered genes by patient's offspring). Safety concerns have been raised regarding genome editing in human germline, where unpredictable changes can be transmitted to following generations.
- **Ecological impacts:** A 'gene drive' can propagate a set of genes with negative traits throughout a population which may lead to disappearance of whole targeted population with severe ecological consequences.
- **Difficulty in regulation:** The precise genetic modifications obtained through CRISPR Cas9 technique makes it more difficult to identify a genetically modified organism once outside the lab and also to regulate such organisms in the market.
    - 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.
- **Uncontrolled clinical trials**: There are at present no standard norms for standardisation of norms for clinical trials for checking the efficacy of the treatment.

Way Forward

- The scientific community must **lay down principles to distinguish between 'good' & 'bad' uses of gene editing**:
    - **Promoting Wellbeing**: Research must be designed to increase human health and wellbeing. Early stage and uncertain applications must minimize risk.
    - **Transparency:** Researchers must fully disclose information about benefits, risks, and implications to stakeholders.
    - **Due Care:** Clinical research involving human patients must proceed cautiously and conservatively, only upon full evaluation of evidence, and under strict supervision.
    - **Responsible Science:** Research must adhere to the highest experimental and analytical standards.
    - **Respect for Persons:** Research must acknowledge the dignity of all individuals and that all individuals have equal moral value, regardless of their genetic profile.
    - **Equity:** Benefits & burdens of the research must be broadly and equitably accessible.
    - **Transnational Cooperation:** Researchers must commit to international collaboration to harmonize regulation of the application of genome editing technologies.
- Bioethicists & researchers believe that human genome editing for reproductive purposes should not be attempted at this time until more safety and effectiveness research can be done, risks & benefits weighed, and a social consensus reached. All clinical trials proceeding in human germline editing should be permitted only when there are no reasonable alternative forms of disease prevention.

Ethical Challenges around Gene Editing

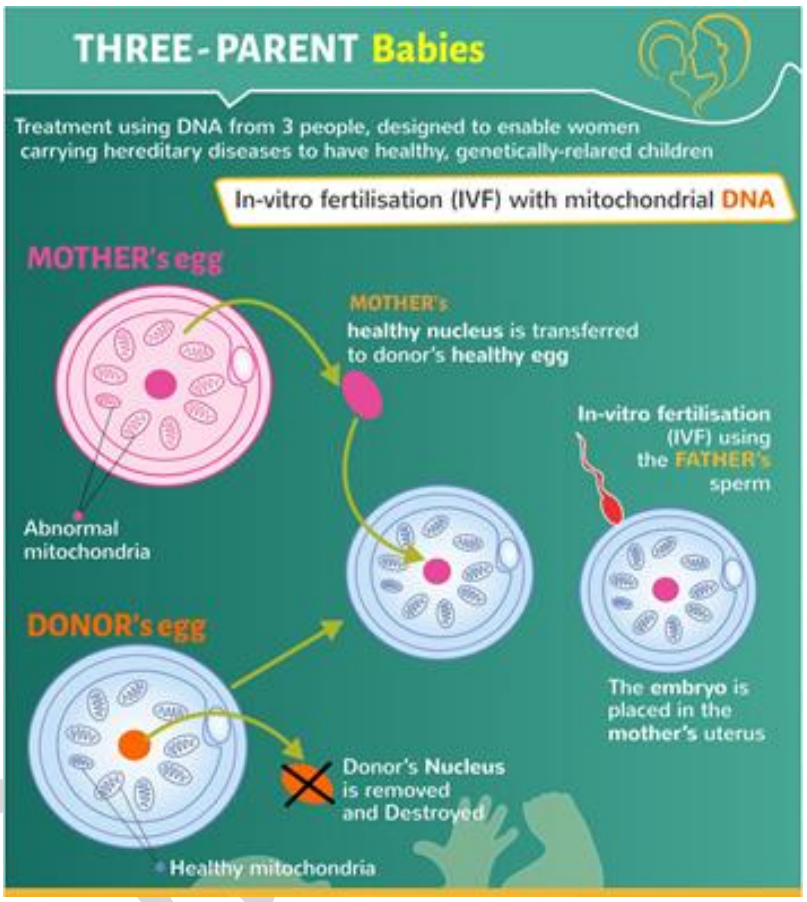
- **Concerns over 'Designer Babies':** Engineering human embryos raises the prospect of designer babies, where embryos are altered for social rather than medical reasons e.g. to increase height or intelligence.
- **Justice and Equity:** There is concern that genome editing will only be accessible to the wealthy and will increase existing disparities in access to health care and other interventions. Taken to its extreme, germline editing could create classes of individuals defined by quality of their engineered genome (e.g. super-intelligence/extra-ordinary beauty). Thus, the use of genetic enhancement would lead to an abhorrent form of social inequality, and that is unjust.
- **Informed consent:** Critics say that it is impossible to obtain informed consent for germline therapy because the patients affected by the edits are the embryo and future generations. Testing new technology on humans which may have inter-generational adverse impact without necessary safeguards amounts to treating humans as means to an end, a violation of **Kantian ethical principle**.
- **Genome-Editing Research Involving Embryos:** Many people have moral and religious objections to the use of human embryos for research. India & Canada doesn't allow genome-editing research on embryos, while US has banned federal aid from being used to support germline gene editing.
- **Regulations for consumers:** Regulation of patents is challenging as many economic interests are involved and may lead to litigations. The case of biotechnological companies patenting human genome sequences for therapeutic use puts too much emphasis on profits, which raises ethical issues.

- It is important to have continuing public deliberation to decide whether or not germline editing should be permissible.

1.2.1. 3-PARENT BABY

Why in news?

Recently, a team of Greek and Spanish doctors has produced a baby from three people **using maternal spindle transfer technique (a method of Mitochondrial Replacement Therapy).**



Background

- The mitochondria are organelles inside cells that are involved in releasing energy by **producing adenosine triphosphate (ATP)**, the key energy currency that drives metabolism.
  - Mitochondria are referred to as the **powerhouse of the cell.**
- In addition to energy production mitochondria also **helps to regulate the self-destruction of cells** (aptosis), necessary for **production of substances such as cholesterol** and heme (a component of haemoglobin).
- While most of DNA is found in cell nucleus, some DNA is also found in the mitochondria, it is called mitchochondrial DNA (mtDNA).
- Mitochondria are **inherited solely from the mother** and this results into cases of babies been born with **rare mitochondrial diseases** if mother has the faulty mtDNA.
- Certain disorders caused due to mtDNA dysfunction are diabetes, respiratory disorders, Huntington's disease, Parkinson's disease, Alzheimer's disease etc.
- There is currently **no cure for mitochondrial diseases.**

About "three-parent" babies

- **Mitochondrial Replacement therapy (MRT)** is a form of **In Vitro Fertilization (Assisted Reproductive Technology).**
- It 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**.

Process of MRT

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

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.

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.

- 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.
- **Advantages:** It could **prevent severe genetic diseases** being passed from mother to offspring and can be used to **treat infertility.**
- The United Kingdom became the first country in 2015, to have officially approved procedures to create **"three-parent" babies.**

1.3. GENOME SEQUENCING

Why in News?

International biologists have launched an ambitious **Earth BioGenome Project** to **sequence, catalog and characterize the genomes of all of Earth's eukaryotic biodiversity** (organisms whose cells have a nucleus enclosed by membranes) over a period of ten years.

What is Genome Sequencing?

- **Genome** is an organism's complete set of DNA, including all of its genes. Each genome contains all of the information needed to build and maintain that organism.
  - In humans, a copy of the entire genome—more than 3 billion DNA base pairs—is contained in all cells that have a nucleus.
- **Genome sequencing** is figuring out the order of DNA nucleotides, or bases, in a genome—the order of As, Cs, Gs, and Ts that make up an organism's DNA.

Benefits of Genome Sequencing

- **Saving Biodiversity:** Genome Sequencing help record the genomes of organisms at risk. Given Climate Change and related worries such as loss of forest cover, about 50% of current biodiversity could be lost by the end of the 21st century in what is being referred to as the Sixth Great Extinction.
- **Discovery of Unknown Species:** It is believed that there are somewhere between 2 million and 3 million eukaryotic species on the planet. Only about half have been identified so far.
- **New Resources:** It should also lead to the discovery of new drugs, new biofuels, and boost agricultural technologies, with obvious commercial benefits.
  - It will be possible to develop disease, insect and drought resistant crops.
- **Generate Revenues:** It could help to boost scientific capacity and generate revenues for poor countries with rich biodiversity.

About Earth BioGenome Project

- It involves projects by various countries:
  - **US-led project** to sequence the genetic code of tens of thousands of vertebrates
  - **Chinese project** to sequence 10,000 plant genomes
  - **The Global Ant Genomes Alliance**, which aims to sequence around 200 ant genomes.
- **UK participants, led by the Wellcome Sanger Institute,** will also sequence the genetic codes of all 66,000 species inhabiting Britain in a national effort called **the Darwin Tree of Life**.
- Currently, fewer than 3,500, or **about 0.2 per cent of all known eukaryotic species** on Earth have had their genome **sequenced**.
- Physical samples would be stored frozen in liquid nitrogen in four or more facilities located in different parts of the world, and repositories of **digitised information** would be created.
- The completed project will generate at least 1 exabyte (that is, 1 billion gigabytes) of data, which is to be **shared online for free.**
- The initiative would produce a **database of biological information** that provides a platform for scientific research and supports environmental and conservation initiatives.
- The participating institutions would **raise their own funding** as far as possible. However, the project has the backing of the World Economic Forum
- The potential benefits of EGP are compared to those from **Human Genome Project**, which has transformed research into human health and disease.

Human Genome Project (HGP):

HGP-Read:

- This was an international and multi-institutional effort that took 13 years [1990-2003] to produce a blueprint of the human genome.
- The HGP has revealed that there are probably about 20,500 human genes composed of over 3 billion base pairs.
- India did not participate in HGP-read.

HGP-Write:

- This project was launched in 2016 to write or build an artificial human genome from scratch with sophisticated bioengineering tools.
- Potential applications include growing transplantable human organs, engineering immunity to viruses in cell lines, engineering cancer resistance into new therapeutic cell lines, and accelerating high-productivity, cost-efficient vaccine etc.

- **Better Understanding:** It will revolutionize the understanding of biology and evolution and thus create new approaches for the conservation of rare and endangered species by providing a high-resolution, base-by-base view of the genome
  - Scientists also hope that being able to study the entire genome sequence will help them understand how the genome as a whole works—how genes work together to direct the growth, development and maintenance of an entire organism.

Other related projects

Genome India Project

- It was launched in 2017 by the Centre for Brain Research at the Indian Institute of Science (IISc) in collaboration with Institute of Bioresources and Sustainable Development (a national institute of the Department of Biotechnology).
- It seeks to carry out Whole Genome Sequencing (WGS) of over 2,000 individuals spanning different ethnic, linguistic and socio-cultural sections of the northeastern states.
- It would help in understanding the genetic origins of the different ethnic groups and also an increased understanding of the genetic disease burden which would help in the development of personalised medicine.

100k GenomeAsia Project: A group of Indian scientists and companies are involved with a 100k GenomeAsia project, led out of the Nanyang Technological University (NTU), Singapore, to sequence the whole genomes of 100k Asians, including 50,000 Indians.

- **Huge information:** It delivers large volumes of data in a short amount of time to support assembly of novel genomes.
- **Understanding outside the genes**: Genes account for less than 25 percent of the DNA in the genome, and so knowing the entire genome sequence will help scientists study the parts of the genome outside the genes. This includes the regulatory regions that control how genes are turned on an off, as well as long stretches of "nonsense" or "junk" DNA—so called because we don't yet know what, if anything, it does.
- **Sequencing of other species**: While this method is commonly associated with sequencing human genomes, the scalable, flexible nature of next-generation sequencing (NGS) technology makes it equally useful for sequencing any species, such as agriculturally important livestock, plants, or disease-related microbes.
- **Understanding diseases**: Genomic information has been instrumental in identifying inherited disorders, characterizing the mutations that drive cancer progression, and tracking disease outbreaks.
- **Environment protection**: The knowledge generated by this sequencing will help in environmental protection by detecting bacteria and other organism that may pollute air, water, soil and food.

Challenges for genome sequencing

- **Ethical and social issues**: If handled carelessly genetic information can threaten us by discrimination by potential employers and insurers.
- **Tedious task:** The most difficult part of genome sequencing is to acquire and process high-quality samples from species that are hard to reach.
- **Lack of Technologies:** New technologies such as specimen-collecting drones may need to be developed.
- **IPR issue:** There are complicated protocols involved in transferring physical samples and genetic data across borders, and there are bound to be disputes about the sharing of the benefits obtained.
- **Legal Frameworks:** While the Nagoya Protocols of 2014 provide a framework for such transfers, the United Nations Convention on Biological Diversity will have to work out new protocols and, ideally, create a new, transparent and equitable legal framework.

Related News

Recently, Indian Human Microbiome Initiative, led by The National Centre for Microbial Resource (NCMR) - National Centre for Cell Science (NCCS) has been put up for approval.

About Human Microbiome Project (HMP)

- Human Microbiome Project is a research initiative of **US's National Institute of Health** with the mission to generate the resources and expertise needed to characterize the human microbiome and analyze its role in health and disease.
- Launched in 2007, it is focused on identifying and characterizing human microbial fauna and elucidating their roles in health and diseases.
- Some methodologies used in HMP are:
  - **Metagenomics** as a culture-independent method of broad microbial community characterization

- **Whole Genome Sequencing (WGS)** to provide a "deep" genetic perspective on aspects of a given microbial community, *i.e.* individual bacterial species

Human Microbiome Research in India

- **India doesn't have a dedicated national human microbiome project**. But, the proposed Indian Human Microbiome Initiative holds a lot of potential.
- The project will include collection of saliva, stool and skin swabs of 20,000 Indians across various ethnic groups from different geographical regions.
- Scientists have found that **Indian population, particularly tribals, have distinct gut microbiota** than individuals from other parts of the world. Such tribal populations **largely unaffected by "modern" diet** and **have lower prevalence of lifestyle diseases** and their study would shed some light on mutualism between gut microbiota and the host.

Importance of the Human Microbiome

- The collective genome of all micro-organisms contained within the human body, residing inside tissues & bio-fluids is called Human Microbiome. It includes bacteria, archaea, fungi, protists and viruses.
- Microbial communities play a key role in many aspects of host physiology:
  - Metabolism of otherwise complex indigestible carbohydrates and fats
  - Production of essential vitamins
  - Maintaining immune systems
  - Acting as a first line of defense against pathogens
  - Influence the susceptibility to certain infectious diseases, as well as contribute to disorders such as obesity and diabetes
  - Determines how one responds to a particular drug treatment
- The diversity of microbes that make up human microbiome could lead to novel therapies e.g. an infection caused by a 'bad' bacterial species can be treated by promoting the growth of 'good' bacteria.
- Up to 90% of all diseases can be raced in some way back to the gut and health of the microbiome.

1.4. MANAV: HUMAN ATLAS INITIATIVE

Why in news?

Department of Biotechnology (DBT) recently launched **MANAV: Human Atlas Initiative**.

Details

- **MANAV Project** aims to create an open and interactive atlas of human biology, compiling, curating and synthesizing data at the molecular, cellular, tissue and organismic level from scientific literature and public databases.
- For the first time, Indian scientists will be **mapping every single tissue** of the human body to have deeper understanding of the roles of tissues and cells linked to various diseases.
- Participating institutes include National Centre for Cell Science (NCCS) and Indian Institute of Science, Education and Research (IISER), Pune. Besides, Persistent Systems Limited has co-funded the project (alongwith DBT) and is developing the platform.
- The project can be signed up by students who are in their final year graduation and above. Even participants having a science background but not necessarily involved in active scientific research can be part of this network.
- Initially, DBT will accommodate colleges that operate the DBT Star College scheme to register for this Human Atlas programme.

Benefits and applications

- **Physiological and molecular mapping** – holistic ananlysis : The aim of the project is to understand and capture the human physiology in two stages – in a normal stage and while in a disease stage. Such a database on individual tissues, once ready, can come handy in-
  - tracing the causes of a disease,
  - understanding specific pathways,
  - decode the body's disease stage linked to tissues and cells,
  - develop disease models through predictive computing.
- **Drug discovery:** The teams will also study any potent elements or molecules that have never been used in the form of drugs, to target the specific cells or tissues.

- **Customise and personalize medicine:**
  - Patient specific support for medicine/ treatment decisions
  - Understanding of pre-clinical and clinical assessment of healthcare products
  - Personal health forecasting
- **Skill development of student community:** students will be the backbone on assimilating the information. This platform will impart key skills to the student community to read classified scientific literature, in this case, on individual tissue-basis, and perform annotation and curation.
- **Future research:** Since all the information generated will pass through multiple levels of reviews, it will be an Atlas or a reliable collection on human body tissues. It will also identify gaps in the current biological knowledge, which could be basis for future studies - for both future researchers and to the clinicians and drug developers, who finally handle human bodies in disease conditions; and future policies.

2. NANOTECHNOLOGY

Why in News?

Recently, Department of Biotechnology under Ministry of Science and Technology has prepared draft guidelines for evaluation of nano-pharmaceuticals in India.

About Nanotechnology

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

Nano-Pharmaceuticals

- Nano-pharmaceutical is an emerging field that combines nanotechnology with pharmaceutical and biomedical science with the goal of targeted drug delivery which may improve efficacy and safety profile.
- There are no uniform internationally acceptable guidelines for nano-pharmaceuticals.

Benefits of nano-pharmaceuticals include:

- It overcomes the limitations of the conventional drug delivery systems and **precision targeting** via nano-pharmaceuticals reduces toxic systemic side effects, resulting in **better patient compliance.**
- They offer the **ability to detect diseases** at much earlier stages and the diagnostic applications could build upon conventional procedures using nanoparticles.
- Nano pharmaceutical **reduces the cost of drug discovery,** design & development and enhances the drug delivery process.

Need for regulation of nano- pharmaceuticals

- **Possible adverse effects of nanotechnology on the environment and humans:** For example nanoparticles of sizes comparable to that of human cells can be deposited in lungs and may cause damage by acting directly at the site of deposition or by translocating to other organs or by being absorbed through the blood.
- Their use as undetectable weapon in warfare.
- Incorporation of nano-devices as performance enhancers in human beings.
- Ethical and social issues associated with nano pharmaceuticals.
- Need for orderly growth of the sector and commercialization of nano technology innovations.

Salient features of the Draft guidelines

- Defines nano-pharmaceuticals: as a pharmaceutical preparation containing nanomaterials (size scale range of 1 to 100nm) intended for internal or external application on the body for the purpose of therapeutics, diagnostics and any health benefit.
- Categorises nano pharmaceuticals:
  - According to degradability of nanomaterial: Examples: albumin, chitosan, gelatin, polycaprolactone etc.
  - According to organic or inorganic nature of nanomaterial: Nanomaterial may be organic or inorganic in nature. It may also be multicomponent nanoparticle.
  - According to nanoform of the ingredient: A nanocarrier is a nanomaterial being used as a transport module for another substance like a drug.
  - According to the approval status of drug and nanomaterial.
- It mandates that the stability testing of nanopharmaceuticals should be done according to the general requirements specified in Drugs and Cosmetics Rules, 1945.

Current status of Nanotechnology in India

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

Applications of Nano Technology

- **Medical field:** for various purposes like disease diagnosis, drug delivery, cancer treatment, repair damaged tissue through tissue engineering etc.
- **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.
  - 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.
  - 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

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.
- 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.
  - **Infrastructure Development for Nano Science & Technology Research:** Investigations on the nano scale require expensive equipments like Optical Tweezer, Nano Indentor, Transmission Electron Microscope (TEM), etc. 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:** Promoting 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.

Other initiatives

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

- Novel hydrogen storage systems based on carbon nanotubes and other lightweight nanomaterials
- Photovoltaic cells and organic light-emitting devices based on quantum dots.

Challenges in Nanotechnology

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

Conclusion

Nanotechnology could be both relevant and appropriate to sustainable development practices in India. Therefore, it is necessary to develop responsible nanotechnology governance, encourage the development of appropriate products targeted to help meet critical human development needs, and include methods for addressing the safety, appropriateness; accessibility and sustainability of nanotechnology meet the developing countries like India.

3. HEALTH

3.1. ANTIMICROBIAL RESISTANCE

Why in news?

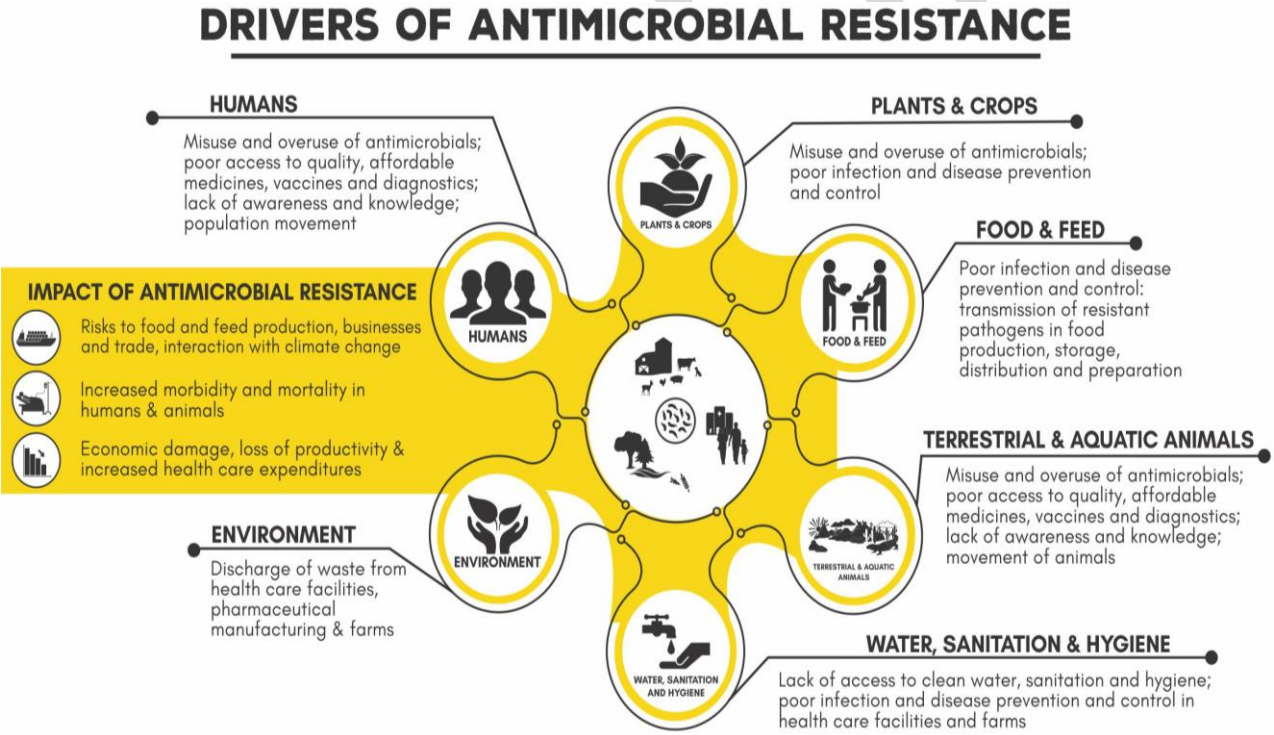
Recently, the Interagency Coordination Group on Antimicrobial Resistance (IACG) has released a report titled, **"No Time to Wait: Securing The Future From Drug Resistant Infections"**, which highlights the financial fall-out of uncontrolled antimicrobial resistance.

Interagency Coordination Group on Antimicrobial Resistance (IACG)

- It was convened by the Secretary-General of the United Nations after the UN High-Level Meeting on Antimicrobial Resistance in 2016.
- The IACG brought together partners across the UN, international organizations and individuals with expertise across human, animal and plant health, as well as the food, animal feed, trade, development and environment sectors, to formulate a blueprint for the fight against antimicrobial resistance.
- The World Health Organization (WHO) provided the Secretariat for the IACG, with contributions from the Food and Agriculture Organization of the United Nations (FAO) and the World Organisation for Animal Health (OIE).

Background

- **Antimicrobial resistance (AMR)** is the ability of a microorganism (like bacteria, viruses, and some parasites) to stop an antimicrobial (such as antibiotics, antivirals and antimalarials) from working against it. As a result, standard treatments become ineffective, infections persist and may spread to others.
- Antibiotic resistance occurs naturally, but misuse of antibiotics in humans and animals is accelerating the process. Poor infection prevention and control further accelerate it.



Key Recommendations of the Report

- **Accelerate Progress In Countries-** in terms of implementation of One Health National Antimicrobial Resistance Action Plans. Also Member States to phase out the use of antimicrobials for growth promotion.
- **Innovate To Secure The Future-** through quality-assured, new antimicrobials (particularly antibiotics), novel compounds, diagnostics, vaccines, waste management

What is 'One Health'?

- It is an approach to designing and implementing programmes, policies, legislation and research in which multiple sectors communicate and work together to achieve better public health outcomes.
- The areas of work in which a One Health approach is particularly relevant include food safety, the control of zoonoses (diseases that can spread between animals and humans, such as flu, rabies and Rift Valley Fever), and combatting antibiotic resistance.

tools, and safe and effective alternatives to antimicrobials for usage.

- **Collaborate For More Effective Action-** through systematic and meaningful engagement of civil society groups, private players and organizations as key stakeholders in the One Health response to antimicrobial resistance at global, regional, national and local levels.
- **Invest For A Sustainable Response-** through greater resource allocation, donations to fund the implementation of National Antimicrobial Resistance Action Plans.
- **Strengthen Accountability And Global Governance-** by urgent establishment of a One Health Global Leadership Group on Antimicrobial Resistance, supported by a Joint Secretariat managed by the Tripartite agencies (FAO, OIE and WHO).

Situation in India

India faces a twin challenge of overconsumption of antibiotics breeding drug-resistant bacteria while ensuring that the poor and vulnerable have easy access. WHO's report states that anti-biotic resistance may cause rise in death of Indians to 20 lakhs per year by 2050.

Steps taken

- To strengthen the surveillance of antimicrobial resistance (AMR) in the country, Indian Council of Medical Research (ICMR) has set up a **National Anti-Microbial Resistance Research and Surveillance Network (AMRRSN)** to enable compilation of National Data of AMR at different levels of Health Care.
- **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. These will be sold on prescription only. They are also marked with Red Line (Red Line Campaign).
- **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 (GAPAMR).
  - 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

- Antimicrobial resistance is a global crisis that threatens a century of progress in health and achievement of the Sustainable Development Goals. Unless the world acts urgently, antimicrobial resistance will have disastrous impact within a generation.
- Because the drivers of antimicrobial resistance lie in humans, animals, plants, food and the environment, a sustained One Health response is essential to engage and unite all stakeholders around a shared vision and goals, such as-
  - Individuals to use antibiotics only when prescribed. Prevent infections by maintaining hygiene.
  - Policy makers should ensure a robust national action plan to tackle antibiotic resistance, improve surveillance of antibiotic-resistant infections.
  - Agriculture sector: Only give antibiotics to animals under veterinary supervision, Vaccinate animals to reduce the need for antibiotics and use alternatives to antibiotics when available.

3.2. IMMUNISATION IN INDIA

Why in News?

Recently, the Union Health Ministry has ordered an inquiry into the type-2 polio virus contamination detected in the vials used for immunisation in Uttar Pradesh, Maharashtra and Telangana.

What is immunisation?

- A **vaccine** is a biological preparation that improves immunity to a particular disease. A vaccine typically contains an agent that resembles a disease-causing microorganism, and is often made from weakened or killed forms of the microbe, its toxins or one of its surface proteins.
- The **agent stimulates the body's immune system to recognize the agent as foreign, destroy it, and "remember" it,** so that the immune system can more easily recognize and destroy any of these microorganisms that it later encounters.

- **Immunization** is a proven tool for controlling and eliminating life-threatening infectious diseases and is estimated to avert between 2 and 3 million deaths each year.
- It is one of the **most cost-effective health investments,** with proven strategies that make it accessible to even the most hard-to-reach and vulnerable populations. It has clearly defined target groups; it can be delivered effectively through outreach activities; and vaccination does not require any major lifestyle change.

About Polio

- It is a **highly-infectious viral disease** which mainly affects young children and can result in permanent paralysis.
- The virus is **transmitted by person-to-person spread mainly through the faecal-oral route or**, less frequently, by a common vehicle (e.g. contaminated water or food) and multiplies in the intestine, from where it can **invade the nervous system and can cause paralysis**.
- There is **no cure and it can only be prevented through immunisation**.
- **Types**: Of the 3 strains of wild poliovirus (type 1, type 2, and type 3), wild poliovirus type 2 was eradicated in 1999 and no case of wild poliovirus type 3 has been found since 2012.
- **Difference between Oral Polio Vaccine (OPV) and Inactivated Polio Vaccine (IPV):** OPV is made up of attenuated or weakened poliovirus and there is a risk of vaccine derived polio. IPV is made up of inactivated (killed) polio virus and will provide immunity from all three strains of polio.
- India was **officially declared Polio free by WHO in 2014**.
- However, samples from some states showed the presence of Type 2 **vaccine derived polio virus (VDVP),** which had undergone ten nucleotide changes.
- If six or more nucleotide changes happen then it is called vaccine-derived poliovirus (VDVP).
- VDVP is **extremely rare and found in children with immune-deficiency** and among populations with low immunity levels.

Types of Vaccines

- **Live-attenuated vaccines:** Live vaccines use a weakened (or attenuated) form of the germ that causes a disease. Live vaccines are used to protect against: Measles, mumps, rubella (MMR combined vaccine) Rotavirus Smallpox Chickenpox Yellow fever.
- **Inactivated vaccines**: use the killed version of the germ that causes a disease. Inactivated vaccines are used to protect against: Hepatitis A Flu (shot only) Polio (shot only) Rabies.
- **Subunit, recombinant, polysaccharide, and conjugate vaccines:** They use specific pieces of the germ — like its protein, sugar, or capsid (a casing around the germ). These vaccines are used to protect against: Hib (Haemophilus influenzae type b) disease Hepatitis B HPV (Human papillomavirus), Whooping cough (part of the DTaP combined vaccine) Pneumococcal disease Meningococcal disease Shingle
- **Toxoid vaccines:** They use a toxin (harmful product) made by the germ that causes a disease. Toxoid vaccines are used to protect against Diphtheria Tetanus.

Types of Immunization

- **Active immunization:** In this the vaccine prevents an infectious disease by activating the body's production of antibodies that can fight off invading bacteria or viruses.
- **Passive immunization:** In this antibodies against a particular infectious agent are given directly to the child or adult, is sometimes appropriate.
  - These antibodies are taken from a donor and then processed so the final preparation contains high antibody concentrations. passive immunizations provide only short-term protection that often lasts just a few weeks before the antibodies are worn down and removed from the bloodstream.

Challenges to immunization

- Weak Vaccine Preventable Diseases (VPDs) surveillance system
- Lack of data on disease burden in India and resulting perception that the disease is not important public health problem;
- Lack of diagnostic tools for certain vaccine preventable diseases that could be used without sophisticated instruments or specialized training;
- Limited economic evaluations to show cost effectiveness of vaccines over other interventions to support decision-making;
- Lack of a financial sustainability plan for the introduction of new vaccines in the UIPalso affects decision making in this area.
- Shortage of trained manpower to manage the UIP at the Center as well as State levels, for innovations in vaccines, for disease surveillance and for procurement and effective vaccine management.

Way forward

- **Strengthening of health management information systems,** including data recording and registration systems, called Mother and Child Tracking System (MCTS).
- The **linking of already available systems with the unique identification** like Aadhaar can facilitate tracking of the beneficiaries.
- Furthermore, **development of universal health cards and electronic record maintenance** for maternal and child health care is highly desirable. This can facilitate care seeking by the migrant population in urban areas and can be used to decide resource allocations.
- Devoting **greater financial resources** towards immunisation coverage with concerted efforts to improve social mobilisation for immunisation is warranted.
- **Strengthening a network of community health workers** in urban and peri-urban areas to contribute towards progress in immunisation coverage by reaching out to both slum as well as non-slum populations is of utmost priority.
- **Facilitating improvement in knowledge and awareness** regarding child immunisation can be intensified with the use of mass media, interpersonal communication, school and youth networks.
- **Reaching out to communities and areas with poor immunisation coverage** with well-articulated strategies for community awareness will be key to success.

Steps taken by Government for Immunization

Intensified Mission Indradhanush (IMI)

- It has been launched by the Government of India to reach each and every child under two years of age and all those pregnant women who have been left uncovered under the routine immunisation programme.
- It targets to immunize all children against seven vaccine preventable diseases namely Diphtheria, Pertussis, Tetanus, Childhood Tuberculosis, Polio, Hepatitis B and Measles. In addition to this, vaccines for Japanese Encephalitis, Haemophilus influenza type B, inactivated polio vaccine, Rotavirus vaccine and Measles Rubella vaccine are also being provided in selected states.
- **Success of Intensified Mission Indradhanush (IMI)**
  - Full Immunization Coverage has **increased by 18.5 percentage points** (from 50.5% to 69%) between 2015 to 2018 in 190 IMI districts.
  - Four phases of Mission Indradhanush have **reached to more than 2.53 crore children and 68 lakh pregnant women** with life-saving vaccines.
  - Earlier the increase in full immunization coverage was 1% per year which has **increased to 6.7% per year** through the first two phases of 'Mission Indradhanush'.
  - It is **one of 12 best practices from around the world** to be featured in a special issue of the British Medical Journal.

Universal Immunisation Program (UIP)

- It aims to protect children from life threatening conditions by providing vaccination.
- It is 100% funded by central government and covers all children and pregnant women.
- The program now consists of vaccination for 12 diseases- tuberculosis, diphtheria, pertussis (whooping cough), tetanus, poliomyelitis, measles, Hepatitis B, Diarrhoea, Japanese Encephalitis, rubella, Pneumonia (Heamophilus Influenza Type B) and Pneumococcal diseases (Pneumococcal Pneumonia and Meningitis).

3.3. MALARIA VACCINE

Why in news?

Government of Malawi recently launched the world's first malaria vaccine in a landmark pilot programme.

More in news

- The country is the first of three in Africa in which the vaccine, known as **RTS,S** (Trade name: **Mosquirix**), will be made available to children up to 2 years of age.
- Financing for the pilot programme has been mobilized through a collaboration among three key global health funding bodies: GAVI, the Vaccine Alliance; the Global Fund to Fight AIDS, Tuberculosis and Malaria; and Unitaid.

RTS,S

- RTS,S/AS01 (RTS,S) is the **world's first malaria vaccine** shown to provide partial protection against malaria in young children.
- RTS,S aims to trigger the immune system to de**fend against the first stages of malaria when the Plasmodium falciparum parasite enters the human host**'s bloodstream through a mosquito bite and infects liver cells.

- The vaccine is designed to **prevent the parasite from infecting the liver**, where it can mature, multiply, reenter the bloodstream, and infect red blood cells, which can lead to disease symptoms.
- It has been developed by British pharmaceutical company **GlaxoSmithKline** in **partnership with the PATH Malaria Vaccine Initiative (a non profit organisation).**

Malaria

- Malaria is a communicable disease caused by ***Plasmodium* parasites** that are transmitted to people through the bites of infected **female Anopheles mosquitoes.**
- It is preventable and curable.
- In 2017, 5 countries accounted for nearly half of all malaria cases worldwide: Nigeria (25%), the Democratic Republic of the Congo (11%), Mozambique (5%), India (4%) and Uganda (4%).

India and Malaria

- As per the World Malaria Report 2017 of World Health Organization (WHO), the estimated malaria cases from India are 87% in South East Asia region.
- The **National Framework for Malaria Elimination (NFME) 2016-2030** lays out the vision, mission, broad principles and practices to achieve **the target of malaria elimination by 2030** synchronising with the Global Technical Strategy (GTS) for Malaria 2016-2030 of World Health Organisation (WHO).
- The Government has drafted **National Strategic Plan for malaria elimination (2017-2022)** wherein the country has been stratified based on the malaria burden into four categories – category 0 to category 3 and based on this the intervention of malaria control and prevention are being strengthened.

WHO Global Technical Strategy for Malaria 2016-2030

- Adopted by the World Health Assembly in May 2015, it provides a technical framework for all malaria-endemic countries.
- It is intended to guide and support regional and country programmes as they work towards malaria control and elimination.
- The Strategy sets ambitious but achievable global targets, including:
  - Reducing malaria case incidence by at least 90% by 2030.
  - Reducing malaria mortality rates by at least 90% by 2030.
  - Eliminating malaria in at least 35 countries by 2030.
  - Preventing a resurgence of malaria in all countries that are malaria-free.

The Global Malaria Programme (GMP)

- The WHO Global Malaria Programme (GMP) coordinates WHO's global efforts to control and eliminate malaria by:
  - setting, communicating and promoting the adoption of evidence-based norms, standards, policies, technical strategies, and guidelines;
  - keeping independent score of global progress;
  - developing approaches for capacity building, systems strengthening, and surveillance; and
  - identifying threats to malaria control and elimination as well as new areas for action.

"High burden high impact approach"

- A new country-driven response – "High burden to high impact" – was launched in Mozambique in November 2018. It will be supported by WHO.
- The approach will be driven by the 11 countries that carry the highest burden of the disease (Burkina Faso, Cameroon, Democratic Republic of the Congo, Ghana, India, Mali, Mozambique, Niger, Nigeria, Uganda and United Republic of Tanzania).

Related news

- Recently the Indian Council of Medical Research has launched the **'Malaria Elimination Research Alliance (MERA) India'** to prioritise, plan and scale up research to eliminate the disease from India by 2030.
- 'Malaria Elimination Research Alliance-India (MERA-India)' is a **conglomeration of partners** working on malaria control.
- The **principal activity of the alliance** is to prioritise, plan, conduct, scale up and translate relevant research in a **coordinated and combinatorial way** in order to have a tangible impact on the population who are at risk of malaria.
- It intends to complement the efforts on national scale while contributing to the **broader global agenda.**
- It will facilitate **trans-institutional coordination** and **collaboration** around a shared research agenda which responds not only to programmatic challenges and **addresses gaps in available tools** but also proactively contributes **to targeted research.**

3.4. NATIONAL ACTION PLAN FOR VIRAL HEPATITIS CONTROL

Why in News?

Recently, Ministry of Health and Family Welfare launched National Action Plan for Viral Hepatitis.

About National Action Plan for Viral Hepatitis

- The Plan provides a strategic framework, based on which **National Viral Hepatitis Control Program** was launched in 2018 under National Health Mission.
- It is in line with the Government of India's deep commitment towards **elimination of viral hepatitis.**

About Hepatitis

- It is an **inflammation of the liver** often **cause by virus** and other **infections, toxic substances** (e.g. alcohol, certain drugs).
- There are **5 main hepatitis viruses**, referred to as types A, B, C, D and E.
  - Viral **hepatitis types B and C** can cause **chronic** hepatitis and are responsible for 96% of overall hepatitis mortality while **Hepatitis A and E** usually cause **acute hepatitis**.
  - **Hepatitis A and E** are typically caused by ingestion of **contaminated food or water.**
  - **Hepatitis B, C and D** usually occur as a result of contact with **infected body fluids** such as during receiving blood, invasive medical procedures using contaminated equipment, transmission from mother to baby at birth, sexual contact etc.
  - There are vaccines to prevent hepatitis A, B and E**.** However, **there is no vaccine for hepatitis C**.
  - Also, **Hepatitis D virus** (HDV) infections occur **only** in those who are infected with **Hepatitis B Virus**.
- The infections can progress to **other health complications and liver cancers**.
- The challenge in eliminating chronic viral hepatitis is due to the **infected person being unaware of their chronic carrier status** and to the potential for them to continue to infect others for decades.

About National Viral Hepatitis Control Program

- Its goal is **ending viral hepatitis** as a public health threat in the country by **2030**.
- It aims to **reduce morbidity and mortality** due to viral hepatitis.
- The key strategies include:
  - **Preventive and promotive interventions** with focus on awareness generation, safe injection practices and socio-cultural practices, sanitation and hygiene, safe drinking water supply, infection control and immunization
  - **Co-ordination and collaboration** with different Ministries and departments
  - **Promoting diagnosis and providing treatment** support for patients of hepatitis B & C
  - **Building capacities at national, state, district levels and sub-district level up to Primary Health Centres (PHC) and health and wellness centres** such that the program can be scaled up till the lowest level of the healthcare facility in a phased manner.

3.5. ELIMINATION OF TUBERCULOSIS

Why in news?

Recently, **World Bank and the Government of India** signed a loan agreement of $400 million for **the Program Towards Elimination of Tuberculosis.**

More about the agreement

- This program **will cover nine States** and it will **support the government's National Strategic Plan to end TB in India by 2025.**
- It will **provide financial incentives to private sector care providers** for reporting cases of TB and ensuring that their patients complete the treatment regimen.
- It will also provide **Direct Benefit Transfers to patients** for acquiring the critical nutrition needed during treatment.
- It will **strengthen the detection, treatment and monitoring of Drug-Resistant Tuberculosis** and will track progress in the detection of additional drug resistance.
- The program will help the Government of India strengthen the monitoring and implementation of **Nikshay—the government's web-based TB case monitoring system**.

About Tuberculosis

- It is communicable disease (through air) caused by **bacteria (Mycobacterium tuberculosis)** that most often affect the lungs (pulmonary TB) and sometimes also affects other organs (extrapulmonary TB).

- TB is among **India's** most deadly infectious diseases, with an estimated **2.8 million confirmed cases in 2015,** according to a **World Health Organization (WHO) report.**
- India's **TB burden is the highest in the world,** followed by Indonesia and China.
- About a 1/3rd of the world's population is diagnosed with **latent TB (without evidence of clinically manifested active TB),** which means they have been infected by the TB bacteria from actively sick people without their knowledge.
- **Drug Resistant TB:**
  - **Multidrug Resistance TB (MDR):** It is TB that does not respond to at least isoniazid and rifampicin (2 of the most powerful first line drugs).
  - **Extensively drug-resistant tuberculosis (XDR-TB):** It is resistant to at least four of the core anti-TB drugs. It involves multidrug-resistance (MDR-TB), in addition to resistance to any of the fluoroquinolones (such as levofloxacin or moxifloxacin) and to at least one of the three injectable second-line drugs (amikacin, capreomycin or kanamycin).
  - **Totally drug-resistant tuberculosis (TDR-TB):** TB which is resistant to all the first- and second-line TB drugs.
- **Observations in World TB Report 2018 for India**
  - India accounted for 27% of the total new infections of TB in 2017, which is the highest among the top 30 high TB burden countries in the world.
  - India also led in cases of **Multi-Drug Resistant TB** (MDR-TB). Nearly a quarter of the world's MDR-TB cases are in India (24 per cent).
  - **Roadmap toward ending TB in Children and Adolescent**
  - It is systematic pathway which will guide the stakeholders to contains the prevalence of Child and Adolescent.

Govt intervention to eliminate TB

- Under **Universal Immunization Programme**, Vaccination is provided for 12 life threatening diseases: **tuberculosis**, diphtheria, pertussis (whooping cough), tetanus, poliomyelitis, measles, Hepatitis B, Diarrhoea, Japanese Encephalitis, rubella, Rotavirus and Pneumonia (added in May 2017)
- Under **Mission Indradhanush**, Immunisation against seven vaccine preventable diseases namely; Diphtheria, Pertussis, Tetanus, **Childhood Tuberculosis**, Polio, Hepatitis B and Measles.
- **Revised National TB Control Programme (RNTCP)** is being implemented under the umbrella of National Health Mission which has achieved global benchmark of case detection and treatment success and achieved millennium development goals in 2015 of halting and reversing the incidence of TB.
- **Integrated Health Information Platform (IHIP)** under Integrated Disease Surveillance Programme (IDSP) is a real time, village wise, case based electronic health information system with GIS tagging which will help in prompt prevention and control of epidemic prone diseases.
  - Information from other branches like **tuberculosis control programme**, maternal and child health programme and non-communicable disease programme is included in this platform.

National Strategic Plan to end TB in India by 2025

- RNTCP released this framework in 2017 for the **control and elimination of TB in India by 2025.**
- It provides **goals and strategies for the country's response to the disease during the period 2017-2025** and aims to direct the attention of all stakeholders to the most important interventions to eliminate TB.
- It targets **to eliminate TB five years ahead of the global End TB targets under Sustainable Development Goals** to attain the vision of a TB-free India.
- TB elimination have been integrated into the four strategic pillars of **"Detect – Treat – Prevent – Build" (DTPB).**
  - **Detect:** Find all Drug Sensitive TB and Drug Resistant TB cases with an emphasis on reaching TB patients seeking care from private providers and undiagnosed TB in high-risk populations.
  - **Treat:** Initiate and sustain all patients on appropriate anti-TB treatment wherever they seek care, with patient friendly systems and social support.
  - **Prevent** the emergence of TB in susceptible populations.
  - **Build** and strengthen enabling policies, empowered institutions, additional human resources with enhanced capacities, and provide adequate financial resources.

Why India leads in burden in TB?

- **Poor medical infrastructure:** Public-health facilities that specialise in TB in India are already overstressed and unregulated, with little political will to change the situation.
- **Misuse of Drugs:** Irrational use of first-line and second-line anti-TB drugs is the other problem with TB care in India. New strains of TB have developed resistance to the standard medicines.
- **Unaware about disease and delayed diagnosis:** A high proportion of missed and mistreated cases fuel India's TB epidemic. These cases are not notified to the public system and most remain either undiagnosed or inadequately diagnosed.

- **Non accessibility of drugs:** Indian patients have been fighting to get access to new **anti-TB drugs such as bedaquiline and delamanid** which has been only introduced in few centers.
- **Less effective Treatment:** In India, the regimen of antimicrobial drugs is often spread out over a longer period of time than in other countries, making it harder for patients to see signs of progress. So some people simply stop taking their medication.
- **Lack of awareness:** The first line of defense against the spread of TB is raising awareness in communities which is severely hampered by lack of money.
- **Linkage with air pollution:** Several studies have concluded there is a possible link between air pollution and the risk of active tuberculosis. In India, the rise of TB infections has coincided with the dismal air quality index in many Indian cities.
- **Other health related factors:** Among the other major risk factors for TB, including alcohol, smoking, diabetes, HIV and undernourishment.

Global Efforts for TB

- **Moscow Declaration to End TB:** It is the outcome of first global ministerial conference on ending TB, in 2017.
- **WHO- End TB Strategy**
  - **Vision:** A world free of TB with zero deaths, disease and suffering due to TB.
  - It has three high-level, overarching indicators and related targets for 2035:
    - ✓ 95% reduction in number of TB deaths compared with 2015.
    - ✓ 90% reduction in TB incidence rate compared with 2015.
    - ✓ Zero the level of catastrophic costs for TB-affected families.
- **Triple-Billion Goals:** It is associated with WHO General Programme of Work 2019-2023 linked to SDgs health goals. This stressed the need of;
  - 1 billion more people are benefiting from Universal Health Coverage.
  - 1 billion more people are better protected from health emergencies,
  - 1 billion more people are enjoying better health and well-being.

Way forward

- **Improve health infrastructure and diagnosis:** Improve public sector clinics and hospital and improving accessibility and drugs availability.
- **Increase budget allocation:** to execute the TB control program more aggressively and effectively.
- **Effective use of medicine:** Government need to quickly roll out daily fixed-dose regimen under directly observed treatment short course throughout the country and introduce new diagnostic technology and newer anti-TB drugs.
- **Effective role of private sector:** The huge private sector in the country, where at least 50% cases of TB report for their treatment, needs to be engaged rapidly and effectively.
- **Improve detection:** An effective surveillance and follow-up of all TB patients need to be ensured.
- **Use of better drugs:** Prioritise newer antibiotics like bedaquiline and oral drugs over injectables, which are less effective.
- **Reduce poverty:** Rural Employment Guarantee Scheme is a step in the right direction. Once the socio-economic status improves, TB declines.
- **Social acceptance:** There is also a need for an adequate social, emotional, and nutritional support to all TB patients.

3.6. LEPROSY IN INDIA

Why in News?

Initial reports of Leprosy Case Detection Campaign of the National Leprosy Eradication Programme (NLEP) indicated an all-time high of nearly **50,000 new leprosy cases in Bihar.**

Current scenario

- India was officially **declared to have eliminated leprosy in 2005** when new cases fell to less than 1 per 10,000, yet India still accounts for the largest number of leprosy affected people in the world (58 per cent).

What is Leprosy?

- Leprosy is a chronic infectious disease caused by **Mycobacterium leprae** and is **highly contagious.**
- The bacteria has a **long incubation period.** Once a person is infected, it can take **6-10 years or even 20 years** for the first symptoms to surface.
- The disease **mainly affects the skin**, the peripheral nerves, the mucosa of the upper respiratory tract and the eyes.
- It is curable and treatment provided in the early stages averts disability.

Mycobacterium Indicus Pranii (MIP)

- It is an **indigenous vaccine for leprosy** developed by National Institute of Immunology.
- It is now being introduced into the National Leprosy Elimination Programme (NLEP). It will boost the immune system against the bacterial disease.

- Indian research contributed to the development of **Multi-Drug Therapy** or MDT, now recommended by WHO, which led to the shortening of treatment and higher cure rates.
- In recent years, along with other countries, India has repealed legislation that discriminates against persons affected by leprosy.
    - In 2016, it repealed the draconian colonial-era Lepers Act and in January 2019 Lok Sabha passed a bill seeking to **remove leprosy as a ground for divorce.**

Challenges in eradicating leprosy

- **Antimicrobial resistance in leprosy:** Global data shows that a total of 8% of the Mycobacterium leprae bacterial strains studied showed **gene mutations conferring resistance towards drugs such as rifampicin, dapsone and ofloxacin.**
- **Non-adherence to drugs:** Due to various reasons a significant number of patients become irregular and default from MDT.
- **Issues with 2005 declaration of Leprosy elimination:**
    - It led to the **diversion of focus** as both **funding as well as resources declined** and the frontline workers stopped making household visits to identify undetected cases, shifting instead to voluntary patient registration.
    - The **dermatologists didn't send patients for treatment**, as the strong rhetoric of elimination made them believe leprosy is a disease of the past.
    - **Neither funders nor young researchers are attracted** to an officially eliminated disease, even if it is still ubiquitous.
- **Stigma about leprosy:** Fear of stigma, and the resulting discrimination, discourages individuals and their families from seeking the help they need.
- **Lack of funding:** Financial crunch in leprosy research and awareness campaigns leads to a shortfall in human reserves and trained medical professionals who can diagnose the disease correctly in its nascent stage.

Measurers taken to eradicate Leprosy

International

- **Multidrug therapy**, made available by WHO free of charge to all patients worldwide since 1995, provides a simple yet highly effective cure for all types of leprosy.
- In 2016, WHO launched **The Global Leprosy Strategy 2016–2020: accelerating towards a leprosy-free world** which aims to reinvigorate leprosy control efforts and avert disabilities, especially among children affected by the disease in endemic countries.

Government of India Initiatives

- **National Health Mission** aims to reduce prevalence of Leprosy to <1/10000 population and incidence to zero in all districts.
- Ayushman Bharat's 1,50,000 **Health and Wellness Centres** across the country plan to **screen all Indians for leprosy.**
- **Sparsh Leprosy Awareness Campaign** aims at communicating the importance of early detection and treatment of leprosy.
- New preventive approaches like **chemoprophylaxis and immuno-prophylaxis are being** considered to prevent transmission.
- **30th of January** (Martyrdom Day of Mahatma Gandhi) was celebrated all over India as **Anti Leprosy Day** to spread public awareness about the disease.
- **A Leprosy Case Detection Campaign** was launched in 2016, involving house-to-house screening and referral of patients for diagnosis.
- **12th Five year plan** had set out to achieve **elimination of leprosy at the district level by 2017**.

India's National Leprosy Eradication Programme

- It is a centrally sponsored Health Scheme of the Ministry of Health and Family Welfare which aims to eradicate leprosy from India.
- **Strategies for Leprosy elimination:**
    - **Decentralized integrated leprosy services** through General Health Care system.
    - **Early detection & complete treatment** of new leprosy cases.
    - Carrying out **house hold contact survey** in detection of Multibacillary (MB) & child cases.
    - **Early diagnosis & prompt MDT,** through routine and special efforts
    - **Involvement of Accredited Social Health Activists (ASHAs)** in the detection & complete treatment of Leprosy cases for leprosy work
    - Strengthening of Disability Prevention & Medical Rehabilitation (DPMR) services.

- Information, Education & Communication (IEC) activities in the community to improve self-reporting to Primary Health Centre (PHC) and reduction of stigma.
- **Intensive monitoring and supervision** at Primary Health Centre/Community Health Centre.

Way forward

- **Avoid shallow declarations:** India remains a long way away from **elimination at the state or district levels**, let alone eradication. It is necessary to learn lessons and avoid creating an environment of complacency.
- **Speedy implementation of the Health and Wellness Centres (HWC) initiative** in the true spirit of comprehensive primary healthcare approach.
- **Enhancing training of health-care providers**: in communication and behaviour change skills, and by improving the **patients' access to quality care and friendly services.**
- **Adherence to MDT:** can be improved by multiple initiatives that target the views and actions of patients, health-care workers, and society.
- **Removal of stigma:** Leprosy program managers should **design positive health messages and use innovative media to appeal** to and reach target groups to motivate leprosy patients to seek early treatment and the community to accept leprosy patients.
- **Creating Livelihood Opportunities:** Those who have been cured at an early stage and can work, should be given **opportunities to learn skills and trades** that would enable them to work.

3.7. NON-COMMUNICABLE DISEASES

Why in News?

The 73rd session of the United Nations General Assembly (UNGA) adopted a declaration called "Time to Deliver: Accelerating our response to address NCDs for the health and well-being of present and future generations".

About NCDs

- According to WHO, Noncommunicable diseases (NCDs), also known as **chronic diseases are diseases of long duration** which are a result of a combination of genetic, physiological, environmental and behavioral factors.
- The four major non-communicable diseases are: **cardiovascular diseases, cancers, respiratory diseases** and **diabetes.**
- Noncommunicable diseases (NCDs) kill 41 million people each year, equivalent to 71% of all deaths globally.
- While NCDs were not included in the Millennium Development Goals, they are now an important target in the Sustainable **Development Goals**, under which countries would have to "**reduce by 1/3rd**, pre-mature mortality from non-communicable diseases through prevention and treatment, and promote mental health and wellbeing" by 2030.

Causes of NCDs

- **Behavioural Factors:** Modifiable behaviours, such as tobacco use, physical inactivity, consumption of processed food with enriched salt and sugar content and the harmful use of alcohol, all increase the risk of NCDs.

Some facts about NCDs in India

- NCDs are reason for more than 60% death in India.
- India's Ministry of Health and Family Welfare recently received the prestigious UN Inter-Agency Task Force Award for "outstanding contribution to the achievement of NCD (Non-Communicable Diseases) related SDG targets"
- NCDs are reason for more than 60% deaths in India.
- According to the World Economic Forum (WEF), India stands to lose $ 4.58 trillion (Rs 311.94 trillion) due to non-communicable diseases between 2012 and 2030

Steps taken By India

- WHO has developed a comprehensive Global Monitoring Framework and Action Plan for prevention and Control of NCDs. **India is the first country globally to adopt it to its National Context**.
- **National Health Policy** advocates pre-screening and sets the target to reduce premature mortality via NCDs by 25% by 2025.
- The central government is implementing **National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS)** for interventions up to District level under the National Health Mission.
- A flexi pool of funds for Non-Communicable Diseases (NCD) has been created.
- **NCD IT solution under Ayushman Bharat** covers program-level data for screening, referral, diagnosis, treatment and follow-up activities of non-communicable diseases with an aim to connect health workers, doctors and decision-makers in a single, integrated platform.
- Niti Aayog has proposed models for PPP to increase the role of private hospitals in treating non-communicable diseases.

- **Metabolic factors:** These include raised blood pressure, obesity, high blood glucose levels, etc. These risks are often increased due to behavioural factors.
- **Structural factors:** The risks have been aggravated by the increasing sedentary life styles, Urban settlements with lack of open spaces and recreational activities, stressed work culture, pollution etc.

Impact of NCDs

- **Poverty:** The rapid rise in NCDs is predicted to impede poverty reduction initiatives in low-income countries, particularly by increasing household costs associated with health care.
- **Loss of Workforce**: Productive demographic dividend can be impacted due to such diseases which may take a toll on the economy. This also increases the Dependency ratio of the country.
- **Impact on children**: NCDs impact on children is a major concern, in particular the rising levels of obesity.

Way Forward

- **Healthy Lifestyle:** Promote behavioral changes such as reducing tobacco and alcohol consumption, promoting healthy diets, physical activities such as Yoga, sports, exercise, etc.
- **Increase Governmental health expenditure:** Actions related to reduction of blood pressure, control of diabetes and provision of competent primary care supplemented by cost-effective specialist clinical care for treatable NCDs will benefit all age groups.
- **Stringent Norms for processed and ready to eat food:**
  - The UN declaration has asked food manufacturers to reduce salt, free sugars and saturated and industrially-produced trans fats in their products.
  - It also said that manufacturers should use nutrition labelling on packaged food to inform consumers, and restrict the marketing of unhealthy foods and beverages to children.
- **Private sector participation**: In developing countries, private companies must complement governmental efforts to develop programmes to combat NCDs by:
  - establishing tobacco free workplaces
  - improving access to and affordability of safe, effective and quality medicines and technologies in the prevention and control on non-communicable diseases
- **Better Urban planning:** It should support safe and pleasurable physical activity (For eg. pedestrian and bicycle lanes in Lucknow, open park gyms in Delhi), and also ensure sufficient green spaces and a pollution free environment.
- **Spread awareness:** Spreading awareness about unhealthy lifestyle choices and building a robust early screening system.

3.8. RARE DISEASES

Why in News?

After **withdrawing the National Policy for Treatment of Rare Diseases (NPTRD),** the Minister of Health and Family Welfare has approved a proposal for **adding a sub-component under the umbrella scheme of Rashtriya Arogya Nidhi (RAN)** for provision of **one-time financial assistance to those below threshold poverty line** for specified rare diseases which require one-time treatment.

Rashtriya Arogya Nidhi

- The RAN was set up to provide **financial assistance to patients**, living below poverty line and who are suffering from **major life threatening diseases**, to receive medical treatment at any of the super speciality Hospitals/Institutes or other Government hospitals.
- The financial assistance to such patients is released in the form of **'one-time grant'**, which is released to the Medical Superintendent of the Hospital in which the treatment has been/is being received.
- It has been set up as society registered under the Societies Registration Act, 1860.

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.
- The most **common rare diseases** include Haemophilia, Thalassemia, Sickle-cell Anaemia, auto-immune diseases, etc.
- They affect 6%- 8% of the total population in the country. 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.
- The Union Health Ministry termed the current policy "untenable" as the policy was to be implemented under the National Health Mission. (The ambit of the NHM is restricted to primary and secondary health care but **rare diseases come under tertiary care**).
- **One-time financial assistance** is being provided as an interim measure till a new policy is framed. A committee has been set up to frame a new policy.

Criticism of the move: Why India Needs a policy on rare disease?

- **Need for Continuous Treatment:** Most of the rare diseases for which treatment is available are progressive. They require continuous support and not just one-time assistance as an interim arrangement can never be a substitute for a policy.
  - The withdrawn Policy highlighted the measures and steps, both in the short as well as in the long term, that need to be taken to deal comprehensively with rare diseases. The policy sought to strike a balance between access to treatment with health system sustainability.
- **Pushes Families in Poverty:** Its impact on families is often catastrophic in terms of emotional as well as financial burden. The exorbitant cost of treatment per patient, which ranges anywhere from ₹25 lakh and ₹4 crore per year, is out of reach even for middle-class families.
- **Significant Population Impacted**: While there is no registry of rare diseases patients in India (the policy provided for one), according to government's own estimates there are between 70-90 million patients.
- **Difficulty in R&D**: Rare diseases are difficult to research upon as the patient pool is very small and it often results in inadequate clinical experience. The policy envisaged a R&D framework which cannot be attained through one time financial support.
- **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.

3.9. FIXED DOSE COMBINATIONS (FDCS)

Why in news?

Recently, the Ministry of Health and Family Welfare in exercise of powers conferred by the Drugs and Cosmetics Act, 1940 has prohibited the manufacture for sale, sale or distribution for human use of 328 Fixed Dose Combinations (FDCs) and restricted the manufacture, sale or distribution of six FDCs subject to certain conditions.

Drug regime in India

- Drugs are regulated by the **Drugs and Cosmetics Act, 1940** and **Drugs and Cosmetic Rules, 1945.**
- **Central Drugs Standard Control Organization (CDSCO),** under the Ministry of Health and Family Welfare, is the authority that approves new drugs for manufacture and import.
- State Drug Authorities are the licensing authorities for marketing drugs.
- **Drugs Technical Advisory Board (DTAB):** It is the highest statutory decision-making body under the Union Health ministry on technical matters. It is constituted as per the Drugs and Cosmetics Act, 1940.

Background

- In 2016, the health ministry had banned 349 FDCs, claiming they were **"unsafe" and "irrational"** for consumption on the recommendation of **Chandrakant Kokate committee (2015)**. However, the matter was contested by the affected manufacturers in various High Courts and the Supreme Court of India.
- The Drugs Technical Advisory Board on a direction from Supreme Court, formed **Nilima Shirsagar committee** to review the safety, efficacy and therapeutic justification of 344 fixed dose combination (FDC) drugs. The committee also recommended the continuation of the ban along with other observations such as:
- Pharma companies whose products were under scrutiny provided **"irrelevant" data** that relied on biased studies and almost 95%, failed to prove safety, rationality and compatibility of these FDC.

- Experts believe combination drugs to be unsafe because unaware physicians can prescribe wrong dosage that can in turn make human body resistant to treatment.
- Over the years, India has become a **"dumping ground" for FDCs** that are not approved in other countries for consumption.
- The DTAB in its report recommended that there is no therapeutic justification for the ingredients contained in 328 FDCs and that these FDCs may involve risk to human beings.
- Market size of the banned drugs is estimated to be around Rs 20-22 billion and will impact the country's top drugmakers.

About FDC

- An FDC is a cocktail of two or more therapeutic drugs packed in a single dose. Several cough syrups, painkillers and dermatological drugs in India are FDCs.
- **Benefits**: They are known to offer specific advantages over the single entity preparations, such as increased efficacy, and/or a reduced incidence of adverse effects, possibly reduced cost and simpler logistics of distribution relevant to situations of limited resources
- **Cheaper for consumer**: patient can buy just one FDC medicine to treat multiple illness symptoms.
- **Good For Business**: For pharma companies, FDC's are cheaper and easier to combine existing active ingredients to make new products than to discover new medicines. They are also not covered under the ambit of price control regime.
- According to All India Drugs' Action Network (AIDAN), the market of unsafe, problematic FDCs in India is at least one fourth of the total pharma market valued at ₹1.3 trillion.

3.10. NEW RULES FOR DRUGS & CLINICAL TRIALS

Why in news?

The Ministry of Health & Family Welfare has notified the Drugs and Clinical Trials Rules, 2019 with the aim of promoting clinical research in the country.

About the new rules

- The new rules **reduce the time for approving applications** to 30 days for drugs manufactured in India and 90 days for those developed outside the country.
- Patients would be enlisted for trials with an **informed consent** and an **ethics committee will monitor the trials** and **decide on the amount of compensation** in cases of adverse events
- In case of injury to clinical trial subject, **medical management** will be provided by the sponsor as long as required as per the opinion of the investigator or till such time it is established that the injury is not related to the clinical trial.
- **Compensation** in cases of death and permanent disability to a trial subject will be decided by the Drug Controller General.
- **Local clinical trial** may be waived for approval of a new drug if it is approved and marketed in any of the countries (EU, UK, Australia, Japan and US) specified by the Drugs Controller General with the approval of the government.

Existing regulatory requirements for Clinical Trials in India

- Clinical trials in India are primarily regulated through the provisions of the **Drugs and Cosmetics Act, 1940**. Further, the **Medical Council of India Act, 1956** and **the Central Council for Indian Medicine Act, 1970** also regulate the conduct of clinical trials in India.
- **The Indian Council of Medical Research (ICMR)**, the apex regulatory body for clinical trials, was set up to promote research culture in India and develop infrastructure for clinical trials.
- A clinical study in India has to be **registered** with **Clinical Trial Registry of India (CTRI)** before recruiting any volunteer. It is an open repository of all clinical studies for public use. It has been established by ICMR.
- **Drug Controller General of India (DCGI)** is responsible for giving regulatory permissions for the conduct of clinical trials and is responsible for approval of marketing licenses for drugs in India.
- **Ethics Committees (EC)** are designated to approve, monitor & review biomedical and behavioral research involving humans. They follow **International Conference on Harmonization-Good Clinical**

Practice (ICH-GCP) guidelines. They can be affiliated with the study sites (e.g. hospitals/clinics) or can be independent.

- National Accreditation board for hospitals and Healthcare Providers (NABH) a part of Quality council of India has developed a system of accreditation for Ethics Committee (EC).

Issues with Clinical Trial (CT) regulations in India

India has had favorable prerequisites for conducting clinical research and drug development – a large and diverse patient pool (trial participants), a highly skilled workforce of qualified scientists (investigators), medical colleges (sites) etc. Yet, an unfavorable ecosystem has undermined its potential. India has 17% of the world's population & 20% of the world disease burden, but conducts less than 1.4% of global clinical trials. Following are the issues associated with the process of clinical trials in India:

- **Issues in deciding culpability** in case of deaths due to clinical trials.
- **Over-representation of vulnerable sections** among trial subjects.
- **Selective recruitment** by Contract Research Organizations (CROs) exploiting financial needs and medical ignorance.
- **Public opinion in India is not in favor** of CTs as several CROs have been blamed for conducting trials without due concern for procedural and ethical issues.
- Issue of **over-volunteering in bioequivalence studies** where volunteers deceive the investigators by faking medical history and simultaneously enrolling in multiple trials. It poses a risk to volunteer health and may lead to unsafe drugs in market.
- Regulatory inadequacies lead to **severe delays in the approval process.**
- Absence of adequate **regulatory guidance** on specific issues, lack of **clarity on legal terminologies** and **dearth of a proper standardization** by CDSCO.
- Lack of **expertise** and **capacity to undertake accreditation** and absence of periodic revaluation mechanism.

Supreme Court's directives on Clinical Trials

In the case of Swasthya Adhikar Manch, Indore vs. Ministry of Health and Family Welfare & Ors regarding clinical trials, SC laid down the following directives for the process of clinical trials:

- Provide for **examination** of serious adverse events and ensure **compensation** in case of clinical trial-related injury or death.
- Undertake **informed consent** based on correct & complete information about the trial and its possible implications. **Audio-visual recording** of informed consent process and preservation of documentation mandatory.
- CDSCO should lay down **pre-defined standards** for medical institutions to be chosen as clinical trial sites.
- Lay down **Standard Operating Procedure** (SOP) for investigators and norms for **inspection** and **monitoring** of clinical trials by Ethics Committee
- Mandatory **registration** of Ethics Committee & **removing conflict of interest** while formulating it
- Provisions to ensure **confidentiality** of the patient's medical record & treatment history
- **Reimbursement** and **free medical services to participants**. Incentive should not be so large that it acts as an inducement against better judgement.

Significance of the new rules

The new rules take a step forward in making Clinical Trial (CT) process in India compliant with Supreme Court directives and **Ranjit Roy Chaudhury Expert Committee** recommendations.

- The new rules will **speed up the availability** of drugs in India.
- Adherence to certain quality standards will **instill confidence in patients** who will be trial subjects.
- It will **boost clinical trials industry** in India by giving certainty to undertake trials to research groups/ companies.
- It will **promote innovation in indigenous drug development** to meet growing need for medicines in the country.
- It can **generate employment** in the clinical trials industry.

Way Forward

- **Empowering Ethics Committees:**
  - NABH and Forum for Ethics Review Committees in India (FERCI) should develop an IT enabled platform that enables ECs to manage a research project throughout its life cycle
  - Training of every EC member in GCPs
  - NABH should draft model Standard Operating Procedures (SOPs) for ECs
  - NABH should sign MOUs with other agencies of standing to aid faster accreditation of ECs in India

- **Making consent more informed:**
  - Meaningful translation of Informed Consent Forms (ICF) into vernacular languages
  - Development of **audio-visual aids** for clinical research participants
- **Compensating for injury or death related to a clinical trial:**
  - CDSCO should adopt a more focused approach towards passing timely orders for compensation for injury or death related to a trial.
  - Mandatory provision for ancillary care to cater to patients suffering from any other illness during the trial.
- **Addressing uncertainty:** CDSCO should devise a comprehensive strategy to communicate its policies, decisions and regulatory thinking to the market.
- **Incentivizing research:** The Government of India, state governments and institutions should create a fund in order to encourage academic and clinical research.

3.11. NATIONAL MEDICAL DEVICES PROMOTION COUNCIL

Why in News?

To give a fillip to the medical device sector, a **National Medical Devices Promotion Council** will be set up under the Department of Industrial Policy and Promotion (DIPP).

About National Medical Devices Promotion Council

- The Council will be headed by **Secretary, DIPP.** Apart from the concerned departments of Government of India, it will also have **representatives from health care industry and quality control institutions**.
- It will act as a facilitating and promotion & developmental body for the Indian Medical Devices Industry (MDI). It will give a **boost to domestic manufacturing and for exports.**
- It will identify redundant processes and render **technical assistance to the agencies and departments concerned to simplify the approval processes** involved in medical device industry.
- It will **enable entry of emerging interventions** and support certifications for manufacturers to reach levels of **global trade norms** and lead India to an export driven market in the sector.
- Drive a robust and dynamic Preferential Market Access (PMA) policy, by identifying the strengths of the Indian manufacturers and **discouraging unfair trade practices in imports.**

Medical Devices Industry (MDI) in India

- MDI plays a key role in the healthcare ecosystem and "is indispensable in achieving the goal of **health for all citizens of the country.** However, the medical device **market is dominated by imported products,** which comprise of around 80% of total sales. The domestic companies are largely involved in manufacturing low-end products for local and international consumption.
- **Opportunity:** Given the **higher disposable incomes** in the country**, increasing public spending** in healthcare (higher penetration of

Medical Devices Rules, 2017
Salient features:

- It allows the **National Pharmaceutical Pricing Authority (NPPA) to notify 15 medical devices as drugs**, effectively bringing them automatically under **price control regulation.**
- Medical devices will, under the new Rules, based on associated risks and the manufacturers of medical devices will be required to **meet risk proportionate regulatory requirements.**
- Separate provisions for **regulation of Clinical Investigation (clinical trials) of investigational medical devices** (i.e. new devices) have also been made at **par with international practices.**
- It will be for the first time that there will be **no requirement of periodic renewal of licences.** Accordingly, manufacturing and import licences will remain valid till these are suspended or cancelled or surrendered.

National Pharmaceutical Pricing Authority [NPPA]

- It is an **independent body** under Department of Pharmaceuticals under **Ministry of Chemicals and Fertilizers.**
- Its functions are:
  - To **fix/revise** the controlled bulk drugs prices and formulations.
  - To enforce prices and availability of the medicines under the **Drugs (Prices Control) Order, 1995/2013.**
  - To **recover amounts overcharged by manufacturers** for the controlled drugs from the consumers.
  - To **monitor the prices of decontrolled drugs** in order to keep them at reasonable levels.

Central Drugs Standard Control Organization (CDSCO)

- It is the national regulatory body for Indian pharmaceuticals & medical devices under **Ministry of Health & Family Welfare.**

health insurance), improving **medical tourism** along with **luxury healthcare** markets and **increasing FDI** in the sector, India presents an important opportunity for medical device industry both domestically and internationally.

- **Challenges:** Along with numerous opportunities, the market faces various challenges in terms of presence of **multiple regulators**, **archaic laws** (which do not permit manufactures and importers of medical device to promote their product directly to the customer), **weakening rupee** (making it difficult for some medical device importers to promote their product directly to the consumers), and government's price control (e.g. stent capping).

3.12. FOOD FORTIFICATION

Why in news?

The Food Safety and Standards Authority of India (FSSAI) has recently released a report on food fortification.

Food Fortification in India

- Food fortification is the **deliberate addition of one or more micronutrients to food** so as to correct or prevent a deficiency and provide a health benefit.
- The concentration of just one micronutrient might be increased (e.g. the iodization of salt) or there might be a whole range of food–micronutrient combinations.
- Food fortification is a **"complementary strategy"** and not a replacement of a balanced & diversified diet to address malnutrition.
- Fortification is being promoted through both **open market** and **government schemes** like ICDS,MDMS,PDS,etc.
- In National Nutrition Strategy (Kuposhan Mukt Bharat), food fortification has been given a major thrust.
- FSSAI has operationalised standards for fortification of:
  - wheat- flour-rice (with iron, Vitamin B12 and folic acid)
  - milk & edible oil (with Vitamins A and D)
  - double-fortified salt (with iodine and iron).
- It has also launched the **Food Fortification Resource Centre (FFRC)** to promote large-scale fortification of food across India.

Food Safety and Standards (Fortification of Foods) Regulations, 2018

- It has **prescribed standards** for fortification of various food products such as All fortified foods must not fall below the minimum level of micro-nutrients.
- **Quality assurance:**
  - Every manufacturer and packer of fortified food shall give an undertaking on quality assurance
  - random testing of fortificants and fortified food
- Every package of fortified food shall carry name of the fortificant and the logo to indicate. **FSSAI** has recently introduced **+F logo** for **fortified staple food products**.
- The Food Authority shall take steps to encourage the production, manufacture, distribution, sale, and consumption

Why the need for food fortification?

- **Nearly 70% of people** in India **consume less than half** of their **recommended dietary allowance (RDA) of micronutrients**. The deficiency of micronutrients is also known as **"hidden hunger"** and leads to various diseases like Night Blindness, Goitre, Anaemia and various birth defects.
- According to the National Family Health Survey (NFHS-4):
  - **58.4 percent** of **children** (6-59 months) are **anaemic.**
  - **53.1 percent women** in the reproductive age gro up are **anaemic.**
  - **35.7 percent** of children under 5 are **underweight.**
  - Around 50-70% of these birth defects are preventable, caused due to deficiency of **Folic Acid**.

Some International experiences

- **Salt iodization** was introduced in the early 1920s in both Switzerland and the United States of America and has since expanded progressively all over the world.
- In **Venezuela**, wheat and maize flours have been fortified with iron has shown significant reduction in iron deficiency.
- In **Morocco**, fortification of double fortified salt showed improved results in reduction of anaemia.

Advantages of food fortification

- **Health benefits:**
  - Elimination of micronutrient deficiency diseases like anaemia, goitre, xerophthalmia, etc. which are prevalent in India. For eg. according to the National Family Health Survey, around 50% of women and children in India suffer from anaemia.
  - Food fortification can be used as an effective tool to counter vitamin D deficiency. (prevalent in more than 70% of Indian population).
  - It reduces the risk of death from infectious diseases.

- **Wide population coverage:** Since the nutrients are added to staple foods that are widely consumed, it enable to improve the health of a large section of the population.
- **Socio-culturally acceptable:** It does not require any changes in food habits and patterns of people being targeted.
- **Cost-effective:**
  - The Copenhagen Consensus estimates that every 1 Rupee spent on fortification results in 9 Rupees in benefits to the economy.
  - Technology to fortify food is simple and easy to implement.
- **Complements Food security:** Nutritional security is much needed to reap the dividends of implementing the food security act.

Challenges

- **Voluntary nature:** Fortification **continues to be voluntary** rather than mandatory leading to limited efforts to fortify by state governments and private sector.
- **Poor implementation by states:** Although some states have adopted fortification in ICDS, MDMS and PDS, but due to lack of definitive policy guidelines, budgetary constraints, technical knowledge and logistic support, states have not adopted fortification in a holistic manner.
- **Weaknesses of FSSAI:** It lacks resources and manpower to effectively carry out its mandate.
- **Lack of awareness:** There is a lot of misinformation and ignorance about the usage and benefits of fortified food as of now.

Way forward

- **Nationwide Implementation:** Pan-India implementation of fortification via government schemes would amount to only an increment of 1 percent of the total budget allocated annually**.**
- **Support to states:** Merely issuing orders and notifications from Government of India will not suffice as state governments require hand-holding support and should sensitised about the benefits fortification and must be enabled to procure fortified staples in various programs.
- **Ensure Standards:** Compliance with FSSAI standards w.r.t macronutrient content and quality must be strictly enforced.
- **Awareness:** A mass awareness campaign about food fortification is needed to scale up demand from consumers in the open market.
- **Promote food processing industry:** It will go a long way in improving the nutritional value of staple food.

Related News
Eat Right India movement

- The Food Safety and Standards Authority of India (FSSAI) recently organised the Swasth Bharat Yatra, a key element of the 'Eat Right India Movement'.
- It is multi-sectoral effort with primary focus on daily intake of salt, sugar, fat, phasing-out trans-fats from diets and promoting healthier food options.
- It is built on two broad pillars of Eat Healthy and Eat Safe.
- It brings together three ongoing initiatives of FSSAI that target citizens:
  - **The Safe and Nutritious Food (SNF) Initiative**, focused on social and behavioral change around food safety and nutrition at home, school, workplace and on-the-go.
  - **The Eat Healthy Campaign** focused on daily intake of salt, sugar, fat, phasing-out trans-fats.
  - **Food fortification,** focused on promoting five staple foods- wheat flour, rice, oil, milk and salt, with key vitamins and minerals added to improve their nutritional content.
- It has seven broad areas of action—
  - to increase demand for healthier food by influencing each other as role models, caregivers and peers,
  - set standards in schools, promote healthy eating habits and use food as a pedagogical tool,
  - have appropriate consumer friendly nutrition labelling and restriction on marketing to children through a suitable regulation,
  - have higher taxation for unhealthy food through differential GST rates,
  - ensure availability of healthier food options and guide consumers through appropriate menu labelling,
  - redesign choices available at points of sale with increased availability and prominent display of healthier options,
  - encourage food processing industry to formulate their food products by reducing unhealthy ingredients.
- Under the movement, "Aaj se thoda kam campign" was launched to encourage citizens to adopt healthy food habits through social media and mass media.

4. INTELLECTUAL PROPERTY RIGHTS

4.1. INTELLECTUAL PROPERTY RIGHTS

Why in News?

Recently the Union Cabinet approved the proposal for Accession of India to the **Nice, Vienna and Locarno Agreements**, related to the **World Intellectual Property Organization's (WIPO) international classification systems**.

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.

WIPO-Administered Treaties for Classifications

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

- 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, nonobviousness and industrial use.
  - Patents in India are governed by "The patent Act 1970" which was amended in 2005 to make it compliant with TRIPS.
- **Trademark**
  - A trademark means a mark capable of being represented graphically and which is capable of distinguishing the goods or services of one undertaking from those of other undertakings.
  - Trade marks in India are governed by Trade Marks Act 1999 which was amended in 2010.
  - Trade Mark Rules, 2017 has been notified which provides for ease of filing trademarks, rationalised trademark fee etc.
- **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".

IPR scenario in India

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

- **National IPR Policy 2016**
  - It aims to 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.
  - Department of industrial policy and promotion (DIPP) is the nodal agency for all IPR issues and the policy will be renewed every five years in consultation with all the stakeholders.
  - The policy will also suggest incentives such as tax benefits and fee waivers to encourage R&D and IP creation to strengthen the Make In India/Start-up/Digital India initiatives.
  - To protect 'small inventions' developed especially in the informal / unorganised sectors, policy will promote 'utility patents' (with lower compliance burden and shorter period of protection, when compared to the normal patents) only for mechanical innovations.
  - **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.

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.

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 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.

- ✓ 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.

4.2. PROTECTION OF PLANT VARIETIES AND FARMERS' RIGHTS (PPV&FR)

Why in News?

Recently, PepsiCo has **sued nine farmers in Gujarat** for alleged rights infringement on the grounds that they illegally grew its registered **FC-5 potato variety (or FL-2027)** used to make Lays chips.

More on News

- PepsiCo has invoked **Section 64** of the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act, 2001 to claim infringement of its rights, as company has patented FC-5 until January 2031 under the Act.
- Farmers groups **cite Section 39** of the **PPV&FR Act,** which specifically says that a farmer is allowed "to save, use, sow, resow, exchange, share or sell his farm produce including seed of a variety protected under this Act" so long as he does not sell "branded seed".

About the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act, 2001

- India as a signatory to World Trade Organization in 1994, was obliged under Article 27(3) (b) of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), either to **adopt a sui genesis system for plant variety protection or join the Convention of the International Union for the Protection of New Varieties of Plants (UPOV).**
  - The Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act, 2001" was enacted by **adopting sui generis system.**
- It's the **world's only IPR legislation** which grants intellectual property rights not only to the **plant breeders but also to the farmers** by protecting new, extant and farmers' varieties.
- Unlike UPOV, the Act facilitates protection of not only new, but even extant (existing) varieties. That includes those notified under the **Seeds Act (1966),** farmers' varieties and varieties of common knowledge.

Rights under the Act

- **Breeders' Rights:** Breeders will have exclusive rights to produce, sell, market, distribute, import or export the protected variety. Breeder can appoint agent/ licensee and may exercise for civil remedy in case of infringement of rights.
- **Researchers' Rights:** Researcher can use any of the registered variety under the Act for conducting experiment or research. This includes the use of a variety as an initial source of variety for the purpose of developing another variety but repeated use needs prior permission of the registered breeder.
- **Farmers' Rights**
  - A farmer who has evolved or developed a new variety is **entitled for registration and protection** in like manner as a breeder of a variety.
  - A farmer **can save, use, sow, re-sow, exchange, share or sell his farm produce** including seed of a variety protected under the PPV&FR Act, 2001 in the same manner as he was entitled before the coming into force of this Act provided farmer shall not be entitled to sell branded seed of a variety protected under the PPV&FR Act, 2001.
  - There is also a provision for **compensation to the farmers** for non-performance of variety under Section 39 (2) of the Act, 2001; and
  - Farmer shall **not be liable to pay any fee** in any proceeding before the Authority or Registrar or the Tribunal or the High Court under the Act. It will be paid **through National Gene Fund**.

- **Objective**
  - To **recognize and protect the rights of farmers** in respect of their contributions made at any time in conserving, improving and making available plant genetic resources for the development of new plant varieties.
  - To **accelerate agricultural development** in the country, protect plant breeders' rights; stimulate investment for research and development both in public & private sector for the development new of plant varieties.
  - Facilitate the **growth of seed industry** in the country, to ensure the availability of high quality seeds and planting material to the farmers.
- The protection period is for 15 years, and 18 years in the case of trees and vines.
- Establishes **Plant Varieties Protection Appellate Tribunal (PVPAT):** The decisions of the PVPAT can be challenged in High Court. The Tribunal shall dispose of the appeal within one year.
- **Protection of Plant Varieties and Farmers' Rights Authority (PPV&FR Authority):** Established to implement the provisions of the Act by Department of Agriculture and Cooperation, Ministry of Agriculture. **General Functions of the Authority:**
  - Registration of new plant varieties and Maintenance of the **National Register of Plant Varieties for registration of new plant varieties**, essentially derived varieties (EDV) and extant varieties.
  - **Facilitate development and commercialisation** of new varieties through formal linkages with agricultural universities, research institutions and Krishi Vigyan Kendras
  - **Developing DUS (Distinctiveness, Uniformity and Stability) test guidelines for new plant species**: DUS testing is a way of determining whether a newly bred variety differs from existing varieties within the same species (the Distinctness part), whether the characteristics used to establish Distinctness are expressed uniformly (**the Uniformity part**) and that these characteristics do not change over subsequent generations (**the Stability part).**
  - **Maintenance of National Gene Bank** to store the seed material including parental lines submitted by the breeders of the registered varieties
  - **Establish National Gene Fund (2007):** It supports and reward farming /tribal/rural communities who are engaged in conservation, improvement and preservation of genetic resources of economic plants and their wild relatives.
  - **Institute Plant Genome Saviour Community Award**, to community of farmers which is engaged in conservation, improvement and preservation of genetic resources of economic plants and their wild relatives, particularly in areas identified as agro-biodiversity hotspots.

About UPOV

- **Objective:** It's an intergovernmental organization, to provide and promote an effective system of plant variety protection, with the aim of encouraging the development of new varieties of plants, for the benefit of society.
- **Protection to Framers:** The UPOV Convention provides the basis for members to encourage plant breeding by granting breeders of new plant varieties an intellectual property right: the breeder's right.

Impact of Plant Variety Protection

- increased breeding activities,
- greater availability of improved varieties,
- diversification of types of breeders (private breeders, researchers),
- increased number of foreign new varieties,
- encouraging the development of a new industry competitiveness on foreign markets, and
- improved access to foreign plant varieties and enhanced domestic breeding programs.

Difference Between Patent And PPV&FR Act

- A patent deals with IPR over devices of Industrial applications whereas PPV & FR Act, 2001 confers IPR to plant breeders who have bred or developed plant varieties.
- A patent is a set of exclusive rights granted by a state (national government) to an inventor or their assignee for a limited period of time in exchange for the public disclosure of an invention. The PPV&FR Act, give rights to farmers, breeders and researches besides giving protection to varieties of all crop species which are notified under the Act.
- There is also provision for benefits sharing, compensation to the farmers, recognition and award to the farmers for supporting conservation and sustainable use of plant genetics resource.

5. SPACE TECHNOLOGY

Achievement of Indian Space Sector

- Today, the **value of the global space industry is estimated to be $350 billion** and is likely to exceed $550 billion by 2025.
- **India's share is estimated at $7 billion** (just 2% of the global market) covering broadband and Direct-to-Home television (accounting for two-thirds of the share), satellite imagery and navigation.
- India's space programme stands out as one of the **most cost-effective in the world**. India has earned worldwide recognition for launching lunar probes, built satellites, ferried foreign satellites up and has even succeeded in reaching Mars.
- **Indian Space Research Organisation (ISRO)** established in 1969 has formal co-operative arrangements in place with 33 countries and three multinational bodies.
- **Various achievements are as follows:**
    - **Satellite Communication**: The first area was of satellite communication, with **INSAT and GSAT** as the backbones, to address the **national needs for telecommunication, broadcasting and broadband infrastructure.**
        - ✓ Gradually, bigger satellites have been built carrying a larger array of transponders. About 200 transponders on Indian satellites provide services linked to areas like **telecommunication, telemedicine, television, disaster management etc.**
        - ✓ **GSAT-11,** the heaviest satellite is part of ISRO's new family of high-throughput communication satellite (HTS) fleet that will drive the country's Internet Broadband from space to untouched areas. It is built to provide throughput data rate of 16 gbps.
        - ✓ **GSAT 29** is a multi-beam, multiband communication satellite of India which will bridge the digital divide of users including those in Jammu & Kashmir and North Eastern regions of India.
    - **Earth Observatory**: Beginning with the **Indian Remote Sensing (IRS) series** in the 1980s, today the **RISAT, Cartosat and Resourcesat** series provide wide-field and multi-spectral high resolution data for land, ocean and atmospheric observations.
        - ✓ These resources cover weather forecasting, disaster management, agriculture and watershed, land resource, and forestry managements. With higher resolution and precise positioning, Geographical Information Systems' applications today cover all aspects of rural and urban development and planning.
        - ✓ **EMISAT** developed by DRDO under Project Kautilya is India's 1st Electronic Intelligence Satellite which will increase the situational awareness of the armed forces by providing the location and information of hostile radars placed at the borders.
    - **Space Observatory: Astrosat** launched in 2015 is India's first dedicated multi wavelength space observatory. It enables the simultaneous multi-wavelength observations of various astronomical objects with a single satellite.
    - **Navigation:** The **GPS-aided GEO augmented navigation (GAGAN),** a joint project between ISRO and Airports Authority of India, augmented the GPS coverage of the region, improving the accuracy and integrity, primarily for civil aviation applications and better air traffic management over Indian airspace.
        - ✓ This was followed up with the **Indian Regional Navigation Satellite System (IRNSS),** a system based on seven satellites in geostationary and geosynchronous orbits. In 2016, the system was renamed NavIC (Navigation with Indian Constellation).
    - **Small Satellite:** Globally, 17,000 small satellites are expected to be launched between now and 2030. ISRO is developing a small satellite launch vehicle (SSLV) as well. It is a prime candidate, along with the proven PSLV, to be farmed out to the private sector.
    - **Space exploration missions:** The most notable of these have been **the Chandrayaan and the Mangalyaan** missions, with **a manned space mission, Gaganyaan**, planned for its first test flight in

Unispace Nanosatellite Assembly & Training Programme (UNNATI)

- ISRO launched a **capacity building programme on Nanosatellite development** named UNNATI.
- It is an initiative to commemorate the 50th anniversary of the first United Nations conference on the exploration and peaceful uses of outer space **(UNISPACE+50).**
- It would **provide opportunities to the participating developing countries** to strengthen in assembling, integrating and testing of Nanosatellite.

2021. These missions are not just for technology demonstration but also for expanding the frontiers of knowledge in space.

- **Launch Vehicles:** None of the above missions would have been possible without mastering the launch-vehicle technology. Beginning with the Satellite Launch Vehicle (SLV) and the Augmented Satellite Launch Vehicle (ASLV), ISRO has developed and refined the Polar Satellite Launch Vehicle (PSLV) and GSLV as its workhorse for placing satellites etc.
- **Outreach programmes:**
  - ✓ **Village Resource Centres**: ISRO launched the idea of Village Resource Centres to work in collaboration with local panchayats and NGOs. Expanding this for rural areas is a formidable challenge but has the potential to transform rural India if properly conceived as a part of the India Stack and the Jan Dhan Yojana.
  - ✓ **Young Scientist Programme:** It is ISRO programme for school students which aims to inculcate and nurture space research fervor in young minds.
  - ✓ **Samvad with Students:** ISRO launched a student outreach programme called Samvad with Students where ISRO chairman meets the students during his outstation visits and address their queries and quench the scientific thrust.
  - ✓ **ISRO-Student Collaborations:** ANUSAT (Anna University Satellite), Student Satellite (STUDSAT), YOUTHSAT, SRMSAT, Jugnu etc.

5.1. ISRO'S INITIATIVES

5.1.1. LAUNCH VEHICLES IN INDIA

Why in news?

Indian Space Research Organisation (ISRO) successfully launched the **PSLV-C45 rocket** from Satish Dhawan Space Centre SHAR, Sriharikota (Andhra Pradesh), which injected EMISAT and 28 international customer satellites into their designated orbits.

About Launch Vehicles in India

- Launch Vehicles are **used to transport and put satellites or spacecrafts into space**. In India, the launch vehicles development programme began in the early 1970s.
- The first experimental **Satellite Launch Vehicle (SLV-3)** was developed in 1980. An Augmented version of this, **ASLV**, was launched successfully in 1992.
- India has two operational launchers: **Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV).**
- In order to achieve **high accuracy in placing satellites into their** orbits, a combination of accuracy, efficiency, power and immaculate planning are required.
- ISRO's Launch Vehicle Programme spans numerous centres like
  - **Vikram Sarabhai Space Centre**, located in Thiruvananthapuram, is responsible for the design and development of launch vehicles.
  - **Liquid Propulsion Systems Centre** and **ISRO Propulsion Complex**, located at Valiamala and Mahendragiri respectively, develop the liquid and cryogenic stages for these launch vehicles.
  - **Satish Dhawan Space Centre, SHAR**, is the space port of India and is responsible for integration of launchers. It houses two operational launch pads from where all GSLV and PSLV flights take place.
- So far, India has made **tremendous progress in the field of development of launch vehicles**.
- **Polar Satellite Launch Vehicle (PSLV)**
  - It is designed mainly to deliver the **"earth-observation" or "remote sensing" satellites** with lift-off mass of up to about 1750 Kg to **Sun-Synchronous circular polar orbits** of 600-900 Km altitude.
  - After its **first successful launch in October 1994**, PSLV emerged as the reliable and versatile workhorse launch vehicle of India with 39 consecutively successful missions by June 2017.
  - PSLV is a **four-staged launch vehicle** with alternating solid and liquid stages.
  - It is the **first Indian launch vehicle** to be equipped with **liquid stages**. It is also equipped with **strap-on external motors.**
  - It has successfully launched **Indian Remote Sensing (IRS) satellites, Chandrayaan (2008), Mangalyaan (2013), Astrosat, INRSS etc.**
  - First time ISRO launched a rocket that **injected satellites in three different orbits** using **PSLV-C45**

- **Geosynchronous Satellite Launch Vehicle GSLV**
  - It was developed to launch the **heavier INSAT class of Geosynchronous satellites into orbit**. In its third and final stage, GSLV uses the indigenously developed Cryogenic Upper 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.
    - ✓ **Geosynchronous Satellite Launch Vehicle Mark II (GSLV Mk II)** is the largest launch vehicle developed by India, which is currently in operation.
      - This fourth generation launch vehicle is a three stage vehicle with four liquid strap-ons.
      - The indigenously developed cryogenic Upper Stage (CUS), which is flight proven, forms the third stage of GSLV Mk II.
      - Recently, ISRO launched satellite-**GSAT-29** through the launcher **GSLV-Mk III D2** which is the **second launch of GSLV-Mk III,** which earlier in 2017 carried GSAT-19 satellite as the first development flight.
    - ✓ **Significance of GSLV-Mk III**
      - Its successful launch provide a thrust to future space missions such as Chandrayaan 2, ISRO's moon and man missions etc.
      - India is among six nations — apart from the US, Russia, France, Japan and China — to possess cryogenic engine technology. The launch further expand ISRO's space programmes on several fronts such as commercial international space market.
- **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.
  - ISRO launches smaller rockets from the Rohini series on suborbital and atmospheric flights for aeronomy and meteorological studies.
  - They also serve as **platforms for testing prototypes of new components or subsystems** intended for use in launch vehicles and satellites.
- **Reusable Launch Vehicle – Technology Demonstrator (RLV-TD)**
  - It is one of the most technologically challenging endeavors of ISRO towards developing essential technologies for a **fully reusable launch vehicle to enable low cost access to space.**
  - The configuration of RLV-TD **is similar to that of an aircraft** and combines the complexity of both launch vehicles and aircraft.
  - The winged RLV-TD has been configured to act as a flying test bed to evaluate various technologies, namely, hypersonic flight, autonomous landing and powered cruise flight.
  - In future, this vehicle will be scaled up to become the first stage of India's reusable two stage orbital launch vehicle.
- **Scramjet engine**
  - 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.

Related news

Recently, DRDO successfully flight tested the second indigenously developed '**Solid Fuel Ducted Ramjet** (SFDR)' propulsion-based missile system.

- At present, the conventional missiles use booster or sustainer configuration with solid or liquid propellants. They do not allow the missile enough energy to maintain its speed and tackle a maneuvering target.
- SFDR technology, based on the **ramjet propulsion system** depends only on its forward motion at supersonic speed to compress intake air and the engine flow-path components have no moving parts.
- Unlike solid rocket propellant whose formulation is approximately 20% fuel and 80% oxidizer, the solid ramjet fuel is **100% fuel and obtains oxidizer from air,** with the result being approximately **four times the specific impulse** as compared to solid rocket propellant.
- Hence, this **air breathing ramjet propulsion technology** helps propel the missile at high supersonic speeds (above Mach 2) for engaging targets at long ranges.

- 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
  - ✓ It is **an improvement over the ramjet engine** as it efficiently operates at hypersonic speeds and allows supersonic combustion.

5.1.2. HYPERSPECTRAL IMAGING SATELLITE (HYSIS)

Why in News?

- ISRO's PSLV C43 launched **India's first Hyperspectral Imaging Satellite (HysIS)** along with 30 foreign satellites from Satish Dhawan Space Centre, Sriharikota.
- HysIS is an earth observation satellite built around ISRO's Mini Satellite-2 (IMS-2) bus.

About the Hyperspectral Imaging Technology

- It combines the power of **digital imaging and spectroscopy** to attain both spatial and spectral information from an object.
- This result can be then used to identify, measure and **locate different materials and their chemical and physical properties.** Every pixel in the image contains a continuous spectrum (in radiance or reflectance) and can be used to characterize the objects in the scene with **great precision and detail.**
- Hyperspectral images provide much more detailed information about the scene by dividing the spectrum into **many more bands than a normal color camera**.
- It was first tried by ISRO in an experimental satellite in May 2008 and later on Chandrayaan-1 mission for mapping lunar mineral resources. This is the first time a full-fledged hyperspectral imaging satellite has been launched.

Related Information

Spectral Imaging

It is imaging that uses multiple bands across the electromagnetic spectrum like using infrared, the visible spectrum, the ultraviolet, x-rays, or some combination of the above.

Hyperspectal imaging vs multi spectral imaging

- The main difference between multispectral and hyperspectral is **the number of bands and how narrow the bands are**.
- Hyperspectral imaging (HSI) uses **continuous and contiguous ranges of wavelengths** (e.g. 400 - 1100 nm in steps of 0.1 nm) whilst multispectral imaging (MSI) uses a **subset of targeted wavelengths at chosen locations** (e.g. 400 - 1100 nm in steps of 20 nm).
- Hyperspectral imagery consists of much **narrower bands (10-20 nm)**.

Application

- **Hyperspectral remote sensing** is used for a range of applications like agriculture, forestry, soil survey, geology, coastal zones, inland water studies, environmental studies, detection of pollution from industries and the military for surveillance or anti-terror operations.
- **Other utilities include** online industrial monitoring/sorting/classification to laboratory measurements, clinical instruments for medical diagnostic and airborne and satellite based remote sensing tools.
- **Challenges:** This technology is accompanied with **high cost and complexity**. There is a need for fast processing of data (fast computers), sensitive detectors and large data storage capacities for hyperspectal data.

5.1.3. ADITYA L1

Why in news?

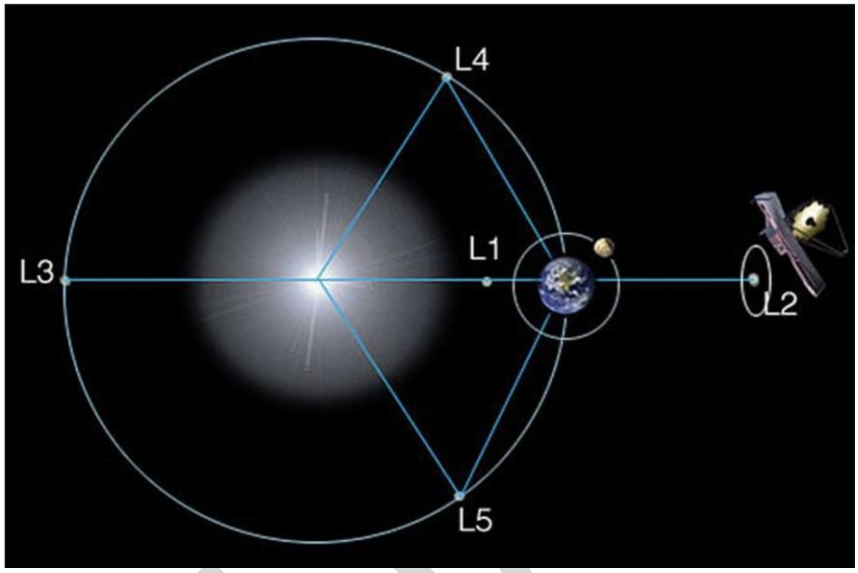
India will launch Aditya-L1, its first mission to study the sun, in 2020.

About Aditya L-1

- It is a **satellite designed to study the solar corona** (outer layers of the Sun) which is quite similar to NASA's Parker Solar Probe.
- It will be placed in a halo orbit around a vantage point in space known as **L1 Lagrange point.**
  - **Halo Orbit** is periodic, three-dimensional orbit near the L1, L2 and L3 lagrange point (unstable) in a three body system.

- **Lagrange Point** is the point where the combined gravitational force of two large bodies is equal to the centrifugal force that is felt by a third body which is relatively smaller. There are about 5 such points in a two body system.
- 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.**
- It 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.



Payloads and their science objectives

- **Visible Emission Line Coronagraph** (VELC): To study the diagnostic parameters of solar corona and dynamics and origin of Coronal Mass Ejections; magnetic field measurement of solar corona.
- **Solar Ultraviolet Imaging Telescope** (SUIT): To image the spatially resolved Solar Photosphere and Chromosphere in near Ultraviolet (200-400 nm) and measure solar irradiance variations.
- **Aditya Solar wind Particle Experiment** (ASPEX): To study the variation of solar wind properties as well as its distribution and spectral characteristics.
- **Plasma Analyser Package for Aditya** (PAPA): To understand the composition of solar wind and its energy distribution.
- **Solar Low Energy X-ray Spectrometer** (SoLEXS): To monitor the X-ray flares for studying the heating mechanism of the solar corona.
- **High Energy L1 Orbiting X-ray Spectrometer** (HEL1OS): To observe the dynamic events in the solar corona and provide an estimate of the energy used to accelerate the particles during the eruptive events.
- **Magnetometer**: To measure the magnitude and nature of the Interplanetary Magnetic Field.

Related News

Recently, scientists from Indian Institute of Science Education and Research have developed a way of predicting the intensity of activity in the next solar cycle (approximately from 2020 to 2031).

What is Sun-spot Cycle?

- The amount of magnetic flux that rises up to the Sun's surface varies with time in a cycle called the solar cycle. This cycle lasts 11 years on average. This cycle is referred to as the sunspot cycle.
- They are darker, magnetically strong, cooler areas on the surface of the sun in a region called the photosphere.

Why this is important?

- It will help in understanding of the long-term variations of the Sun and its impact on earth climate which is one of the objectives of India's **first solar probe – 'Aditya L-1 Mission'.**
- The forecast will be also useful for scientific operational planning of the Aditya mission

How does Sunspot Cycle affect the Earth?

- An important reason to understand sunspots is that they affect space weather.
- During extreme events, space weather can affect electronics-driven satellite controls, communications systems, air traffic over polar routes and even power grids.
- Some believe that they are correlated with climate on earth. For instance, during past periods of low sunspot activity, some parts of Europe and North America experienced lower-than-average temperatures.

5.1.4. INDIA'S SPACE ECONOMY

Why in news?

Recently the **New Space India (NSIL)**- new commercial arm of India Space Research Organisation (ISRO)- **has got its first customer** who has bought payload slot on the ISRO's newest rocket — **Small Satellite Launch Vehicle (SSLV).**

Background

- From a modest beginning in the 1960s, India's space programme has grown steadily – from its initial decades priority to achieve **self-reliance** to develop a **robust national industry to support the government-funded national programme**, which had been conceived and executed by the Indian Space Research Organisation (ISRO). As a result, India's space industry is **now extensive, though not fully integrated**.
- India launched 239 satellites for 28 different countries as of October, 2018. Commercial launches for foreign nations are negotiated through **Antrix, the commercial arm of the Indian Space Research Organization (ISRO).**

Need for Commercialising the Space Sector

- **To augment Global space footprint:** Value of the global space industry is **likely to exceed $550 billion** by 2025. Despite ISRO's impressive capabilities, India's share is estimated at **2% of the global market**.
  - **Space has always been monopolised by the first world** due to the **technology-transfer constraints** and the **dual-use nature of space systems** leading to **concentrated markets and islands of capabilities** on a global landscape.
- **Space-a competition driven sector:** For instance, **Luxembourg** is seizing opportunities to become a big space economy player **and China** is significantly increasing the number of its active space assets through **massive public investment as well as opening its skies to private entrepreneurs.** Hence, we must **deregulate the space sector** and create an environment for private industry and perhaps become a **global space technology hub**.
  - India has emerged as a major space power with the technology and ability to launch satellites and other space products at globally low cost. This needs to be harnessed commercially.
- **Inadequate capacity:** Indian Space Research Organisation (ISRO) is all set to double the number of satellites it launches by next year. However, with the existing **shortage of manpower and funds**, the demand for space-based services in India is far greater than what ISRO can supply. Private sector investment is thus critical.
- **Untapped Potential:** This includes several applications including
  - GIS-based decision support, positioning and location-based services,
  - homeland security,
  - disaster management,
  - wide-band connectivity to remote rural areas and
  - mobile multimedia services

About New Space India Limited: A wholly owned Government of India undertaking/ Central Public Sector Enterprise (CPSE), under the administrative control of **Department of Space (DOS)** to **commercially exploit** the research and development work of ISRO. NSIL has been envisaged to cater a growing demand for its commercial services in the wake **of Global New Space Movement.** It has been incorporated to carry out the following roles and functions as part of its mandate viz

- Small Satellite technology transfer to industry, wherein NSIL will obtain license from DOS/ISRO and sub-license it to Industries;
- Manufacture of **Small Satellite Launch Vehicle (SSLV)** in collaboration with **Private Sector**;
- Product ionisation of **Polar Satellite Launch Vehicle (PSLV)** through Indian Industry;
- Product ionisation and marketing of **Space based products** and services, including launch and application;
- **Transfer of technology** developed by ISRO Centres and constituent units of DOS;
- **Marketing spin-off technologies** and products/services, both in India and abroad.

How NSIL will be different from Antrix?

- **Antrix** facilitates satellite launch vehicles such as Small Satellite Launch Vehicle (SSLV) and Polar Satellite Launch Vehicle (PSLV) for foreign markets. Whereas, **NSIL will expand its commercialisation activities domestically as well.**
- In the domestic space, there is a **huge demand for Geospatial information** through earth observation, communication and navigation space, NSIL would be addressing this space.

About Antrix Corporation

- **Antrix** was incorporated in September 1992, as a private limited company, and was wholly owned by the Government of India, with the objective of promoting and commercially exploiting the space products developed by ISRO.
- A total of 239 satellites were commercially launched by **Antrix Corporation Limited** during the last three years.
- Because of the wide diversity in ISRO's activities and capabilities, the business portfolio of Antrix, too, was spread into many areas including:
  - provision of spacecraft systems, subsystems and components;
  - remote- sensing services;
  - satellite communications transponder leasing services;
  - launch services;
  - mission-support services etc.

Benefits of Commercialisation of Space Sector

- **Entrepreneurial Ecosystem:** It will inspire many entrepreneurs in India leading to the establishment of several innovative start-up initiatives like
  - In 2017 the Bangalore based Team Indus launched a rover which could be landed on the Moon and beam back images and videos paving way for India's entry into **Google Lunar XPRIZE competition**.
  - **Earth2Orbit** (India's **first space startup**) is all set to solve climate change from outer space.
  - **Dhruva Space**, a Bangalore based start-up became the first in India to design and manufacture satellites with a capacity to manufacture at least 10-12 satellites annually.
- **Employment generation:** As the space sector expands with bigger projects and missions, more skilled expertise will be required. Commercialisation thus will also channelize employment via the growing number of new space companies and start-ups.
- **Academic Opportunities and R&D:** Private industry should be seen as allies to ISRO. It saves their time for bigger, challenging innovations and operations; and most important research and development. Commercialising and privatising, will bring research-based curriculum, reflecting the demands of the industry to see Aeronautics and Space sector as a career option.

Global NewSpace Movement

- **NewSpace**, is a global phenomenon where space entrepreneurs are developing products and services which are focused on **spaceflight by using private funding**.
- **SpaceX, OneWeb and PlanetLabs** are companies which work independently to the government and often challenge the traditional space methods which are **expensive and time-consuming.**
- Developments in **Artificial Intelligence (AI) and big data analytics** has led to the emergence of 'New Space' — a disruptive dynamic based on using end-to-end efficiency concepts.
- The new space economy **consists of independent private players** across the value chain, from launch vehicles to satellite payloads.

New Space' start-ups

- The New Space start-ups discern a synergy with government's flagship programmes like **Digital India, Start-Up India, Skill India and schemes like Smart Cities Mission**.
- They see a role as a **data-app builder between the data seller (ISRO/Antrix) and the end user**, taking advantage of the talent pool, innovation competence and technology know-how.
- In India, the progress and entrepreneurial initiatives of **Team Indus, Astrome Technologies, Bellatrix Aerospace, Dhruva Space, Earth2Orbit,** etc. are pioneering in this space.

Way Ahead

- **For India, continued investment by the government** is crucial if the country aspires to play a globally significant role in diplomacy, socio-economic advances and international security**.**
- **A robust infrastructure** should be enabled by both government expenditure and private investments or through public–private partnerships.
- **National Space Ecosystem:** India's space industry should be modelled as an important part of the larger ecosystem, addressing space assets manufacturing, private ownership of space assets, national level space services and global market access.
- **Draft Space Activities Bill,** 2017 had been put up for public consultation, but the legislative process has since not moved forward. The most important objective of the new space bill ought to be to clear the **decks for the private sector**.

The Space Activities Bill, 2017

It is a proposed Bill to promote and regulate the space activities of India. The new Bill encourages the participation of non-governmental/ private sector agencies in space activities in India under the guidance and authorisation of the government through the Department of Space.

- **International Coordination:** The government needs to provide assistance to the space industry for safe and secure use of their assets in space, for Space Situation Awareness, and for an appropriate engagement with the industry to facilitate internationally coordinated resources such as orbit- spectrum coordination.

5.2. NASA AND EUROPEAN MISSIONS

NASA Mission	Objective/Implications
Parker Solar Probe	• It is first to fly direct into the Sun's atmosphere known as corona. The Sun's unstable corona produces: solar winds, flares, magnetic and plasma explosions. • It will take measurements of the Sun's electric fields and waves.
New Horizons probe	• It recently completed the flyby of the Kuiper Belt object nicknamed Ultima Thule and set the record for the most distant object ever visited by a spacecraft. • It is the **first mission to the Pluto System and the Kuiper belt**. • **Ultima Thule is** a **contact binary** i.e it's a single object, with two lobes, but the lobes are gently in contact. NASA dubbed the **larger lobe Ultima**, and the other, which is about three times **smaller, Thule.** • **Kuiper Belt** is **a donut-shaped region of icy bodies beyond the orbit of Neptune.** o The icy objects of the Kuiper Belt are remnants left over from the formation of the solar system. o Many Kuiper Belt objects have remained unchanged for billions of years, and could provide clues to the history of the Solar System, and possibly the conditions that led to the evolution of a habitable world like Earth. o **Pluto also lies in the Kuiper belt.**
Hubble Telescope	• It is a **joint venture between NASA and the European Space Agency** (ESA) — was launched in its orbit 552 km above Earth. • It is the first major optical telescope to be placed in space. • It has the ability to see in multiple wavelengths — near infrared, visible light and near ultraviolet. • It has helped scientists understand how planets and galaxies form, figuring the age and size of universe, new moons of pluto, understanding the season of the planets, exoplanet science etc.
ICESat (Ice, Cloud, and land Elevation Satellite)-2	• ICESat (Ice, Cloud, and land Elevation Satellite) is the benchmark **Earth Observing System mission** for measuring ice sheet mass balance, cloud and aerosol heights, as well as land topography and vegetation characteristics. • The ICESat, was launched in 2003 and ended in 2009. From it, scientists learned that sea ice was thinning, and ice cover was disappearing from coastal areas in Greenland and Antarctica.
Visualizing Ion Outflow via Neutral Atom Sensing-2 (VISIONS-2) Mission	• It is a **sounding rocket mission** to get a **closer look at the how the Earth's atmosphere is slowly leaking** into space. • The **aurora borealis** is of keen interest to the VISIONS-2 team as they are fundamental drivers in the process of **atmospheric escape.** • The auroras are formed when **energetic electrons, accelerated in the electric and magnetic fields from sun in near-Earth space**, crash into and excite atmospheric gases, which emit bright hues of red, green, and yellow as they relax back to a lower energy state. • The lights are seen **above the magnetic poles of the northern and southern hemispheres.** They are known as **'Aurora borealis'** in the north and 'Aurora Australis' in the south.
Atmospheric Waves Experiment	• It is expected to be launched in **August 2022**, attached to the exterior of the Earth-orbiting International Space Station. • It will investigate how waves in the lower atmosphere, caused by variations in the densities of different packets of air, impact the upper atmosphere. • The experiment will focus on colourful bands of light in Earth's atmosphere, called **airglow**, to determine **what combination of forces drive space weather in the upper atmosphere**. • Earlier it was thought that only Sun's constant outflow of ultraviolet (UV) light and particles, solar wind, could affect airglow region. However, now researchers have learned that Earth's weather also have effect on it.

European Mission	Objective/Implications
BepiColombo Mission	• It is Europe's first mission to Mercury which will set off in 2018 and reach there in 2025. • It is a joint mission between ESA and the Japan Aerospace Exploration Agency (JAXA), executed under ESA leadership. • The mission comprises two spacecrafts: the Mercury Planetary Orbiter (MPO) and the Mercury Magnetospheric Orbiter (MMO). • The mission will help in finding out the possibility of water in Mercury. The surface temperature of Mercury varies from 450 degree Celsius to -180 degree Celsius (areas permanently in shade). • Mercury is the smallest and least explored terrestrial planet in our Solar System. Till now only NASA's Mariner 10 and US Space Agency's Messenger has flown past the planet.

5.3. BLACK HOLE

Why in news?

Recently, the Event Horizon Telescope revealed the **first ever photograph of the shadow of a black hole.**

About Black Hole

- A black hole is a region of space-time, which exhibits the **property of extremely intense gravitational force,** which is so strong, that **nothing, not even light,** can escape it.
- Black holes were predicted by the **Einstein's theory of general relativity**, which showed that when a massive star dies, it leaves behind a **small, dense remnant core**.
- If the core's mass is more than about three times the mass of the Sun, the force of gravity overwhelms all other forces and **produces a black hole.**
- In the center of a black hole is a **gravitational singularity**, a one-dimensional point which contains a **huge mass in an infinitely small space, where density and gravity become infinite and space-time curves infinitely**, and the laws of physics as we know them **cease to operate**.
- Black holes **cannot be directly observed** because they themselves do not emit or radiate light, or any other electromagnetic waves that can be detected by instruments built by human beings. But the area just outside the boundary of the black hole (**Event Horizon**), which has vast amounts of gas, clouds and plasma swirling violently, **emit all kinds of radiations**, including even visible light. Hence, the **presence of black holes can be inferred** by detecting their effect on other matter nearby them.
- Now, the **Event Horizon Telescope** has captured the **just outside region** of a black hole, located 55 million light-years from Earth, at the centre of a galaxy named **Messier 87.** The image shows **a photon (light quantum)** can orbit the black hole without falling in**.** This is called the **'last photon ring'.**

Event Horizon Telescope (EHT)

- A long-standing goal in **astrophysics** is to **directly observe** the immediate environment of a black hole. The **'event horizon'** is the boundary defining the region of space around a black hole from which nothing can escape.
- The EHT is an **international collaboration** to continue the progress in achieving this goal, using the technique of **Very Long Baseline interferometry (VLBI)** at short wavelengths.
- In this technique, a network of 8 **ground-based radio telescopes** have been linked and exploit the rotation of our planet to form one **virtual Earth-size telescope** observing at a wavelength of 1.3 mm.

Significance

- **Observed the unseeable-** For centuries, the concept of black hole has only been **theorized**, without any actual evidence of it. This is a remarkable confirmation of more than a century of theoretical work.
- **Capturing the event horizon requires perfection-** because the black hole is very small as compared to other celestial bodies and the light has to pass through all sorts of gases and material of the space and the Earth's atmosphere. The telescopes of EHT also have to synchronize in a perfect manner to be able to make simultaneous recordings of the radiations coming in from the black hole region.
- **Better understanding of the universe-** Scientists can compare the actual image with computer-simulated images used earlier to ascertain the differences, which could be explained by instrumentation, observation or other errors. This can provide a test for existing theories of the universe, and lead to a better understanding of black holes and the nature of the universe itself.
- **Enhances the understanding of gravitational force-** which can be useful for the Global Positioning Satellites in order to make them accurate to more than a few metres.

5.4. CLEANING UP SPACE DEBRIS

Why in news?

As part of the space junk cleanup, a new device named **space harpoon** that captures junk has been tested successfully. It is part of the **Remove DEBRIS project**, a multi-organization European effort to create and test methods of reducing space debris.

About Space Debris

- Space debris encompasses **both natural (meteoroid) and artificial (man-made) particles**. Meteoroids are in orbit about the sun, while most artificial debris is in orbit about the Earth. Hence, the latter is more commonly referred to as orbital debris.
- 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).

Why Space Debris is a concern?

- **Obstruction to various space endeavors**
  - NASA estimates that there are about **500,000 pieces** of debris larger than half an inch across in low orbit, posing a potential danger to the 780-odd satellites operating in the area.
  - Space junk **travels at speeds up to 30,000 km an hour**, which turns tiny pieces of orbital debris into deadly shrapnel that can damage satellites, space shuttles, space stations and spacecraft with humans aboard.
- **Increase the cost of missions-** Various space agencies have to manoeuvre their space programme in light of increasing space debris thus adding to extra economic and human resource on space programme.
- **Debris is bound to increase-** Space-scientists concern about the inexpensive, tiny satellites called CubeSats, which are going to add space junk around 15% in next 10 years.

The 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.

Space Harpoon

The harpoon is meant for larger targets, for example full-size satellites that have malfunctioned and are drifting from their orbit. A simple mass driver could knock them toward the Earth, but capturing them and controlling descent is a more controlled technique.

About Inter-Agency Space Debris Coordination 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.
- It aims to exchange information on space debris research activities between member space agencies, to facilitate opportunities for cooperation in space debris research, to review the progress of ongoing cooperative activities, and to identify debris mitigation options.
- ISRO is also a member of this committee.

Initiatives taken towards Space Debris cleanup

- **Committee on the Peaceful Uses of Outer Space,** and **Inter-Agency Space Debris Coordination Committee (IADC)** advocates Global mitigation measures including preventing the creation of new debris, designing satellites to withstand impacts by small debris, and improving operational procedures such as using orbital regimes with less debris, and predicting and avoiding collisions. However, these guidelines are only voluntary in nature and there is no international treaty on space debris currently.
- **UK-** The Remove Debris mission is led by the Surrey Space Centre at the University of Surrey. UK and co-funded by various other partners from EU.

Anti-satellite (ASAT) missile and Space Debris

- **Mission Shakti** which was launched recently was done in a low orbit of less than 300 kilometres and at a particular angle to ensure that minimal debris were disbursed above into space to avoid damage to other satellites or the International Space Station (ISS).
- In contrast, when China tested its ASAT missile in 2007 destroying one of its own weather satellites, it created close to 2500 pieces of space debris.

- **European Space Agency- e. Deorbit mission,** which would target an ESA-owned derelict satellite in low orbit, capture it, then safely burn it up in a controlled atmospheric reentry.
- **Japan-** It launched **Kounotori 6 satellite,** which uses 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.
- **India-**
    - A team of ISRO and Physical Research Laboratory are working on setting up an observatory to track the space junk.
    - A multi- object tracking radar (MOTR) developed by the Satish Dhawan Space Centre allows ISRO to track 10 objects simultaneously. It tracks India's space assets and space debris, for which India was solely dependent on data provide by the US space agency NASA till early 2016

6. IT & COMPUTERS

Digital infrastructure in India

- Government of India has been at the forefront of **using technology in different aspects of governance**, be it satellite based communication in 1980s or use of electronic messaging much before the advent of internet in the country or even the use of video conference for monitoring the implementation of Government programmes and schemes across the country.
- **National Informatics Centre**, an attached office of Ministry of Electronics and IT, has been closely working with Government in provisioning state-of-the-art infrastructure in the form of nationwide network (NICNET), Data Centres, and Video Conferencing facilities to name a few.
- **Digital India,** one of the flagship programmes of the Government, has given significant push to adoption of technology and has brought a paradigm shift in the delivery of services to citizens and also the way Government engages with citizens.
- **Key components of digital infrastructure for Government**
    - **Pan India Network:** NICNET, the Pan India communication network for exclusive use of Government has continuously evolved since 1980s in terms of its geographical expansion, state of the art technology, reliability as well as security architecture. It is at the base of all Government communications right from Government to Government, Government to citizen as well as Government to business communication.
    - **National Knowledge Network**: It provides Multi gigabit nationwide network connected through 10G backbone and extends high speed connectivity to leading Research and Academic Institutions of the country.
    - **National Cloud (MeghRaj)**: In order to utilize and harness the benefits of Cloud Computing. Government of India initiated a Government Cloud initiative titled "MeghRaj" in 2014. Setting-up of a secured cloud infrastructure has reduced considerable amount of time in provisioning of digital infrastructure.
    - **Geospatial Technology**: Geographical Information Systems (GIS) have improved the accessibility of various e-Govemance services by offering location based access, visual gap analysis and actual on-site representation of various activities.
        - ✓ **Bharat Maps** is a multi-layered GIS platform / web service comprising of seamless country wide base maps, satellite images and hybrid maps aligned as per the global geo spatial standards.
        - ✓ GIS is helping MGNREGA workers to get information about availability of work in the near locations, work site location information, real time transparent attendance and payment information. At the same time, it is benefitting the citizens by enabling geo portal for MGNREGA assets, which will enhance the concurrent social audit by citizens and facilitate feedback information on current status of work, quality validation, etc.
    - **Direct Benefit Transfer (DBT):** Earlier, there was an inherent delay in the transfer of funds due to multiple layers of governance. With the advent of technology and Direct Benefit Transfer (DBT) coming up a paradigm shift has been experienced in the way benefits are transferred to the citizens.
    - **Cyber Security:** To address ever increasing threat of cyber-attacks in terms of their magnitude as well as their sophistication, **Computer Emergency Response Team (NIC-CERT) group** has been constituted with an objective of analyzing, monitoring and responding to cyber threats on critical government cyber infrastructure, like websites, emails and various services.
    - **For rural development,** the government has harnessed technology for implementing various ICT applications in over 10 programs including Pradhan Maotri Aawaas Yojana – Gramin (PMAY-G), Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), National Social Assistance Program (NSAP), Deen Dayal Upadhyay Grameen Kaushalya Yojana (DDUGKY), Deendayal Antyodaya Yojana National Rural Livelihood Mission (DAY-NRLM).

6.1. DATA LOCALIZATION

Why in news?

In clarification to its directive in April 2018 on 'Storage of payment system data', RBI announced that the payment system providers need to store entire payments data in a system only in India.

About RBI's data localization directive

RBI issued a directive advising all Payment System Operators (PSOs) to ensure that the entire data relating to payment systems is stored within databases located in India.

What is data localization?

- Data localization is a concept that the **personal data of a country's residents should be processed and stored in that country**. It may restrict flow entirely or allow for conditional data sharing or data mirroring (in which only a copy has to be stored in the country)
- There is a growing perception that data localization will aid countries asserting sovereignty in digital domain, ensure informational security of its citizens & fare better in governance (as it goes digital).

- Directives are **applicable to Payment System providers** authorized by RBI under Payment and Settlement Systems Act, 2007. This includes many companies from payment gateways like MasterCard and Visa to e-wallets like PayTM.
- It includes end-to-end transaction details and information pertaining to payment or settlement transaction.
- There is **no bar on overseas processing of strictly domestic transactions**; however in such cases, the data should be deleted from the systems abroad and brought back to India not later than the one business day or 24 hours from payment processing, whichever is earlier.
- **Data can be shared with the overseas regulator**, if required, depending upon the nature/origin of transaction with prior approval of the RBI.

Other measures towards data localization

- In 2018, a draft data protection law by **BN Shrikrishna Committee** also recommended that **all personal data of Indians have at least one copy in India**. It also defined a category of data as **critical personal data**, which must be stored and processed only in India.
- A similar clause was incorporated in **Government's draft e-commerce policy**, which recommended localization for "**community data** generated by users in India from various sources including e-commerce platforms, social media, search engines etc."
- **Draft Digital Information Security in Healthcare Act (DISHA)** seeks to empower the health regulator to localize data.

Need for data localization

- **Economic development of the country:** Data is the new oil, an economic resource, fueling the 4th Industrial Revolution.
  - Digital data in India to increase from 40,000 PetaByte (PB) in 2010 to 2.3 million PB by 2020 – twice as fast as the global rate. If India houses all this data, it will become **2nd largest investor in the data centre market** and **5th largest data centre market** by 2050. This will give significant push to **AI led economy** in India.
  - India has **2nd highest FinTech adoption rate** amongst major economies in the world. Data localization would give a push to **domestic production of high value digital products**.
  - **Domains of cloud computing, data analytics etc.** can become major job creators in future.
  - There is a **push among government department to use AI tools** and **attempt a predictive approach to policy making**. With data localization, there is a scope of greater access to 'public data' collected by companies (e.g. traffic data collected by like Uber, street level data collected by Google Maps) for the Government.
- **Increase India's tax revenue:** Extensive data collection & processing by technology companies, and unfettered control of user data has allowed them to freely monetize Indian users' data outside the country without paying any taxes.
  - Localization would lead to a **larger presence of MNC's in India** overall, through local offices, and **increase tax liability** and **open more jobs**.
  - Data localization is **supported by domestic companies like PayTM and PhonePe** as it will level the playing field, currently rendered unequal due to **differences in tax liabilities** of international companies and those having permanent establishment in India. E.g. **Google India tax dispute** over advertisement revenue under litigation in court.
- **Maintain data sovereignty & citizens' data privacy:** With data stored in remote servers, the accountability of service providers (like Google, Facebook etc.) reduces as it is outside the purview of Indian regulatory authorities. With data localization, **regulatory oversight on end-use of data** will improve and **business jurisdiction related loopholes** will be plugged. E.g. Facebook shared user data with **Cambridge Analytica** to influence voting.
- **Issue of national security:** Data localization will help law enforcement agencies to get access to user data for investigation and prosecution

- Currently, companies are dependent on **Mutual Legal Assistance Treaties (MLATs)** to obtain data from US companies leading to delays and legal challenges in foreign jurisdictions.
- In many countries like US, **tech companies are legally barred** from disclosing data to foreign law enforcement agencies.

Challenges associated with data localization

- **Economic Costs:**
  - Cross-border data flows have contributed **$2.8 trillion** to the **global economy in 2014**, set to increase to $11 trillion by 2025. Stringent localization norms could affect **innovation & ease of doing business in India**.
  - **India's Information Technology Enabled Services (IteS)** and **Business Process Outsourcing (BPO)** industries (. E.g. TCS/Wipro) thrive on **cross border data flows** and would **incur significant additional costs** if data localization is strictly implemented. This could be further a drag on India's IT industry which is already under pressure due to emergent technologies like machine learning and artificial intelligence.
- **Security Concerns:**
  - Isolating **payment systems** from global data network would **reduce their operational efficiency** and make transactions prone to **frauds, systemic risks or a single point of failure**. Moreover, according to Symantec's **Internet Security Threat Report 2017,** India is **3rd most vulnerable** country in terms of risk of cyber threats (e.g. malware, spam & ransomware etc.) due to inadequate cybersecurity infrastructure.
- **Push to protectionism in global trade:**
  - It hampers a globalized, competitive internet marketplace, where costs and speeds determine information flows, rather than nationalistic borders.
  - It might trigger a vicious cycle of data localization requirements by other countries
- **Access issues will remain:** Law enforcement require only "access to data" for their investigation and the physical location of server is immaterial.
  - Data localization norms may not increase accessibility of **data kept in encrypted form** (e.g. WhatsApp)
- **Privacy concerns:** There is no evidence that data localization leads to better privacy or security. **Threat of state surveillance** and **misuse of personal data** of citizens by the Government will remain.
- **Increase of conflicts**: This may be perceived as a protectionist policy which may lead to other countries following suit and increased conflict over data sharing.
- **Cloud Computing Softwares:** Cloud computing softwares have taken advantage of the economies of scale and an infrastructural architecture across the world. Thus, when there is a threat presumed in one part of the world, the algorithm would move the data to another location or even in multiple locations. However, this flexibility may be hampered due to data localization.

Global Practices

- **China/Russia:** There are stringent data localization norms in China/Russia. In China, any cross border flow of personal data requires security assessment. Additionally, "Critical Information Infrastructure Operators" need to store certain personal and business information within China.
- **US:** Electronics Communications Privacy Act (ECPA) bars US-based service providers from disclosing electronic communications to any law enforcement entity unless requirements under US law are met.
- **European Union:** General Data Protection Regulation (GPDR) allows cross-border movement of data, but requires destination country to have stringent cybersecurity rules.

Way Forward

- **Before universalizing the policy of data localization,** the Government needs to provide a push to local capabilities in data storage and processing
  - **Infrastructure status** to data centres/server farms
  - Adequate **physical infrastructure** (energy, real estate and internet connectivity) for setting up such centres
- India should put in place in a **cybersecurity law** to ensure protection of private data of citizens.
- To promote ease of access of data to law enforcement agencies, the government should seek to enter into **bilateral agreements**.
  - **Clarifying Lawful Overseas Use of Data (CLOUD) Act of US** seeks to de-monopolize control over data from US authorities & allows tech companies to share it with foreign governments. India must **upgrade its data protection regime** to qualify for the benefits under CLOUD Act.

6.2. SUPERCOMPUTING IN INDIA

Why in News?

Recently PARAM Shivay, the first super computer designed & built under the National Supercomputing Mission by C-DAC (Center for Development of Advanced Computing) at IIT-BHU was launched.

Supercomputing in India

- The supercomputer is a computer with a **high-level computational capacity compared to a general-purpose computer**.
  - Performance of a supercomputer is **measured in floating-point operations per second (FLOPS)** instead of million instructions per second (MIPS).
- It is typically used for **scientific and engineering applications** that must handle very large databases or do a great amount of computation (or both).
- **Application areas:** Climate Modelling, Computational Biology, Atomic Energy Simulations, National Security/ Defence Applications, Disaster Simulations and Management, Computational Material Science and Nanomaterials, Cyber Physical Systems, Big Data Analytics etc.
- **India has 4 supercomputers** in the Top-500 list of the world's top 500 supercomputers with **Pratyush and Mihir** being the fastest supercomputers in India.
  - Two other systems, ranked 206th and 497th, are presently operating at a software company and at IITM, respectively.
- **Pratyush:**
  - Launched in January 2018, it is the fourth fastest High Performance Computer (HPC) **dedicated to climate modelling in the world.**
  - Its peak capacity is 4 Petaflops in compute, it has 9 Petabytes of storage capacity and 30 Petabytes of archival capacity.

Related Information

Top-500 Project

- Started in 1993, it ranks **the 500 most powerful non-distributed computers** in the world.
- It publishes an updated list of the supercomputers twice a year.
- Currently, **China dominates** the list with 229 supercomputers, leading the second place (United States) by a record margin of 121.
- Since June 2018, the **American "Summit"** is the world's most powerful supercomputer, based on the **LINPACK benchmarks**.
- LINPACK benchmark are a measure of a system's floating point computer power. It measures how far a computer solves a nxn system of linear equations.

About C-DAC

- It is the premier R&D organization of the Ministry of Electronics and Information Technology (MeitY) for carrying out R&D in IT, Electronics and associated areas.
- **PARAM 8000**, first supercomputer of India, was built by CDAC.
- It was established after denial of import of Cray Supercomputer (dual use technology which could be used for nuclear weapon simulation), due to arms embargo.

About National Supercomputing Mission

- The Mission, launched in **2015**, envisages empowering our national academic and R&D institutions spread over the country by installing a vast supercomputing grid comprising of more than **70 high-performance computing facilities.**
- **Objective:**
  - To make India one of the world leaders in Supercomputing and to enhance India's capability in solving grand challenge problems of national and global relevance.
  - To attain global competitiveness and ensure self-reliance in the strategic area of supercomputing technology.
- **Salient Features:**
  - The mission would be implemented jointly by **Department of Science and Technology (DST) and Department of Electronics and Information Technology (DeitY)** through two organizations the Centre for Development of Advanced Computing (C-DAC) and the Indian Institute of Science (IISc), Bangalore.
  - The Mission envisages **empowering our national academic and R&D institutions** spread over the country by installing a vast supercomputing grid comprising of more than 70 high-performance computing facilities
  - These supercomputers will also be **networked on the National Supercomputing grid over the National Knowledge Network (NKN)**, a programme under same ministry which connects academic institutions and R&D labs over a high-speed network.
  - The Mission also includes development of **highly professional High Performance Computing (HPC) aware human resource. PARAM Shavak** is one such machine that has been deployed to provide training.

- India has become the only country worldwide to have an Ensemble Prediction System (EPS), running weather models at a 12-km resolution due to Pratyush.

- **Mihir:** It has been installed at the National Centre for Medium Range Weather Forecasting (NCMRWF), New Delhi.

Application of Supercomputing

- **Weather Forecasting:** The processing power of supercomputers help climatologists predict, not only the likelihood of rain in your neighborhood, but also the paths of hurricanes and the probability of tornado strikes. Weather prediction has reached accuracy of forecast as well as real time tracking of natural phenomenon.
- **Scientific Research:** Like the weather, scientific research depends upon the number-crunching ability of supercomputers. For example, Researchers at the European Organization for Nuclear Research, or CERN, found the Higgs-Boson particle by analyzing the massive amounts of data generated by the Large Hadron Collider.
- **Data Mining:** Some supercomputers are needed to extract information from raw data gathered from data farms on the ground or in the cloud. For example, businesses can analyze data collected from their cash registers to help control inventory or spot market trends.

Challenges to Supercomputing in India:

- **Limited funding:** Limited investments and delayed release of funds have held India back. Even after launching NSM, only 10 per cent of its total budget has been released at the end of three years.
- **Limited Hardware development**: India's stronghold is in software development, it has to depend on imports to procure the hardware components required for building supercomputers.
  - Cutting edge technology in hardware components is difficult to procure as supercomputing is a niche field. Even a large part of BullSequana will only be assembled in India.
- **Brain Drain**: Large Multi-National Corporations (like Google) have also entered the supercomputing field. Competing with such MNCs to retain talent for developing and maintaining supercomputers proves difficult for Government.
- **Limited manufacturing capability**: Actual chip design and manufacturing is difficult to achieve (due to many factors like high initial investment needed, limited availability of rare earth metals).

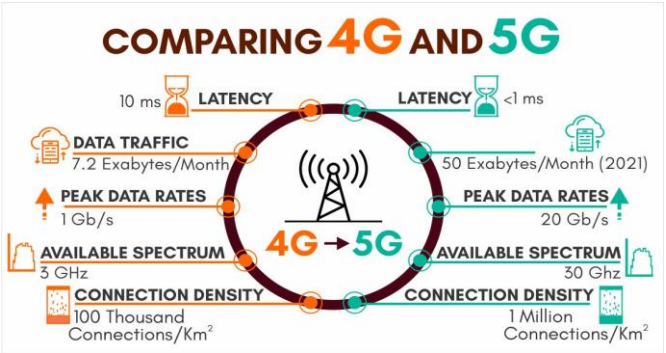
Way forward

- **India has software skills and personnel base** which can be effectively leveraged to propel innovation on the software components of supercomputer technology.
- India can focus its **research on new approaches** like Quantum Computing and Optical Computing.
- **Increase in funding** is also required which will promote the manufacturing within India.

6.3. 5G NETWORK

Why in news?

Department of Telecommunications has decided to allow mobile operators to start 5G trials from June.



Background

- 5G is a wireless communication technology using **radio waves** or radio frequency (RF) energy to transmit and receive data.
- It is the next generation mobile networks technology after 4G LTE networks. 5G technologies will enter services gradually, beginning in 2019 and advance to a full range of services by 2024.
- 5G connections in India are forecasted to reach 88 million by 2025, equivalent to around 7% of the total connections base in the country.
- 5G will underwrite USD 12.3 trillion of global economic output by 2035, with investment in the value chain expected to generate a further USD 3.5 trillion in output and provide support for 22 million jobs by 2035.

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. It can also support Virtual Reality and Augmented Reality services.
- 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.**
  - **In agriculture**, 5G can enable improvement in the entire value-chain, from precision farming, smart irrigation, improved soil and crop monitoring, to livestock management.
  - **In manufacturing**, 5G will enable use of robotics for precision manufacturing, particularly where humans cannot perform these functions safely or accurately.
  - **In the energy sector**, 'smart grids' and 'smart metering' can be efficiently supported. With the rise of renewable and storage technologies, low latency communications will be critical to manage these grids.
  - **In health-care**, 5G can enable more effective tele-medicine delivery, tele-control of surgical robotics and wireless monitoring of vital statistics.

- **2G and 3G mobile networks** relied on microwave wireless backhaul to connect cell sites with the nearest switching centre.
- **4G LTE introduced IP-based connectivity**, replacing copper- or microwave-based cell sites with optical fibre.
- **5G deployment** is based on optical fibre infrastructure.

Steps taken

- **BharatNet programme**: Plans to link 2.5 lakh gram panchayats through optical fibre network.
- **National Digital Communications Policy 2018,** envisages a digitally empowered economy and society, which essentially means that the information and communications needs of the citizens and enterprises are met with a ubiquitous, resilient and affordable digital communications infrastructure and services.
- The Government has launched a program titled **'Building an End-to-End 5G Test Bed'**. The program envisages close collaboration between the universities and small technology companies to build broadly compliant with the 3GPP standards.
- Several smaller academic R&D programs around 5G themes have also been funded by **DST and MEITY**.
- Ericsson has installed the first public access 5G test bed at IIT Delhi.
- The report of **the Steering Committee of the High Level Forum** laid out three priority areas in 5G:
  - **Deployment –** An early roll out of 5G services to maximise the value proposition of 5G as a technology.
  - **Technology –** To build indigenous industrial and R&D capacity, especially for the design and Intellectual Property.
  - **Manufacturing** – To expand the manufacturing base for 5G technologies, which includes both semiconductor fabrication and equipment assembly and testing.

Challenges

- **Huge Investment Required:** India needs a massive Rs 5 lakh crore ($70 billion) investment to bring in 5G.
- **Expensive spectrum:** Indian spectrum prices are some of the highest in the world and the allocated quantity is well below global best practices, while 40% of the spectrum is lying unsold.
- **Lack of uniform policy framework:** Delays due to complex procedures across states, non-uniformity of levies along with administrative approvals have impacted telecom service providers in rolling-out Optical Fibre Cables (OFC) and telecom towers.
- **Local Regulatory Issues:** Many of the local rules and regulations are prohibiting the rapid and cost-effective roll-out of small cells in city centres where 5G is initially expected to be most in demand.
- **Debt scenario in the industry**: According to ICRA, the collective debt of telecommunications service providers (TSPs) stands at Rs 4.2 lakh crore.
- **Low optical fibre penetration:** India lacks a strong backhaul to transition to 5G. Backhaul is a network that connects 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.
- **High Import of Equipment's**: Imports account for a 90 per cent of India's telecom equipment market. However due to lack of local manufacturing and R&D, Indian telecom providers have no option other than to procure and deploy 5G technologies from foreign suppliers.

- **Security:** According to the **Global Cyber Security Index** released by the **International Telecommunication Union (ITU)**, only about half of all the countries had a cybersecurity strategy or are in the process of developing one. The index, which was topped by Singapore at 0.925 saw India at 23rd position.

Way Forward

- **Spectrum Policy:** India's spectrum allocation for public wireless services should be enhanced significantly. Also, the cost of spectrum relative to per capita GDP is high and should come down.
- Create a **5G Program Office within Department of Telecommunications and an Oversight Committee.**
- New civil infrastructure like highways, roads, canals and utilities(gas, electricity, water) lines should be mandated to provide Common Telecom Infrastructure resources such as ducting and power junction boxes to support 5G infrastructure.
- Security audits, a prerequisite for importing of equipment before deploying in Indian networks, needs to be simplified.
- **Support 5G investment:** Indian government and regulators should ensure the long-term sustainability of the industry and its ability to fund the significant investment required for 5G network deployments.
    - Policy-makers may consider the use of licensed, unlicensed and shared spectrum to create a balanced spectrum ecosystem – one that encourages investment, makes efficient use of spectrum and promotes competition.
    - Where market failure has occurred, governments may consider stimulating investment in fibre networks and passive assets through setting up PPPs, investment funds and offering grant funds, etc.
- **Favorable Taxation Policy:** Reducing taxation and regulatory fees on revenues could contribute to further evolution of the tax framework.
- **5G Pilot:** Policy-makers may consider encouraging 5G pilots and test beds to test 5G technologies and use cases and to stimulate market engagement.

6.4. CYBER-PHYSICAL SYSTEMS

Why in News?

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

What is Cyber-physical system (CPS)?

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

Advantages of CPS technologies

- **Enhanced security capabilities**: It can play role in expediting design and delivery of trustworthy, adaptable and affordable systems, operations in cyberspace and autonomous systems to augment security operations.
- **Disaster Management**: CPS technologies including next generation public safety communications, sensor networks, and response robotics can dramatically increase the situational awareness of emergency responders and enable optimized response through all phases of disaster events.
- **Energy**: They are essential for the creation of energy infrastructure, optimization and management of resources and facilities and allowing consumers to control and manage their energy consumption patterns like smart meters.
- **Healthcare**: CPS correct-by-construction design methodologies are needed to design cost-effective, easy-to-certify, and safe products.

- **Transportation:** They can (potentially) eliminate accidents caused by human error, Congestion control, traffic-based grid jams.
- **Agriculture:** They will play a key role in helping to increase efficiency throughout the value chain, improving environmental footprint and creating opportunities for a skilled and semi-skilled workforce.

Challenges in CPS

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

About National Mission on Interdisciplinary Cyber-Physical Systems

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

CPS	Internet of things
• They are physical and engineered systems whose operations are monitored, coordinated, controlled and integrated by a computing and communication core. • CPS engineering has a strong emphasis on the relationship between computation and the physical world. • They are not necessarily connected with internet. • Ex: It may be individual system which integrates the physical and cyber technology like smart electricity meters.	• It is the network of devices such as vehicles, and home appliances that contain electronics, software, actuators, and connectivity which allows these things to connect, interact and exchange data. • IoT has a strong emphasis on uniquely identifiable and internet-connected devices and embedded systems. • They are connected to internet. • The Internet of Things (IoT) forms a foundation for this cyber-physical systems revolution. • Ex: Smart Home in which all appliances are connected to each other through internet like TV is connected to mobile, lights are connected to mobile etc.

6.5. PROGRESS OF DIGITAL LITERACY PROGRAMS IN INDIA

Why in News?

Recently a report on review of National Digital Literacy Mission was laid in Parliament by the Parliamentary Standing Committee on Information Technology.

About Digital Literacy

- As per the Ministry of Electronics and Information Technology, Digital Literacy is defined as the ability of individuals and communities to understand and use digital technologies for meaningful actions within life situations. Any individual who can operate computer/laptop/tablet/smart phone and use other IT related tools is being considered as digitally literate.
- Digital Literacy holds important in areas such as using Government Schemes, Digital Payments, e-governance, Agriculture, Education, Health, Employment etc.

Current Status of Digital Literacy in India

- **Low Digital Literacy**- Among people in the age group of 14-29 years, only 18.3% were able to operate a computer in rural areas as compared to 48.9% in urban areas.
- **Ineffective usage of digital literacy-** An IIT-Delhi study found that while beneficiaries were now comfortable using social media, they were not as adept at browsing the internet for education opportunities and employment listings among others.

Background of Government Initiatives

- The Government of India launched the **'Digital India' campaign** for transforming India into a digitally empowered society and economy.
- One of the goals of this campaign is to **empower those who are IT-illiterate** so that they are competent enough to use IT and related applications for effectively participating in the democratic processes and enhancing their livelihood opportunities.
- In this context, the Ministry of Electronics and Information Technology initiated the **National Digital Literacy Mission** (NDLM) as a means of realising the vision of 'Digital India'.
- **Under the mission**, beneficiaries undergo a 20-hour training programme in using computers and other digital devices, browsing the Internet and sending and receiving emails.
- The original deadline for the National Digital Literacy Mission was 18 months but it was extended to 27 months before it was scrapped in June 2016. While the programme was still running, the government introduced the **Digital Saksharta Abhiyan, or DISHA**, in January 2015.
- Under these two schemes, a total of 53.67 lakh beneficiaries were trained, out of which around 42% were from rural India.
- In 2017, the government launched the **Pradhan Mantri Gramin Digital Saksharta Abhiyan** by improving upon previous two schemes.

'Pradhan Mantri Gramin Digital Saksharta Abhiyan' (PMGDISHA)

- **Objectives**: To make **six crore persons** in rural areas, across States/UTs, digitally literate, reaching to around 40% of rural households by covering one member from every eligible household.
- **Implementing Agency**: The scheme is implemented by CSC eGovernance Services India Limited, a Special Purpose Vehicle (SPV) incorporated under the Companies Act 1956, (herein after referred to as 'CSC-SPV'), under the overall supervision of Ministry of Electronics & Information Technology, with active collaboration of all the State Governments and UT Administrations.
- **Duration:** The duration of the Scheme is up to 31st March, 2019.
- **Coverage of scheme:** The Scheme is applicable for rural areas of the country.

Issues with government schemes

- **Lack of Consolidation of Schemes-** Parallel schemes creates confusion in the minds of intended beneficiaries and makes the evaluation difficult.
- **Focus on quantitative parameters instead of quality of training-** There is inconsistency and variation in the findings of the independent studies with regard to data on various aspects such as usage of digital device, level of confidence etc. Further, there is no component of monitoring repeat transactions by individuals trained in NDLM, DISHA and PMGDISHA schemes to ensure that there is a behavioral change in the trainees and they continue to make use of digital/IT tools even after completion of their training.

- **Unrealistic data-** Under NDLM scheme, 16 out of total 36 States/UTs have achieved 100% certification of enrolled candidates. The committee found these to be unrealistic.
- **Duplication of beneficiaries-** The first impact assessment study, conducted by the research and advocacy group Council for Social Development, found that two-thirds of the beneficiaries of the scheme were not eligible for it.

Achievements of the previous Schemes based on independent studies by IIT Delhi and Council for Social Development, Delhi

Majority beneficiaries-

- Claimed to gain confidence to learn new things easily
- Felt more aware about their educational needs
- Felt happy to reach anyone they want through computer and internet

Challenges in expanding Digital Literacy in India

- **Lack of awareness** about the benefits of digital literacy among the masses.
- **Lack of availability of requisite training infrastructure and resources at several places in the country –** As per National Sample Survey Office (NSSO) 71st Round report on social consumption relating to education, the proportion of households in the country having computers during 2014 was around 14% (only 6% in rural households and 29% in urban households possessed computer).
- **Internet connectivity issues** as well as **Localization/Language issues** in rural areas.
- **Inadequate support from State Govt. & other stakeholders-** such as by North- Eastern states.
- **Insufficient financing for scheme-** Only Rs. 500 cr. released which is much less than allocated outlay.

Recommendations of the Parliamentary Standing Committee

- **Need for Long-term planning and perceptible outcomes-** should be the focus of government schemes, rather than having short-term parallel schemes with different names.
- **Change the criteria to increase coverage-** The current restriction of covering only one person per household in the existing schemes should be removed.
- **Need for qualitative impact assessment-** by focusing on qualitative parameters through continuous feedback mechanism and strengthening of monitoring mechanism to ensure that there is a positive behavioral change in successful trainees and they continue to use digital/IT tools even after completion of their training
- **Promote Digital Finance** through schemes like Digital Finance for Rural India: Creating Awareness and Access through Common Service Centres (CSCs), which was closed earlier.
- **Enhanced enrolment of training partners-** with proven expertise in IT domain so as to achieve the set targets.
- **Usage of low cost, easy to use -** such as feature/smart phones and associated apps, which are popular among, masses in comparison to the conventional IT hardware and allied software. The content may be user-friendly and appropriate for all ages.
- **Focus on laggard States/UTs-** The good practices in some States may be replicated in other States and also the States which are very supportive and doing very well need to be incentivized so that there is visible impact.

7. ALTERNATE/NUCLEAR ENERGY

7.1. NUCLEAR PROGRAMME IN INDIA

Why in news?

A swimming pool type research reactor **"Apsara-upgraded"** has become operational at Bhabha Atomic Research Centre (BARC), Trombay.

Nuclear power sector in India

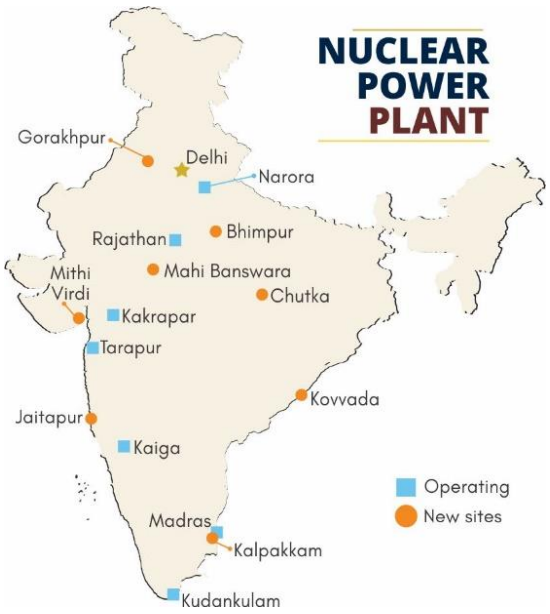
- Nuclear energy has emerged as a **viable source** in recent times.
- **Important minerals** used for the generation of nuclear energy are uranium and thorium.
- Uranium deposits occur in the **Dharwar rocks**. Geographically, uranium ores are known to occur in several **locations along the Singbhum Copper bel**t.
- **Atomic Energy Commission** was established in 1948, progress could be made only after the establishment of the Atomic Energy Institute at Trombay in 1954 which was renamed as the Bhabha Atomic Research Centre in 1967.
- The important nuclear power projects are Tarapur (Maharashtra), Rawatbhata near Kota (Rajasthan), Kalpakkam (Tamil Nadu), Narora (Uttar Pradesh), Kaiga (Karnataka) and Kakarapara (Gujarat).
- **India's three stage nuclear programme:** The long-term goal of India's nuclear program has been to develop an advanced heavy-water thorium cycle.
    - **Stage 1- Pressurized Heavy Water Reactor (PHWR)**
        - ✓ PHWRs are **fuelled by natural uranium, and light water reactors**, which produce plutonium incidentally to their prime purpose of electricity generation.
        - ✓ Heavy water is used as moderator and coolant.
        - ✓ U-238 → Plutonium-239 + Heat
    - **Stage 2-Plutonium fuelled Fast Breeder Reactor**
        - ✓ It uses fast neutron reactors burning the plutonium-239 with the blanket around the core having uranium as well as thorium, so that further plutonium (ideally high-fissile Pu) is produced as well as U-233.
    - **Stage 3- Advanced Heavy Water Reactors (AHWRs)**
        - ✓ It will burn thorium-plutonium fuels in such a manner that breeds U-233 which can eventually be used as a self-sustaining fissile driver for a fleet of breeding AHWRs.
        - ✓ An alternative stage 3 is molten salt breeder reactors (MSBR), which are firming up as an option for eventual large-scale deployment.

Apsara-U

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

Need for nuclear development in India

- **Energy security**: Nuclear security is an important component of achieving energy security. Nuclear energy has the potential to provide a large scale of electricity generation that itself would help lift the standard of living for millions of population.
- **Less impact on climate:** Nuclear reactors do not produce greenhouse gases like power plants using coal and, therefore, can increase electricity generation without contributing to climate change.
- **Replacing conventional energy resources:** Increased share of nuclear power in the Indian energy mix will help diminish the reliance on fossil fuels and it will replaced conventional coal based energy plants.



- **Continuous supply of electricity**: They can provide a steady supply of electricity because unlike solar and wind power sources, nuclear plants can operate when there is no sun or wind and are not affected by fluctuations in water availability like hydroelectric plants.
- **Nuclear Energy and Foreign Policy Nexus:** Nuclear energy plays a substantial role in the formation of bilateral relations among nations. For example, the 2008 Indo-US nuclear agreement did not just support India's domestic power plants but strengthened Indo-US bilateral relations while giving India the recognition of being a responsible nuclear weapon state with strong non-proliferation credentials

Challenges

- **Uranium contamination of ground water due to Mining:** Recently, a study has found uranium contamination in groundwater from aquifers in 16 Indian states. For example most of the wells tested in Rajasthan and Gujarat had more uranium than the WHO's recommended limit of 30 µg/L.
- **Purity of Uranium:** In comparison to world occurrences, uranium deposits established in India are mostly of low-grade (less than 0.15per cent U).
- **Shift towards Renewable energy:** This has often been cited as a factor that calls for a shift away from nuclear fuel. The plants, with a shorter processing route, need to incorporate measures to maximize the re-use of water, high recovery of the product and minimum discharge of effluents.
- **Anti-nuclear protests**: Following the 2011 Fukushima nuclear disaster in Japan, populations around proposed Indian Nuclear power plant sites have launched protests. **E.g. Protests in Jaitapur protests and Mithi Virdi**.
- **Syncing with foreign players:** India's current manufacturing capability only covers the supply chain for 700 MW pressurized heavy-water reactor (PHWR) with foreign reactors inevitably requiring foreign supplier agreements. Engaging with foreign suppliers means dealing with problems of capacity, queued bookings and uncertainty
- **Manpower needs**: To scale up nuclear energy in India, human resource for nuclear engineering is paramount. India currently faces a shortfall in nuclear scientists and engineers.
- **Other Issues**: Factors such as problems on land acquisition, rehabilitation/resettlement of affected persons, reserve forest/tiger sanctuary locations, socio-political issues, public consensus, etc. also influence the decisions on mining and exploitation of established uranium and thorium resources in the country.

Way forward

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

- ensure maintenance of the skills base
- maintain continued effective safety regulation
- foster progress on facilities for waste disposal and management must be given serious consideration.
- maintain and reinforce international non-proliferation arrangements.

7.2. CHINA'S ARTIFICIAL SUN

Why in news?

China has recently reported that it is close to completing its **"artificial sun"- Experimental Advanced Superconducting Tokamak (EAST) reactor**, after it achieved an ion temperature of 100 million degrees Celsius.

Background

- Nuclear fusion has been the focus of the researchers as the **solution for clean energy**, which can replace the conventional sources of energy like coal, oil, gas etc.
- But the application and control of fusion process is not easy to harness. A very high pressure and temperature is required to initiate

International Thermonuclear Experimental Reactor

- It is an international nuclear fusion research and engineering megaproject, which will be the world's largest magnetic confinement plasma physics experiment.
- The project is funded and run by seven member entities—the **European Union, India, Japan, China, Russia, South Korea, and the United States.**
- The goal of ITER is to demonstrate the scientific and technological feasibility of fusion energy for peaceful use.
- **The tokamak** is an experimental machine designed to harness the energy of fusion. Inside a tokamak, the energy produced through the fusion of atoms is absorbed as heat in the walls of the vessel.

the fusion process. Even if those conditions are created, then the energy generated during the process is prone to bursts, which can be deadly.

- The scientists have been working on harnessing this process from a long time, the most prominent among them being the **International Thermonuclear Experimental Reactor** (ITER).
- China is working on an **Experimental Advanced Superconducting Tokamak (EAST) reactor** — an **"artificial sun"** designed to mimic the nuclear fusion process the real Sun uses to generate energy.
- The machine, called **HL-2M Tokamak**, is being constructed at the Southwestern Institute of Physics in China.

Nuclear Fusion Process

- It involves light elements, such as hydrogen, smashing together to form heavier elements, such as helium. For fusion to occur, hydrogen atoms are placed under high heat and pressure until they fuse together. When this happens, a tremendous amount of energy is released in the process.
- Reaction between **two hydrogen isotopes, deuterium (D) and tritium (T) has been identified as the most efficient fusion reaction in the laboratory setting**. The **DT fusion reaction** produces the highest energy gain at the "lowest" temperatures.
- At extreme temperatures, **electrons are separated from nuclei** and a gas becomes a **plasma**—an ionized state of matter similar to a gas.

Nuclear Fission	Nuclear Fusion
A heavy nucleus breaks up to form two lighter nuclei.	Two light nuclei combine to form a heavy nucleus.
It involves a chain reaction.	Chain reaction is not involved.
The heavy nucleus is bombarded with neutrons.	Light nuclei are heated to an extremely high temperature.
Disposal of nuclear waste is a great environmental problem.	Disposal of nuclear waste is not involved.
Raw material is not easily available and is costly.	Raw material is comparatively cheap and easily available.

- Composed of electrons and ions, plasmas are very tenuous environments, nearly one million times less dense than the air we breathe. Fusion plasmas provide the environment in which light elements can fuse and yield energy.
- The tokamak device uses **magnetic fields** to contain and control the hot plasma, to keep the plasma away from the reactor's walls, so that it doesn't cool down and lose its energy potential.
- **Three conditions must be fulfilled** to achieve fusion in a laboratory:
  - **Very high temperature** (on the order of 15million Celsius);
  - **Sufficient plasma particle density** (to increase the likelihood that collisions do occur);
  - **Sufficient confinement time** for fusion to occur

Significance of Nuclear Fusion

- **Large amount of energy-** Fusing atoms together in a controlled way releases nearly four million times more energy than a chemical reaction such as the burning of coal, oil or gas and four times as much as nuclear fission reactions.
- **Sustainability-** Fusion fuels are widely available and nearly inexhaustible. Deuterium can be distilled from all forms of water, while tritium will be produced during the fusion reaction as fusion neutrons interact with lithium.
- **Environment friendly-** Fusion doesn't emit harmful toxins like carbon dioxide or other greenhouse gases into the atmosphere
- **Limited risk of proliferation:** Fusion doesn't employ fissile materials like uranium and plutonium
- **No risk of meltdown:** A Fukushima-type nuclear accident is not possible in a tokamak fusion device. It is difficult enough to reach and maintain the precise conditions necessary for fusion—if any disturbance occurs, the plasma cools within seconds and the reaction stops.

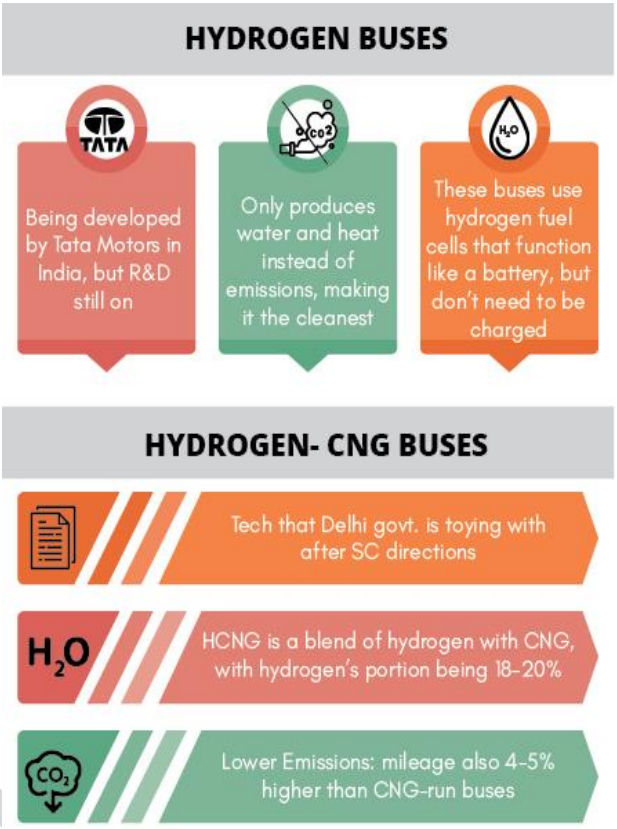
7.3. HYDROGEN-CNG

Why in News?

Delhi is all set to be **India's first city to launch hydrogen-enriched CNG (HCNG) buses** in 2019.

More on News

- The decision follows a Supreme Court direction for the Delhi government to explore the feasibility of introducing zero emission and cost-effective hydrogen-run public buses. Also, the Ministry of Petroleum & Natural Gas had issued a draft notification, following a NITI Aayog proposal, for H-CNG as an automotive fuel.



What is HCNG?

- HCNG is a vehicle fuel which is a **blend of compressed natural gas and hydrogen**, typically 8-50% hydrogen by volume.
- Existing natural gas engines can be used with HCNG, although higher hydrogen blends require re-tuning of the engines for optimal performance. Studies indicate that HCNG mixtures with 20- 30% hydrogen by volume are optimal for vehicle performance and emissions reduction.

Advantages of HCNG

- **No retrofitment required**- It does not need any modification of the engine or retrofitment. Only some calibration is required thus allowing governments and agencies to promote the use of hydrogen to greater number of people at less cost.
  - It is usable with the existing CNG infrastructure. It requires only small hydrogen storage and a column for the mixing of hydrogen with natural gas. Safety properties are similar to CNG.
- **Lower pollutant emissions**- Global HCNG testing to date has demonstrated the fuel's potential to reduce nitrous oxide (NOx), carbon dioxide (CO_2), carbon monoxide (appx 70%) and hydrocarbon emissions (appx 15%) vehicle emissions compared to traditional CNG.
  - Hydrogen addition to natural gas can **decrease engine's unburned hydrocarbons** and speed up the combustion process.
- **Improves fuel economy**- It improves the engine efficiency, lowers fuel consumption upto 5 per cent as compared to a CNG bus.
- The thermal efficiency of both Natural gas and HCNG increases with increase in load which makes it an ideal fuel for high load applications and heavy-duty vehicles.

Related Information

- Before this, in 2002, to help the deteriorating condition of pollution in Delhi, the government had introduced CNG (Compressed Natural Gas) buses.
- Besides this the pollution is expected to be handled by following Bharat Stage emission norms throughout the country. Recently, Delhi became the **first city** in the country to **supply ultra-clean Bharat Stage (BS) VI grade fuel** (both petrol and diesel).

Challenges

- **Determining the most optimised hydrogen/compressed natural gas ratio-** If the hydrogen faction increases above a certain limit, it will result in abnormal combustion such as pre-ignition, knock and backfire occur.
- **Ensure safe infrastructure**- Probably most evident challenge for wide-spread use of the new fuel is the current lack of infrastructure. Similar to other gaseous fuels, natural gas and hydrogen are both lighter than air, therefore if there is a leak it will quickly disperse into air with adequate ventilation.
- **Cost and continuous availability-** The cost of Hydrogen is higher than cost of Natural gas resulting in HCNG being costlier than CNG. Further, continuous availability of HCNG needs to be assured before embarking on its major use in IC engines.
- **Continued engine performance**, emissions and durability testing in variety of engine types and sizes need to be developed to increase consumer and manufacturer confidence.

Conclusion

Most vehicles today run on either diesel or petrol leading to higher pollution levels. Rising pollution levels have led to the need for cleaner fuels. Hence we need to re-examine our sources of energy. In the current scenario, there is clear potential for the use HCNG as a method of reducing emissions from CNG vehicles. However, although there is currently a large amount of research taking place regarding the HCNG fuel, there are certainly many steps to take before wide-spread implementation can occur.

Related News

Germany has rolled out world's first hydrogen fuel cell powered trains called **Coradia iLint.**

About Hydrogen fuel cell

- It is a fuel cell that combines hydrogen and oxygen to produce electricity with water and steam as the only biproducts.
- The excess energy can be stored on board in ion lithium batteries.
- It is a climate friendly fuel as it does not emit carbon dioxide or particulate matter as the case with conventional fuels like diesel, coal etc.

How the hydrogen fuel cell works?

- A fuel cell is composed of an **anode, a cathode, and an electrolyte membrane**.
- A fuel cell works by passing **hydrogen through the anode** of a fuel cell and **oxygen through the cathode**.
- At the anode, the hydrogen molecules are split into electrons and protons.
- The **protons pass through the electrolyte membrane**, while **the electrons are forced through a circuit, generating an electric current and excess heat**.
- At the cathode, the protons, electrons, and oxygen combine to produce water molecules.
- Unlike **traditional combustion technologies that burn fuel**, **fuel cells undergo a chemical process** to convert hydrogen-rich fuel into electricity.
- Fuel cells **do not need to be periodically recharged like batteries**, but instead **continue to produce electricity as long as a fuel source is provided.**

7.4. GAS HYDRATES

Why in news?

Researchers at Indian Institute of Technology (IIT) Madras have experimentally shown that **methane and carbon dioxide** (CO_2) can exist as gas hydrates.

What are gas hydrates?

- They are formed when a gas such as methane gets trapped in well-defined cages of water molecules forming crystalline solids. It is a **solid ice-like form of water** that **contains gas molecules in its molecular cavities.**
- Natural gas hydrates **occur on continental margins and shelves** worldwide from Polar Regions to the tropics.
- Gas hydrate reservoirs are generally **associated with biologically rich cold seep ecosystems at the seafloor**. Cold seeps are locations where hydrocarbon-rich fluid seeps up from below the sea floor, often as methane or hydrogen sulfide.
- It is estimated that total amount of carbon in the form of methane hydrates,

Extraction of gas hydrates: The natural gas from gas hydrate can be produced via:

- **Depressurization:** Drilling of hole into the layer of hydrate and reducing the pressure beneath. This technique is implemented for hydrates only in polar regions beneath the permafrost.
- **Thermal stimulation:** via steam injection, hot brine solution etc. that raises the temperature of the local reservoir outside the hydrate region to cause the dissociation of the hydrate, thus releasing free gas which can be collected.

However, no country in the world has so far developed the technology to produce gas hydrates commercially and economically.

Issues with extraction: Gas hydrates are also important for **seafloor stability studies**, because "melting" gas hydrate may cause seafloor "land" slides. Methane released from gas hydrate may therefore play a significant role in climate change.

Indian Initiative

- **The National Gas Hydrate Programme (NGHP)** is of national importance considering India's phenomenal growing energy demand. The programme was **initiated in 1997.** It first conducted studies in 2006.
- India has entered into an **agreement with Canada** to develop technology in this regard.
- IIT Madras, in collaboration with GAIL, is working to recover methane from methane hydrate from the **Krishna-Godavari Basin** and sequester CO_2 simultaneously.

far **exceeds the carbon content in all the fossil fuel** reserves put together and hence these are supposed to be the future potential energy resource.

- Combustion of methane, is more CO_2 efficient than that of any other hydrocarbon. Hence, using methane from gas hydrate compared to other hydrocarbons is **relatively climate friendly**.
- According to the latest estimates of the US Geological Survey, India has the **second largest gas hydrate reserves after America**. The Krishna-Godavari (KG), Cauvery and Kerala basins alone have 100-130 trillion cubic feet of estimated reserves.
- The carbon dioxide hydrate produced in the lab by the IIT team raises the possibility of **sequestering or storing carbon dioxide as hydrates** under the sea bed.

8. MISCELLANEOUS

8.1 SCIENTIFIC RESEARCH IN INDIA

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 **6th position for scientific publications and ranks at 10th for patents** which included only resident applications. The total number of patent applications filed by scientists and inventors in India increased to 61,788 in FY19 (up to Dec 18) from 47,857 in FY18.
- India has improved its innovation ranking from 29 spots in **Global Innovation Index** in last five years from 81th position in 2014 to 52th position in 2019.
- 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.**
- According to WIPO, India is **the seventh largest patent filing office in the World**.

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.
- **No uniform policy:** Government has not yet come up with a uniform and integrated policy for research and development which could aggregate the efforts of various institutes.

Government Initiatives

- **Prime Minister Research Fellows (PMRF):** 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.
- **Impactful Policy Research in Social Sciences (IMPRESS):** It aims to identify and fund research proposals in social sciences with maximum impact on the governance and society.
- **Scheme for Promotion of Academic and Research Collaboration (SPARC):** It aims to boost joint research with global universities from 28 countries and get international expertise to solve major national problems, train Indian students in the best laboratories, deepen academic engagement and improve the international ranking of Indian Institutes.
- **Impacting Research Innovation and Technology (IMPRINT**): It is a national initiative of Ministry of Human Resource Development (MHRD) which aims to address engineering challenges in 10 technology domains relevant to India through an inclusive and sustainable mode.
- **Atal Innovation Mission:** It is a flagship initiative set up by the NITI Aayog to promote innovation and entrepreneurship across the length and breadth of the country, based on a detailed study and deliberations on innovation and entrepreneurial needs of India in the years ahead.
- **STARS Scheme (Scheme for Translational and Advanced Research in Science):** Under this, 500 science projects would be funded.

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.

8.2. WOMEN IN SCIENCE

Why in news?

Ministry of Science and Technology recently invited applications for **Women Scientists Scheme**.

More about news

- The scheme is meant to encourage women in S&T domain, preferably those having a **break in career** (between the age group of 27-57 years) and not having regular employment, to explore possibility of re-entry into the profession.
- Through this endeavor of the **Department of Science and Technology**, concerted efforts have been made to give women a strong foothold into the scientific profession. The candidates selected for the scheme will get job training in the area of Intellectual Property Rights (IPR), along with monthly stipend and potential research grant.

Present Scenario

- As per the National Task Force on women in science report, only 15% of the Indian research and development workforce are women, while the global average is 30%.
- According to a report "Women in Science & Technology" by an inter-academy panel, only 12.6% of women opt for studying science and 16.34% opt for engineering & technology at undergraduate level.
- The percentage of women faculty at high profile institutes like TIFR, IITs, IISc is only 10-12%.
- The Shanti Swarup Bhatnagar Awards, instituted in 1958 by CSIR, include less than 20 women awardees in 61 years.

Relevant Government Initiatives

- **KIRAN (Knowledge Involvement in Research Advancement through Nurturing) Scheme**: An umbrella of women specific programmes such as-
  - **CURIE (Consolidation of University Research for Innovation and Excellence in Women Universities)** to develop state-of-the-art infrastructure in women universities in order to attract, train and retain promising girls students in S&T domain. KIRAN is providing budgetary support for creating **Women Technology Park (WTP)** where appropriate S&T packages for women are developed to improve livelihood and health & nutrition besides reducing drudgery in order to enhance their quality-of-life.
  - **Mobility Scheme**: It will address relocation issue (marriage, transfer of husband to any other location within the country, attending ailing parents, and accompanying children studying in different city) of women scientists working in regular position in Government Organizations.
- **Indo-U.S. Fellowship for Women in STEMM (Science, Technology, Engineering, Mathematics and Medicine)**: It will provide opportunities to Indian Women Scientists, Engineers & Technologists to undertake international collaborative research in premier institutions in U.S.A, to enhance their research capacities and capabilities. It is a joint endeavor of Department of Science and Technology and Indo-U.S. Science and Technology Forum (IUSSTF).

- **UDAAN:** launched by **Ministry of Human Resource Development** to address the lower enrolment ratio of girl students in science and engineering colleges. The aim of UDAAN is to enrich and enhance teaching and learning of Science and Mathematics at Senior Secondary level by providing free and online resources to every girl, with a focus on special incentives and support to 1000 selected disadvantaged girls per year.
- **Biotechnology Career Advancement and Re-orientation Programme (BioCARe):** An initiative of **Department of Biotechnology**, it mainly focuses on Career Development of employed/ unemployed women Scientists upto 55 years of age. The purpose is to build capacities for women Scientists employed fulltime in Universities and small research laboratories or unemployed women Scientists' after a career break so as to help them undertake independent R&D projects.

Constraints faced by women

- **Social conditioning:**
  - The gender bias against women.
  - When it comes to peer recognition, women are at loss as they muster less support.
  - Women in high positions rarely groom other women.
- **Role of caregivers:**
  - Traditionally, women have donned the role of caregivers for centuries and this often gets reinforced through laws and institutions in our society. This leads to dual responsibilities.
  - This sets women back at the early stages of their careers.
  - Even in later stages, circumstances force women to seek early retirement.
- **Marginalization:**
  - Systemic gender discrimination and biased career review processes.
  - Women are marginalized even at faculty positions and in field of science and technology
- **Work environment:**
  - Lack of support for gender diversity in work environment.
  - For the same position and recognition, women have to work harder. It deters women from pursuing this field, causing a major leak at the post doctoral level.

8.3. INDIA-BASED NEUTRINO OBSERVATORY

Why in News?

The National Green Tribunal (NGT) upheld the environmental **clearance granted to the India-based Neutrino Observatory (INO),** a major research facility proposed in **Theni district of Tamil Nadu.**

What is INO?

- It is one of the **biggest experimental particle physics projects** undertaken in India.
- The project includes:
  - construction of an **underground laboratory** and associated surface facilities at Pottipuram in Bodi West hills of Theni District of Tamil Nadu,
  - construction of an **Iron Calorimeter (ICAL) detector** for studying neutrinos, which will include the world's largest magnet, and
  - setting up of **National Centre for High Energy Physics at Madurai,** for the operation and maintenance of the underground laboratory, human resource development and detector R&D along with its applications.

Why delays in clearance?

- NGT had **suspended environmental clearance (EC)** granted to INO and demanded the project to make a fresh application.
- MoEFCC categorized it as a **Category B project** for which Environmental Impact Assessment (EIA) is not necessary. However, **Madhikettan Shola**

What are Neutrinos?

- The elusive neutrinos are **second most abound particles in the universe,** yet a lot more is to be understood about them.
- They interact very little with anything and pass through everything that's why it's **hard to detect** them**.**
- They carry **no electrical charge and nearly massless.**
- It occurs in **3 different types/flavors**, separated based on mass (electron-neutrino, muon-neutrino, tau-neutrino).
- It is **produced in the core of the sun** & millions of them roam around in the solar system.
- They are key to **understanding the evolution of universe** and energy production in the Sun and the stars.

Misconceptions related to neutrinos

Several misconceptions related to neutrino research led to common opposition to the project

- **Harmful to the human body:** They are least harmful of elementary particles, as they hardly interact with matter. In fact, trillions of solar neutrinos pass through our body every second without doing any harm to us.
- **Effect of the associated radiation:** No radiation is involved as INO only studies atmospheric neutrinos produced by cosmic rays in the atmosphere.
- **Potential uses in weaponization:** They are often confused with neutrons, which can be used to produce nuclear weapons.

National Park in Idukki district of Kerala was just about 4.9 km from the proposed project site and the Tamil Nadu-Kerala border was just a km away, making it a Category "A" project

- Being located within 5 km of a wildlife sanctuary, it requires **specific approval by the National Board for Wild Life**

Potential ecological concerns

- Contamination of ground water due to leaching of chemicals
- Negative impact on the aquifers and nearby dams due to the vibrations caused by blasting the rocks
- Tectonic fracturing may make geological structure unstable, increasing vulnerability of already ecologically sensitive Western Ghats
- If INO moves from studying atmospheric neutrino properties to probing accelerator-produced neutrinos, it would require precision underground facilities to contain radioactivity

Significance of INO

- It will give **a boost to scientific studies in India** and encourage students to take up Science and Research as profession.
- It has been **gaining urgency** in the recent years with **China** announcing the construction of a similar **neutrino observatory in Jiangmen province.**
- Nicknamed the **'blueprint of nature'** by scientists, neutrinos are an important tool for mankind to learn how matter evolved from simple particles into more complex composites, creating everything around us.

Other neutrino study projects

- LAGUNA (Large Apparatus studying Grand Unification & Neutrino Astrophysics) in Europe
- Hyper Kamiokande Detector at Kamioka Observatory in Hida (Japan)
- DUNE (Deep Underground Neutrino) project in South Dakota (US)

How neutrino research is useful?

- **Messengers of cosmic information**, as they travel large distances without much interaction. Can revolutionize the existing understanding of astrophysics, astronomy and communication
- **Basic building blocks** of matter, along with quarks and electrons. Enhance understanding of basic physical laws
- **Role in nuclear non-proliferation** through remote monitoring of nuclear reactors, where neutrinos are produced in abundance
- As they change their direction and spin based on the medium, they can be **used to map natural resources inside the earth**
- **Helpful in understanding of dark matter (which constitute 95% of earth)**, as they are one of the few particles that can pass through it
- **Rapid analysis of geo-neutrinos** (produced by radioactive decay of uranium, potassium and thorium in the earth's crust) by the monitoring systems, called **Neutrino Tomography**, could provide vital seismographic information & may help us **detect early defect inside the earth**
- Neutrinos can **pass right through the earth** and thus, **neutrino-based communication systems** are better than round the earth communication through cables, towers and satellites. **No data transmission loss** as they rarely interact with other particles. If there is any extra-terrestrial life, most effective way to communicate with them

8.4. PROTON THERAPY

Why in News?

Vice President of India inaugurated **India's first proton therapy centre** in Chennai for the treatment of Cancer.

More in news

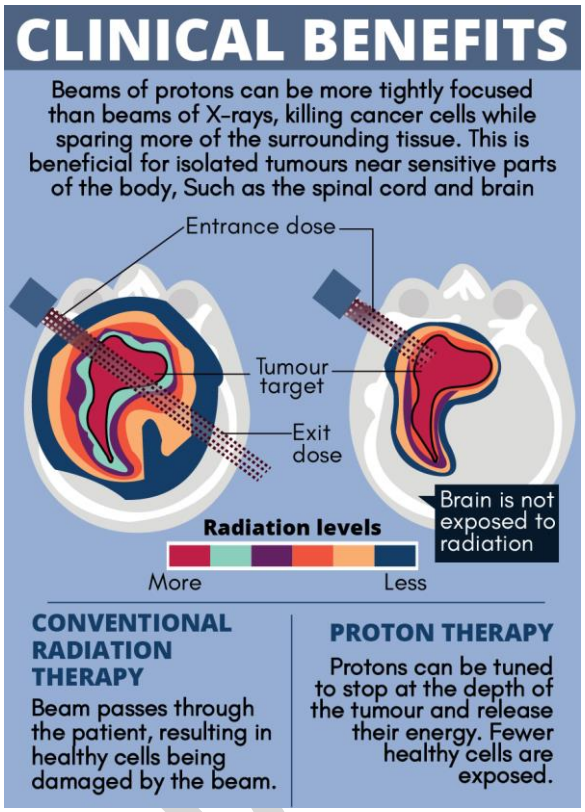
- The name of the centre is Apollo Proton Cancer Centre (APCC) and is launched by **Apollo Hospitals Group.** It is **South Asia's first** such centre.
- With this India becomes **16th country in the world** to offer the therapy.

Proton

- Atoms are the basic units of matter and the defining structure of elements. Atoms are made up of three particles: protons, neutrons and electrons
- The **proton** has a positive electrical charge, equal and opposite to that of the electron.
- The number of protons in an atom determines the chemical behaviour of the element.

About Proton Therapy

- It is a type of radiation therapy which uses protons rather than x-rays to treat cancer.
- It is considered as one of the most advanced forms of **external beam radiation therapy for cancer treatment** in the world. It is also known as **Proton Beam Therapy** and offers high levels of precision as compared to other treatment options.
- It is particularly effective for paediatric cancers and tumours affecting the brain, eye, colon, breast, gastrointestinal area, pelvis, and prostate and those close to the spinal cord, brain stem and other vital organs.



Advantages over standard radiation therapy

- **Standard radiation therapy** utilises x-rays, which deposits the majority of the radiation dose immediately upon entering the body. While X-ray beams are effective in controlling many cancers, they also deliver an 'exit dose' along the path beam. This exposes not just the targeted tumor to the radiation, but also the nearby healthy tissues.
- This exit dose is a cause of concern as the damage to the normal tissue or organs can affect the patient's quality of life post-treatment.
- In comparison, protons slowly deposit their energy as they travel towards the cancerous tumor and then due to a unique physical characteristic called the **Bragg Peak,** deposit the majority of the **radiation dose directly in the tumor.**
    - **Bragg Curve** describes energy loss of ionizing radiation during travel through matter.
- Proton beams target the tumour with **sub-millimetre accuracy,** leaving the nearby tissues and organs unharmed. Also there is **no 'exit dose'** in case of proton beam. Protons stop after depositing the radiation dose in the tumor.

Challenges with Proton Therapy

- Proton Therapy is **highly specialised and expensive** treatment.
- It is **not applicable to all type of cancers.**
- More **research and clinical trials are needed** to make this treatment more affordable and applicable to all types of cancers.

8.5. FORWARD SEARCH EXPERIMENT (FASER)

Why in news?

CERN have approved a new experiment named FASER designed to identify light and weakly interacting particles.

Forward Search Experiment (FASER)

- FASER is a proposed experiment dedicated to searching for **light, extremely weakly-interacting particles** at the **Large Hadron Collider (LHC).**
- Such particles may be **produced in the LHC's high-energy collisions** in large numbers in the far-forward region and then travel long distances through concrete and rock without interacting.
- A small and inexpensive detector placed in the far-forward region may therefore be capable of extremely sensitive searches. The **FASER program is specifically designed to take advantage of this opportunity**.
- These particles may decay to visible particles in FASER, which is placed 480 m downstream of the **ATLAS interaction point**.

Significance of FASER Programme

- FASER has the **potential to discover dark photons, dark Higgs bosons, heavy neutral leptons, axion-like particles, neutralinos and many other long-lived particles**, as well as provide new information about

neutrinos, with potentially far ranging implications for particle physics and cosmology and **understanding of dark matter**.

- FASER has been designed to be **sensitive to the many possible forms of light**, weakly-interacting particles, and to **differentiate signal from background**.
- In addition, the FASER program has strong prospects for providing new insights into neutrinos. It may also provide **interesting information about Standard Model (SM) particles** by detecting the first neutrinos at the LHC.

Related Information

- **ATLAS** is an enormous multi-purpose detector situated at one of the crossing points of the two oppositely directed proton beams of the Large Hadron Collider's (LHC).

Large Hadron Collider

- The LHC accelerator, located at CERN on the French-Swiss border near Geneva, is housed in an enormous tunnel roughly 27 km in circumference and 100 m underground.
- The LHC and its detectors were designed to **study the smallest fundamental building blocks** that make up our universe – to find out what these building blocks are and how they interact (and don't interact) with one another.

Physics Beyond Colliders (PBC)

- PBC is an exploratory study aimed at **exploiting the full scientific potential of CERN's accelerator complex** and its scientific infrastructure in the next two decades through projects complementary to the LHC, High Luminosity LHC (HL-LHC) and other possible future colliders.
- FASER Programme is one such component of PBC.

Dark Matter

- **Composition of the universe:** 68% dark energy, 27% dark matter, 5% normal matter.
- The chief property of dark matter is that it is "dark", i.e. that it **emits no light.**
- In addition, **dark matter must interact with visible matter gravitationally.** So, the dark matter must be massive enough to cause the gravitational effects that we see in galaxies and clusters of galaxies.
- The two main categories of objects that scientists consider as possibilities for dark matter include MACHOs and WIMPs.
    - **MACHOs (Massive Compact Halo Objects):** MACHOs are objects ranging in size from small stars to super massive black holes. MACHOS are made of ordinary matter (like protons, neutrons and electrons). They may be black holes, neutron stars, or brown dwarfs.
    - **WIMPs (Weakly Interacting Massive Particles):** WIMPs are the subatomic particles which are not made up of ordinary matter. They are "weakly interacting" because they can pass through ordinary matter without any effects. They are "massive" in the sense of having mass (whether they are light or heavy depends on the particle). The prime candidates include neutrinos, axions, and neutralinos.

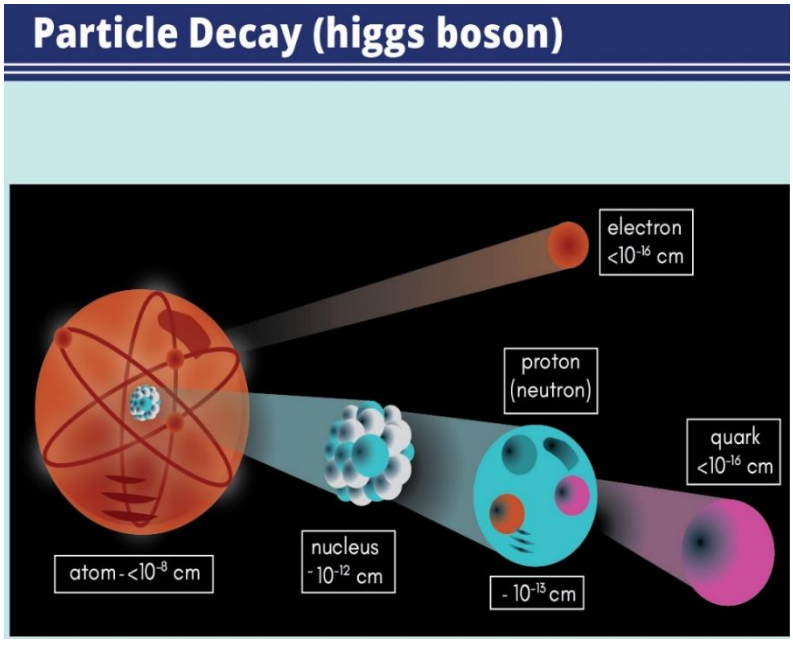
8.6. PARTICLE DECAY

Why in News?

Recently, Scientist at **CERN** observed the Higgs boson decaying to fundamental particles known as bottom quarks.

More on news

- Higgs bosons decay into pairs of the following particles in the following percentages: bottom quarks (58 percent), W bosons (21 percent), Z bosons (6 percent), tau leptons (2.6 percent) and photons (0.2 percent).
- **Significance:** It validates the theory of Standard Physics which states that about 60% of the time a Higgs boson will decay to a pair of bottom quarks.



- Standard Model: It's built upon the idea that the Higgs field endows quarks and other fundamental particles with mass.
- Standard Model **doesn't include dark matter** that makes up 85 percent of mass in the universe—or a description of how gravity works at the quantum level.

- A quark **is one of the fundamental particles** in physics. They **join to form hadrons, such as protons and neutrons,** which are components of the nuclei of atoms.
- The study of quarks and the interactions between them through the strong force is called particle physics.
- The antiparticle of a quark is the antiquark**. Quarks and antiquarks are the only two fundamental particles that interact through all four fundamental forces of physics**: gravitation, electromagnetism, and the strong interaction and weak interactions.
- A quark **exhibits confinement,** which means that the quarks are not observed independently but always in combination with other quarks. This makes determining the **properties (mass, spin, and parity) impossible to measure directly**.
- There are **six flavors of quarks**: up, down, strange, charm, bottom, and top. The flavor of the quark determines its properties.

About Higgs Boson

- It is popularly known as the **God particle** and is responsible for giving mass to fundamental subatomic particles.
- It was discovered by **Large Hadron Collider (LHC**) at CERN, the European Organization for Nuclear Research.
- CERN is the world's largest nuclear and particle physics laboratory. At CERN, scientists and engineers are probing the fundamental structure of the Universe.
- LHC accelerator hosts two large-particle physics detectors capable of observing Higgs bosons — the **Compact Muon Solenoid (CMS)** and **A Toroidal LHC Apparatus (ATLAS).**

India's Participation at CERN

- India has been at **CERN since the 1970s** and Indian scientists have been participating at CERN actively.
- India **became an officially associate member with the CERN in 2017**. Now, India is at second stage where it **can propose experiments and also vote for how things happen at CERN.**
  - It will also **open opportunities for Indian industries to participate directly in the CERN project.**
- The scientists of India had been engaged with the **Large Hadron Collider (LHC) experiment, A Large Ion Collider Experiment (ALICE) and Compact Muon Solenoid (CMS) experiments**, and with the accelerator itself
  - **ALICE** is a heavy-ion detector on the LHC ring while as the CMS is a general-purpose detector at the LHC
- India has made major contributions in terms of **designing, developing and deploying software for the Worldwide Large Hadron Collider Grid (WLCG)**.
- Grid Tier2 centers established at Variable Energy Cyclotron Centre (VECC), Kolkata and Tata Institute of Fundamental Research (TIFR), Mumbai have provided the pledged resources **facilitating running of computational jobs by various CERN collaborations.**

8.7. GRAPES-3

Why in news?

For the first time in the world, researchers at the **GRAPES-3** muon telescope facility in **Ooty** recently measured the **electrical potential,** size and height of a **thundercloud** simultaneously.

More on news

- Learning about the properties of thunderclouds can be useful in following ways:
  - **Navigation** of aircraft and preventing short circuits.
  - If its **energy** could be harnessed, it would change the landscape of the energy sector. This thunderstorm cloud carried about 2 gigawatts (GW) of power, making this single cloud more **powerful** than most powerful nuclear power plants in the world.

GRAPES-3 Muon Telescope

- Gamma Ray Astronomy PeV EnergieS phase-3 (GRAPES-3) is designed to study cosmic rays with an array of air shower detectors and a large area muon detector.
- It is a collaboration of the Tata Institute of Fundamental Research, Mumbai, India and the Osaka City University, Osaka, Japan.

How was it detected?

- Clouds have negative charges along their lower side and positive charges on top and can be several kilometres thick.
- **Muons** and other particles are produced when cosmic rays bombard air particles surrounding the earth. The muons produced can have positive or negative charge. These particles have about half the spin of electrons but 200 times the weight, and are very good at penetrating matter.
    - When a positively charged muon falls through a cloud, it loses energy; while a negatively charged muon gains energy when falling through the cloud and gets detected. Since there are more positive than negative muons produced in nature, the two effects don't cancel out, and a net change in intensity is detected.
- Using an array of muon-detecting sensors and four electric field monitors spread over several miles, the researchers measured the average drop in energy between muons that passed through the thundercloud and those that didn't pass through it. From this energy loss, it was calculated how much electric potential the particles had passed through in the thunder cloud.

8.8. CALL FOR TWO TIME ZONES IN INDIA

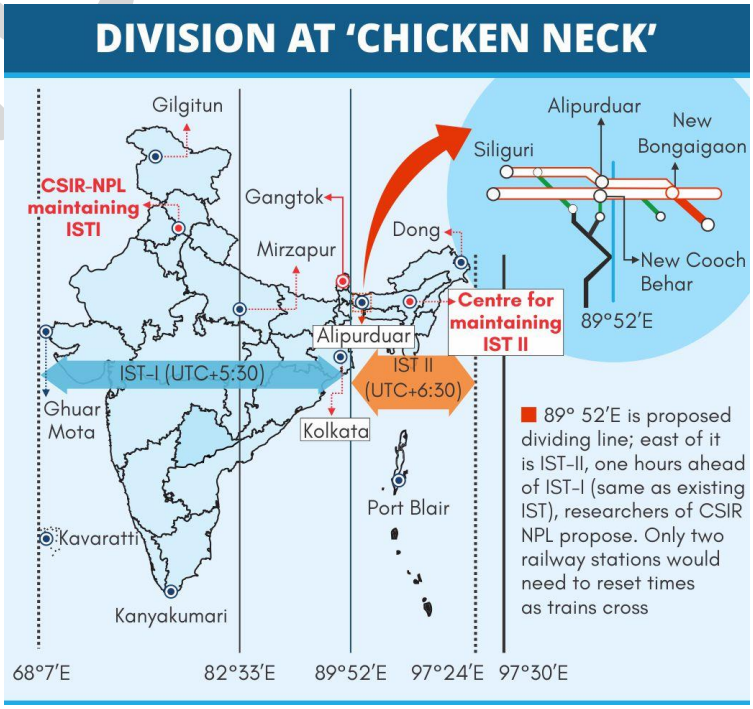
Why in news?

Council of Scientific & Industrial Research's National Physical Laboratory (CSIR-NPL), which maintains Indian Standard Time (IST), has published a research article describing the necessity of two time zones.

- Since independence in 1947, the IST has been the official time for the whole country.
- **India's time zones were first established in 1884**. Pre-independence India had two time zones. In the East, **Calcutta Time** was 5:30:21 hours ahead of GMT, while **Bombay Time** in the West was 4:51:00 hours ahead of GMT.
- Calcutta Time was abandoned in 1948 and Bombay Time in 1955.
- Assam already has **a Bagaan (tea garden) Time**, set an hour ahead of Indian Standard Time (IST)

Need for two time zones

- At present, the country observes a single time zone based on the longitude passing through 82°30'E.
- India extends from 68°7'E to 97°25'E, with the **spread of 29°** representing **almost two hours** from the geographic perspective. Early sunrise in the easternmost parts- (as early as 4AM in June) in the Northeast - causes the loss of many daylight hours by the time offices or educational institutions open, and that early sunset (4PM in winters), for its part, leads to higher consumption of electricity.
- The researchers estimated **energy savings at 20 million kWh** if we follow two time zones. This will have ecological and environmental benefits too.
- It will have an **impact on circadian rhythm** of the body and thus would have health benefits due to better leisure time and sleep. This, in turn, would enhance the **productivity of people**.



Proposal for new time zone

- The research paper proposes to call the two time zones IST-I (UTC + 5.30 h) and IST-II (UTC + 6.30 h).
- The proposed **line of demarcation is at 89°52'E**, the narrow border between Assam and West Bengal. States west of the line would continue to follow IST (to be called IST-I). States east of the line — Assam, Meghalaya, Nagaland, Arunanchal Pradesh, Manipur, Mizoram, Tripura, Andaman & Nicobar Islands —would follow IST-II.

- **Location of the line is explained as:** "As the railway signals have not yet been fully automated in the country, the border between the two time zones should have a very narrow spatial-width with minimum number of train stations so that the train timings while crossing the border can be managed manually without any untoward incidents."

Legal/Govt Position on Time Zones

- In 2002, based on a suggestion by then governor of Tripura, the **Department of Science and Technology (DST)** formed a high-level committee to explore the feasibility of two time zones. The **committee rejected the idea of separate time zones.**
- In 2006, the **Planning Commission** recommended the introduction of two time zones in the country, saying it would save "a lot of energy".
- The **Guwahati High Court**, last year dismissed a PIL seeking a direction to the Centre to have a separate time zone for the Northeast.

Problems with multiple Time zones

- Having more than one time zone will **create confusion** and different timings would have to be framed for airlines, railways and communications services. For example; our railway schedules, signaling and track utilization will be a nightmare to manage.
- Different time zones can be potentially problematic in India. Government offices in those states will close at different times and would be accessible only 75% of the time which can cause a **potential loss of productivity**.
- The **lack of time coordination** w.r.t essential services such as banking etc. might further alienate the NE region from the rest of the India.

Countries with most number of time zones
France: 12
United States of America: 11
Russia: 11
United Kingdom: 9

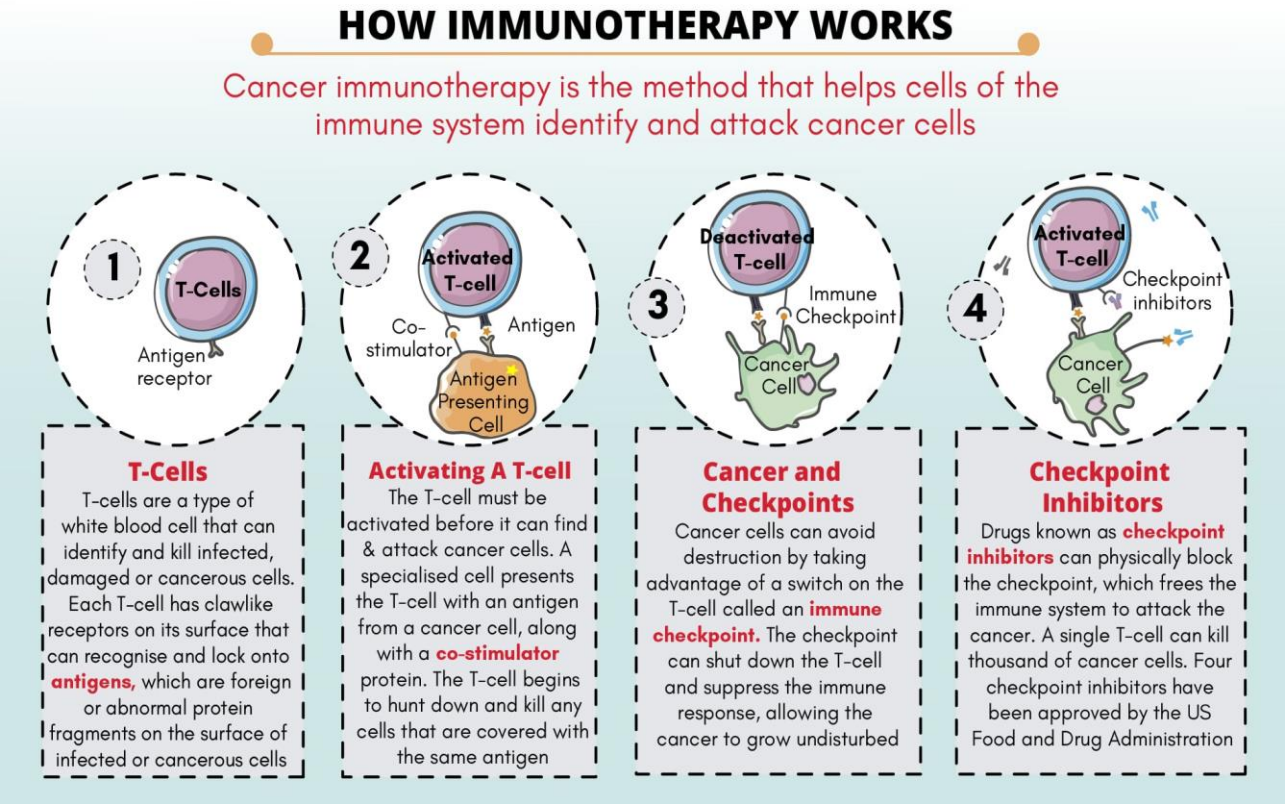
Alternative to Multiple Time Zones

- Given the energy saving benefits, a 2012 research paper commissioned by the Union Ministry of Power recommends to **advance IST by half-an-hour**. Also the National Institute of Advanced Studies (NIAS) in Bangalore recommended advancing IST by half-an-hour so that it is six hours ahead of GMT.
- This also keeps us away from the **complicated process of Daylight Saving's Time (DST)** followed in western countries.
- As per NIAS research, advancing the IST by half an hour will-
  - **Save energy 2.7 billion units every year**. The energy demand in the evenings due to domestic lighting will be reduced by about 16 per cent.
  - Result in estimated **saving of about Rs 1,500 crore per annum** for the nation.
  - **Increase the productivity** of the general population. India is primarily an agrarian economy and utilising sunlight is essential for maximum productivity.
  - It will optimally accommodate benefits of a separate time zones without creating a chaos.

8.9. NOBLE PRIZES 2018

8.9.1. NOBEL PRIZE IN PHYSIOLOGY OR MEDICINE

- It has been jointly awarded to **James P. Allison** and **Tasuku Honjo** for their **discovery of 'immune checkpoint therapy,'** a cancer treatment.
- Working: By stimulating the inherent ability of our immune system to attack tumor cells by releasing the brakes on immune cells.
- **James P. Allison** studied a known protein that functions as a **brake on the immune system**. He realized the potential of releasing the brake and thereby unleashing our immune cells to attack tumors. He then developed this concept into a brand new approach for treating patients.
- **Tasuku Honjo** discovered a protein on immune cells and, after careful exploration of its function, eventually revealed that it **also operates as a brake**, but with a different mechanism of action. Therapies based on his discovery proved to be strikingly effective in the fight against cancer.

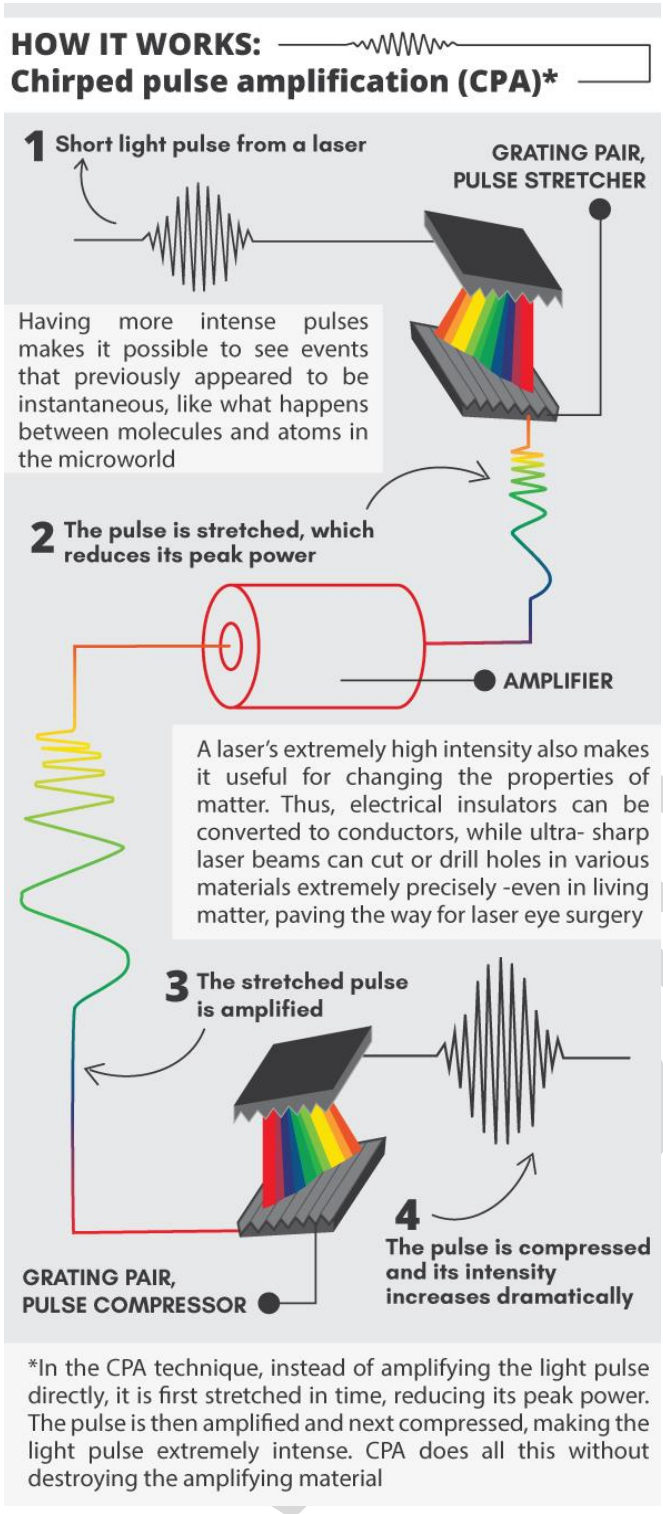


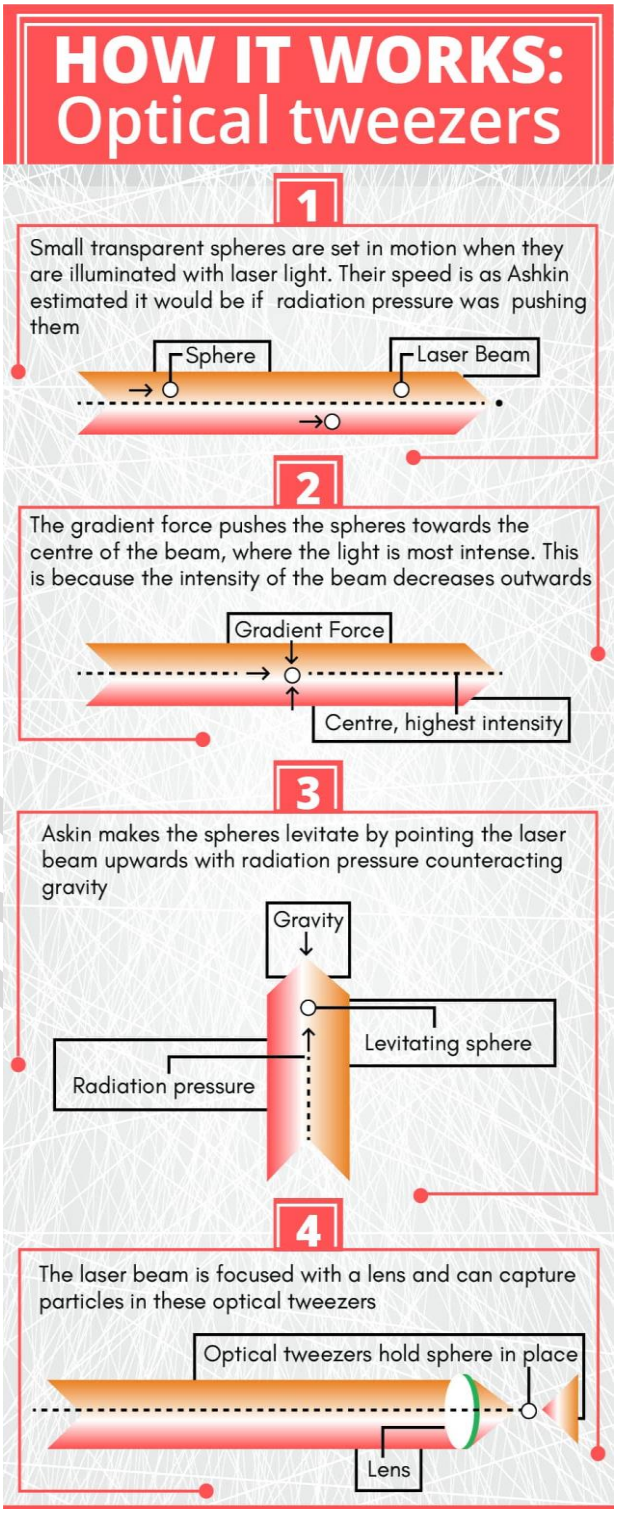
8.9.2. NOBEL PRIZE IN PHYSICS

- Nobel Prize in Physics 2018 was awarded for groundbreaking **inventions in the field of laser physics** with one half to **Arthur Ashkin** for the **optical tweezers** and their application to biological systems, the other half jointly to **Gérard Mourou and Donna Strickland** for their method **of generating high-intensity, ultra-short optical pulses.** Donna Strickland is third women to win Physics Noble.

Application

- **Optical Tweezers** are widely used to investigate the machinery of life.
- **Chirped Pulse Amplification (CPA)** for subsequent high-intensity lasers. Its uses include the millions of corrective eye surgeries that are conducted every year using the sharpest of laser beams.





8.9.3. NOBEL PRIZE IN CHEMISTRY

- The Nobel Prize in Chemistry 2018 was divided, one half awarded to **Frances H. Arnold for the directed evolution of enzymes,** the other half jointly to **George P. Smith and Sir Gregory P. Winter** for the **Phage Display** of peptides and antibodies. Ms. Arnold, only the fifth woman to win a chemistry Nobel.

Application

- **First directed evolution of enzymes**, which are proteins that catalyse chemical reactions, has been used in manufacturing of chemical substances, such as pharmaceuticals, and the production of renewable fuels for a greener transport sector.
- **Phage Display,** where a **bacteriophage** – a virus that infects bacteria – can be used to evolve new proteins. It has produced anti-bodies that can neutralise toxins, counteract autoimmune diseases and

cure metastatic cancer. **Adalimumab, a first protein evolved through phage display,** is used for rheumatoid arthritis, psoriasis and inflammatory bowel diseases.

- **Phage display allows** scientists to study protein interactions on a large-scale and select proteins with the highest affinity for specific targets. It provides a means to identify target-binding proteins from a library of millions of different proteins without the need to screen each molecule individually.