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Rapid Revision Program 2021

Ready Reckoner

Science and Technology



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RRP 2021 – Science and Technology Ready Reckoner

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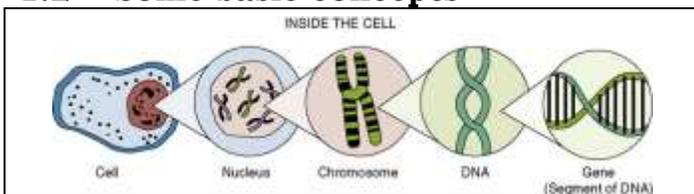
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1. Biotechnology and Genetic Engineering

1.1 Introduction

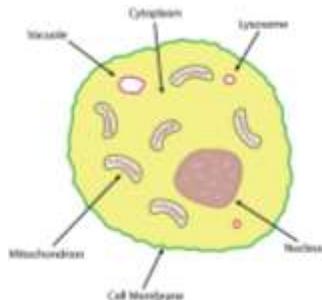
- Made up of two words: ‘bio’ and ‘technology’.
- ‘Bio’ means life and ‘technology’ means application or harnessing of science for a specific purpose.
- Therefore, the term ‘biotechnology’ refers to modification or use of any living organism for any useful purpose.
- The term was coined by **Károly Ereky in 1919**
- Important tool of biotechnology is **GENETIC ENGINEERING** also known as **recombinant DNA technology**

1.2 Some basic concepts



Cell

Cells are the basic building blocks of living things. The human body is composed of trillions of cells, all with their own specialised function.



- Cells group together to form tissues, which in turn group together to form organs, such as the heart and brain.
- The nucleus is based at the centre of the cell and is the ‘control room’ for the cell.

Chromosome

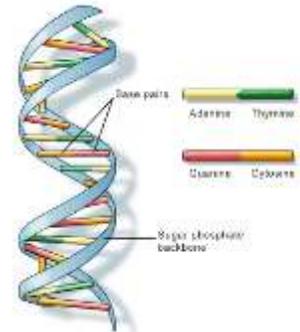
- Inside the nucleus we have chromosome.

Chromosomes are bundles of tightly coiled DNA located within the nucleus of almost every cell in our body.

- Humans have **23 pairs of chromosomes** (46 in total): one set comes from your mother and one set comes from your father.
- 22 non-sex chromosomes and 1 pair of sex chromosomes

DNA and its structure

DNA or deoxyribonucleic acid is a long molecule that contains our unique genetic code.



- DNA contains four basic building blocks or ‘bases’: adenine (A), cytosine (C), guanine (G) and thymine (T).
- DNA is a double-stranded molecule and has a unique ‘double helix’ shape, like a twisted ladder.
- Each strand is composed of long sequences of the four bases, A, C, G and T.
- The bases on one strand of the DNA molecule pair together with complementary bases on the opposite strand of DNA to form the ‘rungs’ of the DNA ‘ladder’.

	<ul style="list-style-type: none"> The bases always pair together in the same way, A with T, C with G. Each base pair is joined together by hydrogen bonds.
Genome	<ul style="list-style-type: none"> A genome is an organism's complete set of genetic instructions. Each genome contains all of the information needed to build that organism and allow it to grow and develop.
Gene	<ul style="list-style-type: none"> Genes are small sections of DNA within the genome that code for proteins. They contain the instructions for our individual characteristics – like eye and hair colour. The purpose of genes is to store information. The genes that an organism carries for a particular trait is its genotype and the physical manifestation of the instructions are the organism's phenotype.

		and may have been the molecule used to store genetic blueprints in primitive organisms.
Structural Features	B-form double helix. DNA is a double-stranded molecule consisting of a long chain of nucleotides.	A-form helix. RNA usually is a single-strand helix consisting of shorter chains of nucleotides.
Composition of Bases and Sugars	deoxyribose sugar phosphate backbone adenine, guanine, cytosine, thymine bases	ribose sugar phosphate backbone adenine, guanine, cytosine, uracil bases
Propagation	DNA is self-replicating.	RNA is synthesized from DNA on an as-needed basis.
Base Pairing	AT (adenine-thymine) GC (guanine-cytosine)	AU (adenine-uracil) GC (guanine-cytosine)
Ultraviolet Damage	DNA is susceptible to UV damage.	Compared with DNA, RNA is relatively resistant to UV damage.

1.2.1 Differences between DNA and RNA

Comparison	DNA	RNA
Name	Deoxyribo Nucleic Acid	Ribo Nucleic Acid
Function	Long-term storage of genetic information transmission of genetic information to make other cells and new organisms.	Used to transfer the genetic code from the nucleus to the ribosomes to make proteins. RNA is used to transmit genetic information in some organisms



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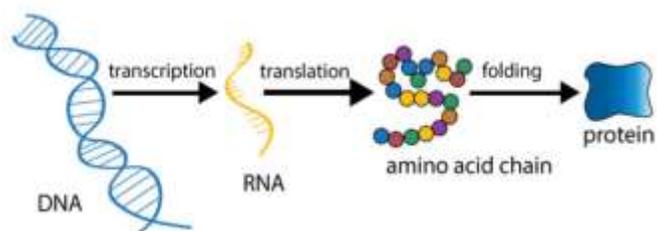
1.2.2 Cell Organelles and Functions

Cell Organelle	Organelle Functions
Nucleus	Contains DNA
Nucleolus	Makes ribosomes
Mitochondria	Releases Energy
Chloroplast	Converts sunlight into sugar
Ribosomes	Makes protein
Endoplasmic Reticulum	Carries proteins in passage ways
Golgi Bodies	Packages and ships protein
Lysosomes	Breaks stuff down
Cell Wall	Protects and supports the cell
Cell membrane	Controls what enters/exits the cell
Vacuole	Storage
Cytoplasm	Fluid that holds organelles
Flagella	Movement
Pili	Attach to other cells
Capsule	Protects bacteria and causes disease
DNA	Genetic Material

1.2.3 Gene Expression

It is the process by which the instructions in our DNA are converted into a functional product, such as a protein.

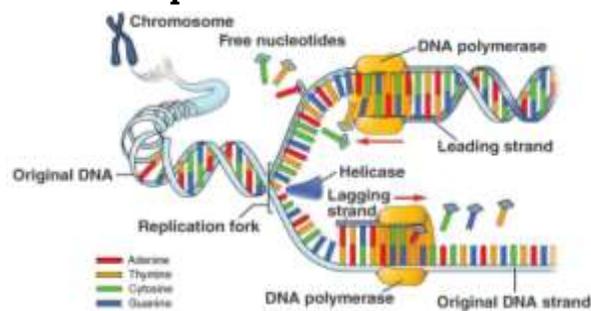
- Gene expression has two key stages - transcription and translation.
- In **transcription**, the information in the DNA of every cell is converted into small, portable RNA messages (m-RNA).
- During **translation**, these messages travel from where the DNA is in the cell nucleus to the **ribosomes** where they are 'read' to make specific proteins.



1.2.4 Gene Silencing

- It is the regulation of gene expression in a cell to prevent the expression of a certain gene.
- Gene silencing can occur during either transcription or translation and is often used in research.

1.2.5 DNA Replication



- DNA replication is the process by which DNA makes a copy of itself during cell division.
- Enzyme **helicase** helps in the process of separating two DNA strands.
- A short piece of RNA called a primer acts as the starting point for DNA synthesis.

Pharmacogenomics

- It is the study of how genes affect a person's response to drugs.
- This relatively new field combines pharmacology (the science of drugs) and genomics (the study of genes and their functions)
- Aims to develop effective, safe medications and doses that will be tailored to a person's genetic makeup.

DNA Technology (Use & Application) Regulation Bill 2019



Introduced for the regulation of use and application of DNA technology for the purpose of establishing identity of missing persons, victims, offenders, under trials and unknown deceased persons

Key provisions of the bill

Use of DNA Data: DNA testing is allowed only in respect of matters listed in the Schedule to the Bill.

- These include offences under the Indian Penal Code, 1860, and for civil matters such as paternity suits.
- Further, the Schedule includes DNA testing for matters related to establishment of individual identity.

Consent for the collection of DNA for some cases like arrested person having punishment of up to 7 years. If the punishment is beyond 7 years then consent is not required.

DNA Data Bank: establishment of a National DNA Data Bank and Regional DNA Data Banks, for every state, or two or more states.

Bill provides for **removal of the DNA profiles** of the following persons:

- Of a suspect if a police report is filed or court order given,
- Of an undertrial if a court order is given, and
- On written request, for persons who are not suspect, offender or undertrial, from the crime scene or missing persons' index

DNA Regulatory Board: The Bill also provides for the establishment of a DNA Regulatory Board, which will supervise the DNA Data Banks and DNA laboratories.

Functions of the Board:

1. Advising governments on all issues related to establishing DNA laboratories or Data Banks, and
2. Granting accreditation to DNA laboratories.
3. Further, the Board is required to ensure that all information relating to DNA profiles with the Data Banks, laboratories, and other persons are kept confidential.

1.3 Genetic Engineering

- It is the direct manipulation of DNA to alter an organism's characteristics (**phenotype**) in a particular way.
- Also called as genetic modification
- This means changing one base pair (A-T or C-G), deleting a whole region of DNA, or introducing an additional copy of a gene.
- It can be applied to any organism, from a virus to a sheep.

1.3.1 Genome Editing

Genome editing is a way of making specific changes to the DNA of a cell or organism. An enzyme cuts the DNA at a specific sequence, and when this is repaired by the cell a change or 'edit' is made to the sequence.

- Genome editing can be used to add, remove, or alter DNA in the genome.
- Genome editing in human embryos is against law.

- It is useful in treating genetic diseases like leukaemia and AIDS.
- It is also useful in producing high yield variety seeds.

1.3.2 Basics on Genetic Engineering

Sl. No.	Keyword	Meaning and Purpose
1	Restriction Enzymes	Enzyme that cuts the DNA
2	Ligase	Enzyme that catalyses joining of two molecules in DNA
3	Vector	Vehicle to carry foreign genetic material (of others) into another cell.
4	Plasmids	Are type of vector used to introduce foreign DNA into Bacteria
5	Probe	Probe is a sample DNA piece to compare the gene in the DNA.

Designer Babies

- It refers to a baby that has been given special traits through genetic engineering.
- This is done by altering the genes of the egg, sperm, or the embryo.

1.3.3 Gene Therapy

Gene therapy is when DNA is introduced into a patient to treat a genetic disease. The new DNA usually contains a functioning gene to correct the effects of a disease-causing mutation.

There are two different types

1. **Somatic gene therapy:** transfer of a section of DNA to any cell of the body that doesn't produce sperm or eggs. Changes are not passed to subsequent generations.

2. **Germline gene therapy:** transfer of a section of DNA to cells that produce eggs or sperm. Effects of gene therapy will be passed onto subsequent generations.

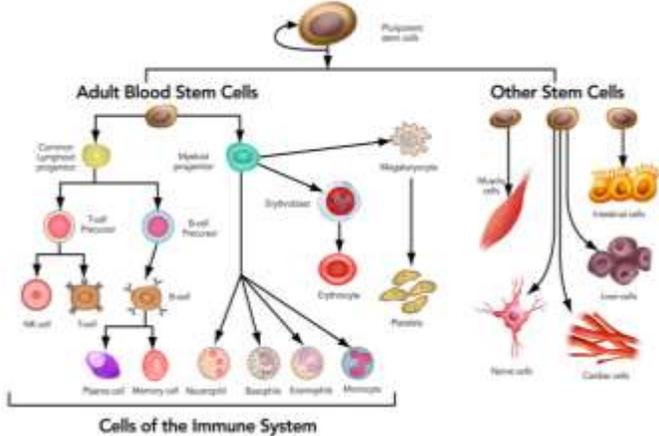
NOTE: Gene Therapy for Cancer - US has recently approved the first gene therapy to fight childhood leukaemia.

National Guidelines for Gene Therapy

Indian Council of Medical Research (ICMR) published "National Guidelines for Gene Therapy Product Development and Clinical Trials"

- It aims to ensure that the gene therapies can be introduced in India and their clinical trials can be performed in an **ethical, scientific and safe manner**.
- Also, spur innovation and accelerate research for **rare diseases**.
- It explains the responsibilities of investigators, sponsors, institutions. It also lists the considerations like quality assurance, manufacturing and control.
- The guide also explains on the principles to hold while signing international collaboration and procurement of **Genetic Therapeutic Products (GTP)**.
- The GTP are entities that deliver nucleic acid by various means for therapeutic benefit to patients.

1.3.4 Stem cell Therapy



- Stem cells are the raw materials for other body cells.
- They are considered raw materials, because all other cells with specialised functions are generated from these cells.

Two important properties

- Ability of self-renewal into numerous cells.
- Ability to specialise into various body cells types such as blood cells, brain cells, heart muscle.

Stem Cells are of three types

- Embryonic Stem cells
- Somatic Stem Cells
- Induced Pluripotent cells

Embryonic Stem Cells	Somatic stem Cells	Induced Pluripotent Stem Cells
<ul style="list-style-type: none"> • Embryonic stem cells are derived from embryos. • They are totipotent in that they can be differentiated into most of the cell 	<ul style="list-style-type: none"> • Somatic stem cells or adult stem cells. • These are undifferentiated cells present in differentiated cells in a tissue or organ. 	<ul style="list-style-type: none"> • These are Pluripotent cells. • Obtained through reprogramming of somatic cell. • Low rate of reprogramming

<p>types.</p> <ul style="list-style-type: none"> • They can produce a clone of the entire organism. • Use is ethically questionable in many countries • Due to the lack of complete immune-compatibility, organs and tissues generated from them, will likely be immune-rejected 	<ul style="list-style-type: none"> • They help in repair and maintenance of specific tissue or organ where they are present. • No risk of rejection during auto-transplantation • Less/no risk of tumour formation. • Limitation: Limited number in tissue 	<ul style="list-style-type: none"> • No ethical problems. • Personal regenerative medicine. • Low risk of immune rejection
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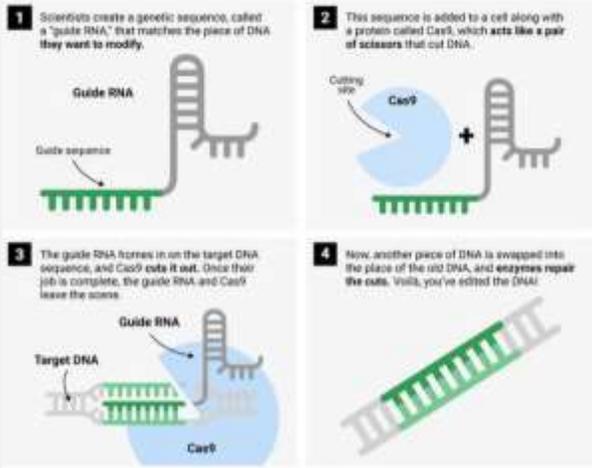
Potency of Cells

- **Totipotent cells** can be specialised into all cell types in a body with the addition of extra-embryonic or placental cells. Embryonic cells within the first two cell divisions after fertilization are the only cells that are totipotent.
- **Pluripotent cells** can be specialised into all the cell types that make up the body; eg. embryonic stem cells

The difference between totipotent and pluripotent cells is only that **totipotent cells** can give rise to **both the placenta and the embryo.**

- **Multipotent cells** can be developed into more than one cell type, but their ability to specialise is more limited than pluripotent cells. E.g. Adult stem cells and umbilical cord blood stem cells

CRISPR-Cas9



- CRISPR-Cas9 is a genome editing tool that is creating a buzz in the science world.
- CRISPR-Cas9 is a unique technology that enables geneticists and medical researchers to edit parts of the genome by removing, adding or altering sections of the DNA sequence.
- It is faster, cheaper and more accurate than previous techniques of editing DNA and has a wide range of potential applications.
- CRISPR- **Clustered Regularly Interspaced Short Palindromic Repeats**
- CRISPR uses an enzyme called Cas9 to cut strands of DNA at precisely targeted locations and insert new genetic material into the gap

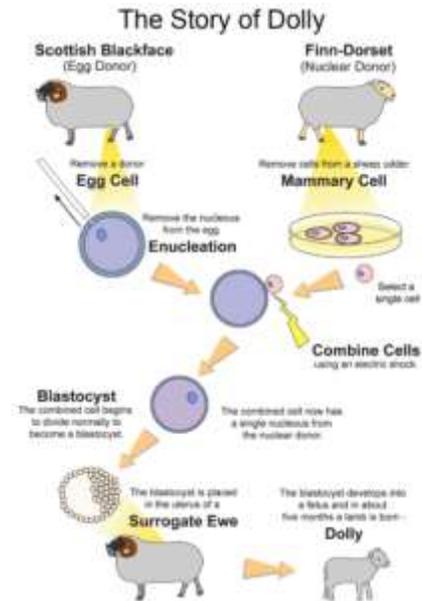


1st Gene-Edited Babies: Lulu And Nana

- In 2018 a Chinese doctor for the 1st time performed gene editing on the embryonic stem cell using **Crispr technique**.

- The CRISPR technique was used to modify the CCR5 gene on the embryonic cells of the couples to make them resistant to the **HIV virus**.
- One of the couples subsequently gave birth to twins – Lulu and Nana.

1.3.5 Cloning



- It is a process of asexual reproduction in which the offspring or the progeny is an exact replica of the single parent donor who has contributed the genetic material.
- Each cell is equipped with genetic information of an organism, which has the ability to develop into full organism.
- First successfully cloned animal was a sheep called **Dolly** in the year 1997 at Roslin Institute of Technology, Scotland.

India's achievements in animal cloning

- **Samrupa:** In 2009, the world's first cloned buffalo calf at National Dairy Research Institute (NDRI)
- **Garima:** It was the world's second cloned buffalo at NDRI
- **Cirb Gaurav:** In 2016, the scientists at the Central Institute for Research on Buffaloes

(CIRB), cloned a buffalo offspring named 'Cirb Gaurav'.

DNA Fingerprinting / DNA profiling

- DNA fingerprinting refers to identifying complete (or partial) set of genetic information of a particular individual.
- A sample of blood, saliva, semen, vaginal lubrication or other appropriate fluid or tissue from personal items can be used for DNA fingerprinting.
- Every human has unique DNA.

1.3.6 Genetically Modified Organisms



GMOs are organisms whose genetic materials have been altered using genetic engineering techniques to provide the organisms with certain special characteristics. GMOs can include plants, animals and even microorganisms. E.g. golden rice, BT cotton etc

Used to

- Increased yield of a crop
- Increased nutritional content of a crop
- Developing resistance to
 - a) Abiotic stresses like temperature, salinity or herbicide resistant
 - b) Biotic stresses like insect-resistant crops.

GMO crops in India

BT cotton is the only genetically modified crop that is commercially allowed in India from 2002.

Regulation

- Genetically modified organisms and the products thereof are regulated under **Environment (Protection) Act, 1986.**
- India is also a signatory to the **Cartagena Protocol on Biosafety.**
- **India adopted biosafety rules under EPA** in 1989 called Rules for the manufacture, use, import, export & storage of hazardous microorganisms, genetically engineered organisms or cells.
- Accordingly, Genetic Technology, Genetic Engineering including gene editing and gene drives are regulated under EPA, 1986 in India

GM crops are regulated by GEAC, whereas GM food is regulated by FSSAI

Regulator	Objectives and functions
Genetic engineering appraisal committee	<ul style="list-style-type: none"> • Formed under environmental protection Act of 1986 • Apex body under Ministry of Environment, Forest and Climate Change (MoEFCC). • Regulates manufacturing, use, import, export and storage of hazardous microorganisms or genetically engineered organisms (GMOs) and cells in the country. • Responsible for giving technical approval of proposals relating to release of GMOs and products including experimental field trials.
Food Safety and Standards Authority of India- FSSAI	<ul style="list-style-type: none"> • Autonomous statutory body established under the Food Safety and Standards Act, 2006 (FSS Act).

	<ul style="list-style-type: none"> • Under Ministry of Health & Family Welfare • It regulates manufacture, storage, distribution, sale and import GM food.
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BT BRINJAL	<ul style="list-style-type: none"> • Bt brinjal is genetically engineered by inserting a gene from the soil bacterium <i>Bacillus thuringiensis</i> for its insecticidal property. • The gene disrupts the digestive system of the insect that feeds on the crop, thus killing the insect. • Since 2010 there is an indefinite moratorium on commercial cultivation of Bt Brinjal in India.
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BT Crop	Information
BT COTTON	<ul style="list-style-type: none"> • BT cotton is the only genetically modified crop that is commercially allowed in India from 2002. • BT cotton grown in India is genetically modified for developing resistance to the pink bollworm pest in the crop. • This is done by inserting ‘Cry1Ab’ and ‘Cry2Bc’ genes from the soil bacterium, <i>Bacillus thuringiensis</i> (Bt), into the cotton seed.
HTBT COTTON	<ul style="list-style-type: none"> • Short for Herbicide Resistant Bt Cotton. • The cotton seed is inserted with ‘Cp4-Epsps’ gene from soil bacterium, <i>Agrobacterium tumefaciens</i>. This produces a modified protein glyphosate which makes it herbicideresistant. • It is not allowed to be cultivated in India
GM Mustard (DMH-11)	<ul style="list-style-type: none"> • DMH-11 yields about 30% more than the traditional reference mustard variety. • It helps in boosting edible mustard oil production thus, reducing huge import bill for edible oil. • GM mustard is resistant to herbicides. • Supreme Court has stayed permission to develop GM mustard.

Golden Rice	<ul style="list-style-type: none"> • International Rice Research Institute along with its partners has successfully cultivated Golden Rice in a controlled environment. • Golden Rice is a new type of rice that contains beta-carotene (provitamin A), which is converted into vitamin A as needed by the body and gives the grain its golden color. • It can provide up to 50% of the daily requirement of an adult for vitamin A. It is intended to fight against vitamin A deficiency (VAD) • It reduces water use by up to 30 per cent without any yield loss.
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But it has a low shelf life of not more than 3 months. It loses nutrients after that.

Vitamin A	<p>It is a fat-soluble vitamin that is good for healthy vision, skin, bones and other tissues in the body.</p> <p>Two types of vitamin A.</p> <ul style="list-style-type: none"> • Preformed vitamin A, also called retinol, is found in animal products like milk, egg, meat etc • Pro-vitamin A is found in plant-based foods such as fruits and vegetables like orange carrot etc. <p>Deficiency leads to</p> <ul style="list-style-type: none"> • Night blindness
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- A higher risk of infections, especially in the throat, chest, and abdomen.
- Follicular hyperkeratosis, leading to dry, bumpy skin.
- Fertility issues
- Delayed growth in children

Genetically Modified Mosquitoes

- A new initiative aims at reducing the population of **Aedes aegypti mosquito** by introducing genetically modified version of mosquitoes
- Genetically modified mosquitoes involve producing transgenic male *Aedes aegypti* mosquito, which carries a **new gene fatal** only to female mosquitoes
- GM male mosquitoes will then breed with normal females in the wild.
- In the next generation, only the males would survive, and these would breed again, with normal females.
- After a few generations, the female population will be drastically reduced and eventually whole mosquito population

1.3.7 Assisted Reproductive Technology (ART)

- ART includes medical procedures used primarily to address infertility.
- This subject involves procedures such as **in vitro fertilization (IVF)**, intracytoplasmic sperm injection (ICSI), cryopreservation of gametes or embryos, and/or the use of fertility medication.
- ART may also be used in surrogacy arrangements, although not all surrogacy arrangements involve ART.

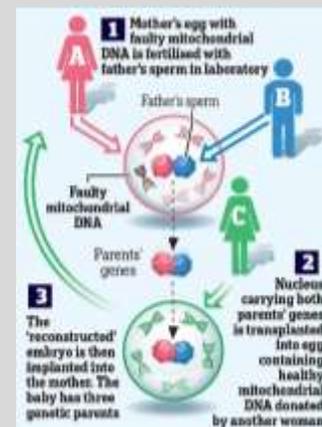
Methods used in ART

- 1. In vitro fertilization:** It is the technique of letting fertilization of the male and female

gametes (sperm and egg) occur outside the female body.

- 2. Intracytoplasmic sperm injection (ICSI):** is beneficial in the case of male factor infertility where sperm counts are very low or failed fertilization occurred with previous IVF attempt(s). The ICSI procedure involves a single sperm carefully injected into the center of an egg using a microneedle.
- 3. Zygote Intrafallopian Transfer (ZIFT):** egg cells are removed from the woman's ovaries and fertilized in the laboratory; the resulting zygote is then placed into the fallopian tube.
- 4. Gamete Intrafallopian Transfer (GIFT):** a mixture of sperm and eggs is placed directly into a woman's fallopian tubes using laparoscopy following a transvaginal ovum retrieval.

Three parent Baby and Mitochondrial DNA



- In addition to DNA in the nucleus, some **DNA is also present in the mitochondria.**
- Mitochondrial DNA only has one chromosome and it codes for **only specific proteins responsible for metabolism.**
- Mitochondrial DNA is **inherited only from the mother** and thus it is more effective to trace human ancestry.
- **Three parent Baby technique** is resorted to when the actual mother is suffering from an incurable **mitochondrial disease.**

1.4 Miscellaneous in Shorts

Topic	Details
Earth Bio-Genome Project	<ul style="list-style-type: none"> International collaboration to sequence and digitize the genomes of every eukaryotic biodiversity on Earth over a period of 10 years. It will map the genomes of roughly 1.5 million species, i.e., all the complex life forms known to man. It is an open-source DNA database. The initiative was inspired by Human Genome Project which ended in 2003 Provides a platform for scientific research and supports environmental and conservation initiatives. ISSUE- May lead to digital bio-piracy (because it is open-source) which is against the principle of Nagoya protocol to convention of Biodiversity that requires sharing of benefits with the local communities
Human Genome Project (HGP)	<ul style="list-style-type: none"> It was an international scientific research project which got successfully completed in the year 2003 by sequencing the entire human genome of 3.3 billion base pairs. The HGP led to the growth of bioinformatics which is a vast field of the research. The successful sequencing of the human genome could solve the mystery of many disorder in humans and gave us a way to cope up with them.
Genome Sequencing	<ul style="list-style-type: none"> It 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. The human genome is made up of over 3 billion of these genetic letters.
Manav: Human Atlas Initiative	<ul style="list-style-type: none"> Launched by Department of Biotechnology It is a project to construct a comprehensive map of every tissue of the human body. It seeks to capture human physiology at the tissue level in natural and diseased state. <p>Objectives</p> <ul style="list-style-type: none"> To provide better biological insights of human physiology To understand the roles of tissues and cells linked to various diseases. Develop disease models through predictive computing Drug discovery

Indigen Genome Project	<ul style="list-style-type: none"> Implemented by the CSIR-Institute of Genomics and Integrative Biology (IGIB), Delhi and CSIR-Centre for Cellular and Molecular Biology (CCMB), Hyderabad. It aims to undertake whole genome sequencing of thousands of individuals representing diverse ethnic groups from India. IndiGen will have applications in a number of areas including predictive and preventive medicine with faster and efficient diagnosis of rare genetic diseases. 	
Genome India Project	<ul style="list-style-type: none"> It is a project to carry out whole-genome sequencing of Indians. Also called ‘Bioscience Mission for Precision Health and Optimal Well-being’ It is aimed at studying the diversity of Indians and its impact on lifestyle, environment and genes that is inherited. It will help in development of personalized medicines. 	<ul style="list-style-type: none"> The initiative will involve large number of India from various geographies, caste, tribal and linguistic groups. The Genome Sequencing will be a combined initiative of Ministry of Health and Family Welfare, Department of Health Research, Department of Biotechnology The initiative will include sequencing genomes and link it to human health disease as a research initiative.
National Genomic Grid (NGG)	<ul style="list-style-type: none"> The grid will be formed in line with the National Cancer Tissue Biobank (NCTB) which is set up at the Indian Institute of Technology, Madras. It will collect samples from cancer patients to study genomic factors influencing cancer and identifying the right treatment modalities for the Indian population. The grid will have four parts, with the country divided into east, west, north and south Significance- The genomic samples will help researches to have India specific studies on cancers. 	
India’s Brain Map	<ul style="list-style-type: none"> National Brain Research Centre (NBRC) is preparing an Indian Brain Template (IBT). It is one-of-its-kind database of brain templates. 	

	<ul style="list-style-type: none"> Brain templates are MRI images that provide anatomical information of human brains. The IBT is funded by the Department of Science and Technology.
International Centre for Genetic Engineering And Biotechnology (ICGEB)	<ul style="list-style-type: none"> Intergovernmental organisation established as a special project of United Nations Industrial Development Organization, in 1983 The Organisation has three Component laboratories in Trieste Italy, New Delhi, India and Cape Town, South Africa Became fully autonomous since 1994
Arogyapacha (Trichopuszeylanicus)	<ul style="list-style-type: none"> Scientists decoded genome Known as ‘Miracle plant’ for its medicinal properties Endemic to the Agastya hills in the southern Western Ghats Known for its traditional use by the Kani tribal community to combat fatigue Studies have also proven its anti-oxidant, aphrodisiac, anti-microbial, anti-inflammatory anti-tumour, anti-ulcer, hepatoprotective and anti-diabetic properties.
Parthenogenesis	<ul style="list-style-type: none"> A reproductive strategy that involves development of a female (rarely a male) gamete (sex cell) without fertilisation or development of an embryo from an unfertilised egg cell It is an adaptive strategy when sexual reproduction is not possible due to environmental conditions.
Cultured Meat	<ul style="list-style-type: none"> Lab-grown meat is called with many names- cultured meat, in vitro meat, synthetic meat, artificial meat. It is made by growing muscle cells in a nutrient serum and encouraging them into muscle-like fibres. Simpler animal products, such as artificial milk or hen-free egg whites, can be created by yeast that has been genetically altered to produce the proteins found in milk or eggs. These are then extracted and blended in the right amounts 
Biofortification	<ul style="list-style-type: none"> Biofortification – breeding crops with higher levels of vitamins and minerals, or higher protein and healthier fats – is the most practical means to improve public health. Breeding for improved nutritional quality is undertaken with the objectives of improving – Protein content and quality Oil content and quality Vitamin content Micronutrient and mineral content.

2. Health and Diseases

2.1 Introduction

Health: As per WHO, Health is defined as the **state of complete physical, mental and social well-being** and not merely absence of disease.

Disease: A disease is a particular abnormal condition that negatively affects the structure or function of all or part of an organism, and that is not due to any immediate external injury.

Diseases are often known to be medical conditions that are associated with specific symptoms and signs.

2.2 Immune System of Human body

An infection can be seen as a battle between the invading pathogens and the host. Our bodies are equipped to fight off invading microbes that may cause disease. These are called our natural defences. (corona virus is proven to be more dangerous for persons with weak immune system).

2.2.1 First Line of Defence- Physical Barriers

The first line of defence is **non-specific** and aims to **stop microbes from entering the body**. The skin and mucous membranes act as a physical barrier preventing penetration by microbes.

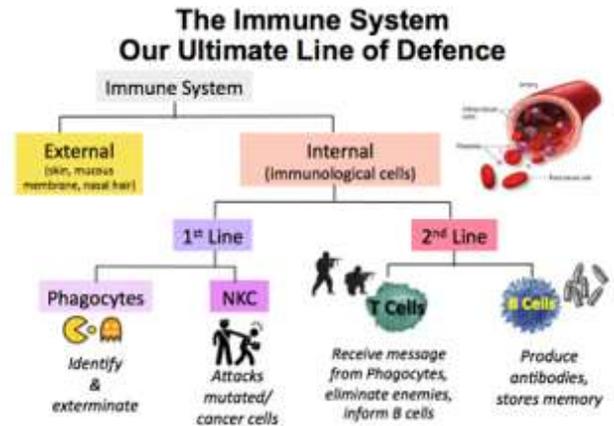
Examples –

- If the skin is cut then the blood produces a clot which seals the wound and prevents microbes from entering.
- Urine as it flows through the urinary system flushes microbes out of the bladder and urethra.

2.2.2 Second Line of Defence- Phagocytosis

- If microbes do manage to get inside the body then the second line of defence is activated.
- This is also non-specific as it stops any type of microbe.

- Phagocytes are a type of white blood cell that move by amoeboid action. They send out pseudopodia which allows them to surround invading microbes and engulf them.



- Phagocytes release digestive enzymes which break down the trapped microbes before they can do any harm. This process is called phagocytosis.

2.2.3 Third/ Final Line of Defence-Immune Response

- The invading microbe or pathogen is called an antigen. It is regarded as a threat by the immune system and is capable of stimulating an immune response.

Antigens

- Antigens are proteins that are found on the surface of the pathogen.
- Antigens are unique to that pathogen.
- The whooping cough bacterium, for example, will have different antigens on its surface from the TB bacterium.

Antigen-Antibody Mechanism

- When an antigen enters the body, the immune system produces antibodies against it.
- A type of white blood cell called a **lymphocyte recognizes the antigen** as being foreign and **produces antibodies** that are **specific to that antigen**.

- Each antibody has a unique binding site shape which locks onto the specific shape of the antigen.
- The antibodies destroy the antigen (pathogen) which is then engulfed and digested by macrophages.
- White blood cells can also produce chemicals called antitoxins which destroy the toxins (poisons) some bacteria produce when they have invaded the body.

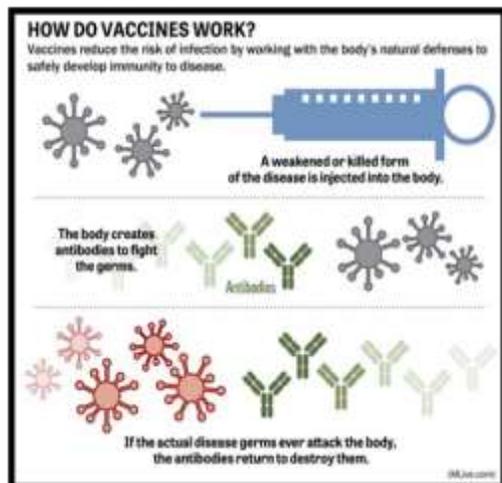
Memory Cells

- Once a person has had a disease, they don't normally catch it again because the body produces memory cells that are specific to that antigen.
- The memory cells remember the microbe which caused the disease and rapidly make the correct antibody if the body is exposed to infection again.
- The pathogen is quickly destroyed preventing symptoms of the disease occurring.

Herd Immunity

- Herd immunity is the resistance of a group of people to an infection.
- It arises due to the immunity of a high proportion of the population, for example because they have been vaccinated or been exposed to the pathogen before.

2.3 Vaccination



A vaccine is a substance that is introduced into the body to stimulate the body's immune response.

It is given to prevent an infectious disease from developing and the person becoming ill.

E.g. Polio Vaccine, BCG, Measles Vaccine e

2.3.1 Types of Vaccines

Vaccine is a biological preparation that provides active acquired immunity to a particular infectious disease.

These are categorised into 3 generations:

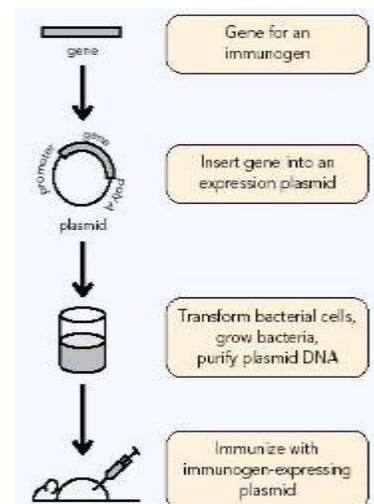
I. First Generation Vaccines

- These vaccines consist of infectious organisms, either in mild or dead form.
- The first-generation vaccines are still widely used today. Eg. Polio vaccine.
- There are chances that mild viruses get into dangerous form.

II. Second Generation Vaccines: (Sub Unit Vaccines)

- These vaccines were created in order to minimise the risks of having the pathogen revert to a dangerous form. Eg. DTP vaccine
- The way these vaccines work is that they do not contain the whole organism, but rather contain only subunits.

III. Third Generation Vaccines- (DNA Vaccine)



They are also called third generation vaccines. These vaccines are made up of a small, circular piece of bacterial DNA (called a plasmid) that has been genetically engineered to produce one or two specific proteins (antigens) from a pathogen

So far, no DNA vaccine has been licensed for use in humans.

Advantages

1. Require short time span for development:
2. DNA vaccines are easy to transport and store
3. Less risk to those who are making the vaccine:

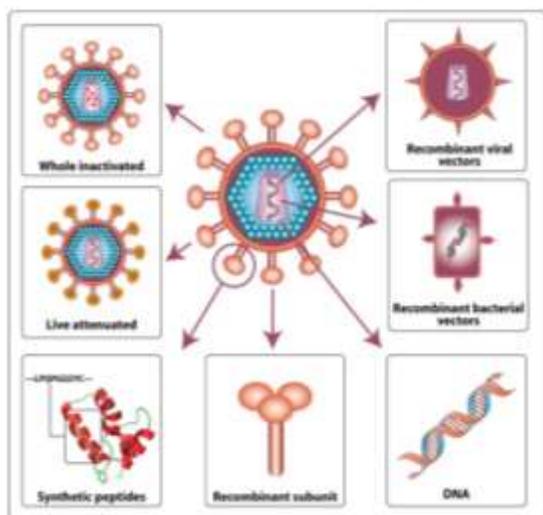
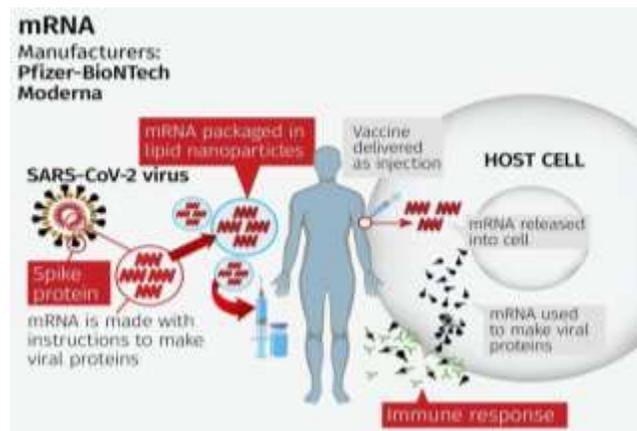


Fig: Types of Vaccines

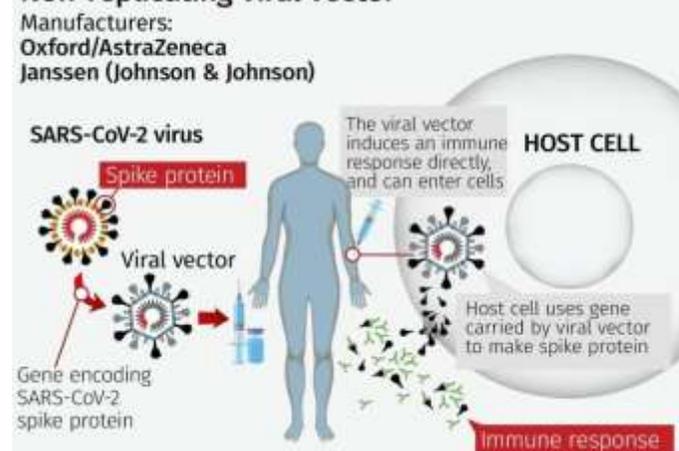
2.3.2 m-RNA (Messenger RNA) Vaccine

- mRNA vaccines are a new type of vaccine to protect against infectious diseases.
- MRNA vaccines teach our cells how to make a protein—or even just a piece of a protein—that triggers an immune response inside our bodies.
- The benefit of mRNA vaccines, like all vaccines, is those vaccinated gain protections without ever having to risk the serious consequences of getting sick with COVID-19.
- COVID-19 mRNA vaccines give instructions for our cells to make a harmless piece of what is called the “spike protein.”

Difference between mRNA Vaccine and Conventional Vaccine



Non-replicating viral vector



Advantages of mRNA Vaccine

- Considered safe as it is non-Infectious.
- mRNA vaccines are fully synthetic and do not require a host for growth.
- Quickly manufactured.
- Considered highly efficacious because of their inherent capability of being translatable into the protein structure inside the cell cytoplasm.
- They do not affect or interact with our DNA in any way.

Covid Vaccines in India

- **COVISHIELD** and **COVAXIN** (vaccines by Bharat Biotech and Serum Institute of India)
- COVAXIN is an inactivated vaccine whereas COVISHIELD is a live vaccine.

- COVISHIELD is “non-replicating viral vector” vaccine. Weakened and genetically modified virus (Chimpanzee Virus is genetically modified with **spike protein** of COVID) is used.
- COVAXIN is an “**inactivated**” vaccine. The corona virus is killed to boost an immune response.

2.4 Antibiotics

Antibiotics are chemicals that kill or inhibit the growth of bacteria and are used to treat bacterial infections. E.g. Penicillin, Tetracycline etc.

How do antibiotics work?

- Antibiotics take advantage of the difference between the structure of the bacterial cell and the host’s cell.
- They either prevent the bacterial cells from multiplying so that the bacterial population remains the same, allowing the host’s defence mechanism to fight the infection or kill the bacteria, for example stopping the mechanism responsible for building their cell walls.

2.4.1 Anti Virals

- Antivirals are a class of medications that are used to treat viral infections.
- Most viral infections resolve spontaneously in immunocompetent individuals.
- The aim of antiviral therapy is to minimize symptoms and infectivity as well as to shorten the duration of illness.
- These drugs act by arresting the viral replication cycle at various stages.
- Currently, antiviral therapy is available only for a limited number of infections. Most of the antiviral drugs currently available are used to treat infections caused by HIV, herpes viruses, hepatitis B and C viruses, and influenza A and B viruses.
- Unlike other antimicrobials, antiviral drugs do not deactivate or destroy the virus but act by inhibiting replication.

- In this way, they prevent the viral load from increasing to a point where it could cause pathogenesis, allowing the body’s innate immune mechanisms to neutralize the virus.

2.5 Antimicrobial Resistance (AMR)

WHO Definition

- 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.
- When the microorganisms become resistant to most antimicrobials they are often referred to as “superbugs”.

Difference between antibiotic and antimicrobial resistance

- Antibiotic resistance occurs when bacteria change in response to the use of antibiotics used to treat bacterial infections (such as urinary tract infections, pneumonia, bloodstream infections) making them ineffective.
- Antimicrobial resistance is a broader term, encompassing resistance to drugs that treat infections caused by other microbes as well, such as parasites (e.g. malaria or helminths), viruses (e.g. HIV) and fungi (e.g. Candida).

2.5.1 Causes for AMR

Antimicrobial resistance occurs naturally but is facilitated by the inappropriate use of medicines

- Using antibiotics for viral infections such as cold or flu, or sharing antibiotics.
- Low-quality medicines,
- Wrong prescriptions and
- Poor infection prevention and control also encourage the development and spread of drug resistance.

2.5.2 Initiatives for Combating AMR

- ‘AWaRe’ tool by WHO
- Global Antimicrobial Resistance Research and Development Hub (Global AMR R&D)
- National Action Plan to Combat Antimicrobial Resistance, 2017

Generic Medicines:

- They are copies of originally researched drugs, but at much lower prices.
- Manufactured after the **expiration of patency** of the drugs.
- Drugs are manufactured and sold by **non-original makers** at much cheaper rates.
- For example, Aspirin and Paracetamol are generic drugs that are often sold under brand names like Disprin and Crocin.
- The dosage, composition, method of intake, benefits, quality, and even side effects of generic medicines are similar to the brand-name version of the drugs.
- Just because generics have a significantly **lower price tag**, it does not mean that these medications are less effective.

Bio-Similar:

- A biosimilar is a biologic medical product that is almost an identical copy of an original product that is manufactured by a different company.
- Biosimilars are officially approved versions of original “innovator” products and can be manufactured when the original product’s patent expires. Reference to the innovator product is an integral component of the approval.

Difference between biosimilars and generics:

- Biosimilars involve developing equivalent of biological entity while generics involve developing equivalent of a chemical entity-the

Active Pharmaceutical Ingredient.

- In case of biosimilars, biological entities being some ward different (and not as it is of replica), every organism has to be engineered to produce the same therapeutic effect while in generics, the copies of API can be generated
- Bio-similars differ from generics – in complexity, in the manufacturing processes and in the data needed to demonstrate similarity for approval. The structure of Generic Simple and well-defined whereas for Bio-similar its Complex with potential structural variations.
- Regulatory procedure to get approval for biosimilars is complex as compared to that of a generic.

2.6 Classification of Diseases

Diseases are categorized into

- I. Communicable
- II. Non-Communicable Diseases.

Characteristics	Communicable Diseases	Non-communicable diseases
Definition	Diseases spread from one to another person. Can be spread through water, air etc	Diseases cannot be transmitted from one to another person
Causative	Pathogens that are highly infectious and vectors transmit these diseases	Here, the causative is allergies, malnutrition, illness due to internal factors, lifestyle changes, environmental changes, abnormalities in cell proliferation
Agent causing	Virus, bacteria,	No agents

infection	etc.	
Inheritance factor	Cannot be inherited from one generation to another	Can be inherited from generation on
Example	AIDS, Typhoid, Tuberculosis, Malaria, Cholera	Allergies, cancer, heart diseases, diabetes
Type of disease	As it can develop almost immediately, it is acute	As it develops over a period of time and lasts for long, it is chronic
Treatment	Traditional methods/therapies	Surgically or specialized methodologies

- They are **not usually considered as living organisms**, as they are very simple and do not carry out most of the living processes which other living organisms perform.
- Viruses are not made of cells, and are sometimes referred to as **virus particles or virions**.
- Viruses are inactive when outside of a living cell, but once their nucleic acid is inside, they take over the cell's activities. Usually, they make many copies of themselves inside the cell, then break out of the cell and infect others.
- Viruses cannot be killed by antibiotics such as penicillin.

Virus	Viroid	Prion
An infective agent that typically consists of a nucleic acid molecule in a protein coat and is able to multiply only within the living cells of a host	The infectious particle smaller than the known viruses, serving as an agent of certain plant diseases	An infectious protein particle similar to a virus but lacking nucleic acid;
Can cause wide variety of infections	Infect only plant cells	degenerative diseases of nervous system
Contains either DNA or RNA as their nucleic acids	Contains a short strand of circular, single stranded RNA as their nucleic acid	Contains only proteins and lack nucleic acids
Contains protein coat surrounding its nucleic acid	No protein coat	-

I. Communicable Diseases

Microbes

Microbes are tiny living things that are found all around us and are too small to be seen by the naked eye.

A few harmful microbes, for example less than 1% of bacteria, can invade our body (the host) and make us ill. Microbes cause infectious diseases such as flu and measles.

Microbes that cause disease are called **pathogens**.

There are 4 types of microbes that cause disease;

1. Viruses
2. Bacteria
3. Fungi
4. Protozoa (also known as protocista).

1. Viruses

- **Viruses** are very small, and most can only be seen with an electron microscope. They just contain a **core of nucleic acid (DNA or RNA)** surrounded by a covering **layer of protein (no cytoplasm, cell membrane or anything else)**.

Viral Diseases

Name	Symptoms	Transmission	Details
Corona Virus/ Novel coronavirus (n- CoV)	Symptoms: Fever, dry cough, tiredness, sore throat, loss of taste or smell, difficulty breathing, loss of movement etc., but also asymptomatic virus.	<p>Zoonotic – transmitted from animals to humans.</p> <p>Route of transmission: through respiratory droplets of an infected person, through aerosols in the air.</p> <p>WHO has named the new coronavirus disease as ‘COVID-19’</p> <p>Recent strains (with a large number of mutations and can spread easily and quickly)</p> <ul style="list-style-type: none"> • B.1.1.7- UK • B.1.31- South Africa • P.1- Brazil • B.1.617.2 - India 	<p>Caused by SARS CoV-2, similar to the one that caused SARS (Severe Acute Respiratory Syndrome) in 2002.</p> <p>Diagnosis: Serological tests, rapid antibody detection tests, Reverse Transcription Polymerase Chain Reaction Test (RT-PCR).</p> <p>Proposed Drugs: Remdesivir, Chloroquine and hydrochloroquine, ritonavir, convalescent Plasma Therapy.</p> <p>Recently Approved Drugs in India: Covishield and Covaxin (vaccines by Bharat Biotech and Serum Institute of India) for emergency use.</p>
Nipah Virus	<ul style="list-style-type: none"> • Fever, muscle pain, respiratory problems. • Inflammation of brain. • Late onset of encephalitis can also occur. 	<ul style="list-style-type: none"> • Zoonotic Virus. • Vector: fruit bats. • Intermediate host: pigs. • It can also be transmitted through contaminated food or directly between people 	They are currently no drug or vaccine
Rota Virus	Fever, nausea, vomiting, abdominal cramps and frequently watery diarrhea.	Transmitted by faecal oral route, contact with contaminated hands, surfaces and objects, respiratory route.	No specific medicine to treat, but it usually resolves within 7 days.
Yara Virus		<ul style="list-style-type: none"> • Discovered in a lake in Brazil. • It infects amoeba and has genes that has not been described before. 	

		<ul style="list-style-type: none"> • It could challenge how Deoxyribonucleic Acid (DNA) viruses are classified. • The Yarravirus does not infect human cell. 	
Measles	High fever, runny nose and cough, red and watery eyes, small white spots inside the cheeks, rashes in face, upper neck, hands and feet.	<ul style="list-style-type: none"> • Contagious air-borne infection of the respiratory tract. • Caused by a virus in the Paramyxovirus family. • Spread through direct contact or coughing, sneezing etc., • It affects mostly children under the age of 5 years. Unvaccinated groups including children, pregnant women and people with weak immune system. 	<ul style="list-style-type: none"> • WHO recommends routine measles vaccination for children and mass immunization campaigns to reduce global measles death. • 2 doses of measles vaccine, either alone or in a measles-rubella combination should be the standard for all immunization programmes.
Rubella/ German Measles		A mild disease but can have serious consequences for pregnant women and their children as it may cause congenital rubella syndrome.	Prevented by Measles-Rubella Vaccine under Universal Immunization Programme.
Zika Virus	Symptoms are generally mild and include fever, rash, conjunctivitis, muscle and joint pain, headache. Symptoms typically last for 2-7 days.	Vector: Aedes Aegypti Mosquito (which bite during the day).	No specific treatment.
Monkey Fever/ Kyasanur Forest Disease	Chills, fever, headache, severe muscle pain, vomiting, gastrointestinal symptoms and bleeding. Patients may experience abnormally low blood pressure, and low platelet, red blood cell and white blood cell count.	<ul style="list-style-type: none"> • It is a tick born (tick which is found on monkeys) viral haemorrhagic (loss of blood) fever. • Endemic to South-Asia. • In India, endemic to Karnataka state. • Family: Flaviviridae. 	There is no specific treatment, but a vaccine is available. Diagnosed through Polymerase Chain Reaction (PCR) or Virus isolation from blood.

		<ul style="list-style-type: none"> • Common host: rodent, shrews and monkeys. 	
Yellow Fever	<p>Associated with Jaundice, hence the name yellow.</p> <p>Symptoms usually present in 2 phases.</p> <p>I Phase: fever, muscle pain and vomiting. Symptoms may disappear after 3-4 days.</p> <p>II Phase: Small percentage of people enters this phase. Experience high fever, Jaundice, abdominal pain and vomiting</p>	<ul style="list-style-type: none"> • Transmitted by infected mosquitoes (Aedes species and Hoemogogus mosquitoes). • The disease cannot be spread by contact from one person to another. 	<ul style="list-style-type: none"> • Prevented by a vaccine known as 17D (yellow fever vaccine). • No specific treatment.
Acute Encephalitis Syndrome (AES)	<p>Confusion, disorientation, coma, high fever, vomiting, nausea, inability to talk and unconsciousness, inflammation of the brain.</p> <p>The disease most commonly affects children and young adults and can lead to morbidity and mortality.</p>	<ul style="list-style-type: none"> • Viruses are the main causative agents. Although other sources such as bacteria, fungi, parasites, chemicals, toxins and through non-infectious agents. • Transmitted by mosquitoes. • Japanese Encephalitis Virus (JEV) is the major cause of AES in India. 	<ul style="list-style-type: none"> • It is not vaccine preventable. • Diagnosis: The National Vector Borne Disease Control Programme in India has set up countrywide surveillance for AES (with a focus on detecting JEV).
West Nile Fever	<ul style="list-style-type: none"> • 80%- Asymptomatic. • 20%- report fever, headache, nausea occasionally with a skin rash and swollen lymph gland. 	<ul style="list-style-type: none"> • It was first identified in the West Nile district of Uganda in 1937. • Vector: Culex species mosquitoes. • Virus can be injected into humans and animals. • Transmitted through contact with other infected animals, their blood or tissues. • Till date no human-to-human transmission is reported. 	<ul style="list-style-type: none"> • No vaccine or specific antiviral treatments are available. • Supportive treatment such as intravenous fluid, pain medication and nursing care.

		<ul style="list-style-type: none"> Commonly found in Africa, Europe, Middle East, North America and West Asia. 	
Acquired Immune Deficiency Syndrome (AIDS)	<ul style="list-style-type: none"> Rapid weight loss, fever, tiredness, lymph glands, diarrhea, pneumonia, sores of the mouth, anus or genitals. 	<ul style="list-style-type: none"> Human Immunodeficiency Virus (HIV) left untreated leads to AIDS. HIV attacks body immune system. HIV infection can occur by transference of blood, breast milk, vaginal fluid or semen. 	<ul style="list-style-type: none"> Human body can't get rid of HIV completely.
Dengue	<ul style="list-style-type: none"> Symptoms include fever, headache, muscle and joint pains, skin rash. The disease may develop into life threatening dengue hemorrhagic fever, resulting in bleeding, low levels of blood platelets and blood plasma leakage. 	<ul style="list-style-type: none"> Vector: Aedes Aegypti Mosquito. 	<ul style="list-style-type: none"> No specific treatment exists. Dengvaxia- Approved by the US Food & Drug Administration. The Indian drug controller has yet to grant approval to Dengvaxia vaccine.
Flu	<ul style="list-style-type: none"> Fever, cough, headache, muscle and joint pain, feeling of unwell, sore throat and a runny nose. 	<ul style="list-style-type: none"> It is a contagious respiratory illness caused by influenza viruses that infect the nose, throat and sometimes the lungs. Four types of influenza viruses are there: namely Influenza A, B, C and D. Influenza A: infects birds and mammals. Common influenza outbreaks caused by Influenza A strains include: H1N1 (Swine Flu); H5N1, H5N8 (Bird 	<ul style="list-style-type: none"> Vaccines are there to prevent the disease.

		<p>Flu).</p> <ul style="list-style-type: none"> • Influenza C: detected less frequently and usually causes mild infections. • Influenza D: primarily affect cattle and are not known to infect or cause illness in people. 	
Ebola Haemorrhagic Fever	<ul style="list-style-type: none"> • Bleeding, vomiting, diarrhea and rash. 	<ul style="list-style-type: none"> • Rare but severe, often fatal illness in humans. • Damages the immune system and organs. • Transmitted among humans through close and direct physical contact with infected bodily fluids, blood, faeces and vomit. • Vector: chimpanzees, fruit bats and forest antelope. 	<ul style="list-style-type: none"> • No standard treatment.
Hepatitis B		<ul style="list-style-type: none"> • Causing agent: Hepatitis B virus • Blood exchange, sexually transmitted disease. • Affect the liver 	Vaccine: Recombivax
Polio or Poliomyelitis		<ul style="list-style-type: none"> • Causing agent: Polio virus. • Transmitted through water/ faecal. • Weak muscles leading to deformations. 	There is no cure for polio. There are two vaccines to prevent it.
Foot and mouth disease	<ul style="list-style-type: none"> • Picornavirus (genus Aphthovirus) 	<ul style="list-style-type: none"> • Animal-to-animal spread. 	
Note: Flavivirus cause yellow fever, dengue fever, Japanese encephalitis, west nile virus and zika virus.			

2. Bacterial Diseases

Bacterial diseases include any type of illness caused by bacteria. Bacteria are a type of **microorganisms**, which are tiny forms of life that can only be seen with a microscope.

Disease	Causative agent	Mode of transmission	Details
Anthrax	Bacillus Anthracis	Contacted with infected meat.	<ul style="list-style-type: none"> Causes Skin infections and gastrointestinal infection that are fatal. Symptoms are fever and chills, chest discomfort, shortness of breath, confusion or dizziness, cough etc., Prevented by Anthrax Vaccine Absorbed (AVA) or Bio Thrax.
Tuberculosis	Mycobacterium Tuberculosis	Airborne discharge through sputum, cough, sneeze etc., of the infected person.	<ul style="list-style-type: none"> Generally, affects the lungs, but can also affect other parts of the body. Persistent fever and coughing, chest pain and blood comes out with the sputum, general weakness. Vaccine: Bacille Calmette-guerin. Common medications include: Isoniazid, Rifampin, Ethambutol and Pyrazinamide. Bedaquiline: anti-TB drug to treat multi-drug resistant disease (MDR-TB) Pretomanid: 3rd new drug developed for the treatment of people with extensively drug-resistant TB or multi drug resistant TB.
Typhoid	A Bacillus rod-shaped bacterium (Salmonella Typhi)	Through contaminated food and water.	<ul style="list-style-type: none"> Continuous fever, headache, slow pulse rate. Reddish rashes appear on the belly. Vaccine: Vivotif.
Cholera	Common shaped bacterium (Vibrio Cholerae)	Contaminated food and water. Carrier: House-fly	<ul style="list-style-type: none"> It often breaks out among crowded areas with poor sanitary conditions. Effects small intestine.

			<ul style="list-style-type: none"> • Symptoms: acute diarrhea, muscular cramps, loss of minerals through urine, and dehydration leads to death.
Diphtheria	Corynebacterium Diphtheriae	Air or direct contact	<ul style="list-style-type: none"> • Symptoms: Sore throat and fever. • Complications may include myocarditis, inflammation of nerves, kidney problems etc.,
Pneumonia	Caused by bacteria or viruses. Streptococcus pneumonia and Haemophilus influenza.	Air borne droplets of sneeze	It is an inflammatory condition of the lung affecting primarily the microscopic air sacs known as alveoli.
Plague	Yersinia Pestis	Air or direct contact	Unhygienic conditions is the main cause.
Leprosy	Mycobacterium Laprae		<ul style="list-style-type: none"> • Affect nerves, skin, eyes and lining of the nose • Rifampicin and clofazimine are now combined with dapsone to treat multibacillary leprocy.

3. Fungi

Fungi (singular **fungus**) are slightly larger than bacteria, and their DNA is contained inside nuclei like plant and animal cells.

- They are more suited to living in a liquid environment.
- Not all fungi cause disease; some are very useful "in nature".

Examples of diseases caused by fungi: Athlete's foot (not only caught by athletes, or confined to the foot!), ringworm (not a worm), etc.

Black Fungus/ Mucormycetes

- Recently it was seen patients who were suffering from COVID 19. Government has notified this as **Epidemic**.
- It is a serious **Fungal infection** but is rare
- Caused by **Mucormycetes**, a group of moulds.
- People who are already suffering from any disease are more susceptible.

- **Symptoms:** Sinuses or lungs gets affected. Pain and redness around the eyes or nose, with fever, headache, coughing, shortness of breath, bloody vomits, and altered mental status.
- Treated with **anti-fungals (Amphotericin B)**

White Fungus/Candidiasis

- Fungal infection caused by a yeast (a type of fungus) called Candida.
- Recently cases were reported in Covid patients.
- Covid-19 patients are more prone to white fungus as it affects the lungs and similar symptoms are created like that of corona virus.
- This Fungus is normally found on various parts of the human body like mouth, throat, gut etc.
- Normally it doesn't lead to infection unless immunity is weakened.
- Anti Fungal Medication is given

4. Diseases Caused by Protozoa

Protozoan infections are parasitic diseases.

Disease	Causing agent	Mode of transmission	Details
Amoebiasis	Entamoeba Histolytica	Contaminated water or food	Symptoms: abdominal pain, mild diarrhea, bloody diarrhea or severe colitis with tissue death and perforation. People affected may develop anemia due to loss of blood.
Kala-Azar or Visceral Leishmaniasis	Leishmania Genus	Vector: sandflies	Symptoms: fever, weight loss, fatigue, anemia and swelling of the liver and spleen. The disease is the second-largest killer in the world (after malaria).
Malaria	Infectious Plasmodium	Female Anopheles mosquitoes	Symptoms: fever, fatigue, vomiting and headaches. World's first vaccine against a parasitic disease: Mosquirix.

II. Non-Communicable Diseases

Disease	Details
Diabetes Mellitus	<ul style="list-style-type: none"> The disease can be diagnosed by blood test or urine test. Causes: Less secretion of insulin hormone from the pancreas. Symptoms: <ul style="list-style-type: none"> More glucose in blood. Excessive and frequent passing of urine. Feeling thirsty and hungry

	<p>frequently.</p> <ul style="list-style-type: none"> Reduces healing capacity of injury. Prevention and cure Control of excessive weight of body. Regulated and controlled diet: Food should not contain sugar and much carbohydrate.
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Cardiovascular Diseases	<p>Causes:</p> <ul style="list-style-type: none"> • Deposition of cholesterol in walls of coronary arteries which restrict flow of blood to heart muscles. This leads to heart attack. • Due to reduced blood supply, oxygen available to muscles, heart's efficiency is affected. <p>a. Hypertension (high blood pressure)</p> <p>Symptoms:</p> <ul style="list-style-type: none"> • Persistent high blood pressure. • It may cause paralysis. <p>Prevention and cure:</p> <ul style="list-style-type: none"> • Do not build up mental pressure. • Low fat diet should be taken. <p>b. Coronary Heart Disease</p> <p>Symptoms:</p> <ul style="list-style-type: none"> • Severe pain in chest gasping for breath. • Blood clot may be formed within the blood vessels. <p>Prevention and cure</p> <ul style="list-style-type: none"> • A diet with low saturated fats may control the formation of cholesterol. • Avoid smoking, alcoholic drinks and drugs. 	<p>Causes</p> <ul style="list-style-type: none"> • No definite cause has been arrived at so far. • Heavy smoking and alcoholism. • Chewing of tobacco. <p>Cancer is a kind of tumorous growth. Tumors are classified into two categories</p> <p>(a) Benign tumor</p> <p>It remains confined to the place of origin and does not spread. It is relatively harmless.</p> <p>(b) Malignant tumor</p> <p>It spread to other parts and growth is rapid. This is serious and may cause death.</p>
Osteoporosis	<p>It is an age dependent disorder with loss of normal density of bone. The bones become fragile and are easily fractured.</p> <p>Treatment</p> <ul style="list-style-type: none"> • Patients are generally treated with vitamin D and calcium supplements. • Changes to lifestyle and diet also recommended. 	<p>Allergy</p> <p>It includes a group of non-infectious diseases. No definite cause is known. It is believed that they occur due to hypersensitiveness of certain individuals to foreign matter which may enter inside the body. Allergens may be pollen grains, feathers, some animals or insects, drugs, medicine, odor etc.</p>
Cancer	<p>It is uncontrolled and unwanted growth of cells.</p>	<p>Genetic Diseases</p> <p>Genetic disorders can be caused by a mutation in one gene (monogenic disorder), by mutations in multiple genes (multifactorial inheritance disorder), by a combination of gene mutations and environmental factors, or by damage to chromosomes.</p> <p>Common genetic disorders in India are:</p> <ul style="list-style-type: none"> • Beta thalassemia is a blood order that reduces the production of hemoglobin. • Cystic fibrosis is a disorder that causes severe damage to the lungs, digestive system and other organs in the body.

- **Sickle cell anemia/ sickle cell disease (SCD)**, is a genetic disease of the red blood cells (RBCs).
- **Spinal muscular atrophy** is a disorder characterized by weakness and wasting in muscles used for movement (skeletal muscles).

2.7 Miscellaneous in Short

Topic	Information
National Health Mission (NHM)	Launched in 2013 subsuming the National Rural Health Mission and the National Urban Health Mission.
National Digital Health Mission (NDHM)	<ul style="list-style-type: none"> • Project under GoI under National Health Policy, 2017. • Objective: To digitize the entire healthcare ecosystem • Recently, centre has approved the Health Data Management Policy of the NDHM that sets out the minimum standard for data privacy protection that should be followed
National Health Profile	<ul style="list-style-type: none"> • Released by the Central Bureau of Health Intelligence (CBHI) under the Directorate general of Health Services.
The India Health Fund	<ul style="list-style-type: none"> • To eradicate TB by 2023 and malaria by 2030. • It is a joint collaborative by the Tata Trusts and the Global Fund.
TRUENAT	<ul style="list-style-type: none"> • WHO has endorsed TrueNat, an indigenous molecular diagnostic tool for TB.
MERA India Initiative	<ul style="list-style-type: none"> • Malaria Elimination Research Alliance • Lunched by ICMR to eliminate malaria by 2030.

New Influenza Research Programme	<ul style="list-style-type: none"> • Joint initiative by India and EU to develop Next generation influenza vaccine. • The programme will get fund under EU funding programme for research and innovation called 'Horizon 2020'.
Drugs Technical Advisory Board (DTAB)	<ul style="list-style-type: none"> • Highest statutory decision-making body on technical matters related to drugs in the country. • Constitutes as per Drugs and Cosmetics Act, 1940. • It is part of Central Drugs Standard Control Organisation (CDSCO) (national regulatory body for Indian pharmaceuticals and medical devices) in the Ministry of Health and Family Welfare.
Vision 23: Public Health Surveillance in India	<ul style="list-style-type: none"> • Released by NITI Aayog. • Basis for surveillance: Individual electronic health record.
Eat Right Movement	<ul style="list-style-type: none"> • Launched by Food Safety and Standards Authority of India (FSSAI). • The movement aims to cut down salt/sugar and oil consumption by 30% in three years, also aims to engage and enable citizens to improve their health and well-being by making the right food choices.
Telemedicine	Telemedicine systems allow health care professionals to evaluate, diagnose and treat patients at a distance using telecommunications technology.

	<p>Advantages:</p> <ul style="list-style-type: none"> Increased access of healthcare Reduced healthcare cost. Increased patient engagement and satisfaction. <p>Recently, Ministry of Health and Family Welfare in collaboration with NITI Aayog and Medical Council of India issued guidelines for telemedicine.</p>
Trans-Fat	<ul style="list-style-type: none"> Trans fats are a form of unsaturated fat. Artificial trans-fat, which are considered harmful, are created during hydrogenation (adds hydrogen to liquid vegetable oils), to make them more solid. But a small amount also occurs naturally (occur in the meat and dairy from ruminant animals). Trans fats are largely present in partially hydrogenated vegetable fats/oils, Vanaspati, margarine and bakery shortenings, and can be found in baked and fried food items. Associated with increased risk of high cholesterol and heart diseases. FSSAI, notifies regulations to limit trans-fat in food items. Aims to limit the use of industrial trans-fat in all fats and oils to not more than 2% by January, 2022. The regulation excludes trans-fatty acids from dairy, meat, fish and their products.

	<ul style="list-style-type: none"> WHO in 2018, had also called for elimination of industrially produced trans-fat from the food supply by 2023.
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Difference between Endemic, Epidemic and Pandemic		
Endemic	Epidemic	Pandemic
<p>It is used to describe a disease that is prevalent or restricted to a particular location, region, or population.</p> <p>Example: Malaria, TB etc.,</p>	<p>Affecting many persons at the same time, and spreading from person to person in a locality where the disease is not permanently prevalent.</p> <p>It occurred at the level of a region or community.</p> <p>Example: H1N1</p>	<p>Pandemic disease is an epidemic that has spread over a large area i.e., it is prevalent throughout an entire country, continent or the whole world.</p> <p>Example: Corona</p>

Diagnosis for COVID – 19			
	MOLECULAR TEST	ANTIGEN TEST	ANTIBODY TEST
Also known as...	Diagnostic test, viral test, molecular test, nucleic acid amplification test (NAAT), RT-PCR test, LAMP test	Diagnostic test, viral test, rapid test	Serological test, serology, blood test, serology test
How the sample is taken...	Nasal swabs, either shallow or deep (nasal tests). Saliva (some tests)	Nasal or nasopharyngeal swab (nasal tests)	Blood from a fingertick or vein
How long it takes to get results...	Less than an hour (at-home tests) and some point-of-care locations, same-day (some point-of-care locations) or 1-3 days (tests sent to a lab for processing). Some tests may take longer in some locations, depending on testing capacity.	Some may be very fast (15-30 minutes), depending on the test	Same day (some point-of-care locations) or 1-3 days (tests sent to a laboratory for processing)
Is another test needed...	Not usually. This type of test is typically highly accurate and usually does not need to be repeated. Some may indicate the need to re-test in certain circumstances.	Maybe. Positive results are usually highly accurate, but false positives can happen, especially in areas where very few people have the virus. Negative results may need to be confirmed with a molecular test.	Sometimes a second antibody test is needed for accurate results.
What it shows...	Diagnoses active COVID-19 infections. Some tests may also diagnose influenza or other respiratory viruses.	Diagnoses active COVID-19 infection. Some tests may also diagnose influenza or other respiratory viruses.	Shows if you've been infected by the virus that causes COVID-19 in the past
What it can't do...	It cannot show if you ever had COVID-19 or were infected with the virus that causes COVID-19 in the past.	It may not detect an early COVID-19 infection. Your health care provider may order a molecular test if your antigen test shows a negative result, but you have symptoms of COVID-19. It also cannot show if you ever had COVID-19 or were	It cannot diagnose COVID-19 at the time of the test or show that you do not have COVID-19

2.7.1 India- Immunization Program

Universal Immunization Programme (UIP)

Immunization Programme in India was introduced in 1978 as 'Expanded Programme of Immunization' (EPI) by the Ministry of Health and Family Welfare, Government of India.

Vaccine Preventable Disease(VPD)	Vaccine
Tuberculosis	BCG (Bacillus Calmette Guerin)
Diphtheria, Pertussis, Tetanus	DPT
Poliomyelitis	Oral Polio Vaccine(OPV) and Inactivated Polio Vaccine(IPV)
Hepatitis B	Hepatitis B Vaccine
Measles	Measles
Tetanus	Tetanus Toxoid(TT)
Haemophilus influenzae type b Infection	Hib containing Pentavalent vaccine (DPT+HepB+Hib) (In Selected States)
Rotavirus Infections	Rotavirus Vaccine
Measles, Rubella	Measles-Rubella(MR) Vaccine
Japanese Encephalitis(JE)	Adult JE Vaccine

3. Nanotechnology

3.1 Introduction

- The term “**Nano Technology**” was first used by Tokyo Scientist “**Norio Taniguchi**” in 1974. But it was popularised by Dr. K. Eric Drexler in his famous book “**Engine of Creation: The coming Era of Nano Technology**” in 1980
- “Nanotechnology is the understanding and control of matter at dimensions between approximately **1 and 100 nanometres**, where unique phenomena enable novel applications.
- Nanotechnology is **highly interdisciplinary**, involving physics, chemistry, biology, materials science, and the full range of the engineering disciplines.

“Nano” is a Greek word which means 'dwarf' or 'very small', it indicates 1 billionth 10^{-9} (10) of something, e.g. 1 Nano meter = 1 billion of a meter

3.1.1 Working Principles of Nanotechnology

There are two principal reasons for qualitative differences in material behaviour at the nanoscale

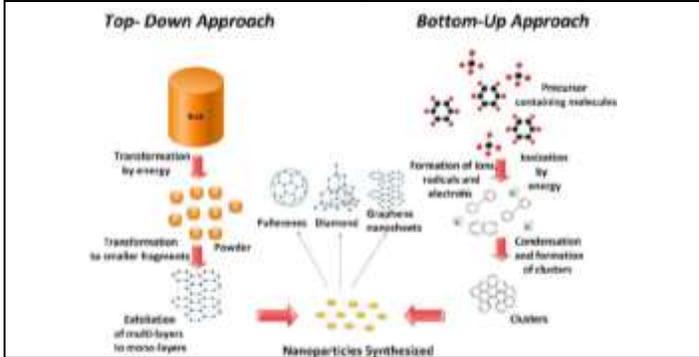
- Quantum mechanical effects** come into play at very small dimensions and lead to new physics and chemistry.
- Very large surface-to-volume ratio** of the structures at nanoscale.

For example, the reactivity of a metal catalyst particle generally increases appreciably as its size is reduced-**macroscopic gold is chemically inert**, whereas at **nanoscales gold** becomes extremely **reactive and catalytic** and even melts at a lower temperature.

3.2 Approaches of Nanotechnology – Two Types

Top-down Approach	Bottom-up Approach
The process of making nanostructures starting with larger structures and breaking away to	The building of nanostructures starting with small components such as atoms or

<p>nano size is called top-down approach. E.g. In some sense all, current microelectronics (like silicon chips) is fabricated using this approach.</p>	<p>molecules is called bottom-up approach. E.g. chemical synthesis of nanoparticles is a typical example of it; Carbon nanotubes built using Graphene</p>
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Comparison

- The **bottom-up approach is more advantageous** than the top-down approach because the former has a better chance of producing nanostructures with **less defects, cost efficient**, more homogenous chemical composition, and better short- and long-range ordering.
- Top-down typically provides **better control**, but is **limited to “countable”** number of structures.

3.3 Nanomaterials

- Particles or powders with particle size less than 100nm are called nanoparticles.

<p>Properties of Nanoparticles</p>	<ul style="list-style-type: none"> (i) As the particle size decreases, surface area increases. This enhances the catalytic activity of the nanoparticles. (ii) Reduction of particle size from micron to nanometre scale influences their optical properties. (iii) Reduction of particle size from micron to nanometre
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	<p>scale influences the thermal properties like melting point and thermal conductivity.</p>
<p>Uses of Nanoparticles</p>	<ul style="list-style-type: none"> (i) Silver nanoparticles have good antibacterial properties, and are used in surgical instruments, refrigerators etc. (ii) Gold nanoparticles are used in catalytic synthesis of silicon nano wires, sensors carrying the drugs and in the detection of tumors. (iii) ZnO nanoparticles are used in electronics, ultraviolet (UV) light emitters, piezoelectric devices and chemical sensors. (iv) TiO₂ nanoparticles are used as photocatalyst and sunscreen cosmetics (UV blocking pigment).

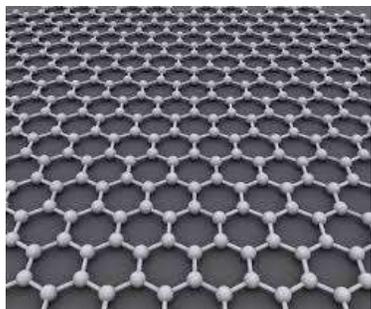
3.3.1 Classification of Nano materials

Classification based on the material involved	
Carbon-based nanomaterials	Metal-based nanomaterials
<p>In this type, as the name implies, carbon will be the basic component. Fullerenes, carbon nanotubes, graphene, etc., belongs to this class</p>	<p>The main component of these particles is metal. These nanomaterials include nanogold, nano silver, and metal oxides such as titanium dioxide, silica, alumina, etc.</p>

Based on the origin	
Natural nanomaterials	Synthetic or artificial nanomaterials:
Nanomaterials of natural origin, for example volcanic ash, insect wings, and opals, shells, corals, spider silk, etc.	These are synthesized using a well-defined protocol in the laboratory. Widely used nanomaterials fall under this category, for example, nanotubes, quantum dots, nanoparticles, etc.

3.4 Graphene

Graphene is a single layer of carbon packed in **hexagonal lattice** with 2D crystalline structure.



Graphene is composed of carbon atoms arranged in tightly bound hexagons and **just one atom thick**.

3.3.4 Properties

- Density $-0.77\text{mg}/\text{m}^2$
- Optical transparency-almost transparent as it absorbs only 2.3% of light intensity independent of wavelength in the optical domain. so it is approximately 98% transparent
- Strength-100 times stronger than steel
- Thermal conductivity-can conduct the heat 10 times better than Cu.

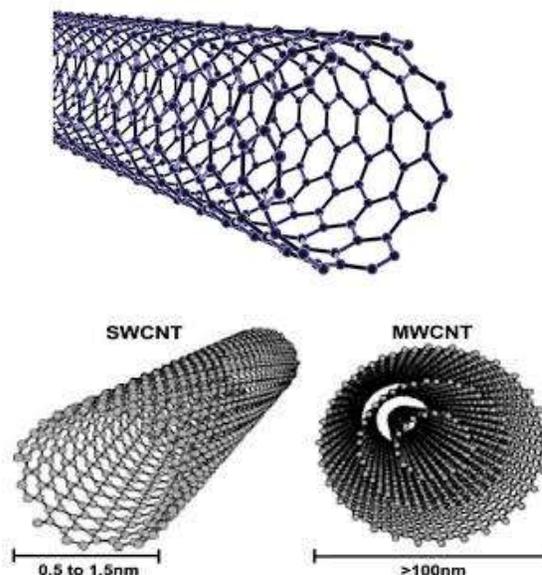
3.3.5 Applications

- Graphene transistors work faster than those made of silicon and their components are packed tightly on a chip and help make efficient computer and other IT devices

- Transparent conductors which are 1 atom thin are used in making touch screen light panels including flexible electronic devices.
- It will help make new super strong materials which are thin, elastic of light weight which can be used to make satellite, airplane.

3.5 Carbon Nanotubes (CNT)

CNT-Discovered by Japanese Sumio Iijimi in 1991. CNT is an individual graphene sheet rolled to form a cylindrical nanotube. it is hallow to form a cylindrical nanotube. It is hallow, tubular and a caged molecule.



3.5.1 Types

- Single walled Nano Tubes** -an individual graphene cylinder of about 0.5nm-2nm in diameter which can be bent into sharp turns and twisted, flattened without breaking.
- Multi walled Nano Tubes** - are collection of several concentric graphene cylinders with diameter greater than 100nm.

3.5.2 Properties

- Strength**- strongest and stiffest material on earth in terms of tensile strength. 100 times stronger yet 6 times lighter than steel.
- Electrical conductors**-can carry 100 times max electric current than an equivalent Cu and

silver wire. So are regarded as an ideal component for electrical circuit.

- c. Thermal conductivity**-are efficient thermal conductors even compared to copper and thermal stability is about 720°C in air.

3.6 Nano Sensors

It is a device that needs use of unique properties of nano materials and nano particles to detect and measure new type of events in the nanoscale.

- 1. Chemical Nano Sensors**- They are used to measure the magnitude such as the concentration of the given gas, the presence of specific type of a molecule or the molecular composition of a substance.
- 2. Bio Nano Sensors**- they are used to monitor biomolecules processes such as antibody antigen interaction. Usually compound of antibody and is able to detect bacteria to virus and even the cancer.

Nanocomposite materials –are materials created by introducing or adding graphene /CNT/carbon particles in the matrix of macroscopic sample material. The resulting nanocomposite may exhibit drastically enhanced properties for e.g. plastics could be made into electronic conductors if only 1% graphene is added into them which also increases the heat resistant including the mechanical robustness.

3.7 Nanomicelles

- Formed when amphiphilic molecules assemble themselves to create a globular structure
- Can be used for effective drug delivery
- They are amphiphilic, i.e. have a hydrophilic outer shell and a hydrophobic interior. This dual property makes them a perfect carrier for delivering drug molecules.
- Can be used to treat various cancers including breast, colon and lung cancer.

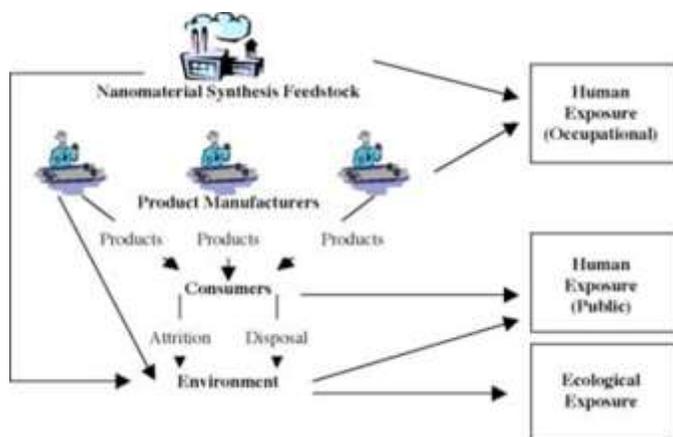
3.8 Applications of Nanotechnology

Field	Applications
Medicine	<ul style="list-style-type: none"> • Delivery of drugs (molecules) to the target. • Treatment and prosthetics using nanomaterials: to produce various implants and dentures. • Diagnostics: The development of nanotechnology in biomedicine • Magnetic nanomaterials are an important source for the production of biosensors. • Nanotech detectors for heart attack. • Nanopores are used in making DNA sequencing
Agriculture	<ul style="list-style-type: none"> • use of nano-nutrients can reduce nutrient run-off into ground water • Nano tubes can help in controlled irrigation system. • Helps to increase soil fertility through fertilizers and Nano biosensors • For Sustainable agricultural practices and increased productivity
Green Nanotechnology	<ul style="list-style-type: none"> • Use of the products of nanotechnology to enhance sustainability. • Producing nanomaterials and products without harming the environment or human health • Producing nano-products that provide solutions to environmental problems.

<p>IT and Electronics</p>	<ul style="list-style-type: none"> To make tiny transistor of CNT that help in developing nanocircuits. The use of CNT will strongly increase the density of hard disk Replacing cathode ray tube by CNT as an electron gun will lead to production of images with extremely high efficiency. 		<ul style="list-style-type: none"> Nanofibers with CNT are used to make strong bullet proof jackets.
<p>Automobile manufacturing</p>	<ul style="list-style-type: none"> Manufacturing strong yet lighter, ant scratch and rust proof automobile component. The increase in surface area to volume ratio in Auto Mobiles Engines will make them utilize fuel more efficiently 	<p>Space</p>	<ul style="list-style-type: none"> Lightweight spacecraft Can significantly reduce the amount of rocket fuel required
<p>Cleaner Water</p>	<ul style="list-style-type: none"> Nano membranes are used with the purpose of softening the water and removal of contaminants Useful in regards to remediation, desalination, filtration, purification and water treatment. Used to convert the contaminating chemical through a chemical reaction to make it harmless. Nano particles can be used to purify and rejuvenate contaminated ponds and lakes. 	<p>Fuels</p>	<ul style="list-style-type: none"> Production of fuels from normal raw materials more efficient.
<p>Textile Industry</p>	<ul style="list-style-type: none"> Nanofibers makes cloth water and stain repellent and even wrinkle free. 	<p>Chemical Sensors</p>	<ul style="list-style-type: none"> Sensors to detect very small amounts of chemical vapours and hence can avoid chemical disaster.
		<p>Solar Cells</p>	<ul style="list-style-type: none"> Nanotech solar cells can be manufactured at significantly lower cost than conventional solar cells.
		<p>Fuel Cells</p>	<ul style="list-style-type: none"> Used to reduce the cost of catalysts used in fuel cells to produce hydrogen ions from fuel such as methanol and to improve the efficiency of membranes used in fuel cells

3.9 Concerns with Nano Technology

3.9.1 On human health



- The extremely small size of nanomaterials can enter into human body easily.
- Because of their small size the tissues can easily absorb nano particles and it may affect the functions of that particular organ (like production of enzymes).
- Presently there are no regulations and safety measures for workers on nanoparticles.

3.9.2 Nanopollution- on Environment

- Nanopollution is a generic name for all waste generated by nanodevices or during the nanomaterials manufacturing process.
- Nanowaste is mainly the group of particles that are released into the environment, or the particles that are thrown away when still on their products.
- We don't know yet if certain nanoparticles will constitute a completely new class of non-biodegradable pollutant.

Nano Science and Technology Mission (NSTM)

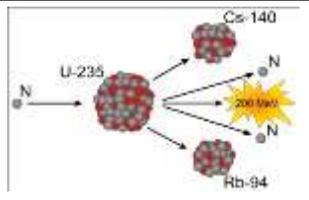
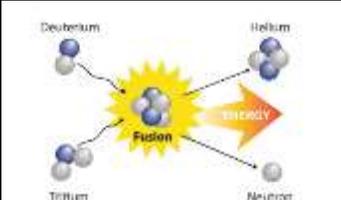
- Launched in 2007
- To promote research and development in nanotechnology.

4. Nuclear Science

4.1 Introduction

- Nuclear physics is the field of physics that studies atomic nuclei and their constituents and interactions.
- A nuclear reaction is considered to be the process in which two nuclear particles (two nuclei or a nucleus and a nucleon) interact to produce two or more nuclear particles or energy.

4.2 Types of Nuclear Reaction

Nuclear fission	Nuclear fusion
It is the splitting of nucleus into smaller nuclei	Two light nuclei combine to form a single heavier nucleus
Not common in nature	Common in nature e.g. sun and stars
It involves chain reaction	No chain reaction
May require high speed neutron	Require high temperature and high-pressure conditions
Produces high energy	Produces three to four times greater energy released by fission.
Fission produces many highly radioactive particles . Disposal is a problem	Few radioactive particles are produced by fusion reaction.
Takes little energy to split two atoms in a fission reaction.	Extremely high energy is required to bring two or more protons close enough that nuclear forces overcome their electrostatic repulsion .
Fission is used in nuclear power plants .	Fusion is an experimental technology for producing power.
Uranium is the primary fuel used in power plants.	Hydrogen isotopes (Deuterium and Tritium) are the primary fuel used in fusion power plants.
	

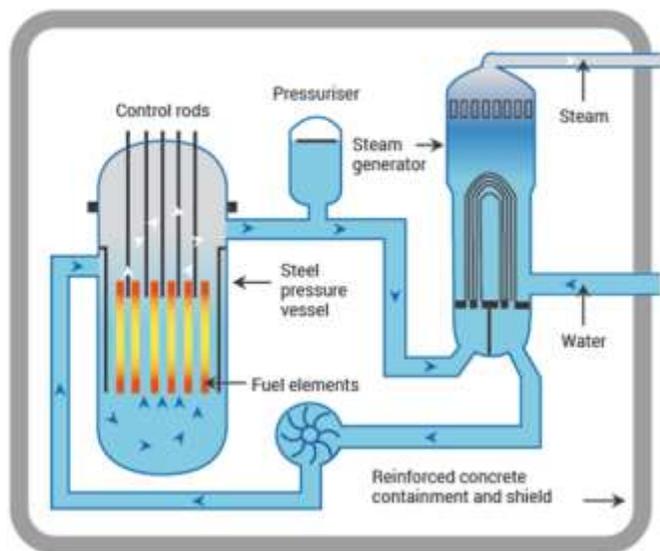
Nuclear Fuel/Fissile material

- It is material capable of sustaining a nuclear fission chain reaction.
- It has a very high chance of fission when bombarded with neutrons.
- It should release 2 or more neutrons under collision.
- It should have a reasonable half-life and is available in sustainable quantities.

e.g Uranium-233, Uranium-235, Plutonium-239, Plutonium-241

4.3 Nuclear Power Reactors (Fission Reactors)

A Pressurized Water Reactor (PWR)



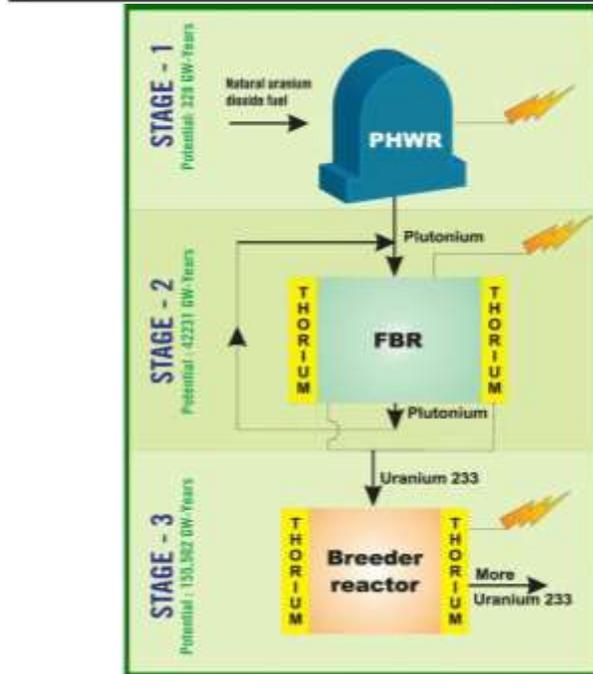
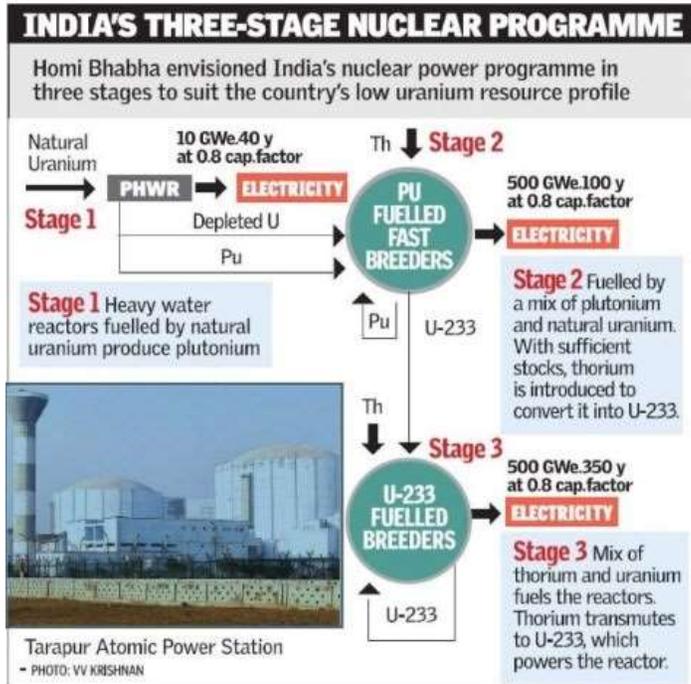
- When a neutron hits a nucleus of a radioactive atom (U-235, Plutonium-239), it triggers a breakup of that nucleus into two large pieces called fission fragments.
- In addition to the two large fragments, two neutrons are usually released which in turn hits the nucleus of other atoms in the reactor setting up what is called a **chain reaction**.
- The chain reaction of fission generates heat which is then used to move a turbine to produce electricity.

Components	Functions
Fuel	<ul style="list-style-type: none"> • Uranium is the basic fuel. Usually pellets of uranium oxide (UO₂) are arranged in tubes to form fuel rods. • Critical Mass- The minimum amount of uranium-235 atoms required to set up the chain reaction is called the critical mass.
Moderator	<ul style="list-style-type: none"> • It slows down the neutrons released from fission so that they cause more fission (hence avoids uncontrolled chain reaction). • It is usually water, but may be heavy water or graphite rods.
Control rods	These are made with neutron-absorbing material such as cadmium, hafnium or boron, and are inserted or withdrawn from the core to control the rate of reaction, or to halt it
Coolant	A fluid circulating through the core so as to transfer the heat from it. Water is coolant.
Heat Exchanger	Uses the heat from the reactor to convert water into steam
Containment System	<ul style="list-style-type: none"> • To protect the pressure vessel from outside intrusion and also to protect those outside from any radiations • Usually thick concrete or steel is used

4.3.1 India's Three-stage Nuclear Power Programme

- Formulated by Homi Bhabha in the 1950s to secure the country's long-term energy independence.

- To be achieved through the use of **uranium and thorium reserves** found in the **monazite sands** of coastal regions of **South India**.



Stage I-Pressurized Heavy Water Reactor [PHWR]

- Natural uranium fuelled PHWR produce electricity while generating plutonium-239 as by-product.

- Heavy water (deuterium oxide, D₂O) is used as moderator and coolant in PHWR

Stage II – Fast Breeder Reactor

- Based on plutonium
- FBRs would **use plutonium-239**, recovered by reprocessing spent fuel from the first stage, and **natural uranium**.
- In order to increase the probability of neutron hitting U₂₃₈, these reactors **do not use a moderator** to slow down neutrons and thus they are called FBR.
- Once the Plutonium-239 is completely used, Thorium is introduced in the reactor to convert it into U-233 that will be used in 3rd stage.

Stage III – Thorium Based Reactors

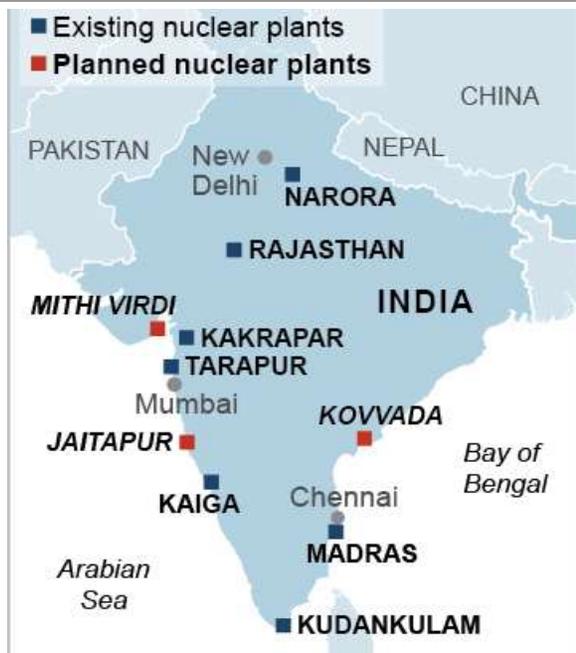
- Advanced nuclear power system involves a self-sustaining series of **thorium-232-uranium-233 fuelled reactors**.

4.3.2 Present State of India's Three-Stage Nuclear Power Programme

- After decades of operating pressurized heavy-water reactors (PHWR), India is finally ready to start the second stage.
- A 500 MW Prototype Fast Breeder Reactor (PFBR) at Kalpakkam is set to achieve criticality.
- However, India is yet to commercialise the FBRs

4.3.3 Nuclear Reactors in India

- Nuclear power in India delivers a total capacity of 6.7GW, contributing to just under 2% of the country's electricity supply.
- India's nuclear plants are controlled by Nuclear Power Corporation of India (NPCIL), a state-owned corporation which was founded in 1987.
- Currently India has 22 nuclear reactors operating in 7 plants generating about 6780 MW of power.



- India plans to build 48 new plants with a target of 63000MW of power by 2032.

1. Kudankulam Nuclear Power Plant, Tamil Nadu
2. Tarapur Nuclear Reactor, Maharashtra
3. Rajasthan Atomic Power Plant, Rajasthan
4. Kaiga Atomic Power Plant, Karnataka
5. Kalpakkam Nuclear Power Plant, Tamil Nadu
6. Narora Nuclear Reactor, Uttar Pradesh
7. Kakkrapar Atomic Power Plant, Gujarat

4.4 Nuclear Fusion Reactor

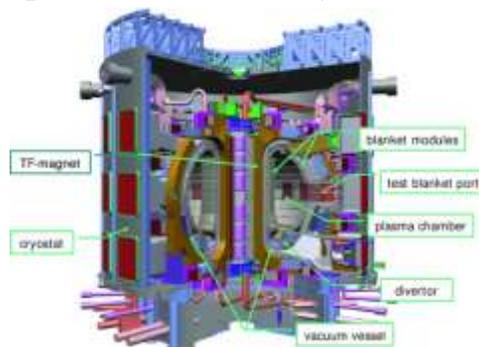
Nuclear fusion reactors are only under experimental stages.

4.4.1 Advantages

- Availability of abundant Hydrogen (which is used as fusion fuel), that can be extracted from water.
- Possibility of generation of low nuclear waste.
- Possibility of low nuclear radiation leaks.

However, they are not commercially viable when compared to nuclear fission reactors and hence lot of research is going on. One such is ITER

4.4.2 ITER (International Thermonuclear Experimental Reactor)



- ITER is a fusion reactor launched in 1985. located in Saint-Paul-les-Durance in **southern France**.
- ITER works on the basis of **Tokamak approach**.
- It is a joint collaboration of 35 countries with the following members China, the European Union, India, Japan, Korea, Russia and the United States.
- At such high temperatures, hydrogen gas is in plasma state (electron and nucleus are not bound) and thus difficult for ordinary containers to hold the hydrogen.
- Thus, under Tokamak approach magnets are used to which confines the hydrogen as long as the nuclei are in motion.
- As a result, this method is sometimes called **‘magnetic confinement’**
- ITER project is about 65% complete and is expected to be completed by 2025.

India and ITER

- India, by contributing to **about ten per cent of the cost**, gets access to one hundred per cent of technology.
- India has contributed the **biggest component in the project** – the **world’s largest refrigerator** that houses this unique reactor, was made in Gujarat by Larsen & Toubro.
- It weighs over 3800 tonnes and is almost half the height of the Qutb Minar.

4.4.3 Cold Fusion

- Cold Fusion is a hypothesized type of nuclear reaction that would occur at, or near, room temperature
- also called Low Energy Nuclear Reaction (LENR)
- Interaction of hydrogen or deuterium gas with metals such as palladium, Zirconium, Nickel is claimed to set off a nuclear reaction at low temperature releasing energy.

Advantages

- Cold fusion seeks to produce nuclear energy without harmful radiation, complex equipment and the application of very high temperatures and pressures.
- It has garnered attention as a way to produce clean energy.

4.5 Miscellaneous in short

Topic	Details
Akademik Lomonosov	<ul style="list-style-type: none"> • World's First Floating Nuclear Power Plant becomes operational in Russia • It will be primarily used to power oil rigs in remote areas of Arctic region where Russia is pushing to drill for oil and gas.
Six Light Water Reactors in Kovvada, Andhra Pradesh	<ul style="list-style-type: none"> • India and USA have agreed to set up the long-pending 6 nuclear reactors in Kovvada, AP. • NPCIL will be responsible for construction and operation of the plant.
Rooppur Nuclear Power Project	<ul style="list-style-type: none"> • India and Bangladesh have signed a Civil Nuclear Cooperation Agreement. • Rooppur Nuclear Power Project is the collaboration

	between the India, Russia and Bangladesh
Kakrapar atomic Power plant, Gujarat	<ul style="list-style-type: none"> • Third unit at KAAP-3 has achieved criticality
Kaiga Atomic Power Station	<ul style="list-style-type: none"> • The Kaiga Atomic Power Station of Karnataka has created a new world record, with one of its units functioning continuously without any interruption for more than 940 days. • Operated by the Nuclear Power Corporation of India.
Prototype Fast Breeder Reactor (PFBR) at Kalpakkam	<ul style="list-style-type: none"> • India's first indigenously developed 500-megawatt (mw) Prototype Fast Breeder Reactor (PFBR) at Kalpakkam in Tamil Nadu has achieved criticality in 2019. • It comes under second stage of India's three-stage nuclear power programme. • Fuel - mixed uranium-plutonium MOX (a mixture of PuO₂ and UO₂.)
Criticality of Nuclear Reactor	<ul style="list-style-type: none"> • It is event of nuclear reactor reaching self-sustained chain reaction. • This means that no external source of neutrons is required to sustain fission in reactor core. • It is precondition of producing useful amounts of energy from the reactor.

5. Defence

5.1 Introduction

5.1.1 India's Defence Policy

The two major objectives of India's Defence policy are:

- Promotion and sustenance of peace in the country
- To develop and maintain adequate Defence infrastructure so as to prepare an adequate safeguard against any aggression.

5.1.2 Defence Research and Development Organization (DRDO)

- **DRDO** is the nodal agency for conducting Defence research in India.
- It was established in **1958**.
- It works under Department of Defence Research and Development of Ministry of Defence.
- DRDO is headed by Scientific Advisor to Defence Minister
- DRDO has established its missile testing range at **Chandipur on Sea**, in **Balasore district** of Orissa.
- Another missile testing site of DRDO is **Wheeler Island** at **Dhamra** in **Bhadrak district** of Orissa.

5.2 Integrated Guided Missiles Development Programme

- Launched by DRDO in **July 27, 1983**
- For the development of 5 different missiles (PATNA)
- All the missiles have been successfully tested.
- The first of these 5 missiles to be tested was "**Trishul**", in 1985 followed by **Agni**, **Prithvi**, **Akash** and **Nag**.
- **Prithvi** is India's first indigenously built ballistic missile.

Types of Missiles

Basis	Classification
According to the Distance Covered / Range	<ol style="list-style-type: none"> 1. Short range: Less than 500 km for e.g., Prithvi I, II and III of India 2. Medium range or intermediate range: Between 500 to 5000 km for e.g. Agni I, II and III of India 3. Long range or intercontinental range: above 5000 km for e.g. Surya of India. <ul style="list-style-type: none"> • Short range and medium range missiles are also called Tactical missiles i.e. weapons used against the enemy forces at shorts range. • Long ranges missiles are also called Strategic missiles i.e. missiles directed against the interior of the enemy's country rather than used in battlefield.
According to the Launch point and the nature of the Target	<ol style="list-style-type: none"> a) Surface to Surface: Prithvi, Agni b) Surface to Air: Akash, Trishul c) Air to Air: Astra
According to the Launch point and the nature of the Target	<ol style="list-style-type: none"> a) Ballistic missiles <ul style="list-style-type: none"> • Are those which make use of their own propulsion to travel through the atmosphere, enter the outer space and re-enter the earth's atmosphere and fall to the surface of the ground largely by

making use of the gravitational pull.

- Can be launched from land and sea-based systems.
- Long ranges upto 1000 km (Agni V- 5000 km)

b) **Cruise missiles**

- Guided unmanned missiles and are used against the targets within atmosphere (i.e., terrestrial targets).
- These missiles are less prone to radar detection.
- They are low level flights which can be launched from land, air and water.
- Short ranges of 300 to 1000 km (Brahmos- 290 to 450 km)
- CMs when fired by a submarine are known as Sea skimming e.g. Klub Missile of Russia, BrahMos of Russia and India.

			missiles under IGMDP
Prithvi II	350 km	500 kg	<ul style="list-style-type: none"> • Airforce version • Single stage-liquid propellant
Prithvi III	350 km	1000 kg	<ul style="list-style-type: none"> • Two stage-solid and liquid propellant.
Dhanush	350 km	1000 kg	<ul style="list-style-type: none"> • Naval version of Prithvi III
Shaurya	600-700 km	1000 kg	<ul style="list-style-type: none"> • Hypersonic canister launched • Both conventional and nuclear warheads. • Both Ballistic and Cruise. • Provides India with a significant second-strike capability.
Prahaar	150 km	250 kg	<ul style="list-style-type: none"> • To replace Prithvi I. • Single stage solid propellant.
Pranash (und)	200 km		<ul style="list-style-type: none"> • Used by Air force and Army. • Single stage solid propellant engine.
Agni I	700-900 km	1000 kg	<ul style="list-style-type: none"> • Single stage solid propellant. • Conventional and Nuclear warhead.

5.2.1 Ballistic Missiles

Surface to Surface missile

Short Range Ballistic Missile

Name	Range	Weapon Payload	Characteristics
Prithvi- I	150 km	1000 kg	<ul style="list-style-type: none"> • Indigenously built Army version nuclear capable missile. • Single stage-liquid propellant • First of the five

Intermediate Range Ballistic Missile			
Name	Range	Weapon Payload	Characteristics
Agni II	2,000-3,500 km	1000 kg	<ul style="list-style-type: none"> 2 stage solid propellant. Conventional and Nuclear warhead.
Agni III	3,000-5,000 km	2000 – 2500 kg	<ul style="list-style-type: none"> 2 stage solid propulsion system Conventional, Thermobaric and Nuclear warhead.
Agni IV	3,500-4,000 km	1000 kg	<ul style="list-style-type: none"> 2 stage solid propulsion. Conventional, Thermobaric and Nuclear warhead.

Intercontinental Ballistic Missile			
Name	Range	Weapon Payload	Characteristics
Agni V	5,500 km	1500 kg	<ul style="list-style-type: none"> 3 stage solid propellants. Nuclear warhead. Multiple Independent Targetable Re-entry Vehicle (MIRV)
Agni VI	11,000-12,000 km	1000 kg	<ul style="list-style-type: none"> Nuclear warhead. 10 MIRV warheads.
SURYA	12,000-16,000 km	3000 kg	<ul style="list-style-type: none"> Developed by India. 3- 10 MIRV warheads

Submarine Launched Ballistic Missile			
Name	Range	Weapon Payload	Characteristics
SAGARIKA	750	1,000	<ul style="list-style-type: none"> Replica of Land based

or K- 15	km	kg	SHAURYA Missile. <ul style="list-style-type: none"> Short range Nuclear capable Ballistic missile. Gets help from Indian Regional Navigation Satellite System. Faster than Agni missiles.
K- 4	3,500 km	1,000 kg	<ul style="list-style-type: none"> Nuclear-capable underwater missile. Launch Pad: Arihant class submarines. Submarine version of Agni III. It is a solid fuelled missile launched underwater capable of withstanding 50 N of water resistance.
K-5 (under development)	5,000 km		<ul style="list-style-type: none"> Launch Pad: Arihant class submarines
k-6 (under development)	6,000 km		<ul style="list-style-type: none"> Intercontinental Submarine launched Ballistic Missile. Launch Pad: Arihant and Arighat class submarines.



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Surface-to-Air (short range) Missiles

Name	Range	Weapon Payload	Characteristics
Trishul	9- 12 km	5 kg	<ul style="list-style-type: none"> Short range low level surface-to-air missile. First missile under IGMDP, to be tested (1985). Due to technical complexities, it could not be deployed.
BARAK- 8	70- 100 km	60 kg	<ul style="list-style-type: none"> India- Israeli medium range surface-to-air missile. Maximum speed of Mach 2. Part of naval air defence system. Both maritime and land- based variants of the system exist.
AKASH	30 km	50 kg	<ul style="list-style-type: none"> Supersonic speed-Mach 2.5. Medium range surface-to-air missile. Part of Air defence system. It can simultaneously engage multiple targets in autonomous mode. It has built in Electronic Counter-Counter Measures (ECCM) features. Indigenous seeker technology.
MAITRI	25-30 km	10 kg	<ul style="list-style-type: none"> Quick Reaction Surface-to-Air Missile (QRSAM). Most effective in combating low flying Aerial targets. Capable of striking targets on the move. Altitudes range from 30 m to 6 km. RF (Radio Frequency) seeker as a part of terminal guidance to hit the target. Capable of multiple target engagement. It is equipped with electronic counter measures against the aircraft jammers to deceive enemy radar.
REVATI	25- 30 km	10 kg	<ul style="list-style-type: none"> Naval version of MAITRI
ROHINI	25- 30 km	10 kg	<ul style="list-style-type: none"> Air Force version of MAITRI.
IGLA-S	Range- 6km,		<ul style="list-style-type: none"> Russia's Very Short-Range Air

	Altitude- 3km		Defence Systems (VSHORAD). <ul style="list-style-type: none"> Man – Portable Shoulder launched Air Defence System.
Vertical Launch Short Range Surface to Air missile (VL-SRSAM)	(under trails)		<ul style="list-style-type: none"> Indigenously developed and designed by DRDO. VL-SRSAM is meant for neutralizing various aerial threats at close ranges including sea-skimming targets.
Medium Range Surface to Air Missile (MRSAM)			<ul style="list-style-type: none"> Jointly developed by DRDO and the Israel Aerospace Industries. MRSAM is a one command control system that track missiles, radar and mobile launcher systems.

Air-to-Air Missile	
Name	Characteristics
ASTRA	<ul style="list-style-type: none"> Beyond Visual Range Air to Air Missile (BVRAAM). First Air-to-Air Missile developed by India. Capable of engaging targets at varying range and altitudes. Single stage, solid fuelled missile and can carry a conventional warhead of kg.

Anti-Tank Guided Missile			
Name	Range	Weapon Load	Characteristics
NAG	3-7 km	8 kg	<ul style="list-style-type: none"> Fire and forget capability. Imaging Infrared guidance with day and night capability. Different Variants: <ul style="list-style-type: none"> Mounted on an infantry combat vehicle: NAMICA (Nag Missile Carrier). Man, portable shoulder carrier. HELINA (Helicopter Launched Nag): Rudra Helicopter, Dhruv and LCH

HELINA	7 km	8 kg	Helicopter launched Nag
SPIKE			<ul style="list-style-type: none"> Israeli 4th generation anti-tank guided missile Fire and forget capability. Can change the target mid-flight as a result of dual-seeker. Better than NAG because NAG is facing seeker issues especially if the temperature of the target is high.
MILAN			<ul style="list-style-type: none"> Portable medium-range, anti-tank guided missile for the Army. To be acquired from France
SPICE 2000			<ul style="list-style-type: none"> Israeli guided bombs for Indian Air Force.

5.2.2 Cruise Missiles

Based on speed Cruise Missiles are classified into:

Subsonic:	Supersonic:	Hypersonic:
These missiles travel at the speed of less than 1 Mach number, less than the speed of sound. Example: Nirbhay	These missiles travel at the speed between 2-3 Mach number. Example: Brahmos	These missiles travel at a speed more than 5 Mach number. Example: Brahmos II (under development)

Mach number: It is the ratio of the speed of a body to the speed of sound in the surrounding medium.

Name	Range	Weapon Load	Characteristics
NIRBHAY	750-1000 km	500 kg	<ul style="list-style-type: none"> Subsonic Cruise Missile. 1st indigenously developed long range cruise missile flying at low altitudes. Can fly at tree-top altitudes as low as 10m. Speed: Mach 0.7 As a result, it has terrain-hugging capability and sea-skimming capability and thus go undetected by enemy radars 2 stage solid fuelled cruise missile.

BRAHMOS	290 km	300 kg	<ul style="list-style-type: none"> Supersonic Cruise Missile. Joint venture missile between India and Russia. Speed: Mach 2.8. After India became a full member to MTCR export control regime, the range of BrahMos has increased from 300 km to 450 km. Fire and forget capability. Capable of being launched from air, land and water.
BrahMos NG			Low weight air-launched version capable of being carried by Light Combat Aircraft, Tejas LCA.
Brahmos II	290 km	300 kg	<ul style="list-style-type: none"> Hypersonic Speed: Mach 6

5.3 India's Missile Defence System

Name	Brief
Ballistic Missile Defence System	<ul style="list-style-type: none"> It is an initiative to protect India from ballistic missile attacks and to develop and deploy multi-layered ballistic missile defence system Introduced in light of the ballistic missile threat from Pakistan, and China

	<ul style="list-style-type: none"> It is a double-tiered system consisting of two land and sea-based interceptor missiles <ul style="list-style-type: none"> The Prithvi Air Defence (PAD) missile for high altitude interception, and The Advanced Air Defence (AAD) Missile for lower altitude interception. 		<ul style="list-style-type: none"> The Akash system is fully mobile and capable of protecting a moving convoy of vehicles. It is in operational service with the Indian Army and the Indian Air Force.
Multi-Layered Air Defence System: S-400	<ul style="list-style-type: none"> The S-400 Triumf is a mobile, long range surface-to-air missile system (SAM) designed by Russia. Alternatives: THAAD (US developed Terminal High Altitude Area Defence System). It can intercept all types of aerial targets including aircraft, unmanned aerial vehicles (UAV), and ballistic and cruise missiles up to the range of 400 km, at an altitude of up to 30 km. Capable of firing three types of missiles to create a layered defence. Note: US offers THAAD missiles to India as an alternative to S-400. 	Multi Layered Air Defence System For Delhi	<ul style="list-style-type: none"> India is developing multi-layered air defence system for its cities besides air defence system for tactical battle areas. 1st Layer: -tier Ballistic Missile Defence System. 2nd Layer: S-400 Layered Defence System 3rd Layer: Barak-8 Long and Medium range SAM. 4th Layer: Akash Medium range Surface-to-Air Missile System 5th Layer: NASAMS 2
Barak-8 Long and Medium Range Surface-To-Air Missile (LRSAM).	<ul style="list-style-type: none"> Indo-Israeli surface-to-air missile Provides a 360-degree defence against various airborne threats. It can engage multiple targets at the same time during day and night in all weather conditions. Both maritime and land-based variants of the system exist. 	Nasams-2	<ul style="list-style-type: none"> India is acquiring NASAMA-2 from US. It will form the inner most layer of Delhi Area Air Defence Plan that has been conceived of. It renders quick reaction 3-dimensional protection at low altitudes of 21 km to various types of aerial threats ranging from drones to ballistic missiles. It will be deployed to protect vital and people in the NCR of Delhi including President's house, Parliament et.,
AKASH Medium Range Surface-To-Air Missile	<ul style="list-style-type: none"> Can target aircraft upto 30 km away, at altitudes upto 18,000 m. It has capability to neutralize aerial targets like fighter jets, cruise missiles and air-to-surface missiles as well as ballistic missiles. 		

5.4 India's Artillery Weapon System

- In the aftermath of the Kargil War of 1999 India announced **its Artillery Rationalisation Programme**.
- The categories of artillery systems include:
 - Long-range guns of towed variety
 - Self-propelled guns mounted on a high-mobility vehicle (K9 Vajra).
 - Light howitzers for difficult mountainous terrains (M777 howitzers).

Name	Brief
Dhanush	<ul style="list-style-type: none"> 1st indigenously produced long-range artillery gun (1mm 4 caliber). 2 varieties: towed and self-propelled gun system variety
K9 Vajra T Guns	<ul style="list-style-type: none"> South Korean long-range gun in the self-propelled mounted gun category 1st ever artillery gun that will be manufactured by private sector in India with L & T India manufacturing 90 of them.
M777 Ultra Light Howitzers	<ul style="list-style-type: none"> Towed medium artillery gun. Light artillery guns with a weight of 4 tonnes. Capable of being air lifted by chinook helicopters.
Sharang	<ul style="list-style-type: none"> Indigenous Artillery Gun. Range: increased from 12 km to 39 km
Advanced Towed Artillery Gun System	<ul style="list-style-type: none"> It is capable of firing at both low angle like a gun and high angle World's only gun with a six-round automated magazine. India's Artillery Combat Command and Control System is named 'SHAKTI'.

5.5 India's Infantry Weapon System

Name	Brief
AK-203	<ul style="list-style-type: none"> 3-generation upgraded modern variant of the AK-47 assault rifle. India will be manufacturing AK 203 in UP in a JV with Russia.
Sig Sauer 716 Assault Rifles	<ul style="list-style-type: none"> Replacement for ageing INSAS Rifles Automatic rifles that are gas-operated.
Carbines	A weapon that has a barrel shorter than rifle

5.6 Aircrafts

Name	Brief
SARAS	<ul style="list-style-type: none"> India's first indigenously designed and developed Light weight civilian passenger aircraft with some defence role. Developed by National Aerospace Laboratory, Bangalore
Advanced Jet Trainer- Hawk	<ul style="list-style-type: none"> British, single engine, advanced jet trainer aircraft. Powered by Rolls Royce MK 871 turbo fan engine.
Unmanned Air Vehicle (UAV)	Nishant Rustom
Air-Borne Warning & Control System (AWACS)	<ul style="list-style-type: none"> Airborne Early Warning and Control (AEW&C) is an Air Borne radar picket system. It is designed to detect aircraft, ships and vehicles at long ranges and perform command and control of the battlespace
Advanced Light Helicopter (ALH)	Dhruv, Apache, Boeing Ch-47 Chinook, P-8a Poseion

5.7 The Aircraft Carriers

1. INS VIKRANT <ul style="list-style-type: none"> 1st aircraft carrier of India. It was decommissioned in 1997 after serving for 37 years. 	4 INS VIKRANT (IAC-1) India's 1 st indigenous aircraft carrier is set to be inducted to Indian Navy by 2022.
2. INS VIRAT <ul style="list-style-type: none"> 2nd and the longest aircraft carrier of India It was decommissioned in 2017 after serving for 6 years (26 years as HMS Hermes and 30 years as INS Virat) 	5 INS VISHAL India's 2 nd indigenous (planned) aircraft carrier to be built in India after INS Vikrant.

3. INS VIKRAMADITYA

- India and Russia signed \$1.5 billion for the acquisition of the warship INS Vikramaditya inducted to the Indian Navy in 2013.
- It is the only aircraft carrier of Indian Navy in operation.

5.8 Submarine Arm of India**Conventional Submarines of India****PROJECT 75- I**

- **6 Scorpene class submarines** are being constructed with Transfer of Technology from France.
 - They will be the core of India's conventional attack submarines.
- 6 submarines of Project 7-I
1. **INS KALVARI- inducted in 2017**
 2. **INS KANDHERI- inducted in 2019**
 3. **INS KARANJ- inducted in 2021**
 4. **INS VELA- to be launched for trails in 2019**
 5. **INS VAGIR- being manufactured and assembled**
 6. **INS VAGSHEER- being manufactured and assembled**

Nuclear-Powered Submarines**Submersible Ship Nuclear (SSN)**

- An SSN is a nuclear-powered general-purpose attack submarine.
- Propelled by nuclear power.
- Capable of launching conventional weapons, torpedoes and cruise missiles.

Submersible Ship Ballistic Missile Nuclear (SSBN)

- Propelled by nuclear power.
- Equipped with nuclear weapon ballistic missile.
- Used as deterrents and attack submarines.

SSN FLEET

- **CHAKRA I**
 - 1st **nuclear powered cruise missile submarine.**
- **CHAKRA II**
 - It was inducted in 2012.
 - INS Chakra can stay underwater as long as it wants.
 - It is an Akula Class Submarine and can carry conventional weapons.
 - Noise levels net to zero.
- **CHAKRA III**
 - India signed a deal with Russia for leasing of a nuclear-powered attack submarine for the Indian Navy for a period of 10 years.
 - Powered by 190 MW nuclear power.

SSBN FLEET

- **ARIHANT**
 - India's **first nuclear ballistic missile submarine.**
 - Under the **Advanced Technology Vehicle (ATV) Programme, India has indigenously built.**
 - INS Arihant (SSBN 80) designated S2 Strategic Strike Nuclear Submarine.
- **ARIGHANT**
 - 2nd **nuclear powered ballistic missile submarine** being built by India.
 - Built under ATV project.
 - It as the code name S3.
 - Expected to be commissioned in 2021.

Anti-Submarine Warfare

INS KAVARATTI

- The INS Kavaatti is one of the four indigenously built anti-submarine warfare stealth corvettes under **Project 28**.
- Commissioned into Indian Navy in 2020.
- Other warfare corvettes are:
 - INS Kamorta-commissioned in 2014
 - INS Kadmatt- commissioned in 2016
 - INS Kiltan- commissioned in 2017

5.9 Important Fighter Jets of India

Name	Characteristics
Tejas LCA (Tejas Light Combat Aircraft)	<ul style="list-style-type: none"> • 4th generation supersonic, single-seat multirole light fighter aircraft. • To replace the Russia-made MIG 21 of the Indian Air Force. • Designed and developed by the Aeronautical Development Agency.
MIG 29	<ul style="list-style-type: none"> • India's premier Air Defence Fighter aircraft. • Light weight air-superiority fighter aircraft developed by Russia. • Twin Engine Jet Fighter inducted in 1985.
SUKHOI-30 MKI	<ul style="list-style-type: none"> • Multirole Combat Fighter Aircraft. • Jointly developed by Russia and India. • Heavy, all-weather and long-range fighter. • Capable of launching up to 6 air-to-air, 6 air-to-surface missiles, 6 laser guided bombs and 850 kg of cluster bombs.
Rafale	<ul style="list-style-type: none"> • Twin-engine medium multirole combat aircraft. • Manufactured by French company Dassault Aviation. • Can carry weapons more than 9 tonnes including air-air, air-ground and air-ship missiles. • Main mission includes air-

	<p>defence/ air-superiority, reconnaissance, close air support dynamic targeting, air-to-ground precision strike/ interdiction, anti-ship attacks, and nuclear deterrence.</p> <ul style="list-style-type: none"> • Weapon systems include SCALP and METEOR missiles. <ul style="list-style-type: none"> ○ SCALP: a precision long range ground attack missile that can take out targets with extreme accuracy. Has a range of 300 km, capped by the missile technology control regime. ○ METEOR: a beyond visual range air to air missile that is possibly the best in its class.
US-2 Amphibious Aircraft	<ul style="list-style-type: none"> • Japanese amphibious aircraft that India is keen to import. • Can land on either land or water.

5.10 Recent steps of Government

Policy	Details
Draft Defence Production and Export Promotion Policy, 2020	<p>By Ministry of Defence</p> <p>Key Guidelines</p> <ol style="list-style-type: none"> 1. Procurement changes include a project management unit to support the procurement process and promote contract management

	<ol style="list-style-type: none"> 2. An evaluation of the Technology Readiness Level (TRL) standards will be provided by a Technology Assessment Cell (TAC). 3. Support for MSMEs/Start-ups to set up an industry-interface indigenization platform and to establish a Defense Investor Cell in the Department of Defence Development. 4. Investments will be encouraged to concentrate explicitly on certain segments and technical areas defined, such as Aero Engines Complex, Maintenance Repair & Overhaul (MRO) development and Essential Technologies & Materials. 		<p>procurement contracts for the armed forces.</p> <ol style="list-style-type: none"> 2. Notify a list of Weapons/Platforms for Import Ban 3. For Imported Spares Indigenisation: <ul style="list-style-type: none"> • New Buy Category (Global-Manufacture in India): to enable international original equipment manufacturers (OEMs) to create 'manufacturing or maintenance entities.' • Request for Information (RFI): RFI stage will examine the ability of prospective foreign suppliers to gradually produce and set up an indigenous ecosystem at the level of spares/sub components. • Reservation in Categories for Indian Vendors: 4. Procurement Mechanism for Time Bound Security, Quicker Decision Making and Business Ease: <ul style="list-style-type: none"> • Setting up the Project Management Unit (PMU) • Simplification of trial procedures • single-stage AoN (Acceptance of Necessity) agreement 				
<p>Draft Defence Production and Export Promotion Policy, 2020</p>	<ul style="list-style-type: none"> • Defence Ministry unveiled DAP • DAP has been aligned with the vision of the 'Aatmanirbhar Bharat' (self-reliant India). • It will replace the 2016 Defence Procurement Protocol (DPP). • As per Apurva Chandra Committee recommendations. <p>Key Highlights of The Policy</p> <ol style="list-style-type: none"> 1. Revised offset policy: Eliminating the inter-governmental agreement (IGA) offset provision, government-to-government security agreements, and single-seller weapons and military platforms 		<p>5.11 Miscellaneous in Short</p> <table border="1"> <thead> <tr> <th data-bbox="846 1759 1127 1808">Topic</th> <th data-bbox="1127 1759 1539 1808">Details</th> </tr> </thead> <tbody> <tr> <td data-bbox="846 1808 1127 1938">Permanent Commission and Command</td> <td data-bbox="1127 1808 1539 1938"> <ul style="list-style-type: none"> • Ministry of Defence versus Babita Punia and Others case (2011-2020) </td> </tr> </tbody> </table>	Topic	Details	Permanent Commission and Command	<ul style="list-style-type: none"> • Ministry of Defence versus Babita Punia and Others case (2011-2020)
Topic	Details						
Permanent Commission and Command	<ul style="list-style-type: none"> • Ministry of Defence versus Babita Punia and Others case (2011-2020) 						

Positions to Women Army Officers:	<ul style="list-style-type: none"> • SC allowed permanent commission (PC) status to women officers in Short Service Commission (SSC) in the Indian armed forces and making them eligible for command positions. 		to a Service Chief. <ul style="list-style-type: none"> • Defence minister's chief military advisor • CDS will not exert any military order • permanent chairman of the CoSC (Chiefs of Staff Committee)
Anti-Satellite (A-SAT) Technologies	<ul style="list-style-type: none"> • Anti-Satellite technology is a counter-space capability of a country to neutralize space-based assets of enemy country. Mission Shakti: <ul style="list-style-type: none"> • Mission Shakti is a joint programme of the DRDO and the ISRO. • As part of the mission, an A-SAT weapon was launched and targeted an Indian satellite in the low earth orbit (Microsat R-Military imaging satellite) which had been decommissioned. • India became the 4th country to conduct an A-SAT missile test after USA, Russia and China. 	Pinaka Missile System	<ul style="list-style-type: none"> • An indigenously developed rocket system • first used in the battlefield during the Kargil War, 1999.
Chief of Defence Staff (CDS)	<ul style="list-style-type: none"> • Ministry of Defence (MoD) created the post • Gen. Bipin Rawat – first CDS • First proposed by Kargil Review Committee (KRC) • Shekatkar Committee - 2016 report, also gave opinions • About CDS • Rank of a four-star General with salary and perquisites equivalent 	Missile Park ‘Agneeprastha’	<ul style="list-style-type: none"> • missile park of the eastern naval command of the Indian Navy. Laid at Vizag.
		CoBRA	<ul style="list-style-type: none"> • Commando Battalion for Resolute Action • special operational unit of the CRPF • Deployed in the anti-Naxal operations grid of India.
		Global Firepower Index, 2021	<ul style="list-style-type: none"> • Out of 13 countries India ranked 4th in the index. • US topped the Index.
		Varunastra- heavy weight Torpedo	<ul style="list-style-type: none"> • Launched by DRDO • It is a ship launched electrically propelled heavyweight anti-submarine torpedo that is capable of targeting quiet submarines.
		RUDRAM	<ul style="list-style-type: none"> • 1st indigenous anti-radiation missile • Developed by DRDO. • To kill enemy radar. • This is twice the speed of the sound.

5.12 Military Exercises

Joint Exercises		
Name	Participant countries	Details
MILAN	Mostly Indian Ocean Region countries, South East Asian Countries	Multi-lateral Naval Exercise
MILEX	BIMSTEC	
MALABAR	India, US, Australia and Japan	Multilateral naval exercise
Tiger-Triumph	India-US	First Tri-service exercise
Ex Cope India	India-US	Air Force
Vajra Prahaar	India-US	Joint Military exercise
Ajeya Warrior	India-UK	Joint military
Nomadic Elephant	India-Mongolia	Joint military exercise
Ekuverin	Indian Army-Maldives	Joint military exercise
Sampriti	Indo-Bangladesh	Joint military exercise
Bongosagar	India-Bangladesh	Mega military exercise-navy
Sundarban Maitri	Indo-Bangladesh	Navy
Mitra Shakti	Indo-Sri Lanka	Army
Slinex	Indo-Sri Lanka	Navy
Ausindex	Indo-Australia	Naval

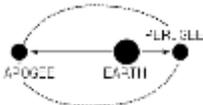
Hand in Hand	Indo-China	Joint military
Desert Eagle	India-UAE	Air Force
Gulf Star	India-UAE	Naval
KAZIND	India-Kazakhstan	Joint Military
KHANJAR	India-Kyrgyzstan	Joint training exercise
INDRA	India-Russia	Joint military
AVIANINDRA	India-Russia	Air Force
SIMBEX	India-Singapore	Navy
MAITREE	India-Thailand	Joint military
CORPET	India-Thailand	Navy
Samudra Lakshmana	India-Malaysia	Navy
Garuda Shakti	India-Indonesia	Military exercise
PASSEX	India-Indonesia	Navy
Varuna	India-France	Navy
Shakti	India-France	Army
Garuda	India-France	Air Force
Ex-Desert Knight 21	India-France	Bilateral air exercise
Shinyuu Maitri	India-Japan	Airforce
Dharma Guardian	India-Japan	Army
JIMEX	India-Japan	Maitime exercise
AFINDEX	India-Africa	Army

6. Space Technology

Technology for use in travel or activities beyond Earth's atmosphere, for purposes such as spaceflight or space exploration. It includes space vehicles such as spacecraft, satellites, space stations and orbital launch vehicles

6.1 Few Basic Concepts and Terminologies

Topic	Meaning/Details
Space	It is a 3-dimensional region that begins where the earth's atmosphere ends.
Microgravity	<ul style="list-style-type: none"> • Gravity is the force exerted by an object on the other object. It is proportional to the mass of the object. • In Space, gravity conditions vary as one move from one body to another. • Microgravity is the condition of less gravity/low gravity situation in the space. • Astronauts are trained and equipped to withstand the microgravity conditions.
Satellite	<ul style="list-style-type: none"> • A Satellite is a body that revolves around another object. A Satellite can be either Manmade (Ex: Astrosat) or Natural (Moon).
Space Craft	<ul style="list-style-type: none"> • Space craft is an artificial object made to revolve around another Planet or Planets other than Earth. Ex: Chandrayn 1, 2, MOM; Voyager-1,2, etc.
Rocket	<ul style="list-style-type: none"> • A rocket is a vehicle that is used to provide thrust for an object. It can be used as a missile or a launch vehicle. It

	consists of - fuel & oxidizer, together called as propellant and the engine.
Launch Vehicle	<ul style="list-style-type: none"> • Launch vehicle is a type of rocket that is used to place satellites or spacecrafts into the Space. • Ex: PSLV, GSLV, GSLV MK III
Telescope	<ul style="list-style-type: none"> • It is an optical instrument designed to make distant objects clearer & appear nearer. • Ex: Hubble Telescope – NASA's one of the most famous and the largest astronomical satellite.
Perigee, Apogee	<ul style="list-style-type: none"> • Perigee- It is the point in a satellite's elliptical path around the Earth at which it is closest to Earth's centre. • Apogee- It is the point of maximum distance between the satellite and the centre of the Earth. 
Lagrange Point	<ul style="list-style-type: none"> • It is a location in space where the combined gravitational forces of two large bodies such as Earth and the Sun or the Earth and the Moon, equal the centrifugal force felt by a much smaller third body. • The interaction of forces creates a point of equilibrium where a space craft may be "Parked to make observations. • Halo Orbit- It is an Orbit around the Lagrange Points.

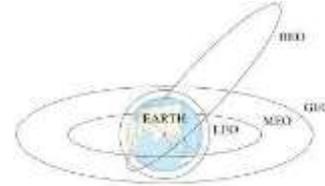
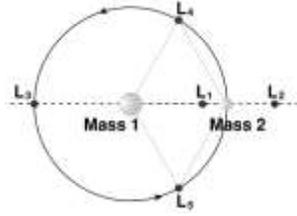
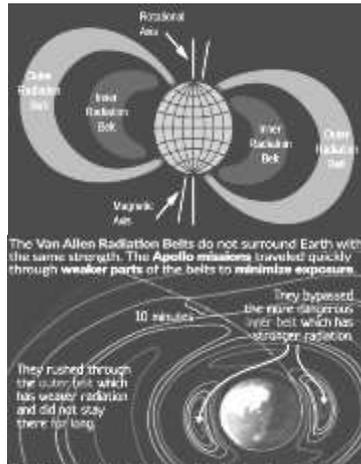


Fig: Types of orbit

Van Allen Radiation Belts

- It is a zone of charged particles. These energetic particles are trapped at high altitudes in Earth’s magnetic field.
- These are intense over Equator and is absent over the Poles. They contain charged particles of both solar and atmospheric origin. They are not part of our atmosphere and are extended into space much beyond the Earth’s atmosphere.



1. Geostationary Orbit (GEO)

- Satellites in GEO circle Earth above the equator from west to east following Earth’s rotation
- Takes 23 hours 56 minutes and 4 seconds
- Travels at exactly the **same rate as Earth**.
- This makes satellites in GEO appear to be ‘stationary’ over a fixed position.
- Placed at an altitude of **35 786 km**.
- Usually, telecommunication satellites and also for weather monitoring satellites.
- Satellites in GEO cover a large range of Earth so as few as **three equally-spaced satellites** can provide near global coverage.

2. Low Earth Orbit

- Most of the satellites are placed. It ranges between (180 km- 2000km).
- Most of the Remote Sensing satellites are placed in this orbit.
- In general satellites are first placed in LEO and then transferred to GEO.
- Each orbit is associated with certain speed. As LEO is near to the Earth, the gravitation pull on the satellites in this orbit is also more. To overcome this, orbital speed of the satellite placed in LEO is more.
- Satellites placed in LEO orbit generally circle the Earth once in 90 min.
- Unlike in GEO Orbit in LEO can be tilted. Hence more routes are available.
- **Ex:** International Space Station, IRS series satellites are placed in LEO.

6.1.1 Orbit

Curved path that an object in space (such as a star, planet, moon, asteroid or spacecraft) takes around another object due to gravity.

Types of Orbit

1. Geostationary orbit (GEO)
2. Low Earth orbit (LEO)
3. Medium Earth orbit (MEO)
4. High Earth Orbit
5. Polar orbit and Sun-synchronous orbit (SSO)
6. Transfer orbits and geostationary transfer orbit (GTO)

3. Middle Earth Orbit

- The range of this orbit is between (2000km – 35,780 km).
- Generally, it takes 12 hrs for the satellite to complete one rotation around Earth.
- It is very commonly used by navigation satellites

Ex: Communication satellites to cover Polar Regions; Earth Observation Satellites, GPS, etc

4. High Earth Orbit

- The range of this orbit is from 35,780KM and above.
- When the height of orbit is 35,780KM, the orbital speed of the satellite becomes equal to the Earth's rotational speed.
- So, this orbit at this height is called as Geo Synchronous (GSyO) or Geo Stationary Orbit (GSO).

Ex: Communication Satellites & Weather Monitors Satellites are place in GSO/GSyO.

5. Polar orbit and Sun-synchronous orbit (SSO)

- Satellites in polar orbits usually travel past Earth from north to south rather than from west to east, passing roughly over Earth's poles.
- Polar orbits are a type of low Earth orbit, as they are at low altitudes between 200 to 1000 km.
- Sun-synchronous orbit (SSO) is a particular kind of polar orbit.
- Satellites in SSO, travelling over the polar regions, are synchronous with the Sun.
- This means they are synchronised to always be in the same 'fixed' position relative to the Sun. This means that the satellite always visits the same spot at the same local time.

6. Transfer orbits and geostationary transfer orbit (GTO)

- Transfer orbits are a special kind of orbit used to get from one orbit to another.
- When satellites are launched from Earth and carried to space with launch vehicles, the satellites are not always placed directly on their final orbit.
- Often, the satellites are instead placed on a transfer orbit: an orbit where, by using relatively little energy from built-in motors, the satellite or spacecraft can move from one orbit to another.
- A high-altitude orbit like GEO without actually needing the launch vehicle

6.2 History of Space Technology

- The first country on Earth to put any technology into space was **Soviet Union**.
- The USSR sent the **Sputnik 1** satellite on October 4, 1957.
- The first successful human spaceflight was **Vostok 1 – USSR**.
- The first artificial object to flyby the Moon was **Luna 1** on January 4, 1959 (USSR).
- Humans first landed on the Moon on July 20, 1969. The first human to walk on the lunar surface was **Neil Armstrong**, commander of Apollo 11 (NASA).
- Interplanetary missions is **Voyager 1**, the first artificial object to leave our Solar System into interstellar space in 2012.

6.3 Space Technology in India

1961- Department of Atomic Energy was entrusted with the subject of Space Research.

1962- INCOSPAR- Indian National Committee for Space Research was formed under DAE.

1966- INCOSPAR was reconstituted as ISRO (Indian Space Research Organization).

1972- GOI established Space Commission and Dept of Space and ISRO were brought under DOS.

6.3.3.1 Difference between PSLV and GSLV

Criteria	PSLV	GSLV
Full Form	<ul style="list-style-type: none"> Polar Satellite launch Vehicle 	<ul style="list-style-type: none"> Geo Synchronous Satellite Launch Vehicle
Delivers/launches	<ul style="list-style-type: none"> Earth observation or remote sensing satellites Satellites of lower lift-off mass to lower earth orbits Low lift-off mass (up to 1750 kg), lesser altitude (600-900 km) 	<ul style="list-style-type: none"> Communication satellites place heavier satellites into higher orbits Higher lift-off mass upto 2500 kg
Payload capacity	<ul style="list-style-type: none"> LEO- 1750 kg GTO- 1425kg 	<ul style="list-style-type: none"> LEO- 4000kg GTO- 2000kg
orbits	<ul style="list-style-type: none"> Sun synchronous circular polar orbits (lower earth orbit) 	<ul style="list-style-type: none"> Initially to geosynchronous transfer orbit (GTO) and further raised to geostationary earth orbits (GEO) It can also be used for LEO
STAGES	4 stages <ul style="list-style-type: none"> 1st and 3rd solid propellant 2nd and 4th liquid propellant 	3 stages <ol style="list-style-type: none"> Solid stage Liquid stage Cryogenic
Major launches	<ul style="list-style-type: none"> Indian Remote Sensing (IRS) series- CARTOSAT, OCEANSAT, RISAT, etc Chandrayaan-1, MOM IRNNS (Indian Regional Navigational Satellite System) - Constellation of 7 Satellites, are place in GTO using PSLV. 	<ul style="list-style-type: none"> INSAT & GSAT Satellites Chandrayan-2 mission Proposed GAGANYAAN mission
Significance	<ul style="list-style-type: none"> PSLV earned its title the workhorse of ISRO through consistently delivering various satellites to low Earth Orbits, Particularly the IRS satellites. It is the first Indian launch vehicle to be equipped with the liquid stages. 	<ul style="list-style-type: none"> GSLV-MK-III also known as ISROs FAT BOY has increased the load carrying capacity of GSLV LEO- 8000kg GTO- 4000kg CE-20, indigenous cryogenic engine was used in this. (3 stages)

Cryogenic Technology: Is the technology of materials at very low temperatures, below-153°C (Boiling point of Methane).

- Cryogenic Rocket technology uses Cryogenic fuel. It is more efficient as it provides more thrust for every kg of propellant compared to solid and earth storable liquid propellant.
- Cryogenic Fuel: Hydrogen@-183°C, Oxygen@-253°C (Oxidizer)

After a Long Journey... India Joins a Small Group
A brief history of the Indian cryogenic engine

1982	First team to make engine	US	1963
1986-91	Early experiments	Japan	1977
1991	Russian agreement	France	1979
1993	Russians back out on technology	China	1984
1994	Indian cryogenic programme formalised	Russia	1987
2000	First engine test (failure)	India	2014
2003	First successful test		
2007	First integration with rocket		
2010	First flight		
2014	FIRST SUCCESSFUL FLIGHT		

- It combines both launch vehicle configuration as well as an aircraft configuration.



- RLV-TD was successfully tested in 2016.
- The final version will take at least 10-15 years to get ready.

2. Scramjet TD

- Scramjet engine is an Air Breathing Propulsion System.
- Scramjet engine uses hydrogen as fuel and oxygen from the atmosphere air as the oxidizer.
- Scramjet engine-TD was successfully tested by ISRO in 2016. ISRO is the fourth country to successfully demonstrate this technology.

Use of Scramjet engine

- Most of the satellite launch vehicles that carrying propellants out of the total propellant, 70% of it is oxidize
- If the launch vehicle can take the oxygen from atmosphere, it is weight can be considerably reduced. Overall cost of launching the satellites also reduces.
- If scramjet engines are combined with RLV, the Future space programs become more efficient and cost effective.

Differences between Ramjet and Scramjet Engine

Ramjet	Scramjet (Supersonic Combustion Ramjet)
The combustion in the combustion chamber happens at sub-sonic speeds.	The combustion in the combustion chamber happens at super-sonic speeds.

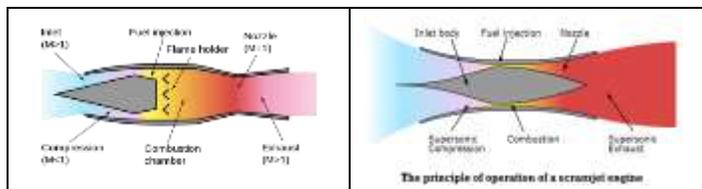
Advantages of Cryogenic Fuel	Constraints of Cryogenic Fuel
<ul style="list-style-type: none"> • High Fuel density • Automatic Cooling of engine • Power density is high • Cleaner Fuel. 	<ul style="list-style-type: none"> • Difficult to storage • Expensive • Health problems in case of leakage.

6.3.3.2 Future launch vehicles of ISRO

1. RLV-TD
2. Scramjet Engine-TD.
3. SSLV- Small Satellite Launch Vehicle

1. RLV-TD

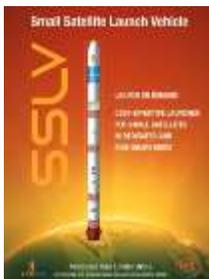
- Reusable Launch Vehicle—Technology Demonstration is one of the most technologically challenging endeavors of ISRO.
- Reusability of launch vehicle enables low cost access to space.



Both Ramjet and Scramjet engines don't have the moving parts inside. Both move at Supersonic speeds. The difference is only at the combustion stage.

3. SSLV- Small Satellite Launch Vehicle

- ISRO is slated to induct the Small Satellite Launch Vehicle in early 2020.
- SSLVs are considered small wonders capable of launching payloads of 500-700 kg in LEO (1/3rd of what PSLV can carry).
- It can reach upto heights of 500 KM in the LEO.
- SSLVs will cost 1/10th of a PSLV and will need only 72 hours for launch in comparison to 45 days for PSLV



Lox Methane Engine

- Liquid Propulsion Systems Centre of ISRO is developing 2 Lox methane-powered rocket engines.
- The 'LOx methane' engine uses methane as fuel and liquid oxygen as oxidizer.
- Methane can be synthesised using water and carbon dioxide in space.
- It is non-toxic. (Di-Methyl Hydrazine and Nitrogen tetroxide is said to be highly toxic)
- Higher specific impulse (read above for Specific Impulse).
- Does not leave a residue upon combustion

Ion Rockets

Small scale ion propulsion is used in a number of missions including NASA's Dawn mission and Deep Space mission, ESA's LISA Pathfinder and

BepiColombo and Japan's Hayabusa Mission.

- Ion rockets are the rockets of the future for deep space exploration.
- They are much more efficient than conventional rockets that use chemical fuels.
- While chemical fuels generate velocities of upto 2 to 3 km/s, ion rockets can achieve velocities of about 4,400 km/s.
- Ion rockets use electric repulsion of ions to propel the rockets.

6.3.4 Satellites Launched by ISRO

<p>Communication Satellites</p>	<ul style="list-style-type: none"> • Established in 1983 with commissioning of INSAT-1B • The Indian National Satellite (INSAT) system is one of the largest domestic communication satellite systems in Asia-Pacific region • Nine operational communication satellites placed in Geo-stationary orbit. • GSAT-17 joins the constellation of INSAT System consisting 15 operational satellites, namely - INSAT-3A, 3C, 4A, 4B, 4CR and GSAT-6, 7, 8, 9, 10, 12, 14, 15, 16 and 18.
<p>Earth Observation Satellites</p>	<ul style="list-style-type: none"> • Starting with IRS-1A in 1988, ISRO has launched many operational remote sensing satellites. • Currently, thirteen operational satellites are in Sun-

	<p>synchronous orbit – RESOURCESAT-1, 2, 2A CARTOSAT-1, 2, 2A, 2B, RISAT-1 and 2, OCEANSAT-2, Megha-Tropiques, SARAL and SCATSAT-1, and four in Geostationary orbit- INSAT-3D, Kalpana & INSAT 3A, INSAT -3DR.</p> <ul style="list-style-type: none"> The data from these satellites are used for several applications covering agriculture, water resources, urban planning, rural development, mineral prospecting, environment, forestry, ocean resources and disaster management. 		<ul style="list-style-type: none"> Developed by- Airports Authority of India (AAI) and Indian Space Research Organization (ISRO). It consists of three geosynchronous satellites (GSAT-8, GSAT-10 and GSAT-15). GAGAN covers entire area from Australia to Africa. Apart from this, it also studies the ionospheric behaviour over the Indian region. <p>(b) Indian Regional Navigation Satellite System (IRNSS): NavIC</p> <p>To provide Reliable Position, Navigation and Timing services over India and its neighbourhood, to provide fairly good accuracy to the user.</p>
<p>Experimental Satellites</p>	<ul style="list-style-type: none"> ISRO has launched many small satellites mainly for the experimental purposes. This experiment include Remote Sensing, Atmospheric Studies, Payload Development, Orbit Controls, recovery technology etc E.g- Aryabhata, Rohini, APPLE, INS 	<p>Space Science & Exploration</p>	<ul style="list-style-type: none"> It encompasses research in areas like astronomy, astrophysics, planetary and earth sciences, atmospheric sciences and theoretical physics. Astrosat, Mars Orbiter Mission, Chandrayaan 1 and 2 programmes of ISRO
<p>Satellite Navigation</p>	<p>(a) GPS Aided GEO Augmented Navigation (GAGAN):</p> <ul style="list-style-type: none"> It is a step by the Indian Government towards satellite – based navigation services in the country. 		

6.3.5 Recent Launches of ISRO

Launch Vehicle	Details
PSLV C-51	<p>Successfully launched Amazonia-1 along with 18 co-passenger satellites (five from India and 13 from the U.S.) on February 28, 2021 from Satish Dhawan Space Centre SHAR, Sriharikota.</p> <p>Amazonia-1 Satellite:</p> <ul style="list-style-type: none"> • Optical earth observation satellite of National Institute for Space Research (INPE). It is a sun-synchronous satellite, the first one to be fully Brazilian-made. • For monitoring deforestation in the Amazon region and analysis of diversified agriculture across the Brazilian territory. • PSLV-C51/Amazonia-1 is the first dedicated commercial mission of NewSpace India Limited (NSIL), ISRO
PSLV C-50	<ul style="list-style-type: none"> • India's communication satellite CMS-01 was successfully launched • From the Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. • PSLV-C50 is the 52nd flight of PSLV <p>CMS-01 Satellite:</p> <ul style="list-style-type: none"> • Communication satellite designed to provide services in the Extended-C Band of the frequency spectrum, which will include the Indian mainland, Andaman and Nicobar and Lakshadweep Islands. • India's 42nd communication satellite and will have a mission life of 7 years. • The CMS-01 will be a replacement for GSAT-12.

PSLV C-49

Launched EOS-01 along with nine international customer satellites from Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota on November 07, 2020.

- PSLV-C49 is the **2nd flight of PSLV in 'DL' configuration** (with 2 solid strap-on motors).

Earth Observation Satellite-01:

- It is also a **Radar Imaging satellite (RISAT)** that works with RISAT-2B and RISAT-2BR1.
- EOS-01 is an earth observation satellite, intended for applications in agriculture, forestry and disaster management support.
- EOS01 uses **synthetic aperture radars** to produce high-resolution images of the land.
- The nine customer satellites from Lithuania (1), Luxembourg (4) and USA (4) were launched under a commercial arrangement with NewSpace India Limited (NSIL).

PSLV C-48

Launched under a commercial arrangement with NewSpace India Limited (NSIL), the new commercial arm of ISRO.

RISAT-2BR1

- RISAT-2BR1 is radar imaging earth observation satellite in the RISAT series.
- Radio imaging satellite with **X-band synthetic aperture radar (SAR)** which **enables all-weather, day-night radio communication**
- The resolution of Risat-2BR is **less than 1 metre.**
- RISAT 2BR is equipped with unfurlable radial rib antenna technology (mobile communication)

	<p>that is primarily used to receive signals, modify them and retransmit back to a hand-held receiver on Earth</p> <ul style="list-style-type: none"> • Application: Agriculture, mining, round the clock border surveillance, coastal management Forestry and Disaster Management. 	<p>GSAT 30</p>	<ul style="list-style-type: none"> • GSAT-30 will replace INSAT-4A in orbit for enhanced coverage • INSAT-4A(2005) is used by cable operators to broadcast their programmes abroad. • Launched in French Guiana • Orbit – Geosynchronous • GSAT-30 for High quality telecommunications, TV broadcasting Services, e-Governance applications etc.
<p>PSLV C-47</p>	<p>CARTOSAT 3</p> <ul style="list-style-type: none"> • Cartosat 3 is a third-generation earth imaging satellite. • It is an advancement over the previous cartosat series satellites with higher spatial resolution parameter. • It has a pan-chromatic resolution capability of 25cm (highest in the world). • Orbit Type: Sun synchronous polar orbit (SSPO) at altitude of 509 km • It was navigated for the first time using the indigenous Vikram processor designed by the ISRO and fabricated within the country. • [The Vikram Processor is to be used for rocket's navigation, guidance and control and also for general processing applications.] <p>Application</p> <ul style="list-style-type: none"> • Cartography for large scale urban planning • Rural resource and infrastructure development • Land Information System and Geographical Information System application for various uses • Change detection in bringing out geographical and man-made features. • Coastal land use. 	<p>GSAT-31</p>	<ul style="list-style-type: none"> • Launched at French Guiana • India's 40th Communication Satellite • To enhance connectivity for ATM's, Cellular Connectivity and ensure uninterrupted DTH Services
		<p>GSAT-7A</p>	<ul style="list-style-type: none"> • Known as India's 'Angry Bird' • Launched by GSLV from SDSC, Sriharikota. • GSAT-7A is only the second dedicated military satellite after 'Rukmini' or GSAT-7 launched in 2013 (Indian Navy). • Dedicated to the Indian Air Force. • It will boost the remotely-piloted aircraft operations by satellite-control of military unmanned aerial vehicles (UAVs).

6.4 ISRO's Interplanetary Missions

Mars Orbiter Mission (MOM)

India successfully launched Mangalyaan in 2014 using PSLV - C25

Launcher - PSLV-XL

Equipment

1. Methane Sensor for Mars (MSM): To measure methane in the atmosphere
2. **Mars Color Camera (MCC):** It gives images and information about the surface features and composition of Martian surface.

- 3. Mars Exospheric Neutral Composition Analyzer (MENCA):** It is a quadrupole mass analyzer capable of analysing the neutral composition of particles in the range of 1–300 amu (atomic mass unit) with unit mass resolution.
- 4. Thermal infrared Imaging Spectrometer (TIS):** TIS measures the thermal emission and can be operated during both day and night.
- 5. Lyman Alpha Photometer (LAP):** a photometer that measures the relative abundance of deuterium and hydrogen from Lyman-alpha emissions in the upper atmosphere.

Objectives

1. Exploration of Mars surface features by studying the **morphology, topography and mineralogy**

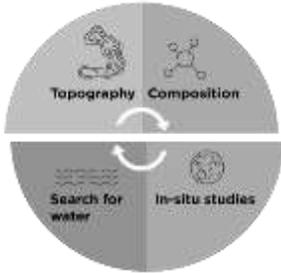
2. Study the constituents of Martian atmosphere including **methane and CO₂** using **remote sensing techniques**
3. Study the dynamics of the upper atmosphere of Mars, effects of solar wind and radiation and the escape of volatiles to outer space

Significance

- First interplanetary mission realized by India
- First Indian spacecraft to successfully survive Van Allen belt crossing 39 times.
- First Mars mission in the world to succeed Mars Orbit Insertion in first attempt.
- Most economical interplanetary mission in the world and paved way for cost-effective access to deep space.

6.5 ISRO's Missions to Moon

Category	Chandrayan-1	Chandrayan-2
Launched in	22 nd October 2008	22 nd July 2019
Launched by	PSLV-XL C11	GSLV Mk III
Equipments	<p>Scientific Payloads from India</p> <ol style="list-style-type: none"> a) Terrain Mapping Camera (TMC) b) Hyper Spectral Imager (HySI) c) Lunar Laser Ranging Instrument (LLRI) d) High Energy X - ray Spectrometer (HEX) e) Moon Impact Probe (MIP) <p>Scientific Payloads from abroad</p> <ol style="list-style-type: none"> a) Chandrayaan-I X-ray Spectrometer (CIXS) b) Near Infrared Spectrometer (SIR - 2) c) Sub keV Atom Reflecting Analyzer (SARA) d) Miniature Synthetic Aperture Radar (Mini SAR) j) Moon Mineralogy Mapper (M3) k) Radiation Dose Monitor (RADOM) 	<p>It consists of-</p> <ol style="list-style-type: none"> 1. Lunar orbiter: It will map the lunar surface and help to prepare 3D maps of it with the help of Orbiter High Resolution Camera (OHRC). OHRC conducted high-resolution observations of the landing site prior to separation of the Lander from the orbiter. 2. Vikram Lander: To touch down softly on the moon's surface. 3. Pragyan lunar rover: It is a robotic vehicle. <p>All were developed in India.</p> <p>Orbiter payloads-</p> <ol style="list-style-type: none"> 1. Terrain Mapping Camera 2 (TMC 2) 2. Chandrayaan 2 Large Area Soft X-ray Spectrometer (CLASS) 3. Solar X-ray Monitor (XSM) 4. Orbiter High Resolution Camera (OHRC)

		<ol style="list-style-type: none"> 5. Imaging IR Spectrometer (IIRS) 6. Dual Frequency Synthetic Aperture Radar (DFSAR) 7. Chandrayaan 2 Atmospheric Compositional Explorer 2 (CHACE 2) 8. Dual Frequency Radio Science (DFRS) experiment
Objectives	<ol style="list-style-type: none"> 1. To design, develop, launch and orbit a spacecraft around the Moon using an Indian-made launch-vehicle 2. To conduct scientific experiments using instruments on the spacecraft which would yield data: <ol style="list-style-type: none"> (a) for the preparation of a three-dimensional atlas (with high spatial and altitude resolution of 5–10 m or 16–33 ft) of both the near and far sides of the Moon (b) For chemical and mineralogical mapping of the entire lunar surface at high spatial resolution. 3. To increase scientific knowledge 4. To test the impact of a sub-satellite (Moon Impact Probe – MIP) on the surface of the Moon as a fore-runner for future soft-landing missions 	<ol style="list-style-type: none"> 1. To demonstrate the ability to soft-land on the lunar surface and operate a robotic rover on the surface. 2. Scientific goals include orbital studies of lunar topography, mineralogy, elemental abundance, the lunar exosphere, and signatures of hydroxyl and water ice. <div style="text-align: center;">  </div> <p>General Objectives:</p> <ol style="list-style-type: none"> 1. Push the boundaries of Scientific Knowledge 2. Engage with public 3. Unleash innovation 4. Expand India's footprint in Space 5. Explore economic possibilities 6. Foster shared aspirations of International Community
Achievements	<ol style="list-style-type: none"> 1. The discovery of the presence of Water / Hydroxyl molecules in lunar soil detected by the Moon Mineralogy Measuring Instrument (M3) of NASA as well as the mass spectrometer in MIP is a major breakthrough that would change the face of lunar exploration. 2. Mini-Synthetic Aperture Radar (Mini-SAR) instrument indicated existence of sub surface water-ice deposits in 	<p>Attempted to soft-land a rover there, a feat achieved by only three countries -- the US, Russia and China.</p> <p>But, Vikram Lander not being able to soft-land a rover on the Moon.</p> <p>ISRO lost contact with Vikram in the penultimate moments when it was just 2.1 km above Moon's surface.</p>

	<p>the northern lunar craters of permanent sun shadow region.</p> <p>3. The impact probe's Chandra's Altitudinal Composition (CHACE) recorded direct evidence of water in 650 mass spectra gathered in the thin atmosphere above the Moon's surface.</p> <p>4. Moon Mineralogy Mapper has discovered new rock types which are very small.</p>	
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Astrosat

- India's 1st dedicated multi-wavelength space observatory.
- Studies outer space objects in X-ray, limited optical and UV spectrum.
- The 1500-odd kg satellite is launched into a 650 km orbit.
- Objectives
- To estimate magnetic field of neutron stars
- Study of binary star system
- Study of regions where stars are born

Exosat

- It is a multi-wavelength space observatory to study the deep space.
- **Successor to Astrosat.**
- It will **explore X-ray sources in the universe.**
- It will study neutron stars, supernova remnants, pulsars, black holes in multiple wavelengths.

- NavIC has a position accuracy of 20 metres in its primary coverage area.
- It can service regions **extending up to 1500 km around India's boundary.**



- There are currently seven IRNSS satellites (1A to 1G) in orbit.
 - 4 satellites - A, B, F, G - are placed in a geosynchronous orbit. (1A is replaced by 1I recently)
 - 3 satellites - C, D, E - are located in geostationary orbit.

NavIC provides two types of services



6.6 ISRO's Navigation System

Indian Regional Navigation Satellite System (IRNSS)

Soon the **mobiles will be featured with IRNSS** in India.

- Also called NavIC is similar to the GPS. Independently developed by India
- IRNSS has a 7-satellites constellation.

1. Standard positioning service- meant for all users.

2. Restricted service - Encrypted service provided only to authorised users like military and security agencies.

Applications:

1. Territorial, aerial and marine Navigation.
2. Location based services-Fleet Management.
3. Geographic data collection & Surveying
4. Disaster Management

Indian Data Relay Satellite System (IDRSS)

IDRSS give India its own **space-to-space tracking and communication** of its space assets. India has planned for IDRSS series in 2020

- Under IDRSS, 2 satellites will be launched in **geostationary orbit** spaced 180 degrees apart to provide continuous contact for any spacecraft in LEO.
- It is primarily meant for providing **continuous/real time communication** of Low-Earth-Orbit satellites including **human space mission to the ground station**.
- It will also **reduce the dependence on the ground stations** in tracking satellites.
- **US, China, Japan and Europe** have such DRS systems.

6.7 Future Missions

6.7.1 India's Space Station

- India plans to have its own space station and modalities for it will be **worked out after the first manned mission, Gaganyaan**.
- The proposed space station is envisaged to **weigh 20 tonnes** and serve as a facility where astronauts can stay for 15-20 days. It would be placed in an orbit 400 km above earth.
- If successful, India will be the **4th country to set up a space station** on its own after Russia, the US and China.
- Nearly \$120 billion was spent on the ISS.

- ISS likely to be wound up in 2028, so China's space station is likely to be the only crewed space station left.
- ISRO says it is a natural extension of India's human space programme and is needed to keep leadership in the space arena.

6.7.2 Shukrayaan-1

It is a proposed orbiter to Venus by the ISRO to study the **surface and atmosphere of Venus**.

Objectives - to study

- Atmosphere of Venus and its chemistry
- Surface and sub-surface features
- Interaction of the planet with solar radiation
- Rotation pattern of Venus

About Venus

- Planet Venus is often described as Earth's 'twin sister' due to similarities in their sizes, densities, composition and gravity.
- About 80% of the surface of Venus is composed of flat plains of volcanic origin.
- The atmosphere of Venus is composed of 95% carbon dioxide and thus high greenhouse effect.
- Unusual thing about Venus is that its rotation period is longer than its orbital period.
- It spins in the direction opposite to the direction in which it orbits the Sun.
- Due to slow rotation of Venus it has no global magnetic field.

6.7.3 Chandrayaan 3

- Chandrayaan-3 is the successor to the Chandrayaan-2 mission and it will likely attempt another soft-landing on the lunar surface.
- Chandrayaan-3 will be mission repeat of Chandrayaan-2 and will only include a lander and a rover similar to that of Chandrayaan-2 and will not have an orbiter
- Although scores of landers sent by Russia, the U.S. and the Chinese have explored the moon's

surface, so far, no other agency has landed in the southern hemisphere of the moon. ISRO hopes to be the first to do so.

- As per ISRO, the total cost of Chandrayaan-3 mission will be over Rs 600 crores. In comparison, the total cost of the Chandrayaan-2 mission was Rs 960 crores.

6.7.4 Mangalyaan-2 (or the Mars Orbiter Mission-2)

- Planned mission by ISRO between **2022 and 2023**.
- The Mangalyaan-2 orbiter will use aerobraking to lower its initial apoapsis and enter into an orbit more suitable for observations.
- This mission, much like the Mangalyaan-1 mission has been planned as an orbiter-alone mission, and won't feature a lander or rover

6.7.5 Aditya – L1 and Gaganyaan

	Aditya-L1	Gaganyaan
Will be launched in	By April 2020.	December 2021
Launched by ISRO	PSLV	GSLV Mk III
Launch Specifications	<p>Aditya L1 will be placed in L1 point from a distance of 1.5million km from the Earth.</p> <p>A Satellite placed in the halo orbit around the Lagrangian point 1 (L1) of the Sun-Earth system has the major advantage of continuously viewing the Sun without any occultation/ eclipses.</p>	<p>So far, USA, RUSSIA and China have launched human space flight missions.</p> <p>As part of the manned Gaganyaan mission, India aims to send a 3-person crew to space for a period of seven days, with the spacecraft placed in a low Earth orbit of up between 300-400km.</p> <p>Specifications—Target: 2022</p> <ul style="list-style-type: none"> • Crew Module Weight: 7 Tons • Crew:3 Members • Cost: 10,000 Cr • Time: 3days • Orbit: LEO
Objectives	<p>A Satellite placed in the halo orbit around the Lagrangian point 1 (L1) of the Sun-Earth system has the major advantage of continuously viewing the Sun without any occultation/ eclipses.</p>	<p>Scientific Objectives-</p> <ol style="list-style-type: none"> 1. Conducting studies in the microgravity environment 2. To achieve higher level reliability in launch and satellite technology. <p>Other Objectives-</p> <ol style="list-style-type: none"> 1. Enhancement of S&T levels in the country. 2. Collaboration between various institutes, academia and industry. 3. Improvement in Industrial Growth. 4. Development of technology for social benefits

<p>India's Preparedness</p>	<ul style="list-style-type: none"> Aditya Mission was conceptualized in 2008 by the Advisory Committee for Space Research. It was initially envisaged as a small 400 kg, low-Earth orbiting satellite with a coronagraph to study the solar corona. An experimental budget of 3 Crore INR was allocated for the financial year 2016—2017. As of July 2019, the mission has an allocated cost of ₹378.53 crore excluding launch costs. Technological and Logistical capabilities to launch this mission are already there with ISRO. 	<p>5. Improving international collaboration.</p> <p>The government has already cleared a budget of Rs. 100 billion for the manned mission.</p> <p>ISRO developed some critical technologies-</p> <ol style="list-style-type: none"> 1. Reentry mission capability 2. Crew escape system 3. Crew module configuration 4. Deceleration and flotation system 5. Sub systems of life supporting system. 6. Thermal Protection System <p>Demonstration:</p> <ol style="list-style-type: none"> 1. Space capsule Recovery Experiment (SRE-2007) 2. Crew Module Atmospheric Re-entry Experiment (CARE-2014) 3. Pad Abort Test (2018) <p>Other developments-</p> <ol style="list-style-type: none"> 1. Human Space Center is established to accomplish this task. 2. Astronaut Training with Russian collaboration is under way. 3. Indigenously Space Suits are developed. 4. Collaborations in life supporting subsystems are going on with France and other domestic institutions. <p>VYOMMITRA - ISRO's humanoid robot that will test-flight Gangayaan in December 2020.</p>
	<p>Aditya will be India's third big extra-terrestrial outing after Moon and Mars</p> <p>400-kg spacecraft to study Sun</p> <ul style="list-style-type: none"> To orbit 1.5 million km from Earth Likely launch in 2019-20 on the PSLV Its 7 instruments to focus on Sun's outer corona, magnetic field, solar winds Sanctioned in 2008 at a cost of Rs. 1275 crore. 	<p>MANNED MISSION</p> <p>16 mins to reach low-earth orbit</p> <p>36 mins from de-boost to landing</p> <p>Crew module recovery in 15-20 minutes</p> <p>COST: Less than ₹10,000 cr</p> <p>LAUNCH: 2022</p> <p>India to be the 4th nation to launch a manned spaceflight mission after the US, Russia and China</p>

6.8 Other Initiatives in Short

Topic	Details
Gemini	<p>The Government of India launched the GEMINI device that will provide information related to disaster warning.</p> <ul style="list-style-type: none"> • Stands for GAGAN Enabled Mariner’s Instrument for Navigation and Information. • This is exclusively designed for fishermen about disasters when they are 10 to 12 km away from the coast.
Paras	<ul style="list-style-type: none"> • Scientific team of Physical Research Laboratory (PRL), Ahmedabad Discovered of a Sub-Saturn Exoplanet around a Sun-like star. • Named EPIC 211945201B/K2-236B <p>About PARAS (PRL ADVANCED RADIAL VELOCITY ABU SKY SEARCH SPECTROGRAPH)</p> <ul style="list-style-type: none"> • It is a spectrograph to find exo-planets. • It is designed and developed by PRL. (Physical Research Laboratory, Ahmedabad) • Main aim is to search for exo-planets around dwarf main sequence stars using radial velocity method.
Project Netra	<p>Network for Space Object Tracking and Analysis</p> <ul style="list-style-type: none"> • ISRO initiated ‘Project NETRA’ – an early warning system in space to detect debris and other hazards to Indian satellites. • It includes a network of observational facilities like connected radars, telescopes, data processing units and a control centre • The system is deployed to predict threats to Indian satellites from space debris, space attacks etc. <p>Under NETRA, the ISRO plans to put up many observational facilities:</p> <ol style="list-style-type: none"> 1. Connected radars, telescopes; 2. Data processing units and 3. Control centre. <p>NORAD - ISRO currently depends on NORAD (North American Aerospace Defence Command) for tracking of space debris and protect its satellites in course and during launches. It is an initiative of USA and Canada.</p>
Joint Lunar Polar Exploration Mission	<ul style="list-style-type: none"> • It was conceptualized as joint mission between JAXA and Indian Space Research Organisation (ISRO) in 2017 which aims to put a lander and a rover on the Moon's surface. • JAXA recently announced that the mission will be launched after 2023. • The mission will target a constantly sunlit region near the Moon's South Pole. • Major Missions: Water Detector; Science instrument and Environment Measuring Instrument

	<ul style="list-style-type: none"> • Objectives: <ul style="list-style-type: none"> ○ Obtain actual data regarding quantity of water of areas where water is anticipated to exist ○ Understand distribution, conditions, form and other parameters of lunar water resources at the moon's South Pole. ○ Improve technology needed to explore surface of low-gravity celestial bodies in order to support future lunar activities.
Himalayan Chandra Telescope	<ul style="list-style-type: none"> • Location: Hanle, Ladakh • Operated by: Indian Institute of Astrophysics (IIA), Bangalore • It is 2.01 meters (6.5 feet) diameter optical-infrared telescope named after India-born Nobel laureate Subrahmanyam Chandrasekhar. • The telescope was manufactured by Electro-Optical System Technologies Inc. at Tucson, Arizona, USA. • It is mounted with 3 science instruments called Himalaya Faint Object Spectrograph (HFOSC), the near-IR imager and the optical CCD imager. • It has helped in analysis of elements in the atmosphere of evolved stars, star formation in external galaxies, Active Galactic Nuclei, stellar explosions like novae, supernovae, gamma-ray bursts and so on.
Nisar	<ul style="list-style-type: none"> • NISAR = NASA ISRO Synthetic Aperture Radar Mission • This satellite will be able to detect the earth's surface movement as small as 0.4 inches over an area. • It will be a three-year mission. To be launched in 2022. • It will scan the globe including Earth's land, ice sheets, and sea ice, every 12 days during its mission. • It is a dual frequency Radar Imaging Satellite, that will be launched in Sun-Synchronous low-earth orbit. • Objectives: <ul style="list-style-type: none"> ○ Tracking subtle changes in the Earth's surface ○ Spotting warning signs of imminent volcanic eruptions ○ Helping to monitor groundwater supplies and ○ Tracking the rate at which ice sheets are melting.

6.9 Missions of NASA

Missions	Features
Dart mission	<ul style="list-style-type: none"> • DART = Double Asteroid Redirection Test • It is a kinetic impactor technique that avoids the potential hit by the asteroids to Earth. • This is also called as AIDA = Asteroid Impact Deflection Assessment Mission • It targets near Earth asteroid Didymos.

Insights	<ul style="list-style-type: none"> It is Mars lander mission launched in 2018. It landed near the equator of Mars to make in-depth analysis of the mars inner space.
Curiosity	<ul style="list-style-type: none"> It is a Mars Rover Mission to explore Mars, launched in 2011 Rover's goals include an investigation of the Martian climate and geology Recently measured highest measure of methane at Gale crater on Martian surface.
Artemis	<ul style="list-style-type: none"> Joint mission of NASA, ESA, JAXA and Canadian Space Agency Aims to send first female and next man to moon by 2024 It studies the impact of solar wind on lunar orbit. <p>Artemis Accord:</p> <ul style="list-style-type: none"> It is a series of bilateral agreements between NASA and its international partners that want to cooperate on Artemis program France, Japan, Australia and Canada have already shown their support. India has not clarified its stand yet
Parker solar probe	<ul style="list-style-type: none"> First spacecraft visit to a star, that will travel to the sun's atmosphere directly Mission is to study sun's outer corona called Photosphere
Solar orbiter	<ul style="list-style-type: none"> Collaboration between NASA and ESA. Aim is to study the sun by taking pictures of it from top and bottom At its closest, it will 42 million km, inside the orbit of planet mercury. It uses Gravity of Venus to enter the solar orbit Recently, first images from Solar Orbiter have revealed omnipresent miniature solar flares, dubbed 'campfires', near the surface of sun
Punch	<ul style="list-style-type: none"> PUNCH = Polarimeter to Unify the Corona and Heliosphere It is focused on understanding the transition of particles from the Sun's outer corona to the solar wind that fills interplanetary space. Expected to be launched in 2022
Galileo	<ul style="list-style-type: none"> aim was to study Jupiter and its mysterious moon. It was the first spacecraft to visit an asteroid, namely Gaspra and Ida
New frontiers program	<ul style="list-style-type: none"> It is a series of space exploration missions conducted by NASA To research several of the Solar System bodies, including the dwarf planet Pluto 3 missions in progress; NEW HORIZONS, JUNO, OSIRIS - REx
New horizons	<ul style="list-style-type: none"> First mission to Pluto and Kuiper Belt launched in 2006 Primary mission to perform a flyby study of the Pluto system in 2015, and a secondary mission to fly by and study one or more other Kuiper belt objects
Osiris – rex	<ul style="list-style-type: none"> The Origins, Spectral Interpretation, Resource Identification, Security – Regolith Explorer spacecraft will travel to near Earth asteroid Bennu Aim is to bring a small sample back to Earth for study by 2023
Dragonfly mission	<ul style="list-style-type: none"> Part of New Frontiers Program It will study Titan, he largest moon of Saturn.

Voyager 1 And Voyager 2	<ul style="list-style-type: none"> • Voyager 1 was launched in 1977 to study outer solar system • Voyager 1 was launched after 16 days of its twin, Voyager 2 • probe's objectives included flybys of Jupiter, Saturn, and Saturn's largest moon, Titan • Voyager 1 made the historic entry into interstellar space, the region between stars, filled with material ejected by the death of nearby stars millions of years ago. • Voyager 2 went on to explore Uranus and Neptune, and is still the only spacecraft to have visited those outer planets.
Dawn mission	<ul style="list-style-type: none"> • Goal: Learn more about formation of early solar system. • Status: Orbiting dwarf planet Ceres. Orbiting giant protoplanet Vesta in 2011-2012. First mission to orbit two targets. Closer Look at Bright Spots.
Cassini - Huygens	<ul style="list-style-type: none"> • The spacecraft was launched with two elements: the Cassini orbiter and the Huygens probe. • Cassini-Huygens reached Saturn and its moons in July 2004, beaming home valuable data that transformed the understanding of Saturn's system
Discovery programme	<ul style="list-style-type: none"> • Series of Solar System Exploration Mission • Important Discovery missions – Lucy; Psyche; Davinci; Io Volcano Observer; Veritas; Trident
Lunar gateway	<ul style="list-style-type: none"> • It is an in-development space station in lunar orbit intended to serve as a solar powered communications hub
Cobe satellite	<ul style="list-style-type: none"> • COBE = COsmic Background Explorer • 1st to confirm Cosmic Microwave Background Radiation
Aura	<ul style="list-style-type: none"> • Earth observation satellite for stratosphere ozone and aerosol in upper atmosphere
SOFIA (Stratospheric Observatory for Infrared Astronomy)	<ul style="list-style-type: none"> • It is a joint project of NASA and the German Aerospace Center to maintain and construct an airborne observatory. • It is designed for infrared astronomy observations in the stratosphere at altitudes of about 12 kilometres. • Recently, it detected water molecules in Clavius Crater, one of the largest craters visible from Earth, located in the Moon's southern hemisphere.
Extreme Ultraviolet High-Throughput Spectroscopic Telescope (EUVST) mission	<ul style="list-style-type: none"> • One of the two Heliophysics missions approved by NASA • It is a solar telescope that will study how the sun's atmosphere releases solar wind and drives eruptions of solar material. • The mission is also known as Solar-C and is led by Japan Aerospace Exploration Agency.
Electrojet Zeeman Imaging Explorer (EZIE) Mission	<ul style="list-style-type: none"> • One of the two Heliophysics missions approved by NASA • The mission will study electric currents in Earth's atmosphere linking aurora to the Earth's magnetosphere.
MARS 2020 Mission	<ul style="list-style-type: none"> • It is a Mars Rover Mission is designed to get better understanding of Geology of Mars and seek signs of life. • Duration: At least one Mars year (687 earth days)

	<ul style="list-style-type: none"> Launched in July 2020 It includes Perseverance Rover and small robotic coaxial helicopter Ingenuity (Ingenuity is a technology demonstration to test the first powered flight on Mars.) <p>PERSEVERANCE ROVER:</p> <ul style="list-style-type: none"> Nick Name: Percy It is the most advanced, most expensive and most sophisticated mobile laboratory sent to Mars. The rover landed on Jezero Crater on February 18th, 2021. (The Jezero Crater is an ancient river delta containing rocks and minerals that could only form in water.)
Sentinel-6	<ul style="list-style-type: none"> The Copernicus Sentinel-6 Michael Freilich Satellite is designed to monitor oceans. Launched aboard SpaceX Falcon 9 rocket. The mission is also called as Jason-CS (Continuity of Service) mission It aims to collect the most accurate data yet on sea level and how it changes over time. It has been developed jointly by the European Space Agency (ESA), NASA, European Organisation for the Exploitation of Meteorological Satellites (Eumetsat), the USA's National Oceanic and Atmospheric Administration (NOAA) and the EU.
TESS (Transiting Exoplanet Survey Satellite)	<ul style="list-style-type: none"> NASA's project to find potential planets orbiting stars close to earth. The primary mission objective of TESS is to survey brightest stars near Earth for transiting exoplanets over two-year period.

6.10 Missions of other Space Agencies

Mission	Agency	Features
Bepi colombo	European Space Agency And Japanese Space Agency	<ul style="list-style-type: none"> Launched in 2018. Carries the Mercury Planetary Orbiter (middle, with one solar wing pointing up) and the Mercury Magnetospheric Orbiter (hidden inside the solar shield, on the far side) to Mercury. Mission will perform a comprehensive study of Mercury, including characterization of its magnetic field, magnetosphere, and both interior and surface structure Recently, it successfully completed its first flyby of Venus.
Rosetta	European Space Agency	<ul style="list-style-type: none"> Launched in 2004 Along with Philae, its lander module, Rosetta performed a detailed study of comet 67P/Churyumov-Gerasimenko (67P).
Clearspace – 1 mission	European Space Agency	<ul style="list-style-type: none"> It is space debris clean mission to be launched by 2025. A four-armed robot, Chaser is to be used It will grab the chosen piece of space trash, one at a time, using its robotic arms and fall back towards Earth in a controlled descent.
Juice	European Space Agency	<ul style="list-style-type: none"> JUICE = JUpiter ICy moons Explorer Orbiter to explore Jupiter and 3 of its moons; Europa, Ganymede and Callisto

		<ul style="list-style-type: none"> • First non-American outer space mission
Copernicus	European Space Agency	<ul style="list-style-type: none"> • European Earth observation satellite • Aim is to monitor Earth and its ecosystem <p>Aeolus satellite:</p> <ul style="list-style-type: none"> • a wind-sensing satellite launched by European Space Agency • part of the Copernicus project, a joint initiative of European Union (EU) and European Space Agency (ESA) to track environmental damage and aid disaster relief operations. • is equipped with single instrument Doppler wind lidar (named Aladin), an advanced laser system designed to accurately measure global wind patterns from space. <p>Recently, EU has announced to provide free access to data of Copernicus Programme to India.</p>
Comet interceptor	European Space Agency	<ul style="list-style-type: none"> • Robotic spacecraft Mission • To be launched in 2028 • To be parked at Sun-Earth L2 point (Lagrange point)
Chang'e 4	China	<ul style="list-style-type: none"> • Lunar exploration mission with orbiter, lander and rover • First mission to dark side of the moon • It will explore the south pole of lunar surface – Aitkin basin
Chang'e 5	China	<ul style="list-style-type: none"> • fifth lunar exploration mission of the Chinese Lunar Exploration Program, and China's first lunar sample-return mission. • By completing the mission, China became the third country to return samples from the Moon after the United States and the Soviet Union. • It returned to Earth in December 2020 • The Chang'e-5 mission collected material in an area north of the Mons Runkner known as Oceanus Procellarum or "Ocean of Storms" which is a vast, unexplored lava plain.
Tiangong 1 And Tiangong 2	China	<ul style="list-style-type: none"> • TIANGONG 1 is China's first prototype space station • It acts as both crewed laboratory and an experimental testbed • TIANGONG 2 is an experimental space laboratory. • Launched in 2016 and deorbited in July 2019
Tianhe-1	China	<ul style="list-style-type: none"> • Permanent Space module of China.
BeiDou	China	<ul style="list-style-type: none"> • Navigation system of China. • China plans to have a total of 33 satellites operating in orbit for BeiDou by the end of 2018 which includes 15 BeiDou-2 satellites and 18 BeiDou-3 satellites. • After completion, the navigation system would become an equivalent of the US Global Positioning System, Europe's Galileo and Russia's Glonass.
Raavana 1	Sri Lanka	<ul style="list-style-type: none"> • It is the first, indigenous satellite of Srilanka launched from ISS • It is a cube satellite • It was deployed with the help of JAXA
Skybot f850	Russia	<ul style="list-style-type: none"> • It is the first humanoid robot of Russia. Also called as Fedor
Spektr-Rg	Russia	<ul style="list-style-type: none"> • Joint collaboration between Roscosmos and Germany.

		<ul style="list-style-type: none"> • All sky surveillance survey satellite
Arktika-M Satellite	Russia	<ul style="list-style-type: none"> • It is a remote-sensing and emergency communications satellite. • The objective is to monitor the climate and environment in the Arctic region. • Russia plans to send up a second satellite in 2023. • These two satellites will offer round-the-clock, all-weather monitoring of the Arctic Ocean and the surface of the Earth.
Hope Spacecraft	UAE	<ul style="list-style-type: none"> • Mars mission to be launched by July 2020 • It orbits Mars to study its atmosphere and its interaction with outer space and solar winds.
Remove debris Mission	Surrey Space Centre	<ul style="list-style-type: none"> • Satellite research project • Some experiments are; <ul style="list-style-type: none"> ○ Net Experiment ○ Vision based navigation ○ Harpoon and deployable target ○ Dragsail
Hayabusa 2	Japan	<ul style="list-style-type: none"> • To bring back the sample from asteroid Ryugu . • Launched in 2018. • Recently, it landed safely in Australia.
Birds Project	Japan	<ul style="list-style-type: none"> • Project to support non-spacefaring countries to build their first satellites. • Birds 1- Ghana, Mongolia, Bangladesh and Nigeria • Birds 2- Bhutan, Philippines and Malaysia
Beresheet 2	Israel	<ul style="list-style-type: none"> • The project aimed at landing an unmanned craft on the moon in 2024. • Beresheet 1 crash landed on moon.

6.11 Space Telescopes

Telescope	Features
James Webb Telescope	<ul style="list-style-type: none"> • To be the successor of Hubble space telescope • provide improved infrared resolution and sensitivity over Hubble • To be launched in 2021 • Will study every phase in the history of our Universe to the formation of solar systems capable of supporting life on planets, to the evolution of our own Solar System. • Collaboration between NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA).
Hubble Space Telescope	<ul style="list-style-type: none"> • Launched into low Earth orbit in 1990 • Built by NASA with help of ESA • Only telescope designed to be serviced in space by astronauts.
Event Horizon Telescope	<ul style="list-style-type: none"> • Planet-scale array of eight ground-based radio telescopes forged through international collaboration

	<ul style="list-style-type: none"> Designed to capture images of a black hole. Recently it captured the image of a black hole Messier 87
Thirty Meter Telescope	<ul style="list-style-type: none"> Proposed extremely large telescope Controversial because of the place chosen for its setup – Mauna Kea, Hawaii. allow astronomers to explore the mysterious period in the life of the universe when the first stars and galaxies were formed, India is a part of the project. From the Indian side, this will be a joint project of the Department of Science and Technology (DST) and the Department of Atomic Energy (DAE). The Indian industries are making the telescope’s sensors, actuators and its mechanical support structure.
Spitzer Space Telescope	<ul style="list-style-type: none"> Part of NASA’s Great Observatory Programme Designed to detect infrared radiation It was able to reveal cooler objects in space
Astrophysics Stratospheric Telescope for High Spectral Resolution Observations at Submillimetre-wavelengths (ASTHROS)	<ul style="list-style-type: none"> NASA’s new mission to send a telescope, on a football stadium-sized balloon, high into the stratosphere to observe wavelengths of light invisible from the Earth. It helps in finding answers about formation of giant stars in the galaxy. It is to be launched in December 2023 from Antarctica.
Antarctic Impulsive Transient Antenna (ANITA)	<ul style="list-style-type: none"> It is a radio telescope to detect ultra-high energy cosmic-ray neutrinos from a scientific balloon flying over the continent of Antarctica. It is the first NASA observatory for neutrinos of any kind.
ARIEL (Atmospheric Remote-sensing Infrared Exoplanet Large-survey) Space Mission	<ul style="list-style-type: none"> By European Space Agency (ESA) It is a space telescope planned for launch in 2029 as the fourth medium-class mission of the European Space Agency's Cosmic Vision programme. It is a 4-year mission. The mission is aimed at observing at least 1,000 known exoplanets using the transit method. It is the first mission studying and characterising the planets' chemical composition and thermal structures. Compared to the James Webb Space Telescope, ARIEL will have more observing time available for planet characterization but a much smaller telescope.

Xuntian	<ul style="list-style-type: none"> • Chinese telescope • 300 times wider than Hubble space telescope • Will capture deep space objects
Spica	<ul style="list-style-type: none"> • JAXA AND ESA • Infrared Space Telescope • Aims to elucidate the process that enriched the universe with metal and dust and led to the formation of habitable world
Gemini	<ul style="list-style-type: none"> • In Hawaii • Radio telescope of USA • Used to measure distance to the galaxy using redshift
Meerkat	<ul style="list-style-type: none"> • First telescope of South Africa • It will be the biggest of the radio telescopes deployed in Southern hemisphere • Will address key questions like how did galaxy form, their evolution etc.,
Square Kilometer Array	<ul style="list-style-type: none"> • It is an intergovernmental radio telescope project being planned to be built in Australia and South Africa <ul style="list-style-type: none"> ○ South Africa – host high and mid-frequency dish antennas ○ Australia – Low-frequency antennas. • Objectives: <ul style="list-style-type: none"> ○ To study the universe and its evolution, origin and evolution of cosmic magnetism and dark energy and evolution of galaxies. ○ To detect very weak extra-terrestrial signals and search for molecules that support life • India – Member

6.12 SpaceX Missions

Mission	Description
CREW-1 Mission	<ul style="list-style-type: none"> • The mission is part of NASA's Commercial Crew Program. • The first operational flight of the SpaceX Crew Dragon spacecraft on a Falcon 9 rocket to the ISS. • The Crew-1 team will conduct microgravity studies.
CREW-2 Mission	<ul style="list-style-type: none"> • The mission is called Crew-2 and is the second crew rotation of the SpaceX Crew Dragon and the first with international partners.

	<ul style="list-style-type: none"> • Members of the mission conduct microgravity studies and investigate food physiology
SN5 Starship	<ul style="list-style-type: none"> • SpaceX has successfully test-launched its “Mars ship”, a stainless-steel test vehicle called SN5. • It is part of the Starship spacecraft • Starship: • Starship is a spacecraft and super-heavy booster rocket meant to act as a reusable transportation system for crew and cargo to the Earth's orbit, Moon and Mars.

7. Advancements in the Field of Fundamental Physics

7.1 LIGO

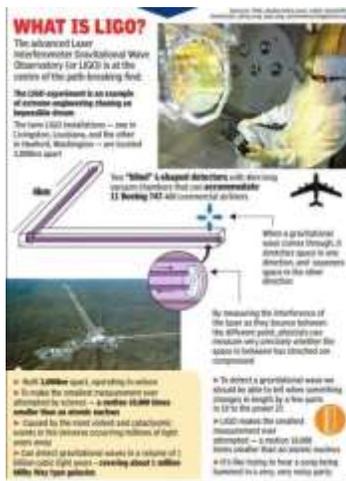
Laser Interferometer Gravitational - Wave Observatory

LIGO is a massive observatory for detecting cosmic gravitational waves and for carrying out experiments.



LIGO is funded by the U.S. National Science Foundation and operated by the California Institute of Technology (Caltech) and the Massachusetts Institute of Technology (MIT).

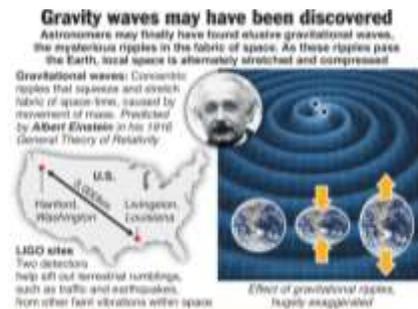
7.1.1 About LIGO



- LIGO's mission is to open the field of gravitational-wave astrophysics through the direct detection of gravitational waves.
- LIGO detectors use **laser interferometry** to measure the distortions in space-time occurring between stationary, hanging masses (mirrors) caused by passing gravitational waves.

- LIGO is a national facility for **gravitational-wave research**, providing opportunities for the broader scientific community to participate in detector development, observations and data analysis.
- Comprises the **world's largest precision optical instruments** and one of the world's largest vacuum systems
- Currently LIGO operates three gravitational wave detectors at **Livingston, Louisiana and Hanford**. They are located 3,000 km apart in the shape of 'L'.

7.1.2 Evolution of LIGO's Detectors



- Construction of LIGO's original gravitational wave detectors (dubbed Initial LIGO or iLIGO) was completed in 1999.
- The first search for gravitational waves began in 2002 and concluded in 2010 during which time no gravitational waves were detected.

7.1.3 Advanced LIGO

- LIGO was rebuilt between 2010 and 2014.
- The deeper search for **gravitational waves began in September 2015**, and within days, LIGO's "advanced" detectors achieved what Initial LIGO could not accomplish in 8 years of operation

7.1.4 Recent Developments

- Merger of black holes that were of unequal masses – in 2020
- LIGO have recently recorded the first merger of black holes that were of unequal masses.

- The LIGO-Virgo collaboration detected collision between two black holes that were 2.4 billion light years away.



- The black holes were 20 and 40 times the mass of the sun. One of the black holes was 29.7 solar masses and the other was 8.4 solar masses.

7.1.5 Collision of two neutron stars – in 2020

- The LIGO detected gravitational waves due to collision of two neutron stars. This is the second time that the gravitational waves are being detected.
- The mass of the neutron stars detected is expected to be 3.3 times and 3.7 times as that of the sun.
- The first neutron star detection was in 2017. However, the second event that was recorded now, is not as strong as the first.
- 2017 Nobel Prize in physics goes to the discovery of Gravitational Waves

Why is the study important?

- The gravitational waves are caused by exploding stars, black holes, merging neutron stars.
- LIGO helps to detect these waves and analyze the information that they carry.
- As the waves interact very weakly with matter, they help to learn about the universe and its origin.

Gravitational Waves

- Gravitational waves are ripples curvature of spacetime which propagate as waves, travelling outward from source at the speed of light.
- They transport energy as gravitational radiation and pass through matter without interacting with it.
- Gravitational waves were first predicted in 1916 by Albert Einstein on the basis of his Theory of General Relativity.



- Strongest sources of gravitational waves are among enigmatic objects in our universe like black holes, supernova, neutron stars and Big Bang.

7.2 LIGO-India (PROJECT IndIGO)



- A new gravitational wave detector to measure ripples in the fabric of space and time is set to be built in India by 2025
- LIGO India will come up in Maharashtra, which will also have two arms of 4 km length.
- LIGO-India project is piloted by Department of Atomic Energy (DAE) and Department of Science and Technology (DST).
- It will be built in collaboration with universities from across the globe

- The new Laser Interferometer Gravitational-Wave Observatory (LIGO) detector will add to the two already operational in the US.

The IndIGO Consortium includes

1. Indian Institutes of Technology (IIT),
2. Indian Institutes of Science Education and Research (IISER) and
3. Delhi University, among others

7.3 Lisa Pathfinder

Short for Laser Interferometer Space Antenna

Mission led by European Space Agency (ESA) with contributions from NASA to build a space-based observatory for detecting gravitational waves. While LIGO is ground based observatory LISA is space observatory.

LISA Pathfinder spacecraft has positioned itself in gravitational stasis at the **first Lagrangian Point (L1)** that lets its instruments hang in freefall.

7.4 Dark Matter

- In the solar system, Mercury, the planet closest to the Sun, takes just 88 days to make one revolution around the sun; while Neptune, the farthest one, takes 165 years to make one round.
- Laws of gravity expect us to see stars closer to the centre of galaxies rotating faster than the stars on the edge.
- However, in most galaxies, the stars closer to the centre and the stars at the edge of the galaxies take almost same time to make one revolution.
- This implied **that something invisible and enveloping the galaxies was giving an extra push to the outer stars, speeding them up.** This entity, known as **'dark matter'**.
- The material is considered to be a 'matter' since it appears to have gravitational attraction, and it is 'dark' because it does not seem to interact with light

- Composition - **27 per cent of the total mass of the Universe**

7.4.1 Dark Energy

- Roughly **68% of the universe is dark energy.** it is a property of space so does not get diluted as space expands.
- As more space comes into existence, more of this energy-of space appears. As a result, dark energy causes the universe to expand faster and faster.
- While Dark matter exerts a "pull" on the universe, **Dark Energy has a contrasting expansionary effect.**
- As is it evident, our universe is expanding, indicating that Dark Energy has a greater abundance than dark matter.
- By the laws of cosmology, the total amount of mass in the universe cannot increase.
- Hence while the amount of Dark matter remains constant, **Dark Energy which is a property of space itself is bound to increase exponentially.**
- Eventually, Dark energy would overcome the influence of dark matter and lead to further expansion of the universe.
- Dark Energy and Dark matter constitute 95% of the total universe



7.4.2 Stephen Hawking's Theory for Mysterious Dark Matter

- The theory proposes that primordial black holes are a source of dark matter.
- He computed that the mass of the primordial black holes could range from as low as one-hundredth of a milligram to as high as more than the mass of a thousand Suns.

Primordial Black Holes (PBH)

- PBH are a **hypothetical type of black hole** that formed soon after the Big Bang
- It is believed that they are formed as a result of collapsing radiations as opposed to the collapse of massive stars, which is the case of any other black holes.
- PBH can be massively large as 3000kms or be extremely tiny like nucleus of an atom.

7.4.3 Recent Developments

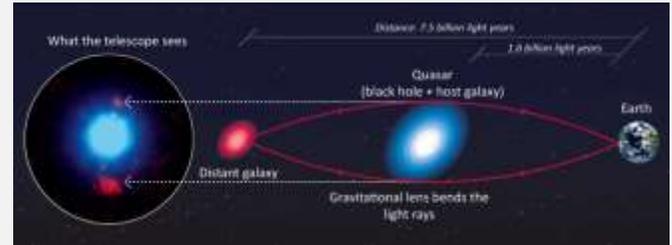
- A group of scientists from Pune have ruled out Stephen Hawking's theory for mysterious dark matter.
- Researchers used the gravitational lensing effect to look for primordial black holes between Earth and the Andromeda galaxy.
- For one whole night, the research team took 190 consecutive images of Andromeda galaxy.
- For Hawking's theory to be true, there should have been at least 1000 Gravity lensing events. But the researchers were able to find only one such event. Hence proving Hawkins theory wrong.

Gravitational Lensing

- Black holes are not radiant and will not be visible through any telescope.
- However, as first suggested by Albert Einstein, if by chance, a tiny primordial black hole eclipses a distant star, light rays of the star will bend around the black hole due to the gravitational force, resulting in the star appearing to be brighter than it originally is for

a short while.

- This is called "gravitational lensing", this rare phenomena can occur only when the star, the black hole and the observer on the Earth are aligned in a straight line.



7.5 Blackholes

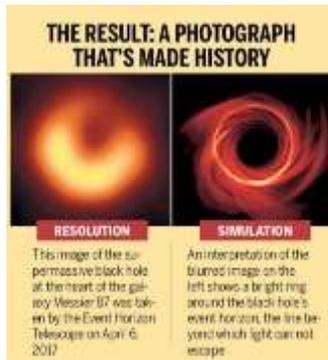
- A black hole is a region in space where the pulling force of gravity is so strong that light is not able to escape.
- A black hole cannot be seen because of the strong gravity that is pulling all of the light into the black hole's center.
- A black hole's gravity can sometimes be strong enough to pull off the outer gases of the star.

7.5.1 Size

- Small black holes are called stellar-mass black holes. They have masses similar to those of larger stars — about five to 20 times the mass of the sun.
- The other kind is supermassive black holes, which are millions to billions of times more massive than the sun.
- While black holes are very massive, that doesn't mean they take up a lot of space. Because they're so dense, they're actually quite small.

7.5.2 Capturing a blackhole

- The first ever blackhole photograph has been captured using **Event Horizon Telescope (EHT)**
- Blackhole has been **named "Powehi"**, meaning embellished dark source of unending creation.



How black hole was captured?

- Advanced space telescopes can identify black holes by observing the behaviour of material and stars that are very close to black holes.
- The hot disk of material **encircling a black hole**, as NASA explained, shines bright.
- The gases in that accretion disk are heated up as they **accelerate toward the black hole**, causing them to glow **extremely brightly**.
- The colours they glow are invisible to us, **but are detectable with an X-ray telescope**.

7.5.3 EHT targeted two Blackholes to capture the image

- Sagittarius A* which is 26,000 light years from the earth, at the centre of the Milky Way.
- Another black hole which is 55 million light years away at the centre of the Messier 87 galaxy in the Virgo galaxy cluster.
- It was able to capture the second one in Messier 87 galaxy.

Nobel Prize in Physics 2020 for Black holes

- Roger Penrose from the UK, Reinhard Genzel from Germany, and Andrea Ghez from the USA.
- Roger Penrose received half of this year's prize for the discovery that a black hole formation is a robust prediction of the general theory of relativity.
- Genzel and Ghez received the second half of the prize for the discovery of a supermassive black hole at the centre of the Milkyway galaxy, now known to be the Sagittarius A*.

7.5.4 Event Horizon Telescope



- EHT is not a single Telescope but a network of ten ground-based radio telescopes that are linked together.
- The EHT links telescopes around the globe **to form an Earth-sized virtual telescope** with unprecedented sensitivity and resolution.
- The EHT project is an international partnership of **thirteen agencies** formed in 2012. Its main objective is to **directly observe the immediate environment of a black hole**.
- The findings will provide insight into the celestial object so dense that their gravitational field swallows everything including light.
- FUNDING- **US National Science Foundation (NSF), the EU's European Research Council (ERC)**, and funding agencies in East Asia.
- Technique Used: The EHT observations use a technique called **very-long-baseline interferometry (VLBI)**.

7.5 Neutrinos

- Neutrinos are subatomic particles that are almost mass less.
- They are generally **emitted during nuclear decays**
- They move nearly at the **speed of light**.
- They have **no electric charge** and are **not affected by electric or nuclear forces**.
- Under most conditions **matter is transparent to neutrinos** and thus neutrinos pass through

all matter almost entirely. Hence, they are difficult to detect.

7.6.1 Indian Neutrino Observatory (INO)

NEUTRINOS
ARE THE second most abundant subatomic particles after photons, and one of the several fundamental particles of the universe is built of. They have no charge, but are thought to have a small, as-yet-undetermined, mass. They are everywhere, but are extremely difficult to detect because they interact poorly with other objects, passing through the human body without a trace.

WILL PLACE a specially built iron calorimeter (ICAL) detector about 1.5 km under the ground, where the chances of detecting neutrinos are higher. The project will also determine the rates of neutrinos, and to establish a "mass order" among the three known types of neutrinos—electron, muon and tau.

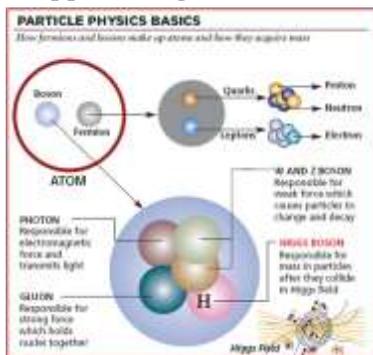
KEY FACTS
NEUTRINOS ARE thought to have been produced just after the Big Bang that created the universe. The average density of the universe is 230 particles per cubic centimetre.
100 TRILLION neutrinos are believed to pass through the human body every second.
\$1,500 CR is the estimated cost of the project building the lab is likely to cost \$0.4 Trn.
50,000 TONNES of magnet will make up the iron calorimeter detector.
23 INSTITUTIONS are part of the project, involving over 500 engineers and physicists.

7.7 The elementary particles in nature - Quarks, Leptons and Bosons

7.7.1 Quarks

- Quark is a fundamental constituent of matter and is defined as an elementary particle.
- These quarks combine to produce composite particles called hadrons, the most stable of which are **neutrons and protons** that are the components of atomic nuclei.
- Quarks cannot exist independently but as a constituent part of the matter.
- There are 6 types of quarks

Antiquarks - The antiparticles that correspond to every flavour of quarks are known as Antiquarks. Antiquarks have the same mass, same mean lifetime and same spin corresponding to quarks, but other properties like electric charge and other charges have opposite sign.



7.7.2 Leptons

- Like quarks, leptons too are of 6 types. However, they do not have any fractional charge. The leptons are: ELECTRON, MUON, TAU and 3 Types OF NEUTRINOS
- Electron being a Lepton is a fundamental elementary particle.

7.7.3 Boson

- Boson is a collective name given to particles that carry forces.
- It has been named after Indian scientist Satyendra Nath Bose.

Higgs Boson Particle

- Peter Higgs suggested that particles did not have mass just after Big Bang.

THE HIGGS BOSON
Renowned the God particle, the Higgs boson was proposed in the 1960s by British physicist Peter Higgs as a way of explaining why other particles have mass. The Higgs boson is theoretically responsible for mass, without which there would be no galaxy and no universe.

LARGE HADRON COLLIDER
Scientists smash protons together to recreate conditions similar to the instant of the Big Bang.

HOW TO SMASH PROTONS
Protons are present in the nuclei of atoms, the basic units of matter. Protons are composed of even smaller particles: three quarks held together by massive gluons.

1 Protons are accelerated at 99,999999% of the speed of light. Quarks and gluons inside the protons collide and explode with enough energy to create the Higgs particle.

2 The Higgs particle has 130 to 200 times the mass of a proton and will last less than a millionth of a trillionth of a second before decaying into a spray of other particles.

3 Evidence for the Higgs particle will be found in the debris sprays and showers left in LHC detectors by the particles created as it disintegrates.

Source: National Geographic, 2012 update

- As the universe cooled and temperature fell below the critical point, an invisible force field got formed which has been termed the Higgs Field.
- The associated particles with the Higgs field have been termed the Higgs Boson.
- It has been theorized that any particle that interacted with these Higgs Boson got mass and those particles that were left out of the Higgs field remained massless.
- As these Higgs Bosons have the capability to grant mass, the primary condition for the existence of matter, they were termed as the **God particle**.

8. Robotics

8.1 Introduction

Robotics is an interdisciplinary field that integrates computer science and engineering. Robotics deals with the design, construction, operation, and use of robots combined with computer systems for their control, sensory feedback, and information handling.

8.2 Aspects of Robots

- Robots all consist of some sort of mechanical construction.
- Robots need electrical components that control and power the machinery.
- Robots contain at least some level of computer programming.

8.3 Types of Robots

1. **Pre-programmed robots** operate in a controlled environment where they do simple, monotonous tasks. An example of a pre-programmed robot would be a mechanical arm on an automotive assembly line.
2. **Humanoid robots** are robots that look like and/or mimic human behavior. These robots usually perform human-like activities. E.g Sophia
3. **Autonomous robots** operate independently of human operators. These robots are usually designed to carry out tasks in open environments that do not require human supervision. E.g - Roomba vacuum cleaner, which uses sensors to roam freely throughout a home.
4. **Teleoperated robots** are semi-autonomous bots that use a wireless network to enable human control from a safe distance. These robots usually work in extreme geographical conditions, weather, circumstances, etc E.g - submarines used to fix underwater pipe leaks during the BP oil spill

5. **Augmenting robots** either enhance current human capabilities or replace the capabilities a human may have lost. E.g robotic prosthetic limbs or exoskeletons used to lift hefty weights

8.4 Applications of Robotics

- Helping fight forest fires.
- Working alongside humans in manufacturing plants (known as co-bots).
- Robots that offer companionship to elderly individuals.
- Surgical assistants.
- Last-mile package and food order delivery.
- Autonomous household robots that carry out tasks like vacuuming and mowing the grass.
- Assisting with finding items and carrying them throughout warehouses.
- Used during search-and-rescue missions after natural disasters.
- Landmine detectors in war zones

8.5 Robotics Process Automation

- RPA is a technology capability that allows the streamlining of operations in the enterprises.
- It also allows them to automate their mundane and tedious processes thereby enabling users to enhance their productivity through higher value adding tasks.
- It is not a defined system and is **yet evolving in nature**.
- New and emerging ideas like **artificial learning, deep learning or better operating systems** can be added to it.

8.5.1 Difference between RPA and the Traditional Automation

- Programmed machinery executes the work in a static way without responding or adapting to the changing environment.
- RPA, on the other hand are adaptive to the changing environment and are very efficient, increase productivity and are safe to work with.

All India Council for Robotics and Automation (AICRA)

- It is a not-for-profit organization established in 2014.
- It sets up standards in robotics & automation and education industry, helping organizations and professionals to solve difficult technical problems, while enhancing their leadership and personal career capabilities.
- The AICRA has announced the launch of a new initiative the 'Tech Startup Program'.
- It will act as incubation environment for startups and other early stage adopters working on Robotics and Robotics Process Automation (RPA) in India.

8.6 Important Robots in News

8.6.1 Sophia Humanoid Robot

The World's first humanoid robot Sophia participated in the 81st edition of Technax, the annual tech festival of the Banaras Hindu University (BHU).



- Sophia is the first robot citizen of the world after Saudi Arabia granted her citizenship in October 2017.
- She is a social humanoid robot, which using **artificial intelligence (AI)** programming, **can imitate human gestures and facial expressions**, and is able **to converse** on predefined topics.
- It was developed by the **Hong Kong-based Hanson Robotics** and 'activated' on February 14, 2016.
- Sophia, with a perfect skin and soft facial muscles, can give as many as 66 facial expressions.

8.6.2 Living Robots: Xenobots

Scientists in the United States have created the world's first "living robots" named "xenobots".



- The robot is tiny and built from the cells of the **African clawed frog**.
- named after the species of aquatic frog *Xenopus laevis* (found in Nigeria and Sudan)
- this is for the first time that **completely biological machines are designed from scratch**
- The xenobots can move toward a target, perhaps pick up a payload and even heal themselves after being cut.
- Applications - during radioactive contamination, gathering microplastic in the oceans etc.

8.6.3 Ai-Da Robot

- Recently an exhibition of art created by a **humanoid AI robot**, named Aida was held at University of Oxford.
- Aida is the **world's first ultra-realistic humanoid artist**, able to draw creatively due to in-built artificial intelligence (AI) technology.
- Ai-Da is named after Ada Lovelace, the English mathematician and writer often called the world's first computer coder.



8.6.4 Vyommitra

Vyommitra, a half-humanoid is being developed by the **Indian Space Research Organisation (ISRO)** for an unmanned space mission later in 2020.



- vyoma = space, mitra = friend
- Called a half-humanoid since she will only have a head, two hands and a torso, and will not have lower limbs.

- She will fly to space on ISRO's GAGANYAAN MISSION in 2022
- It works based on artificial intelligence

8.6.5 Tasks with Vyommitra

- The Vyommitra humanoid will test the ground for the human spaceflight.
- The functions for Vyommitra include attaining launch and orbital postures, responding to the environment, generating warnings, replacing CO₂ canisters, monitoring the crew module, etc.
- She will have lip movement synchronised to mimic speech.
- She will report back to Earth on the changes occurring in the crew module during the spaceflight and return.

8.6.6 Manav- India's First Humanoid Robot

Manav (meaning "human") is India's first humanoid robot which was developed in the laboratory of **A-SET Training and Research Institutes**.

- Manav stands at 2 feet tall and has a weight of 2 kilograms.

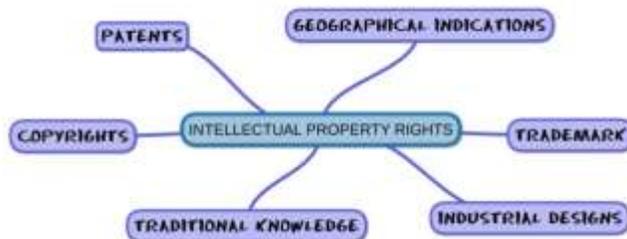
- It is equipped with onboard sound processing and visual processing so it can respond to commands.
- Manav has the capability of Binocular vision processing, giving it the ability to perceive depth and perspective.

9. Intellectual Property Rights

9.1 Introduction

- Intellectual property is a category of property that includes **intangible creations of the human intellect**.
- The main purpose of intellectual property law is to **encourage the creation of a wide variety of intellectual goods**.

9.2 Different IPRs and their Provisions



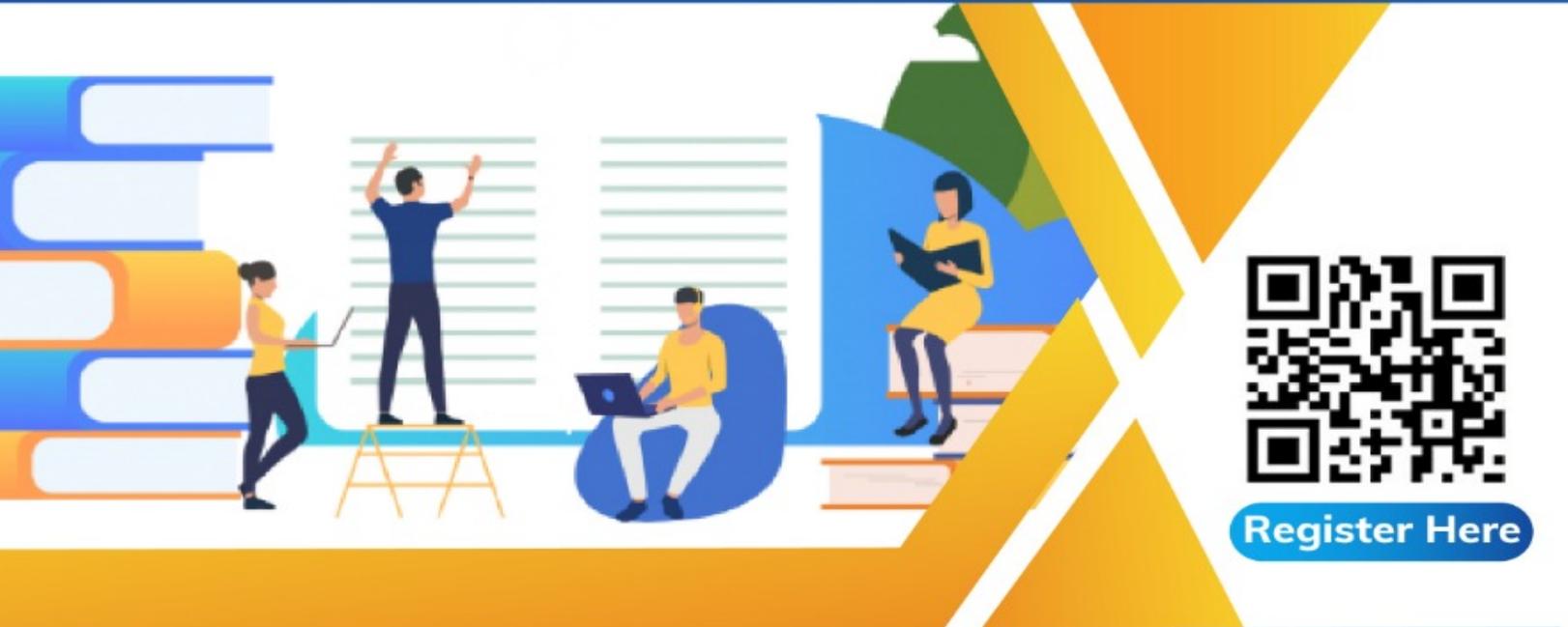
9.3 Details of IPRs

IPR	Meaning	Act and Ministry	Validity/ Renewal	Territorial extent	Other Details
Patent	An exclusive right granted for an invention , which is a product or a process Criteria 1. Novelty 2. Non-obviousness 3. Of Industrial use	Patents Act, 1970 DPIIT, Mo Commerce	20 years from the filing date of the application Renewed by paying patent royalty	only applicable in the country in which a patent has been filed and granted	Following cannot be patented <ul style="list-style-type: none"> • Plants & Animals • Computer Program • Inventions related to Atomic Energy • Methods of agriculture • Frivolous Invention
Trademark	a sign capable of distinguishing the goods or services of	Trademark Act, 1999 DPIIT, Mo	usually ten years . Renewed	once a trademark is recognized or	A trademark gives the entity the right to prevent others

	one enterprise from those of other enterprises	Commerce	anytime within 6 months of expiration	registered in one country, it gains universal recognition	from using the trademark.
Copyrights	The rights that creators have over their literary and artistic works	Copyright Act, 1957 MHRD	Lifetime + 60 years after death No need of renewal	In perpetuity throughout the world.	Books, music, paintings, sculpture & films, to computer programs, databases, advertisements, maps & technical drawings.
Industrial Design	the ornamental aspect of an article	Industrial Design Act, 2000	Ten years Renewable	Rights are limited to the country (or region) where protection is granted	---
GI Tag	<ul style="list-style-type: none"> • Sign used on products that have a specific geographical origin and possess qualities or a reputation that are due to that origin • Registered as a collective or group right 	Geographical Indications of Goods (Registration and Protection) Act, 1999 DPIIT, Mo Commerce	Ten years Renewable , with payment of certain fee.	Rights are limited to the country (or region) where protection is granted Right to use - belongs to producers in the geographical area , who comply with the conditions of production	Conveys an assurance of quality & distinctiveness of a product. All producers from a geographical area can use the GI tag
Traditional Knowledge	Knowledge that is developed , sustained and passed on from generation to generation within a community, often forming part of its cultural or spiritual identity	Traditional Knowledge Act, 2016	--	--	
Plant variety protection	Protection granted for plant varieties. Given to the farmers & breeders	Protection of Plant Varieties & Farmers' Rights (PPVFR) Act, 2001	15 years for field crops 18 years for trees Mo Agriculture		Protect the rights of the farmers in respect of their contribution in conserving plant genetic resources.



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9.4 National IPR Policy 2016

The Policy is in compliance with WTO's (World Trade Organization) agreement on TRIPS (Trade Related aspects of IPRs)

Department of Industrial Policy & Promotion (DIPP), Ministry of Commerce is the nodal department.

The 'Cell for IPR Promotion & Management (CIPAM)', setup under the aegis of DIPP, is to be the single point of reference for implementation of the objectives of the National IPR Policy.

Objectives:

The Policy lays down the following seven objectives:

- 1) **IPR Awareness:** Outreach and Promotion – To create public awareness about the economic, social and cultural benefits of IPRs among all sections of society.
- 2) **Generation of IPRs:** To stimulate the generation of IPRs.
- 3) **Legal and Legislative Framework:** To have strong and effective IPR laws, which balance the interests of rights owners with larger public interest.
- 4) **Administration and Management:** To modernize and strengthen service-oriented IPR administration.
- 5) **Commercialization of IPRs:** Get value for IPRs through commercialization.
- 6) **Enforcement and Adjudication:** To strengthen the enforcement and adjudicatory mechanisms for combating IPR infringements.
- 7) **Human Capital Development:** To strengthen and expand human resources, institutions and capacities for teaching, training, research and skill building in IPRs.

9.5 Terms

9.5.1 Compulsory Licensing

- Compulsory licensing is when a government allows someone else to produce a patented product or process **without the consent of the patent owner.**
- It is permitted under the **WTO's TRIPS (IPR) Agreement**
- Any time **after three years from date of sealing** of a patent, application for compulsory license can be made
- **Indian Patent Act, 1970** regulates the Compulsory Licensing.

9.5.2 Evergreening of Patents

- "Evergreening," is referred to the practice whereby pharmaceutical firms extend the patent life of a drug by obtaining additional 20-year patents for minor reformulations or other iterations of the drug, without necessarily increasing the therapeutic efficacy.
- Section 3(d) in the Indian Patent Act (IPA) does not allow evergreening of patents.

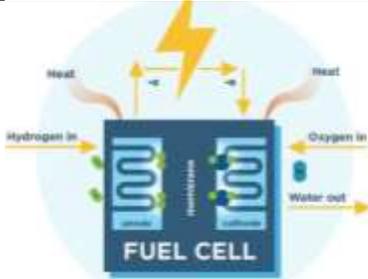
9.5.3 Patent Pooling

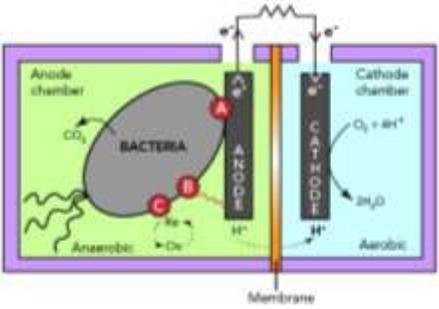
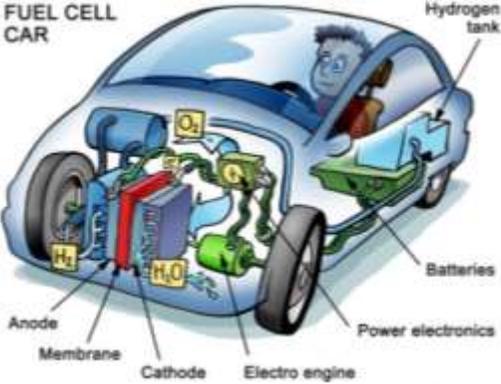
- Patent pools can be defined as an agreement between two or more patent owners to license one or more of their patents to one another or to third parties.
- Often, patent pools are associated with complex technologies that require complementary patents in order to provide efficient technical solutions.

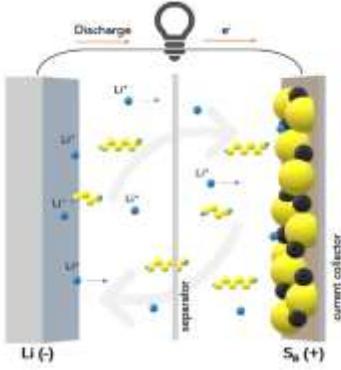
9.5.4 Bio-piracy

- Situation where indigenous knowledge of nature, originating with indigenous people, is used by others for profit, without permission from and with little or no compensation or recognition to the indigenous people themselves

10. Energy Technologies

Cell Or Technology	Details
Organic Photovoltaics (OPV)/ Organic Solar Cell	<p>About OPV or organic solar cells</p> <ul style="list-style-type: none"> OPVs are made from carbon and plastic, are cheaper to make and have far more flexible engineering applications. Completely flexible OPVs can be made with compounds that are dissolvable in ink, which is then printed on to a diverse range of materials. This allows engineers to build semi-transparent solar cells into windowpanes <p>Why they are used less?</p> <ul style="list-style-type: none"> Because of their low efficiency rates. Where silicon photovoltaics convert between 18 to 22 percent of solar energy into electricity, OPVs have only been able to achieve half that rate.
Artificial Leaf	<ul style="list-style-type: none"> Device used to harness solar energy and convert it into usable chemical energy. Generally, a cobalt and silicon coated Perovskite is immersed in water that is split into hydrogen and oxygen in the presence of sunlight. The hydrogen so formed is then used to produce 'syngas' (hydrogen and carbon monoxide) which can be compressed to form liquid fuel that is used in vehicles 
Fuel Cell	<ul style="list-style-type: none"> A fuel cell is a device that converts chemical potential energy (energy stored in molecular bonds) into electrical energy. Fuel cells work like batteries, but they do not run down or need recharging. They produce electricity and heat as long as fuel is supplied. A fuel cell consists of two electrodes—a negative electrode (or anode) and a positive electrode (or cathode)—sandwiched around an electrolyte. A fuel, such as hydrogen, is fed to the anode, and air is fed to the cathode. Both battery and fuel cell produce direct current (D.C). Can be used for power backup in commercial and residential buildings. 

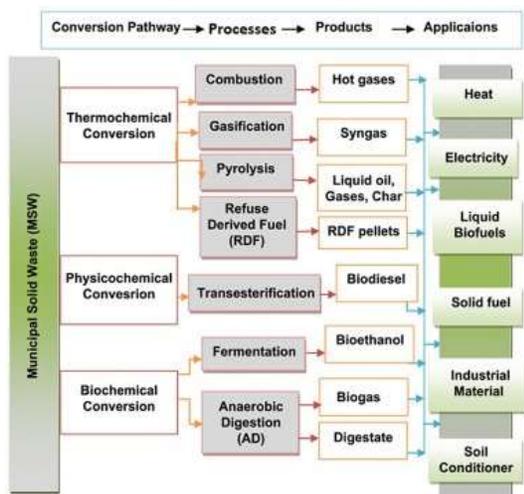
Microbial Fuel Cells	<ul style="list-style-type: none"> Is a bio-electrochemical device that harnesses the power of respiring microbes (bacteria) to convert organic substrates directly into electrical energy It transforms chemical energy into electricity using oxidation reduction reactions It has applications in various fields such as power generation systems, bio-recovery, waste-water treatment, etc. 	
CSIR- High-Temperature Based Fuel Cell System	<ul style="list-style-type: none"> CSIR developed first Indigenous High Temperature Fuel Cell System in partnership with Indian industries under India's flagship program named "New Millennium Indian Technology Leadership Initiative (NMITLI)" The 5.0 kW fuel cell system generates power in a green manner using methanol / bio-methane, with heat and water as bi-products for further use; amounting to greater than 70% efficiency, which otherwise may not be possible by other energy sources 	
Hydrogen-Powered Vehicles	<p>China, Japan and South Korea have set ambitious targets to put millions of hydrogen-powered vehicles on their roads.</p> <p>Supreme Court of India has directed the government to look into the feasibility of Fuel Cell Electric Vehicle (FCEV) to deal with air pollution.</p> <p>The Fuel Cell Electric Vehicle (FCEV) combines hydrogen and oxygen to generate an electric current and water is the only by-product.</p> <p>Advantages</p> <ul style="list-style-type: none"> It is greener technology as the by-products of vehicles are only heat and water. They are far more energy-efficient than traditional combustion technologies. <p>Hydrogen-powered vehicles vs Electric vehicles</p> <ul style="list-style-type: none"> Driving ranges and refuelling times for FCVs are comparable to gasoline cars, whereas EVs require hours to recharge and provide only a few hundred kilometres of range. In general, hydrogen is seen as the more efficient choice for heavier vehicles that drive longer distances. However, lack of refuelling stations which are costly to build, is usually cited as the biggest obstacle to widespread adoption of FCVs. Consumer worries about the risk of explosions are also a big hurdle. Heavy subsidies are needed to bring prices down to levels of gasoline-powered cars. 	

Lithium-Ion Battery	<ul style="list-style-type: none"> Central Electro Chemical Research Institute (CECRI), Karaikudi, Tamil Nadu and RAASI Solar Power Pvt Ltd have signed a Memorandum of Agreement for transfer of technology for India's first Lithium Ion (Li-ion) Battery project. ISRO has approved commercial use of lithium ion battery technology and the battery makers will be required to pay Rs 1 crore as a one-time technology transfer fee to ISRO for every vehicle. It is expected to save 10-15 per cent of the cost of e-vehicles.
Lithium Sulphur Battery	<p>World's most efficient Lithium sulphur battery developed in Australia</p> <ul style="list-style-type: none"> Li-S batteries are generally considered to be the successors of the Lithium-ion (Li-ion) batteries because of their lower cost of production, energy efficiency and improved safety. Their cost of production is lower because sulphur is abundantly available Li-S battery has an ultra-high capacity and has better performance and less environmental impact. While the materials used in the Li-S batteries are not different from those in Li-ion batteries, the researchers have reconfigured the design of the sulfur cathodes to accommodate higher stress without a drop in overall capacity Challenge- short life cycle and poor instantaneous power capabilities 
Iron Ion Battery	<ul style="list-style-type: none"> IIT Madras has fabricated a rechargeable iron ion battery and registered initial success The iron ion battery is cost-effective and the amount of energy that can be stored in the battery is also high Iron has favourable physicochemical properties like lithium Iron is more stable during the charging process and therefore prevents short-circuiting of the batteries. In iron ion battery, vanadium pentoxide is used as the cathode. Vanadium pentoxide was chosen as it has a layered structure with very large spacing between the layers. This, when compared with the popular lithium metal-based batteries helps cut down the cost and make it safer to handle
Thermal Battery Plant	<p>World's first-ever thermal battery plant was recently inaugurated in Andhra Pradesh.</p> <p>Thermal Battery</p> <ul style="list-style-type: none"> Thermal Battery was invented and patented by Dr Patrick Glynn in India 2016. It uses thermal energy to operate, i.e., the energy created by temperature differences. It will also maintain a low carbon footprint, and is less dependent on external factors like weather.

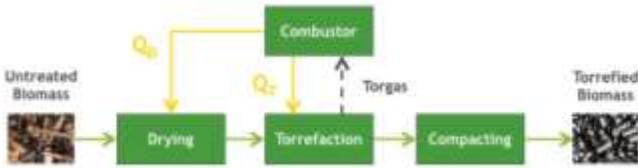
	<p>Working</p> <ul style="list-style-type: none"> • It consists of two parts: a cool zone known as ‘sink’, and a hot source called ‘source’. • Both these sides consist of compounds known as Phase-Changing Materials (PCMs), which can change their state of matter on the basis of a physical/chemical reaction. • When the sink of a thermal battery receives heat, it stores energy, while the source cools down and vice-versa. • Depending on the nature of the battery, the system can derive heat from any source, which makes a thermal battery very versatile. • Applications - Electric vehicles, Telecom infrastructures, Power intensive industries, in electrical grids.
<p>Hydrothermal Carbonisation</p>	<ul style="list-style-type: none"> • IIT-KGP develops Hydro Thermal Carbonization technology for Waste Management for solid waste management. • Technology can convert high moisture municipal solid waste to biofuel, soil amendment and absorbents. <p>Process</p> <ul style="list-style-type: none"> • The technology is aimed at conversion of wet biomass into hydro-char (a coal like fuel) under suitable temperature and pressure conditions. • Moisture in waste is used to the advantage of process which uses water for reaction. • The biofuel generated as recovered output can help curb air pollution. <p>Benefits</p> <ul style="list-style-type: none"> • Technology can be used by civic bodies to effectively manage solid waste. • Once organic waste is entered into process, the outputs generated are all usable. • The hydro-char, rich in carbon and high calorific content, can be utilized as fuel, as an alternative for coal • Its by-products include ash which can be applied as a plant nutrient enhancer
<p>Sodium Sulphur Battery</p>	<ul style="list-style-type: none"> • IIT Madras has designed a new sodium sulphur battery that can be operated at room temperature. • Sodium sulphur batteries use a solid electrolyte, which reduces the diffusion of sodium ions from the anode to the cathode at room temperature. • It works at the temperature of about 300 degrees C. • So in place of a solid electrolyte, a glass fiber separator soaked in the ether-based electrolytes used by the researchers that allow the battery to be operated at room temperature • It has a high-power density and is suitable for large-scale energy storage and space applications • It is cost effective however has safety concerns for widespread adoption
<p>Biggest Floating Solar Power</p>	<ul style="list-style-type: none"> • Developed by the NTPC

<p>Plant Of India</p>	<ul style="list-style-type: none"> At Ramagundam in Peddapalli district, Telangana. 														
<p>Biodiesel from Algae</p>	<p>Biodiesel from algae High oil prices and advances in biotech over the past decade have refueled the algae biofuel race.</p> <p>The process</p> <ol style="list-style-type: none"> After initial growth, algae is deprived of nutrients to produce a greater oil yield. Extraction of oil: A press produces 70-75% of the oils from the plant. Solvents used to separate sugar from oil; solvents then evaporate. Oil is ready: Can be used as oil directly in diesel engines or refined further into fuel. <p>Yield of various plant oils (Gallons per hectare)</p> <table border="1"> <tr><td>Soy</td><td>118</td></tr> <tr><td>Sunflower</td><td>206</td></tr> <tr><td>Sunflower</td><td>251</td></tr> <tr><td>Coconut</td><td>373</td></tr> <tr><td>Coconut</td><td>605</td></tr> <tr><td>Palm</td><td>1,572</td></tr> <tr><td>Algae</td><td>26,417</td></tr> </table> <p>About algae</p> <ul style="list-style-type: none"> Among the fastest growing plants; about 50% of their weight is oil Contains no sulfur; non-toxic; highly biodegradable Algae fuel is also known as algal fuel or alginate 	Soy	118	Sunflower	206	Sunflower	251	Coconut	373	Coconut	605	Palm	1,572	Algae	26,417
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Waste to Energy Techniques (WtE)



Method	Details
<p>Incineration</p>	<ul style="list-style-type: none"> Degradation and complete combustion of waste under high temperature. It is a relatively old method of WtE generation. Incineration generally entails burning waste to boil water which powers steam generators that generate electric energy and heat to be used in home
<p>Pyrolysis</p>	<ul style="list-style-type: none"> Pyrolysis is the thermal decomposition of materials at elevated temperatures in an inert atmosphere (absence of oxygen). It involves a change of chemical composition. Fast Pyrolysis Reactor (FPR) that will thermo chemically decompose any organic or carbon material into energy rich oil and gas. Pyrolysis is most commonly used in the treatment of organic materials.
<p>Gasification</p>	<ul style="list-style-type: none"> Gasification is a unique process that transforms a carbon-based material, such as MSW or biomass, into other forms of energy without actually burning it. It converts the solid and liquid waste materials into usable synthesis gas, or syngas through a chemical reaction

Bio-methanation	<ul style="list-style-type: none"> • Methanogenesis or Biomethanation is the process of combining organic waste materials into biogas and manure. • Biogas is a gaseous fuel that can be easily used for energy generation and production of heat.
Fermentation	<ul style="list-style-type: none"> • In the fermentation process, the sugar in the waste is changed to carbon dioxide and alcohol, in the same general process that is used to make wine. • It is also used to convert food waste into biofuels
Coal Gasification	<p>The Minister of Chemicals & Fertilizers has signed a contract for the coal gasification plant for the urea project at Talchar, Odisha.</p> <ul style="list-style-type: none"> • Transforms the fossil fuel into Synthetic Natural Gas (SNG). • Syngas is a mixture of methane (CH₄), carbon monoxide (CO), hydrogen (H₂), carbon dioxide (CO₂) and water vapour (H₂O). • Can be used to produce a wide range of fertilizers, fuels, solvent and synthetic materials. • The hydrogen obtained from coal gasification can be used for various purposes such as making ammonia, powering a hydrogen economy.
Bio-Coal: Torrefaction Technology	<p>India is testing Swedish technology — torrefaction that can convert rice stubble into ‘bio-coal’.</p> <p>The government has funded a pilot project at the National Agri-Food Biotechnology Institute in Mohali (Punjab) with a Swedish company</p>  <ul style="list-style-type: none"> • Thermal process to convert biomass into a coal-like material to improve the fuel like characteristics. • The process involves heating up straw, grass, sawmill residue and wood biomass to 250 degrees Celsius – 350 degrees Celsius. • During the torrefaction process a combustible gas is released, which is utilised to provide heat to the process. • This changes the elements of the biomass into ‘coal-like’ pellets. These pellets can be used for combustion along with coal for industrial applications like steel and cement production.
Gas Hydrates	<p>Gas hydrates are crystalline form of methane and water, and exist in shallow sediments of outer continental margins.</p> <ul style="list-style-type: none"> • A hydrate is any chemical or mineral that contains water, bound within its chemical structure • Gas hydrates are formed when low molecular weight gases like methane are bound within a solid crystal lattice formed by water molecules. • Naturally methane hydrates are found as sedimentary mineral in the continental shelf areas, permafrost regions, and marine sediments. • Thus methane hydrate sediments are found at conditions of low temperature and high pressure.

11. ICT and Computer

11.1. 5G Network

India has set up a high-level forum to develop a roadmap for adopting 5G in the country and the spectrum auction for 5G is expected during the latter half of 2019.

5G is a wireless communication technology using radio waves or radio frequency (RF) energy to transmit and receive data.

11.1.1 Evolution from First Generation to Fifth Generation

1st Generation	<ul style="list-style-type: none"> It was launched in the 1980s and worked on analog radio signals and supported only voice calls.
2nd Generation	<ul style="list-style-type: none"> It was Launched in the 1990s which uses digital radio signals and supported both voice and data transmission with a Bandwidth of 64 Kbps. The 2G telephone technology introduced call and text encryption, along with data services such as SMS, picture messages, and MMS.
3rd Generation	<ul style="list-style-type: none"> It was launched in the 2000s with a speed of 1 Mbps to 2 Mbps and it has the ability to transmit telephone signal including digitised voice, video calls and conferencing. The term “mobile broadband” was first applied to 3G cellular technology.
GPRS (General Packet Radio Service)	<ul style="list-style-type: none"> Bridge between 2G and 3G. Marks the coming of data transmission - enabled mobile devices to send and receive e-mails and pictures.

	<ul style="list-style-type: none"> GPRS had operating speeds of up to 115 kbps.
4th Generation	<ul style="list-style-type: none"> It was launched in 2009 with a peak speed of 100 Mbps to 1 Gbps and it also enables 3D virtual reality. 4G is different technology compared to 3G. 4G is a common name given to LTE (Long Term Evolution) technology. 4G uses LTE which allows to communicate with voice and data simultaneously. LTE allows transmission of data while voice calls are routed to 2G or 3G networks. Under LTE, you cannot access your 4G data services while on a call.
VoLTE	<ul style="list-style-type: none"> VoLTE is an update to LTE protocol. Allows voice calls to be ‘packaged’ and carried through LTE networks. Thus, enables both data and voice communication over the same 4G network.

11.1.2 Differences between 4G and 5G Networks

5G is the newest mobile network that’s replacing the current 4G technology by providing a number of improvements in speed, coverage, and reliability.

- 5G uses different kinds of antennas, operates on different radio spectrum frequencies, connects many more devices to the internet, minimizes delays, and delivers ultrafast speeds.
- With speeds of up to 100 gigabits per second, 5G is set to be as much as **100 times faster than 4G**.

11.1.3 Low latency

- a) It is a key differentiator between 4G and 5G.
- b) Latency is the time that passes from the moment information is sent from a device until it can be used by the receiver.
- c) Reduced latency means that you'd be able to use your mobile device connection as a replacement for your cable modem and Wi-Fi.
- 5G's **uses of unique radio frequencies** to achieve what 4G networks cannot.
- 4G networks use frequencies below 6 GHz, but 5G uses **extremely high frequencies in the 30 GHz to 300 GHz range.**

11.1.4 Advantages

- Enhanced mobile broadband that can meet high coverage requirements.
- Very **high upload and download speed.**
- 5G can diversify services and has potential to demonstrate spectral efficiency.
- High data speed of 5G Network might help **cloud systems** to stream software updates.
- 5G will help to **incorporate Artificial Intelligence (AI)** in our daily lives.
- It will also facilitate the ecosystem for the **Internet of Things (IoT).**
- It will help in digital growth of country that will result in rise of GDP and employment generation in the country.

11.2. Virtual Sim

Unlike a SIM card, virtual SIMs are not attached to a mobile and created online to help you communicate.

Working Principle

- No physical SIM card issued to the end user.
- Instead, the mobile phones are embedded with a universal SIM card that can be configured to store **data of any operator.** (in physical sim it is only from one particular operator. E.g BSNL sim)

- This enables remote SIM provisioning, which simply means that one may connect to any operator of choice remotely without actually having to buy a physical SIM card.
- You can decide to change operator easily.
- The smart phone can have 'multiple virtual SIM' facilities

11.3. Wi-Fi 6.0

- It is Next generation standard in Wi-Fi technology. Also known as "AX Wi-Fi"
- Connects multiple devices but now with a higher speed than Wi-Fi 5.0
- Improving the network when a bunch of devices are connected.
- It was built for in response to the growing number of devices in the world of IoT Advantages
- Highest standards for security and interoperability.
- Lower battery consumption.
- Increased bandwidth to deliver greater performance with lower latency

11.4. Wi-Fi CALLING (Vowifi)

Bharti Airtel Voice over WiFi (VoWiFi) calling feature, which was launched in December, has crossed 1 million users.

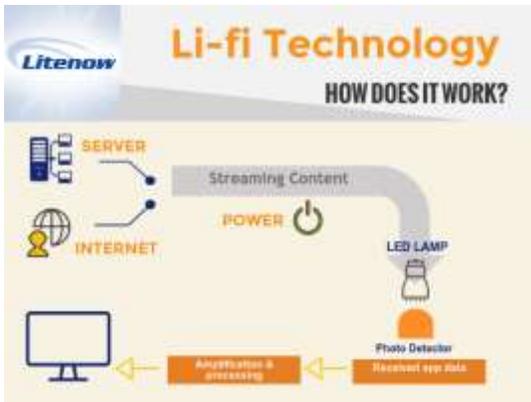


About Wi-Fi CALLING

- It uses **Voice over IP (VoIP) technologies** from mobile devices connected across Wi-Fi. This is in **opposite of technology such as Voice over LTE (VoLTE)**, in which a mobile network operator's (MNO's) licensed spectrum (i.e. 4G LTE) is used to carry packetized voice.
- VoWiFi technology enables users to make outgoing calls even where there is poor cellular connectivity.

- It allows customers to make telco grade calls to any network without any extra charges or any additional calling App/SIM.
- It makes use of high-speed Internet connection, available via broadband, to make and receive high definition (HD) voice calls.

11.5. Li-Fi (Light Fidelity)



Li-Fi is a wireless optical networking technology. Specifically, it is a form of visible light communications (VLC) system that makes use of light-emitting diodes (LED) for data transmission.

It is similar to Wireless Fidelity (WiFi), a technology for wireless local area network communication using microwaves.

Working

- Li-Fi uses visible light as a medium for the transmission of data.
- As a type of VLC system, it requires two components: a photodiode and a light source.
- The photodiode acts as a transceiver that receives light signals and transmits them back.
- The light source transmits data using emitted light as the medium. In this case, light emitting diodes (LED) serve as the light source.
- Data is fed into the light bulb and sends the data at extremely high speeds to the photodiode.
- It converts the data received into a binary data stream perceivable by humans such as video and audio applications.

11.6. Wi-Fi Vs Li-Fi

Advantages of Li-Fi

- Data transmission tests have reached speeds of up to 224 Gbps, roughly 100 times faster than WiFi.
- Visible light is unable to permeate opaque surfaces. Signals emitted by Li-Fi as well as the data transmitted through it remain confined within the space. Hence highly secure from network hijacking

Limitations of Li-Fi

- Li-Fi offers a limited range.
- Li-Fi signals are susceptible to light interferences, including sunlight.
- In reality, installation of Li-Fi systems can become expensive due to the lack of infrastructure.

SrNo.	Comparison Basis	Li-Fi	WiFi
1.	Full Form	Light Fidelity	Wireless fidelity
2.	Operation	Transmits data using bits with help of light from LED bulbs.	Transmits data with help of radio waves with help of WiFi router
3.	Security	Secured (cannot be hacked) as light is blocked by walls.	Not secured (can be hacked) as for RF signal dry walls are transparent
4.	Interference	Do not have any interference issue similar to radio waves.	Has interference issue from nearby access points (routers)
5.	Spectrum	The Spectrum range is 10000times than Wi-Fi	It has radio spectrum range.
6.	Frequency	The frequency band is 100 times of Tera HZ	The frequency band is 2.4GHz, 4.9GHz and 5GHz
7.	Speed	Fast speed internet (greater than 1-3.5Gbps)	Comparatively slow speed (54-250 Mbps)
8.	Where To Use	Anywhere, where light source is present.	Inside a building, typically Within a array of WLAN communications, habitually inside a structure.
9.	Cost	Cheap as LED lamps are used.	Quite expensive.
10.	Data transmission rate	Very high rate of data transmission due to visible light spectrum.	Transmission rate is slow as compared to Li-Fi as RF is used to communicate.
11.	System components	Lamp drivers, LED bulbs and light detectors will form complete Li-Fi system.	Routers have to be installed, devices like laptops, PDAs, desktops are called as stations.

11.7. Biometrics

Biometrics is a branch of information technology that aims towards establishing one's identity based on personal traits.

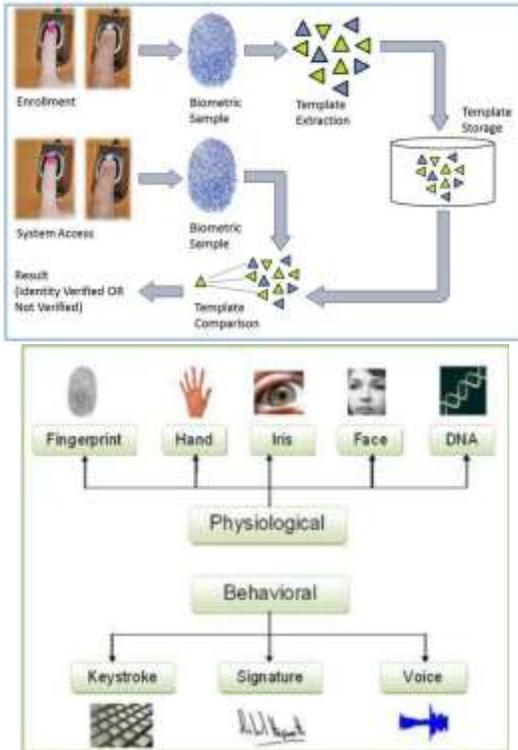
A biometric system is a technology which takes an individual's physiological, behavioral, or both traits as input, analyzes it, and identifies the individual as a genuine or malicious user.

Why Biometrics is Required?

- Authentication (Identification)

- Verification
- Authorization
- Shortcomings of Conventional Security Aids (e.g. PIN and passwords)

Working



11.8. Automated Multi-Modal Biometric Identification System (AMBIS)

Maharashtra government has implemented AMBIS

- AMBIS is an **advanced crime detection system**, for detection of crime based on the available fingerprint, palmprint and iris scan data of criminals on record
- **Components:** An AMBIS unit comprises a computer terminal, a camera, and iris, fingerprint, and palm scanners. It also includes a portable system to dust off and capture fingerprints from crime scenes.
- **Working:** With the integration of the system with facial recognition from CCTV cameras, AMBIS enables the police to cross-reference and put faces to criminals whose fingerprints have been captured on paper over the decades, apart from solving fresh crimes.

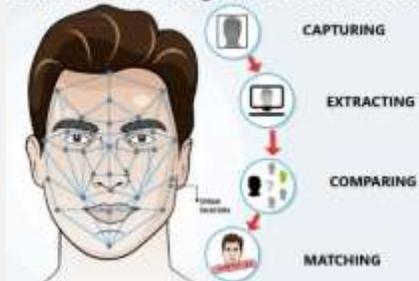
11.9. Automated Facial Recognition System (AFRS)

- Central government wants to create a “repository of photographs of criminals in the country,” and wants to put a system in place to track “missing children and unidentified dead bodies
- National Crime Records Bureau (NCRB) has invited bids to create such system

Facial recognition

- It is a way of recognizing a human face through technology.
- A facial recognition system uses biometrics to map facial features from a photograph or video.
- It compares the information with a database of known faces to find a match.
- Facial recognition can help verify personal identity, but it also raises privacy issues.

Biometrics Face Recognition - How does it Work?



11.10. Biometric Seafarer Identity Document (BSID)



India has become the first country in the world to issue BSID, capturing the facial bio-metric data of seafarers.

- Launched by the Ministry of Shipping and Ministry of Chemical & Fertilizers.
- BSID is an improvement over the two finger or iris based bio-metric data, with modern security features.
- It will give a fool proof identification to Indian seafarers which will facilitate their movement, provide ease of getting jobs and help in identifying them from any location in the world.

11.11. Fastags- National Electronic Toll Collection System (NETC)



National highway collects toll only through FASTags without human intervention

About FASTag

- FASTag is a device that employs **Radio Frequency Identification (RFID)** technology for making toll payments directly while the **vehicle is in motion**.
- FASTag (RFID Tag) is affixed on the windscreen of the vehicle and enables a customer to make the toll **payments directly from the account** which is linked to FASTag.
- FASTag is also vehicle specific and once it is affixed to a vehicle, it cannot be transferred to another vehicle.

About RFID

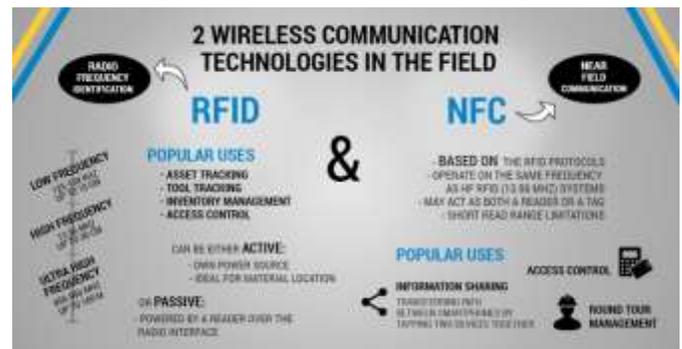
- It is an electronic tag that can exchange data with an **RFID reader through radio waves**.

- In this an **antenna broadcasts energy to the tag**, which in turn returns the modulated energy back in the form of back-scatter.
- It is **faster connection** and its operational **range is about 100m**
- RFID tag typically sends out information hence **only one-way information**.

About NETC and NPCI

- National Payments Corporation of India (NPCI) has developed the National Electronic Toll Collection (NETC) program
- National Payments Corporation of India (NPCI), an initiative of the Reserve Bank of India (RBI) and Indian Banks' Association (IBA), is an umbrella organisation for operating retail payments and settlement systems in India.
- NPCI functions under the provisions of the Payment and Settlement Systems Act, 2007 and It is a non-profit organisation

11.12. RFID Vs NFC



11.13. BHIM 2.0

BHIM app, a UPI based payment interface developed by NPCI that allows real time fund transfer

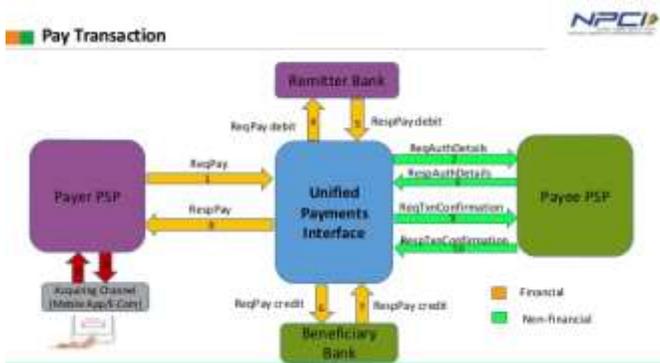
About BHIM

- Bharat Interface for Money (BHIM) is a payment app that lets you make simple, easy and quick transactions using Unified Payments Interface (UPI).

- You can make direct bank payments to anyone on UPI using their UPI ID or scanning their QR with the BHIM app.
- You can also request money through the app from a UPI ID.

UPI working

- It will be an unique identifier that your bank uses to transfer money and make payments using the IMPS (Immediate Payments Service).
- It works 24*7
- An initiative by National Payments Corporation of India's (NPCI)
- The interface will allow account holders across banks to send and receive money from their smartphones using just their Aadhaar unique identity number, mobile phone number or virtual payments address without entering bank account details.



QR code- Quick response code

- A QR code consists of black squares arranged in a square grid on a white background, which can be read by an imaging device such as a camera.
- QR contains information about the item to which it is attached.

Are Bharat QR & BHIM QR Same?

- BHIM QR is UPI Based QR. It is preferably used for P2P or P2M dynamic Transaction using Virtual Payment Address.

- Bharat QR is specifically used for P2M transaction wherein payment is done via cards i.e., Debit card/Credit Card/Pre-paid Card

11.14. Blockchain Technology

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

About COE

- The CoE has developed **Blockchain-based Proof of Concepts (PoCs)** for select government use cases to understand the potential benefits provided by this emerging technology.
- New and previously unforeseen applications of Blockchain in the Government are expected to enhance transparency, traceability and trust in e-governance systems.

About Blockchain Technology

- Blockchain technology is most simply defined as a decentralized, distributed ledger that records the provenance of a digital asset.
- sometimes referred to as Distributed Ledger Technology (DLT)

Facts about blockchain technology



- The information is **packaged into blocks**, which link to form a chain with other blocks of similar information.
- If something is stored on a blockchain, it **cannot be disputed, removed or altered**, without the knowledge and permission of those who made that record. Hence highly secure.

- Once a transaction is sent it is sealed and **cannot be reversed**.
- **Data storage is decentralised** i.e. multiple copies of the same data are stored in different locations and on different devices on the network, such as computers or printers.
- This is known as a **peer to peer (P2P) network**. This means that even if one point of storage is damaged or lost, multiple copies remain safe and secure elsewhere.
- It has radically changed the trust equation in the international transactions by eliminating the middlemen
- **Cost-effective and time-saving-** Since blockchain is a distributed database, it does not need intermediaries thereby reducing cost of transaction.

Working -Blockchain is a combination of three leading technologies:

1. **Cryptographic keys-** consist of two keys – **Private key and Public key**. These keys help in performing successful transactions between two parties.
2. **A peer-to-peer network containing a shared ledger**
3. A **means of computing**, to store the transactions and **records of the network**

Applications

- The Bitcoin Network is the first successful implementation of blockchain technology.
- This technology has high potential in finance sector.
- Healthcare system- storing sensitive patient data.
- Politics- Blockchain is being looked at by an organization called Follow My Vote, which is trying to combat election fraud at the ballot box.
- Other fields- social networks, messengers, games, exchanges, storage platforms, voting systems, prediction markets, online shops

More news on blockchain technology

- Yes Bank adopted blockchain technology to fully digitise vendor financing
- NITI Aayog is building a platform called 'IndiaChain' — a shared, India-specific blockchain infrastructure to leverage the trinity of Jan-Dhan-Yojana, Aadhaar and the mobile)
- SBI leads as the first bank to use KYC and facilitate remittances based on blockchain)
- Last year Coffee Board had launched the Coffee Blockchain initiative.

11.15. Virtual Reality And Augmented Reality

Virtual Reality (VR)

- Computer-generated simulation or recreation of a real life environment or situation
- Coding language used is known as VRML (Virtual Reality Modeling Language) to create a series of images and their interactions.

Augmented Reality (AR)

- Technology that layers computer-generated enhancements atop an existing reality in order to make it more meaningful
- AR is developed into apps and used on mobile devices to blend digital components into the real world in such a way that they enhance one another.



11.16. Darknet

- Refers to the deep hidden internet platform that is used for narcotics sale, exchange of pornographic content and other illegal activities.

- Stay away from the surveillance of law enforcement agencies.
- Owing to its end-to-end encryption, darknet is considered very tough to crack.
- Dark Net itself is only a part of the Deep Web that is a broader concept, which includes sites that are protected by passwords
- Only difference is that while the Deep Web is accessible, the Dark Net is deliberately hidden.
- The part of internet that is readily available to general public and searchable on standard search engines is called as **Surface Web**.

12. Technologies and Innovations in Day-To-Day Life

12.1 Membrane-Based Water Purification Systems (MWPS)- REVERSE OSMOSIS

- Recently, the Union Ministry of Environment has issued a **draft notification** that seeks to ban membrane-based water purification systems (MWPS), primarily reverse osmosis (RO), in areas where the water supplied meets norms
- National Green Tribunal (NGT) in May, 2019, instructed the BAN
- Ban was ordered on the grounds that RO wasted water and that, in the process of removing salts, they often deprived drinking water of essential salts
- It also asked the ministry to lay down a requirement for RO systems manufacturers that the recovery of treated water should be at least 60 per cent as against 20 per cent prescribed by the Bureau of Industry Standards (BIS) in 2015

Note

- Total Dissolved Solids (TDS) = comprise inorganic salts (principally calcium,

magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates) and some small amounts of organic matter that are dissolved in water

- As per a WHO study, TDS levels below 300 mg per litre are considered to be excellent
- Bureau of Indian Standards (BIS) guidelines on drinking water
 - According to BIS standards, drinking water is considered below par if the TDS is above 500 mg/l
 - BIS standards also state that RO system is not recommended for treatment of raw water having Arsenic level above 0.1 mg/l and Fluoride level above 8.0 mg/l)

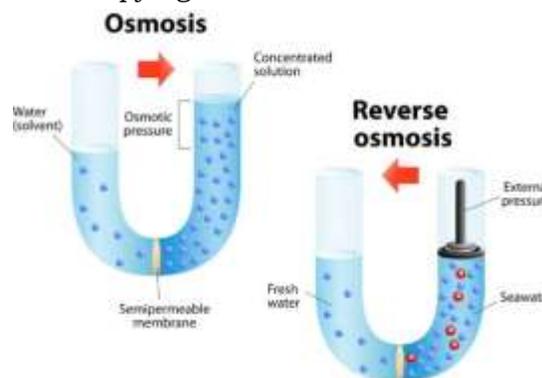
12.1.1 Reverse Osmosis Technology

Reverse Osmosis is a technology that is used to remove a large majority of contaminants from water by pushing the water under pressure through a semi-permeable membrane

Osmosis

It is a naturally occurring process. It is a process where a weaker saline solution will tend to migrate to a strong saline solution. Examples of osmosis are when plant roots absorb water from the soil and our kidneys absorb water from our blood.

Semi-permeable membrane is a membrane that will allow some atoms or molecules to pass but not others. It allows the passage of water molecules but not the majority of dissolved salts, organics, bacteria and pyrogens.



Reverse Osmosis is capable of removing up to 99%+ of the dissolved salts (ions), particles, colloids, organics, bacteria and pyrogens from the feed water

12.1.2 Desalination Technology

- To convert salt water into freshwater, the most prevalent technology in the world is Reverse osmosis (RO)
- Because RO plants convert seawater to fresh water, the major environmental challenge they pose is the deposition of brine (highly concentrated salt water).
- Another problem is that the pressure motors needed to draw in the seawater end up sucking in small fish and life forms
- There are concerns that desalinated water is short of vital minerals such as calcium, magnesium, zinc, sodium, potassium and carbonates
- The alternative desalination technology used is thermal energy sourced from the ocean (There is a low-temperature thermal desalination (LTTD) technique)

Minjur desalination plant, in the state of Tamil Nadu, India. It is the largest desalination plant in India. The second largest plant is in Jamnagar, Gujarat, with a capacity of 96,000m³/day.

1st Solar-Powered Desalination

- IIT-Madras sets up India's **1st solar-powered desalination** plant at Chennai.
- A 10,000-liters-per-day plant in Tamil Nadu offers hope for powering clean water without fossil fuels.
- It uses RO technology powered by solar power.

12.2 Hyperloop

India has mooted its 1st hyperloop project, the Mumbai Pune Hyperloop system.

- The hyperloop concept is a brainchild of Tesla founder Elon Musk.

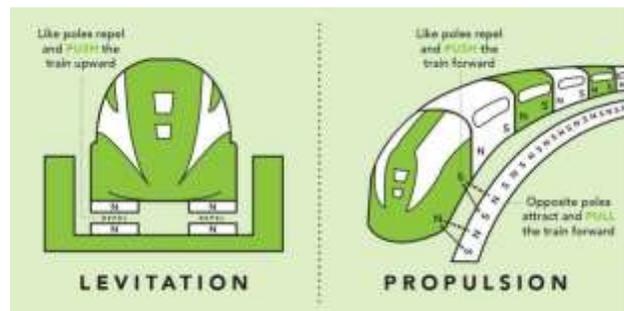
- It is a transportation system where a pod-like vehicle is propelled through a **near-vacuum tube** connecting cities at speeds **matching that of an aircraft**.
- Most of the air has been removed in the tunnel to reduce friction for the pods and hence increase speed.
- Rather than using wheels like a train or car, the pods are designed to float on air skis, using **magnetic levitation to reduce friction**.
- Hyperloop will allow travel at the near-supersonic speeds of 1,200 kilometers per hour, or Mach 0.91.

Working

- Firstly, the track on which the capsules move is essentially an electromagnetic motor laid flat on the floor.
- Each pod is pushed along the track when an electric current is fed through the magnets.
- Where an electric motor spins in a circle, the hyperloop pod is propelled forwards.

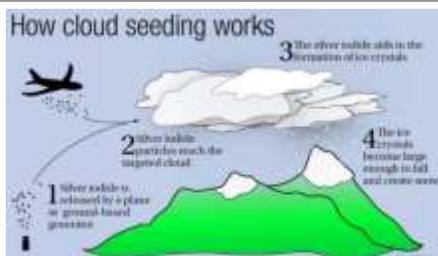
Magnetic levitation- (maglev) or magnetic suspension is a method by which an object is suspended with no support other than magnetic fields.

Magnetic force is used to counteract the effects of the gravitational acceleration and any other accelerations.



12.3 Cloud Seeding

- Process of augmenting the process of precipitation by manipulating the size of condensation nuclei.



- Under this process substances capable of absorbing water vapour (hygroscopic) such as silver iodide, sodium chloride, potassium chloride, dry ice (solid carbon dioxide) are sprayed in the clouds to act as using an aircraft or an artillery gun.
- This catalyzes the growth of condensation nuclei which in turn results in enhanced precipitation.

Applications of Cloud Seeding

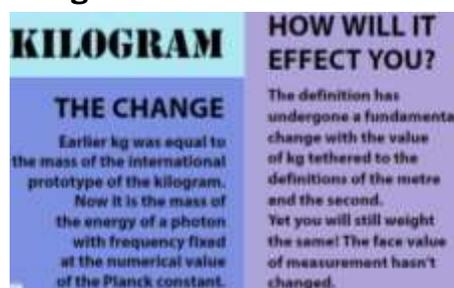
- **Agriculture** –To augment rainfall in drought-stricken areas. For instance **‘Project Varshadhari’** in Karnataka in 2017.
- **Power Generation** – Cloud seeding experiments have shown to augment production of hydroelectric during the last 40 years in Tasmania, Australia.
- **Water Pollution Control** –To maintain minimum summer flows of the rivers and dilute the impact of treated wastewater discharges from municipalities and industries.
- **Weather modification:** Fog Dispersal, Hail Suppression, and Cyclone Modification. Project Sky Water of U.S.A.
- **Air pollution** – Urban areas like Delhi and Mumbai have contemplated the use of cloud seeding to combat air pollution as rain water absorbs particulate matter.

12.4 Redefining Kilogram

General Conference on Weights and Measures (CGPM) is the highest international body of the world for accurate and precise measurements and comprises of 60 countries including India and 42 Associate Members.

- In 2019, the SI base units were redefined in agreement with the International System of Quantities.
- The decision was made at the General Conference on Weights and Measures.
- In 2019, India adopted a global resolution to redefine four of the seven base units -- kilogramme, kelvin, mole and ampere, a move expected to have far-reaching effects, including changes in textbooks.

12.4.1 Kilogram



- Previously, it was defined by the weight of a platinum-based ingot called **“Le Grand K”** which is locked away in a safe in Paris.
- It was followed since 1889.
- Several close replicas were made and distributed around the globe.

12.4.2 Why change now?

- But the master kilogram and its copies were seen to change – ever so slightly – as they deteriorated.
- The fluctuation is about 50 parts in a billion, less than the weight of a single eyelash.
- But accurate measurement is now critical in many areas, such as in **drug development, nanotechnology and precision engineering.**

12.4.3 New definition

- The Kilogram has joined other standard units of measure such as the second, metre, ampere, kelvin, mole and candela that would no longer be defined by physical objects.



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- It now hinges on the definition of the **Planck Constant**, a constant of nature that relates to how matter releases energy.

THE SEVEN FUNDAMENTAL UNITS

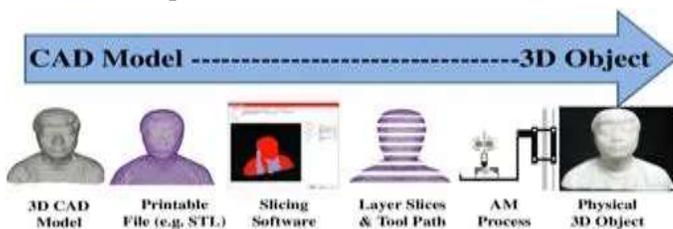
UNIT	QUANTITY	HOW IT IS/WILL BE DEFINED
Meter*	Distance	Based on speed of light
Kilogram**	Mass	To be based on Planck constant
Second*	Time	Based on radiation of caesium-133 atom
Ampere**	Current	To be based on an electron's charge
Kelvin**	Temperature	To be based on Boltzmann constant
Mole**	Amount of substance	To be based on Avogadro constant
Candela*	Luminous intensity	From efficacy of light of specific frequency

*Current definition stands **Being redefined

- Planck constant is $6.62607015 \times 10^{-34} \text{ m}^2 \text{ kg/s}$.
- The Planck constant is a concept in quantum mechanics. One can think of the Planck constant as the **smallest action an electron can take**.

12.5. 3-D Printing

- Also known as additive manufacturing
- It is a process of making three dimensional solid objects by laying down successive layers of material one by one.
- Each layer is a horizontal cross-section of the final object.
- 3D printing is the opposite of subtractive manufacturing, the principle on which the CNC (Computer Numerically Controlled) machines work on which cuts or hollows out a piece of metal or plastic



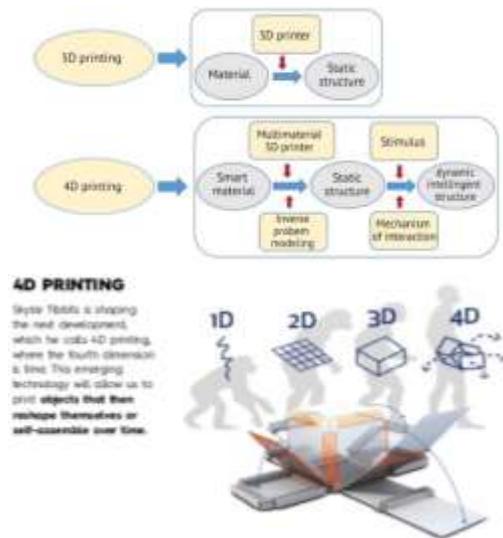
Applications

- Rapid prototyping: Using 3D printers to create prototypes is called rapid prototyping.
- Rapid Manufacturing: Used for short run / small batch custom manufacturing.
- Aviation and Aerospace

- Construction and Architecture
- Furniture and Lighting
- Medical: Bio-printing of implants and prosthetics
- Dental implants

12.6. 4-D Printing

- Scientists have successfully developed the world's first 4D printing for ceramics. This technology is part of the project of **MIT Self-assembly Lab**.
- It can be used to create complex, shape-changing objects.
- 4D Printing is referred to as 3D printing transforming over time. Thus, a fourth dimension is added: time.
- The difference is that the 4D Printing technology uses programmable and **advanced materials (smart materials)** that perform a different functionality by adding hot water, light or heat.



- The 4D printed objects can **re-shape or self-assemble** themselves over time with external stimuli, such as mechanical force, temperature, or a magnetic field.

12.7 E Cigarette Ban

Parliament has passed the Prohibition of Electronic Cigarettes Bill, 2019.

It makes production, manufacture, import, export, transport, sale, distribution, storage and advertisement of e-cigarettes and other **Electronic Nicotine Delivery Systems (ENDS)** a **punishable offence**.

ENDS includes vapes, e-hookahs and e-cigs.

E cigarette



- e-Cigarettes are battery powered devices that work by heating a liquid into an aerosol that the user inhales and exhales.
- The e-cigarette liquid typically contains nicotine, propylene glycol, glycerin, flavorings, and other chemicals.
- These devices belong to a category of vapour-based nicotine products called ENDS.
- E-cigarettes and other ENDS products may look like their traditional counterparts, but they also come in other shapes and sizes and can **resemble daily use products** (like pens and USB drives).
- Several companies selling ENDS in India have positioned these products as a safer, less harmful alternative to traditional cigarettes or as devices that could help users quit smoking.

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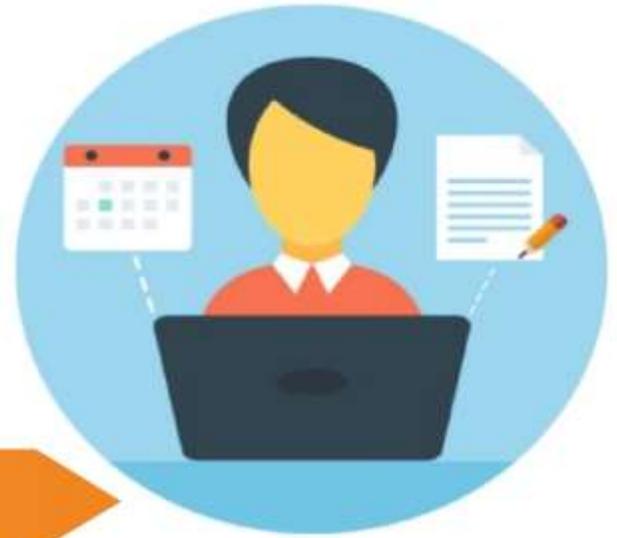


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