

# L1 Cells, DNA, Chromosomes

17 October 2024 03:47 AM

Cell	<ul style="list-style-type: none"><li>• Building block of organisms</li><li>• Prokaryotic cells : Do not have organelles, only outer cell membrane, Bacteria</li><li>• Eukaryotic : Contains True Nucleus (Covered by membrane)</li></ul> <p>The diagram illustrates the structural differences between eukaryotic and prokaryotic cells. On the left, a large circular diagram represents a eukaryotic cell with various organelles labeled: Nucleus, Nucleolus, and Chromatin. Mitochondria are shown as orange ovals, and other organelles like the endoplasmic reticulum and Golgi complex are depicted as pink and blue structures. On the right, a smaller oval diagram represents a prokaryotic cell, showing a single, centrally located nucleoid containing folded chromosomal material. The word 'Cell' is written in red above the eukaryotic cell diagram.</p> <table border="1"><tr><td>Brain</td><td>Nucleus</td></tr><tr><td>Lungs</td><td>Mitochondria</td></tr><tr><td>Stomach</td><td>Lysosomes</td></tr><tr><td>Circulatory</td><td>Endoplasmic reticulum, Golgi Complex</td></tr></table>	Brain	Nucleus	Lungs	Mitochondria	Stomach	Lysosomes	Circulatory	Endoplasmic reticulum, Golgi Complex
Brain	Nucleus								
Lungs	Mitochondria								
Stomach	Lysosomes								
Circulatory	Endoplasmic reticulum, Golgi Complex								
Types	<p><b>Animal cell:</b> Only cell membrane and no cell wall</p> <p><b>Plant cells:</b> Cell membrane + Cell wall (Cellulose based)</p> <p><b>Bacterial cells:</b> Cell membrane + Cell wall (made up of Peptidoglycan)</p> <p>The diagram shows three types of vacuoles: central vacuole in plant cells, food vacuole in animal cells, and contractile vacuole in paramecia. The central vacuole in plant cells is usually filled with water. The food vacuole in animal cells is involved in phagocytosis and digestion. The contractile vacuole in paramecia pumps out excess water. Labels include: food vacuole (several small; used for digestion, secretions, &amp; waste), central vacuole (usually filled with water), contractile vacuole (pumps out excess water), animal cells, paramecium, food vacuole, phagocytosis, contractile vacuole, lysosomes, autophagy, food vacuole, contractile vacuole, nucleus, cytoplasm, pellicle, gills, cytoskeleton.</p>								

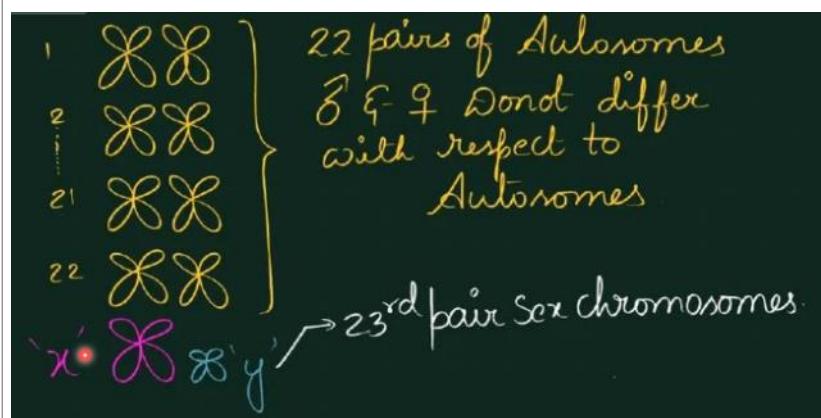
- Plastids : organelle present in plant cells
  - Chromoplast : coloured plastids, xanthophyll (yellow), anthocyanin (Purple)
  - Chloroplast : green coloured plastid helps in photosynthesis (Chlorophyll)
  - Leucoplast : colourless plastids, Amyloplast (Starch), elaioplast (Oil)
    - Interconvertible to store different things in different seasons
- Vacuole : occupies 70% of plant cells
- Lysosomes : suicide bags present in the plant cells.

Nucleic Acids	<ul style="list-style-type: none"> <li>• Present inside the Nucleus</li> </ul> <p>         A - Adenine          T - Thymine          G - Guanine          C - Cytosine          U - Uracil       </p> <p>         Nitrogenous bases          Nitrogenous base + Sugar = Nucleotide          nucleotide + phosphate = nucleotide          chain (polymer) of nucleotides = nucleic acid       </p>
	<p>         RNA: P-R-A, P-R-U, P-R-G, P-R-C, P-R-A       </p> <p>         DNA: P-D-A, P-D-T, P-D-G, P-D-C, P-D-A (top strand)          P-D-T, P-D-A, P-D-C, P-D-G, P-D-T (bottom strand)       </p> <p>Hydrogen bonds</p>
Type	<p>         Deoxy ribo nucleic acid → ATGC          - Deoxy Ribose sugar          - Double stranded → Genetic material       </p> <p>         Ribo nucleic acid          - AUGC          - Ribose sugar          - Single stranded          - Not the genetic material       </p>

- Base Pairing : Bond in DNA
  - A=T, G≡C
- Condensing DNA to make it fit in the nucleus
- 1 Chromatid = 1 DNA
- 2 Chromatids = 1 Chromosomes
- DNA → Replication to make 2 DNA



Chromosomes	<ul style="list-style-type: none"> <li>Each cell contains 23 pairs of chromosomes.</li> <li>First 22 pairs of chromosomes are called Autosomes.</li> <li>Autosomes control / determine the characters that are common for both sexes.</li> <li>23<sup>rd</sup> pair of chromosomes are called allosomes.</li> <li>Allosomes are also called as sex chromosomes.</li> <li>Sex chromosomes are of two types, X &amp; Y</li> <li>X is female sex chromosome. It controls female sex characters and some common characters like color vision, blood clotting, brain development etc. (Larger)</li> <li>Y is male sex chromosome. It controls male sex characters. (Smaller)</li> <li>23<sup>rd</sup> pair in female somatic cells – XX</li> <li>23<sup>rd</sup> pair in male somatic cells - XY</li> </ul>
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- Each cell = 23 pairs of chromosomes = 46 Chromatids = 92 DNA
- X > Bigger than Y chromosome, can perform more function

Turner Syndrome	<p><u>Turner's Syndrome</u></p> <ul style="list-style-type: none"> <li>- Monosomy (XO)</li> <li>- Gender - ♀</li> <li>- Symptoms :-</li> <li>- ♀ infertility, short stature</li> <li>- Some of them are mentally retarded</li> </ul>
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## Upper male Syndrome

1		<u>Super male syndrome</u>
21		- Trisomy - Gender - male
22		Symptoms :- - Taller than avg, - Learning problems, - Criminal bent of mind
		* yy observed in some studies

## Super Female Syndrome

20		<u>Super female syndrome</u>
21		Trisomy of x chromosome Gender: female
22		Symptoms :- - Taller than average - normal fertility
23		- rarely learning difficulties

## Klinefelter Syndrome

1		<u>Klinefelter's syndrome</u>
21		- Trisomy - Gender - ♂
22		Symptoms :- - male infertility
		- Lesser number of sperms or no sperm production
		- feminine characters

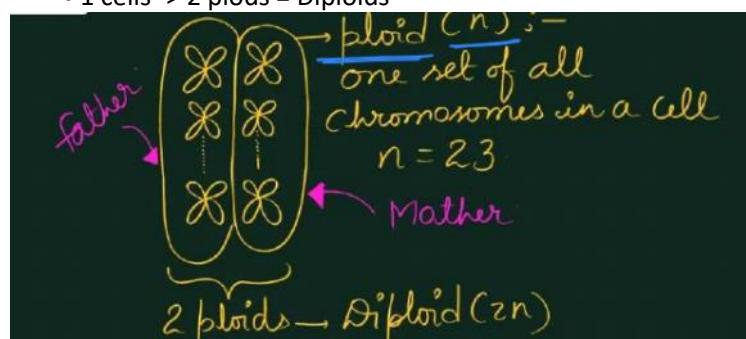
- Inter Sex : Looks Man, have female feature
- Extreme Klinefelter Syndrome : XXXY

## Down's Syndrome

20		<u>Down's syndrome</u>
21		- Trisomy of 21st chr - most common chromosomal aberration
22		Symptoms :- - Delayed development
23		learning disability (Autism)

## Ploids

- 1 Ploid = 23 Chromosomes
  - In each pair, 1 from mother, 1 from father
  - 1 ploid from each parents
  - 1 cells -> 2 plods = Diploids



Ploid(n): One set of all chromosomes in a cell

Diploid (2n):  $2 \times 23 = 46$  chromosomes

Triploid (3n):  $3 \times 23 = 69$  chromosomes

Tetraploid (4n)

Pentaploid (5n)

Hexaploid (6n)

Heptaploid (7n)

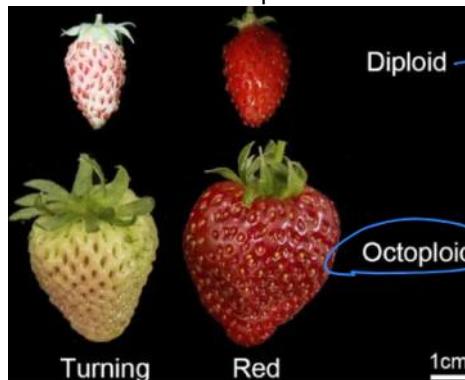
Octaploid (8n)

} Polyploids

- Humans cannot tolerate polyploidy. It is believed that 10% of spontaneous abortions in humans are due to the formation of polyploid zygotes.

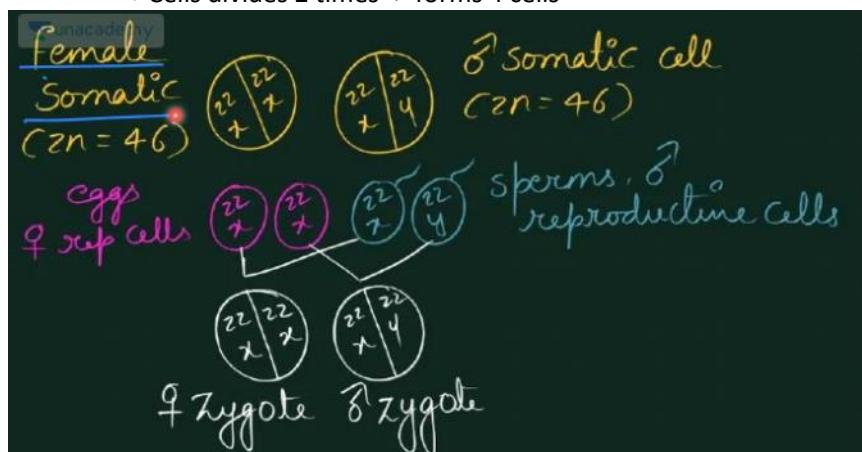
- Most species whose cells have nuclei (**eukaryotes**) are diploid, meaning they have two sets of chromosomes—one set inherited from each parent.
- However, some organisms are polyploid, and **polyploidy is especially common in plants**.
- Most eukaryotes have diploid somatic cells but produce haploid gametes (eggs and sperm) by meiosis.

- Polypliods is possible in plants because they are vegetative/ Asexual reproduction which does not involve chromosomes
- Animal have sexual reproduction in which chromosomes are required



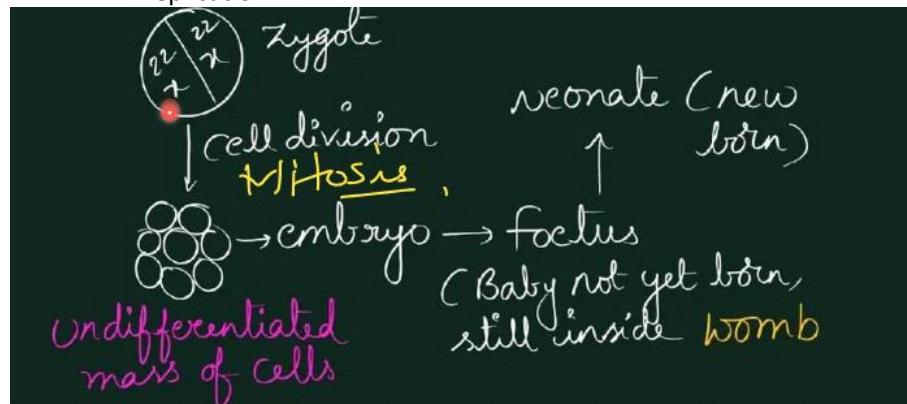
## Reproduction

- Eggs and Sperm : Haploids (half the ploids)
  - Haploids of diploids : Monoploids
  - Haploids exist for sexually reproducing animals
    - Gametes (Eggs and sperms) are required!
- Meiosis : reductional cell divisional (Chromosomes reduce)
  - Cells divides 2 times -> forms 4 cells



- Embryo formation
  - Mitosis : Equational cell divisional

- Cell Divides 1 time -> froms 2 cells
- DNA Replication



Twins	<ul style="list-style-type: none"> <li>• Twins are rare. Women release only 1 egg per month</li> <li>• Male release 500 million sperms, only 1 sperm can fuse</li> <li>• Required for survival of fittest</li> </ul>
Dizygotic Twins	<ul style="list-style-type: none"> <li>• Born from 2 zygotes,</li> <li>• They are not identical but similar as siblings</li> <li>• Reason <ul style="list-style-type: none"> <li>• Low levels of estrogen and progesterone can lead to Dizygotic twins</li> <li>• Genetic</li> </ul> </li> </ul> <p><i>Dizygotic twins / non identical twins / Fraternal twins 2e + 2s → 2 zygotes → 2 babies can be 2♀/2♂/1♀1♂</i></p>
Monozygotic Twins	<ul style="list-style-type: none"> <li>• Reason : Coincidence</li> <li>• 1 egg can split only to two healthy zygote, more split leads to unhealthy</li> </ul> <p><i>Identical twins / Monozygotic twins ie <math>\frac{n}{z} + \frac{n}{y}</math> is <math>2\bar{\delta}/2\bar{\varnothing}</math> 1 zygote <math>\frac{n}{z} \frac{n}{y}</math> → 2 embryos → 2 babies</i></p> <ul style="list-style-type: none"> <li>• Cojoined Twins (Siamese Twins)</li> <li>• Incomplete split of zygote</li> </ul>

# L2 Cloning

18 October 2024

06:10 AM

## Human Cloning

### HUMAN CLONING / ANIMAL CLONING / SOMATIC CELL NUCLEAR TRANSFER:

- **Cloning** is the process of producing individuals with identical or virtually identical DNA.
  - Clone can be described as the child of a single genetic parent.
  - Cloning is majorly of two types, Reproductive cloning, Therapeutic cloning
  - **Therapeutic cloning** creates a line of embryonic stem cells genetically identical to an individual.
  - Advocates support development of therapeutic cloning to generate tissues and whole organs to treat patients who need transplants.
- Therapeutic cloning : Cloned Embryo -> organ manufacture (heart, liver, kidney) for transplant

#### Some facts:

- First cloned sheep – Dolly
- First cloned cat – Copycat.

#### Reproductive cloning of endangered species:

- American scientists in late 2020 announced the first cloning of an endangered animal native to the United States. A **black-footed ferret** was created from the cells of an animal that died over 30 years ago.
- Such use of cloning aims to one day bring back animal species that became extinct.

Scientists of National Dairy Research Institute (NDRI) in Karnal, Haryana have produced several animal clones since 2009. Gantantra and Karnika are the most recent clones.

#### Uses

- Help boost **milk production**
- Provide excellent quality semen for **artificial insemination**

#### NDRI Cloned Calves

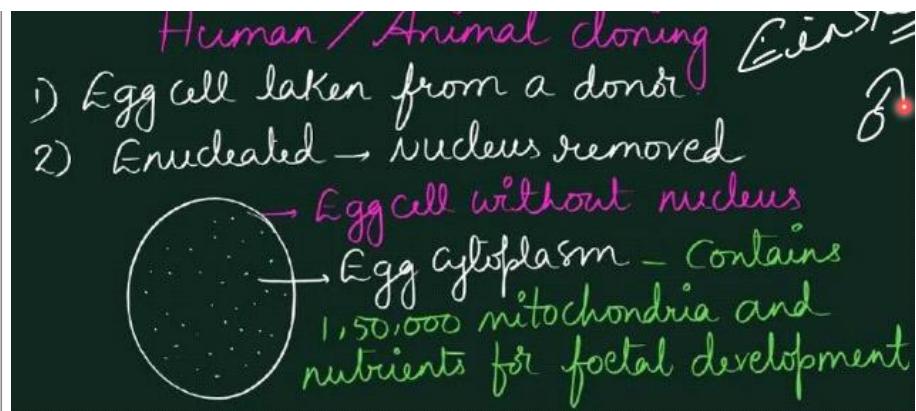


GANTANTRA (MU-8194)  
Closed male calf of superior bull MU-2501  
(Set-16 of Network project)  
D.O.B. 26.01.2022



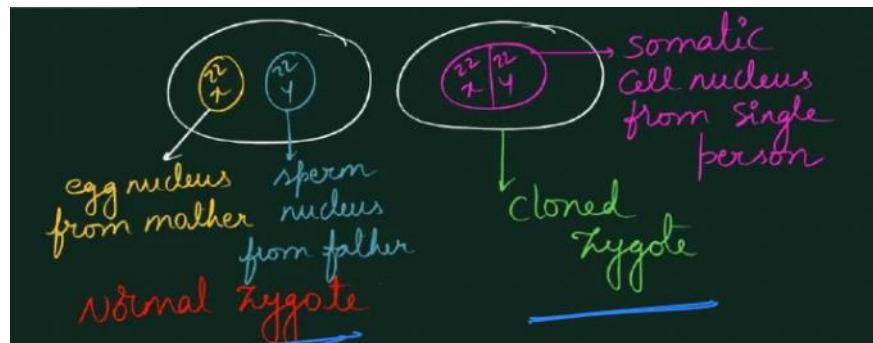
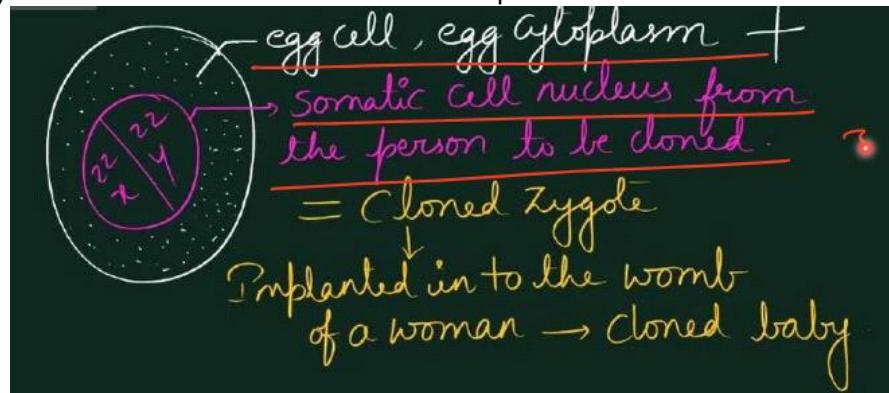
KARNIKA (MU-8184)  
Closed female calf of superior buffalo MU-4316  
(produced 6689 kg of milk in 5<sup>th</sup> lactation)  
D.O.B. 10.12.2021

Procedure



- Somatic Cells / Sperms : 1500 mitochondria
- Egg cells : 1,50,000 mitochondria in cytoplasm

3) Add nucleus from somatic cells from the person to be cloned

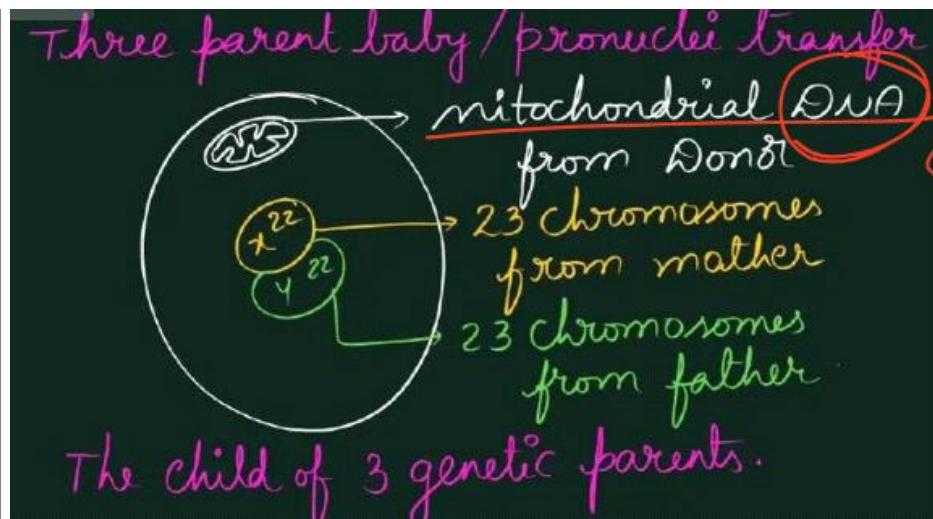


Reason for cloning

- **Reproductive cloning** creates a new organism genetically identical to an individual.
- Advocates for **reproductive cloning** believe that parents who cannot otherwise procreate should have access to the technology.
- Opponents of cloning have concerns that technology is not yet developed enough to be safe and that it could be prone to abuse (leading to the generation of humans from whom organs and tissues would be harvested), as well as concerns about how cloned individuals could integrate with families and with society at large.
- On 8<sup>th</sup> March 2005, the **United Nations General Assembly** adopted the **"Declaration on Human Cloning"**, which states that "**All forms of human cloning are incompatible with human dignity and with protection of human life**"
- Collecting eggs, sperms and somatic cells of endangered species to clone in case they are extinct.

	<ul style="list-style-type: none"> <li>• Cannot clone extinct animal, because we need 1 female to carry baby and give birth           <ul style="list-style-type: none"> <li>◦ Artificial womb can be used</li> <li>◦ Try growth in womb of very similar species.</li> </ul> </li> </ul>
Problem	<ul style="list-style-type: none"> <li>• Clone may not look alike</li> <li>• Problem with increase in population</li> </ul> <p><b>Drawbacks/issues in Reproductive cloning:</b></p> <ul style="list-style-type: none"> <li>• <u>It is very inefficient method</u> (1 clone born out of 277 cloned embryos in case of Dolly and it is the case with several other cloned animals)</li> <li>• Abnormalities such as defects in organ formation in cloned animals.</li> <li>• Methods are laborious and expensive.</li> <li>• Clone need not be 100% identical to the parent due to mitochondrial DNA and the impact of environment on expression of characters.</li> </ul>

Three Parent Baby	<p><b>THREE PARENT BABY / PRONUCLEAR TRANSFER:</b></p> <p><b>Terminology:</b></p> <p><b>Gene:</b> Any functional sequence of nucleotides on the DNA  <b>ATGCC / CCGAAC / TCGATGA /.....</b></p>  <p><b>Mutation:</b> Sudden heritable change in the gene sequence that alters gene function. Mutations in the genes can cause diseases.</p> <ul style="list-style-type: none"> <li>• 99.9 % DNA is present in the nucleus in the form of chromosomes. 0.1% DNA is present in the <b>mitochondria</b>. Mutations in mitochondrial genes cause mitochondrial diseases like <b>Alper's syndrome, Leigh syndrome etc.</b></li> <li>• Such diseases get inherited only from mother (Maternal inheritance)</li> <li>• Gene is functional, Rest is junk gene</li> <li>• MRT : Mitochondrial replace method : Three parent baby to avoid mitochondrial diseases           <ul style="list-style-type: none"> <li>◦ Mitochondria of another donor is used with no disease</li> <li>◦ Donor nucleus ; egg is infused with mother egg nucleus</li> </ul> </li> </ul>
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Pronuclear	<ul style="list-style-type: none"> <li>• Sperm and egg nuclie during fusion / during fertilization</li> <li>• Methods :           <ol style="list-style-type: none"> <li>a. Take donor egg cell</li> <li>b. Take mother egg and father sperm cells -&gt; IVF invitro fertilization in lab</li> <li>c. Create pronuclei</li> <li>d. Pronuclei into donors egg</li> </ol> </li> </ul>
	<ul style="list-style-type: none"> <li>• This technique is to avoid the inheritance of mitochondrial diseases like <b>Alper's syndrome, Leigh syndrome etc.</b></li> <li>• This technique is also called <b>Mitochondrial replacement therapy</b> as it replaces the mother's defective mitochondria with the healthy mitochondria of the donor.</li> <li>• Dr. John Zhang from "New Hope Fertility Center" in New York City was the creator of first three-parent-child (a baby boy), which was performed in Mexico (April 2016) due to restrictions in USA.</li> <li>• Britain is the first country in the world to approve the technique.</li> <li>• <b>Criticism:</b> The procedure has not been tested long enough and argue that changing an embryo in this could pave the way for "<b>designer babies.</b>"</li> </ul>

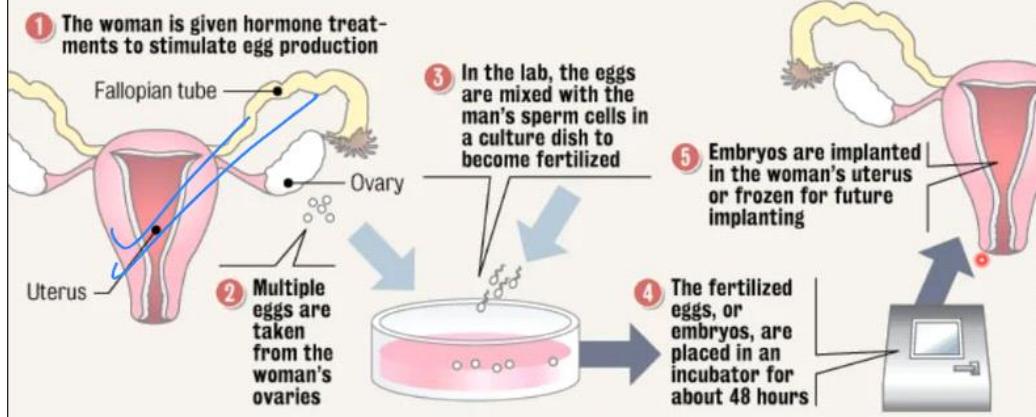
# L3 Assistive reproduction

06 November 2024 11:52 PM

ASSITIVE REPRODUCTION TECHNIQUE	<ul style="list-style-type: none"><li>Any reproduction done outside the Body</li><li>Example : IVF, ETM, Surrogacy, Artificial Insemination</li></ul>
Cells Bank	<ul style="list-style-type: none"><li>Stored in nitrogen vial under -196°C</li></ul> <p><b>THE CONCEPT OF CELL BANKS:</b></p> <ul style="list-style-type: none"><li>The sperm is stored in small vials or straws holding between 0.4 and 1.0 ml of sperm and <b>cryogenically preserved in liquid nitrogen</b> tanks.</li><li>Andrology experts believe sperm can be frozen indefinitely. The UK government places an upper limit for storage of 55 years.</li><li>Before freezing, sperm may be prepared so that it can be used for <b>intracervical insemination (ICI), intrauterine insemination (IUI) or for in-vitro fertilization (IVF) or assisted reproduction technologies (ART)</b>.</li><li>The process of <b>egg preserving</b> (also known as <b>oocyte cryopreservation</b>) is intended to retain the option for women to become pregnant in the future using IVF, in the process, eggs are retrieved from the woman's body and frozen.<ul style="list-style-type: none"><li>Due to risk of early menopause</li><li>If she is undergoing surgery that could involve excision of the ovaries.</li></ul></li><li>Eggs cells are produced in foetal stage before she is born<ul style="list-style-type: none"><li>Stored in ovaries</li><li>Release 1 eggs per month</li><li>Chance of genetic diseases increases<ul style="list-style-type: none"><li>Eggs cells are stored for 30 years</li><li>Exposed to radiation, pollutants, medicines etc</li></ul></li></ul></li></ul>
IVF (In Vitro Fertilization)	<ul style="list-style-type: none"><li>Test tube babies</li><li>Invitro : in living system</li></ul> <p><b>1. IN VITRO FERTILIZATION (IVF):</b></p> <p>In Vitro Fertilization involves collection of healthy ovum and sperms from healthy mother and father respectively and their fusion under appropriate conditions in vitro. If fertilization occurs, the resulting fertilised egg or embryo is transferred into the woman's uterus, where it will implant in the lining of the uterus and develop.</p> <ul style="list-style-type: none"><li>Egg from donor/Mother + sperm from Father/Donor -&gt; zygote<ul style="list-style-type: none"><li>Fusing outside the body</li></ul></li><li>Zygote -&gt; womb of the women donor/mother<ul style="list-style-type: none"><li>Surrogacy -&gt; planted in other women womb</li></ul></li></ul>

# THE IN VITRO FERTILIZATION PROCESS

Used as a remedy for infertility, a woman's egg cells are combined with a man's sperm cells outside the uterus. The fertilized egg is then implanted in the woman's uterus and, if successful, begins the pregnancy cycle. The first baby realized from this fertilization method was born in 1978.



## Embryo Transfer Method

- Zygote is moved to lab for creating embryo in lab -> then transferred in womb
  - This is done after IVF
- Surrogacy : Transfer the embryo from 1 womb to other womb

## 2. EMBRYO TRANSFER TECHNOLOGY:

- Embryo transfer is a procedure by which fertilized egg or young embryo is transferred from donor mother to recipient mother or from test tube (IVF) to the recipient mother. The best stage for transfer is **2-4 cell stage**. Embryo transfer technology is used for rapid multiplication of genetically superior genotype.
- Embryos can be either "fresh" from fertilized egg cells of the same menstrual cycle, or "frozen", **embryo cryopreservation**, and are thawed just prior to the transfer, which is then termed "**frozen embryo transfer**" (FET). The outcome from using cryopreserved embryos has uniformly been positive with no increase in birth defects or development abnormalities.

## Artificial Insemination

- Male can have Oligo Spermea (lesser Sperm Count)
  - Probability of sperm reaching eggs cell decreases
  - Pregnancy Delayed
- Azoo Spermea (No Sperms / No Mobile Sperms)
- Sperm Donor is needed
- In vivo Fertilization

**3. ARTIFICIAL INSEMINATION** - Artificial insemination is a fertility treatment method used to deliver sperm directly to the cervix or uterus. The method is used **for those females who wish to conceive when normal conception is not possible.**

a. **Intra cervical insemination:** ICI is a type of artificial insemination that involves inserting sperm into the cervix. This is the passageway just outside the uterus.

b. **Intra uterine insemination:** IUI is a procedure that involves inserting sperm past the cervix and directly into the uterus.

**4. GAMETE INTRA-FALLOPIAN TRANSFER (GIFT)** - Sperms and eggs are mixed and injected into the fallopian tubes. The fertilization takes

	<p><b>3. ARTIFICIAL INSEMINATION</b> - Artificial insemination is a fertility treatment method used to deliver sperm directly to the cervix or uterus. The method is used <b>for those females who wish to conceive when normal conception is not possible.</b></p> <p>a. <b>Intra cervical insemination:</b> ICI is a type of artificial insemination that involves inserting sperm into the cervix. This is the passageway just outside the uterus.</p> <p>b. <b>Intra uterine insemination:</b> IUI is a procedure that involves inserting sperm past the cervix and directly into the uterus.</p> <p><b>4. GAMETE INTRA-FALLOPIAN TRANSFER (GIFT)</b> - Sperms and eggs are mixed and injected into the fallopian tubes. The fertilization takes place there as it does naturally.</p> <ul style="list-style-type: none"> <li>• Intra Cervical Injection : Injected in Cervix</li> <li>• Intra Uterine Insemination : Injected in Uterus</li> <li>• GIFT Gamete Intra Fallopian transfer : Directly in fallopian tube</li> </ul>
Surrogacy	<p><b>5. SURROGACY</b> - An embryo may be carried by <b>another woman (gestational carrier / Surrogate mother)</b>. The eggs are removed from the infertile woman, fertilized using IVF, and the resulting embryo is placed into the gestational carrier's uterus.</p>

ART Acts	<p align="center"><b>ART &amp; SURROGACY (REGULATION) ACTS 2021</b></p> <ul style="list-style-type: none"> <li>• Indian government has passed two laws - <b>ART</b> and <b>Surrogacy</b> in December 2021.</li> <li>• <b>ART includes all techniques that seek to obtain a pregnancy by handling a sperm or oocyte outside the human body and transferring the gamete or the embryo into the reproductive system of a woman.</b></li> </ul> <p><b>ART act – Highlights</b></p> <ul style="list-style-type: none"> <li>• It aims at the <b>regulation and supervision</b> of ART clinics and ART banks and <b>safe and ethical practice</b> of ART services.</li> <li>• Establishment of a <b>National Registry</b> that acts as Central database with details of all ART clinics and banks in the country.</li> <li>• The act provides that <b>National and state boards</b> for surrogacy constituted Under the Surrogacy regulation act, 2021 will also work for the regulation of ART services.</li> <li>• Egg donor needs to be supported by <b>insurance cover</b>.</li> <li>• A woman can donate oocytes only once in her life</li> <li>• <b>Multiple embryo implantation</b> needs to be regulated.</li> <li>• Children born through ART should be provided all the <b>rights equivalent to biological children</b>.</li> <li>• Donor will not have any parental rights over the children</li> <li>• <b>Stringent punishment</b> upon violating the prescribed provisions. First-time offenders may pay a fine between ₹5 lakh and ₹10 lakh, and for subsequent violations, imprisonment of 8 to 12 years and may also be liable to pay a fine of ₹10 to 20 lakh.</li> </ul>
Surrogacy Act	<ul style="list-style-type: none"> <li>• Commercial Surrogacy is banned</li> <li>• Altruistic Surrogacy is allowed : No payment done, only goodwill</li> </ul>

## Surrogacy act 2021 – Highlights

- It aims to abolish Commercial surrogacy and Only allow altruistic surrogacy
- Allowed only for **Indian & Indian-origin married couples and Indian single woman** (*only widow or divorcee between the age of 35 and 45 years*) will be allowed on fulfilment of the necessary conditions.
- A surrogate mother has to be a **close relative** of the couple, a **married woman** with a **child** of her own, aged between **25-35 years**, can be a surrogate only once in her life.
- **No exchange of money allowed, but medical expenses and insurance cover** for surrogate mothers for **36 months are provided.**
- Establishment of **National and State surrogacy boards.**
- **Severe punishments** to offenders (E.g. Up to 10 year jail and 10 lakhs fine)

Criticism for Act

### **Criticism:**

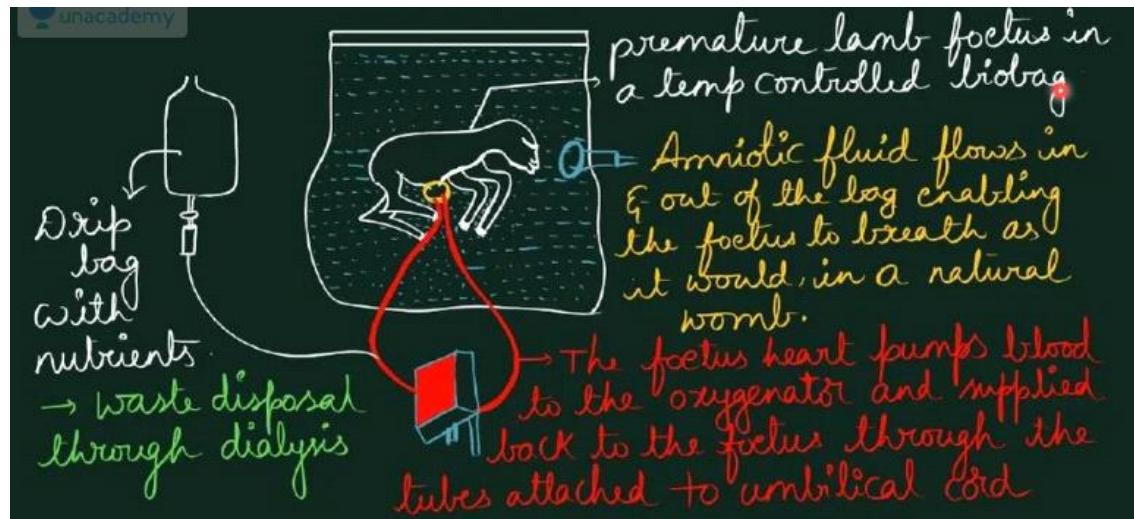
- Does not allow Homo-sexuals and single parents to have a child through surrogacy
- Bill does not clearly define close relatives
- It restricts basic human right of having child.
- Prohibition of payment can lead to more exploitation of the women

Artificial Womb

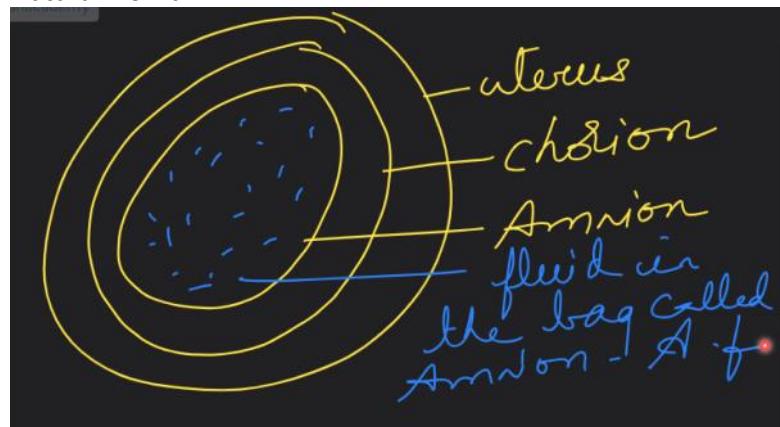
- Also called Bio bags : Simulate the womb conditions
- Lamb foetus has been already tested in womb bag.
- Artificial wombs technique could be used **to help premature or “sick” human babies to survive** and help foetuses in the final stages of multiple pregnancies when the womb becomes so cramped.
- In this technique a foetus of about 17 weeks is placed in a tank filled with liquid to stimulate amniotic fluid. The temperature is kept at constant. A machine pumps nutrients and oxygen into the baby's blood.
- This technique was successfully experimented **on goat foetus in Japan.**

- External Lung is used for gaseous exchange in blood through umbilical cord
  - In Nature it is done by the mother
  - Heart of foetus is used





- Natural womb



- Collect amniotic fluid -> Study the component
- Synthetic / Artificial Amniotic fluid is created

Artificial Fertility  
Technique in  
Biodiversity  
Conservation

### **ARTIFICIAL FERTILITY TECHNIQUES IN BIODIVERSITY CONSERVATION:**

The last male of Northern white Rhino named Sudan was put to rest in 2018

In order to save this subspecies, from extinction scientists are trying the following techniques

1. Fusing the frozen sperm of northern white Rhino with the egg of southern white Rhino and implanting the embryo in the womb of southern white Rhino, I.e., using southern white Rhino as a surrogate.
2. IVF, using the frozen sperm of the male and the eggs of the two surviving females.

- To rescue this species, scientists embarked on an ambitious project named **BioRescue** in 2015, employing reproductive technologies like **in-vitro fertilization (IVF) and stem cell techniques**.
- Recently, the international consortium, **BioRescue**, announced the **first-ever rhino pregnancy** through a lab-made embryo transferred to a **southern white rhino**.
- To ensure behavioral and social skills are passed on, the first **IVF calves must be born in time to learn** from the surviving females.

**Feb 2024**

# L4 Stem Cells, Organoids, Genome

07 November 2024

09:55 PM

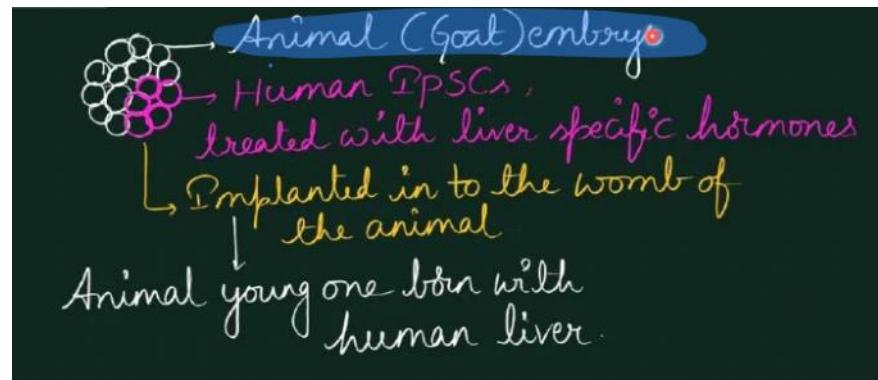
STEM CELL TECHNOLOGY	<ul style="list-style-type: none"><li>• Stem cells that can converted into other cells / Can be differentiated into other cells</li><li>• Stem Cells : Embryonic cells (undifferentiated mass of cells)<ul style="list-style-type: none"><li>• they can differentiated to all other cell types )</li><li>• Can divide unlimitedly into numbers</li></ul></li><li>• Adult somatic cells (Kidney, Heart, hair cells) are not stem cells</li></ul>
Organ transplant	<ul style="list-style-type: none"><li>• Difficult to get a matching donor (Sibling, parent, children are close match)<ul style="list-style-type: none"><li>• Immune system sometime reject foreign organ</li><li>• Immuno suppressive drugs are used<ul style="list-style-type: none"><li>◦ Suppress immune system -&gt; weak immune system</li><li>◦ Body become prone to infections</li></ul></li></ul></li><li>• Kidney (2 kidney) or Liver (Grows back again) , Other organ are different to donate<ul style="list-style-type: none"><li>• Only donate after donor died</li></ul></li></ul>
Stem cells	<p><b>STEM CELLS:</b></p> <p>Undifferentiated or partially differentiated cells that can differentiate into various types of cells and proliferate indefinitely to produce more of the same stem cell.</p> <p><i><u>Stem cell technology aims at manufacturing copies of one's own organs for transplantation.</u></i></p> <p><b>TYPES OF STEM CELLS:</b></p> <ul style="list-style-type: none"><li>• <b>Pluripotent precursor stem cells:</b> Cells that can be differentiated into most of the cell types. E.g. Embryonic Stem Cells.</li><li>• <b>Multipotent precursor stem cells:</b> Cells that can be differentiated in many cell types E.g. Umbilical cord stem cells</li></ul> <ul style="list-style-type: none"><li>• Totipotent Precursor Stem cells : (Total Capacity) , Eg : Zygote ,Can converted into all body parts or can be used to create whole organism</li><li>• Oligopotent precursor stem cells: Cells That can be differentiated Into few other cell types<ul style="list-style-type: none"><li>◦ E.g. Bone marrow cells.</li><li>◦ Bone marrow cells cannot be used to produce organs but they can get converted into different types of blood cells,</li><li>◦ Can be used in the treatment of blood cancer.</li></ul></li></ul>

Induced Pluripotent Precursor Stem Cells iPSCs	<ul style="list-style-type: none"><li>• Need : Many adult haven't stored Stem cells, need to create multipotent stem cells</li><li>• Embryo -&gt; Differentiation -&gt; Somatic Cells</li><li>• Somatic cells -&gt; De differentiation / Genetic Reprogramming -&gt; Embryo</li></ul>
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- **Induced Pluripotent precursor Stem Cells (iPSCs)** are the adult somatic cells that can be induced to show the properties of stem cells, by a process called de-differentiation / **genetic reprogramming**.
- **De-differentiation** can be achieved by activating the transcription of certain important embryonic genes by exposing the somatic cells to specific transcription factors like Oct4, Sox2, Nanog and Lin28.

DNA -> RNA	<ul style="list-style-type: none"> <li>• Replication : DNA -&gt; RNA : Using DNA Polymerase</li> <li>• Transcription : DNA -&gt; RNA : Using RNA Polymerase + helped by transcription factor           <ul style="list-style-type: none"> <li>• Two factors :               <ul style="list-style-type: none"> <li>◦ General : help in transcription of any gene</li> <li>◦ Gene Specific transcription factors</li> </ul> </li> </ul> </li> <li>• Translation : RNA -&gt; Protein : Using Ribosomes</li> <li>• Silent Genes : All genes are present in all cells, but are silent</li> <li>• Active genes : only genes that are required are active</li> <li>• We can activate embryonic genes in cells to make them as Stem cells           <ul style="list-style-type: none"> <li>• Take somatic cells</li> <li>• Activate embryonic genes in them               <ul style="list-style-type: none"> <li>◦ By injecting Embryonic Gene Specific Transcription factors</li> </ul> </li> <li>• They will behave like embryonic -&gt; Pluripotent cells</li> </ul> </li> </ul>
Factors	<ul style="list-style-type: none"> <li>• <b>Shinya Yamanaka won the Nobel Prize</b> in Physiology or Medicine 2012 for iPSc technology.</li> <li>• It is recently found that Oct4 is not needed for genetic reprogramming and in fact not using it improved the efficiency.</li> <li>• In 2014, a research group at Harvard University reported using insulin-producing cells derived from human embryonic stem cells (ESCs) and induced pluripotent stem cells (iPSCs) to lower blood glucose levels in mice.</li> </ul>

iPSCs in organ transplantation	<ul style="list-style-type: none"> <li>• Make copies of one's own organs : Legal, already possible           <ul style="list-style-type: none"> <li>• Heart, Liver, kidney are already manufactured</li> <li>• It can take months or years</li> </ul> </li> <li>• How to make organs / Where to make organs           <ul style="list-style-type: none"> <li>• In laboratory</li> <li>• In animal womb</li> </ul> </li> </ul>
Animal Womb Organs	<ul style="list-style-type: none"> <li>• Raw material : Human IPSC, Animal embryo</li> <li>• Hormones are used to direct iPSCs -&gt; to generate particular organs</li> </ul>



- Need to kill animal baby -> Violates animal rights
  - we already kill goat/ sheep for food
- Pig immune system attack human liver -> no as it is present from start
- Increase size -> grow in the laboratory
- Human immune reject -> No as created from human iPSCs
- Approval done -> till date no organ created yet

### JAPAN APPROVES FIRST HUMAN-ANIMAL EMBRYO EXPERIMENTS (2019):

- **Human-animal chimeras** provide the ability to produce human organs in other species using induced pluripotent stem cells (iPSCs), which would be patient-specific and immune-matched for transplantation.
- Survey conducted in 2020 finds American support for human-animal chimera research.

Xeno transplantation

- Using organ of different organism
- Delete pig genes -> add human genes -> then transplant
- Man died, but we were just experimenting with man who was going to die anyway

### Man gets a transplant of Pig's heart

- There's a **huge shortage of human organs** donated for transplant, driving scientists to **try** to figure out how to use **animal organs** instead.
- In a hospital in Maryland -USA, a doctor (Dr. Griffith) **transplanted a heart from a pig** that had undergone.
- American company – **Revivicor reportedly made 10 modifications**. Four of the pig's genes were inactivated and six human genes were inserted into its genome.
- One of the pig's genes inactivated was **to remove a sugar** in its cells that's responsible for the **hyper-fast organ rejection**.
- The patient's condition made him **ineligible for a human heart transplant** or a heart pump – so had to go with a genetically modified pig's heart.
- The **Food and Drug Administration (FDA)**, which oversees such experiments, allowed the surgery under "**compassionate use**" emergency authorization, available when a patient with a life-threatening condition has no other options.

- Dr. Griffith had transplanted pig hearts into about 50 baboons over five years, before offering the option to the patient (Bennett).
- It is interesting to note that an Indian doctor (Dr. Baruah-Guwhati) performed **xenotransplantation** of pig's heart to a human patient back in 1997 but was imprisoned when patient died after a week.
- Recently scientists also transplanted Kidney from a genetically modified pig into a human patient.

**Benefits:**

- If successful, will provide great relief for the patients waiting for transplantations.

**PRINTABLE ORGANS**

**PRINTABLE ORGANS**

- It uses 3D printing technology to produce tissues and organs.
- For this 3D data about the organ to be printed is obtained by CT scan, MRI etc.
- Using this data, digital model will be created using CAD (Computer aided design) software.
- Printer cartridges are filled with bio ink.
- **Bio ink** usually is a **hydrogel** made up of **alginate or fibrin** polymers, cellular adhesion molecules etc.
- It supports the **cell proliferation, differentiation and physical attachment of cells**.
- The bio ink must be **bio compatible and biodegradable** so that it can degrade up on transplantation of the organ.
- Hydrogel : water based gel
- Cell matrix : cellular adhesion. Cell division, cell differentiation
- **Cells** (stem cells/IPSCs/cells of interest) were mixed within **bioink** formulations and incubated for 2 hours to achieve a printable consistency.
- Bio ink can print 3d structures through a printing nozzle or needle by laying down successive layers of appropriate material.
- 3D bioprinter was made by a Russian company "**3D bio printing solutions**".
- Chinese have made ears and successfully transplanted to children with a birth defect called **microtia** (**A birth defect in which the external ear is underdeveloped or absent**).
- The company **Organovo** produced a human liver using 3D bioprinting, though it is not suitable for transplantation, and has primarily been used as a medium for drug testing.
- Recently a Human heart was produced.

**4D organ Printing**

- If we change the structure of organ

**Organoids**

- Small / miniature organs

- They are tiny, self-organized three-dimensional tissue cultures that are derived from stem cells.
- Such cultures are used to create miniature organs, or to produce only certain types of cells.
- Researchers have produced organoids that resemble the brain, kidney, lung, intestine, stomach, and liver etc.

### Uses

- Will give a detailed view of how organs form and grow
- Provide new insights on human development and disease
- Study how drugs interact with these “mini-organs”
- Potentially revolutionize the field of drug discovery and opening new approaches to personalized medicine.
- Scientists have gained insight into Covid-19 through miniature lungs and are using miniature human brain to understand why some people are suffering from long Covid-19

### Genome Studies

- Genome is haploid genetic context of a cell (23 chromosomes)

### TYPES OF SEQUENCING:

#### ***De Novo sequencing / Whole genome sequencing by Sanger method:***

"From the beginning" or de novo sequencing is the method of building a reference genome. This is achieved by randomly fragmenting the target DNA, sequencing then assembling those individual fragments to build a draft or even finished genome.

**Preimplantation genetic screening:** For chromosomal aberrations and gene mutations like Cystic fibrosis, Sickle cell anemia etc.

#### **Targeted sequencing:**

Sequencing individual genes, gene regions, or sets of genes

#### **Exome sequencing:**

Targeted sequencing of the exome employs sequencing strategies that target coding exons. The exome encompasses approximately 1% of the genome, yet contains approximately 85% of disease-causing mutations

### Human Genome Project

### **HUMAN GENOME PROJECT**

**Genome:** The haploid genetic content of a cell. (Or)  
One copy of the total genetic content of a cell.

**Human genome project:** HGP was an international scientific research project that aimed to determine the complete sequence of nucleotide base pairs that make up the human genome & all the genes it contains.

**Equipment:** DNA sequencer.

#### **Observations:**

- More than 95% of the genome is junk DNA/Noncoding DNA/Selfish DNA.
- We have approximately 30,000 genes in the complete genome.
  - HGP target : know the order of base pairs in complete genome
  - Use of junk DNA :
    - reduce probability of genes getting mutated
    - Junk DNA can get mutated and forms new genes (evolution)

	<ul style="list-style-type: none"> <li>• Taken sample of few lakhs of people</li> <li>• As we want to take common genome</li> </ul>
Genome Projects	<p><b>HUMAN GENOME PROJECTS IN NEWS:</b></p> <ul style="list-style-type: none"> <li>• <b>Human genome project (1990-2003):</b> By International human genome sequencing consortium and Celera Genomics.</li> <li>• <b>100K genome Asia project:</b> Led by Nanyang technological university (NTU), Singapore to sequence the whole genomes of 100K Asian including 50000 Indians.</li> <li>• <b>Indigen project:</b> by Institute of Genomics and integrative biology (IGBI, Delhi) , Centre for cellular and molecular biology (CCMB, Hyderabad). Scientists have also developed “IndiGenome card” and “mobile application for the researchers and clinicians to access the genome information.</li> </ul>
HGP read India Project	<p><b>Genome India project:</b></p> <ul style="list-style-type: none"> <li>• The project was launched in 2020 with the goal of whole genome sequencing of 10,000 individuals for better understanding the genetic variations and disease-causing mutations unique to the Indian population, which is one of the most genetically diverse in the world by the end of 2023.</li> <li>• Sanctioned by the department of Biotechnology.</li> <li>• Centre for Brain research at Indian institute of science acts as a nodal agency and 20 institutes like AIIMS and IITs will take part in it.</li> <li>• The United Kingdom, China, and the United States are among the countries that have programmes to sequence at least 1,00,000 of their genomes.</li> <li>• By sequencing and analysing these genomes, researchers hope to learn more about the underlying genetic causes of diseases and create more efficient, individualized treatments or personalised medicines.</li> </ul> <p><b>Telomere to telomere (T2T) consortium:</b></p> <ul style="list-style-type: none"> <li>• The newly sequenced reference genome T2T-CHM13 includes gapless assemblies for all 22 autosomes and X chromosome.</li> <li>• Telomere : tip of the chromosomes</li> <li>• T2T : Tip to Tip reading of chromosomes</li> </ul>

# L5 Genetic Engineering and Vaccines

08 November 2024 06:45 PM

HGP write (Human Gene Project)	<ul style="list-style-type: none"><li>• Synthesising Genome : Constructing structure (Synthetic Biology)  <b>Human Genome project – Write:</b><ul style="list-style-type: none"><li>• Aims to write or build or synthesize an artificial human genome (All 23 chromosomes) with sophisticated bioengineering tools.</li><li>• The project will be led by US scientists who are currently working on microbial genomes.</li><li>• aims at advancement in “synthetic biology”</li></ul> <b>APPLICATIONS:</b> <b>Pharmacogenomics:</b> is the study of the role of the genome in drug response. The name reflects combination of <b>pharmacology and genomics</b>.<ul style="list-style-type: none"><li>• Gene cloning</li><li>• Gene therapy</li><li>• Genetic engineering</li><li>• DNA profiling</li><li>• Designer babies.</li></ul></li></ul>
Earth Bio genome	<ul style="list-style-type: none"><li>• Gene sequence of every organism  <b>Earth bio genome project:</b><ul style="list-style-type: none"><li>• An initiative by American scientists to sequence the genomes of all (about 8M) earth's eukaryotic species.</li><li>• So far less than 0.2% of eukaryotic genomes have been sequenced.</li><li>• Earth Bio-Genome Project (EBP) is an international consortium of scientists, which aims to sequence 1.5 million species in three phases in a 10 year road map.</li><li>• The project aims to reveal evolutionary connections between species.</li><li>• Indian initiative on Earth BioGenome sequencing (IIEBS) is a nationwide project to decode the genetic information of all known species of plants and animals in the country.</li><li>• The Earth Bio-Genome project includes already ongoing projects such as i5K (insects), B10K (birds), 10KP (plants).</li></ul></li><li>• Gene of Microbes<ul style="list-style-type: none"><li>• Make vaccines ( mRNA vaccines, DNA vaccines)</li><li>• Diagnostics of diseases<ul style="list-style-type: none"><li>○ Ex : RT PCR (Polymerase Chain reaction finding DNA of virus/bacteria in human sample)<ul style="list-style-type: none"><li>■ Amplify the DNA by chain reaction.</li><li>■ The sequence the DNA(bacteria-Human genetic material/ virus) or RNA (Virus )</li></ul></li></ul></li></ul></li></ul>

## DIAGNOSIS OF INFECTIONS AND MICROBIAL IDENTIFICATION:



## GLOBAL INITIATIVE ON SHARING ALL INFLUENZA DATA (GISAID)

- Established in 2008.
- Platform hosted by **Germany**, with multiple researchers across globe contributing to it, and supported by **public and private partnership**.
- Promotes **international sharing** of all **influenza virus sequences** and SARS CoV-2, and related clinical and epidemiological data.
- Classifies the virus based on their mutations.
- It hosts **more than 500,000** SARS-CoV-2 genomes.

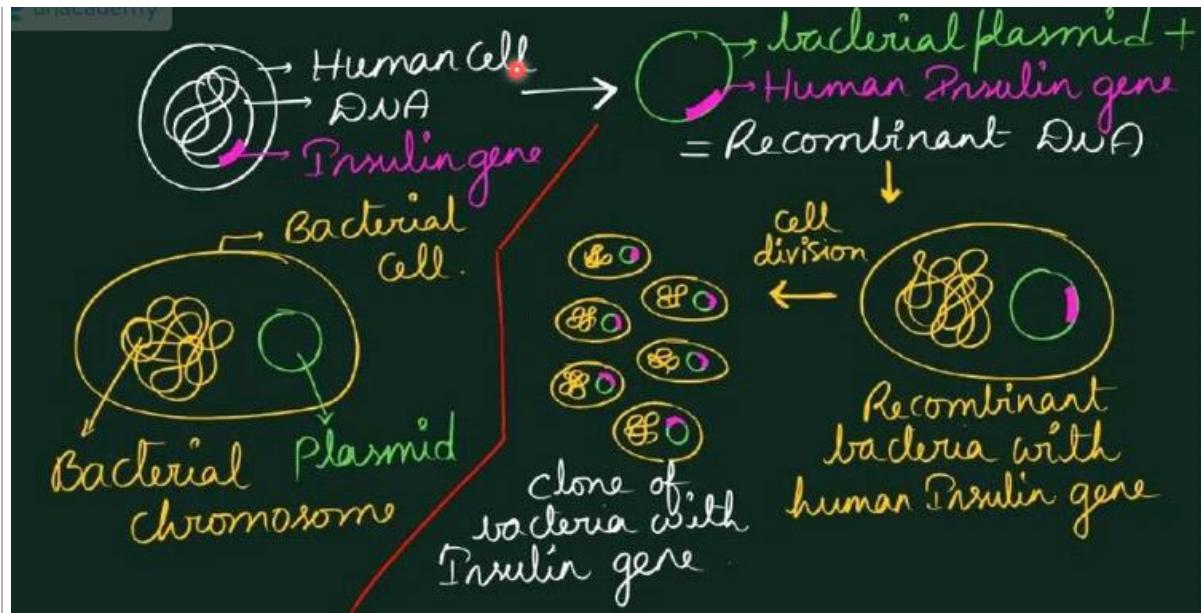
## Indian SARS-CoV-2 Genomic Consortia (INSACOG)

- It is a consortium of labs, established on **18<sup>th</sup> January 2021**.
- Partnership between **Department of Biotechnology & Union Ministry of Health and Family Welfare**.
- Screens samples from states and international travelers to understand the spread of the SARS CoV-2 variants.
- According to the **Genome Evolution Analysis Resource for COVID-19** (GEAR-19), a dashboard built by CSIR- CCMB, India has submitted 5,898 genome sequences.
- To enhance this, the consortium has 10 national laboratories as part of it.
- Recently, 17 new labs planned to be added to ramp up genome sequencing.

## BIOLOGICAL DARK MATTER / DARK GENOME

- Dark Genome : Part of genome about we don't know, could be gene or junk

GE GENETIC ENGINEERING	<ul style="list-style-type: none"><li>• GE : Manipulation or making construction in genes</li><li>• Bacteria with insulin gene will produce the insulin protein<ul style="list-style-type: none"><li>◦ If insulin protein is created -&gt; to be used as injection in insulin injection</li></ul></li><li>• Plasmid : Double stranded DNA, Circular structure,<ul style="list-style-type: none"><li>◦ extra chromosomal (Not part of bacterial chromosomes)</li><li>◦ In GE we use plasmids as vehicles to carry the genes (vector)</li></ul></li></ul>
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## GENETIC ENGINEERING/ RECOMBINANT DNA

### TECHNOLOGY:

#### GENE CLONING

#### PROCEDURE:

- Transfer the gene of interest to a plasmid.
- Transfer the recombinant DNA (Plasmid along with the gene of interest) into a bacterium.
- Let the bacteria multiply along with which the gene also multiplies (Gene cloning).
- The clone of bacteria also produces the protein from the gene of interest which can be harvested and used as a drug for certain diseases.

#### ~~✓ Proteins that can be produced using Gene cloning:~~

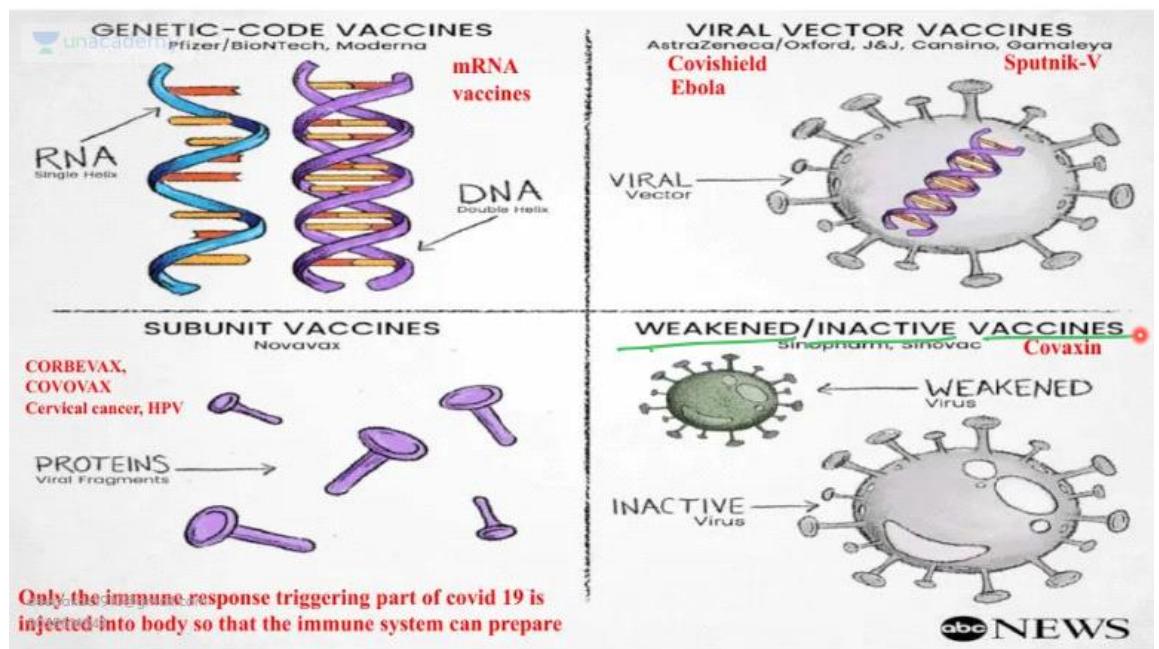
- **Insulin** for the treatment of Diabetes.
- **Blood clotting factors** for the treatment of Haemophilia.
  - ( There are 13 blood clotting factor in the blood of a healthy human. If the factor no. VIII is missing it causes Haemophilia-A & If the factor no. IX is missing it causes Haemophilia-B )
- **Growth hormone** for the treatment of Dwarfism.
- **Interferons (Anti viral proteins)** for the treatment of frequent viral infections.
- **Recombinant vaccines:** Vaccines made using recombinant DNA technology ( Gene cloning )
  - **Eg: Vaccine against Human papilloma virus that cause cervical cancer.**
    - Interferons : General antibodies, any virus can be killed
      - Created by immunity system

production of antibodies)

- Antibodies are produced by immunity system against antigen

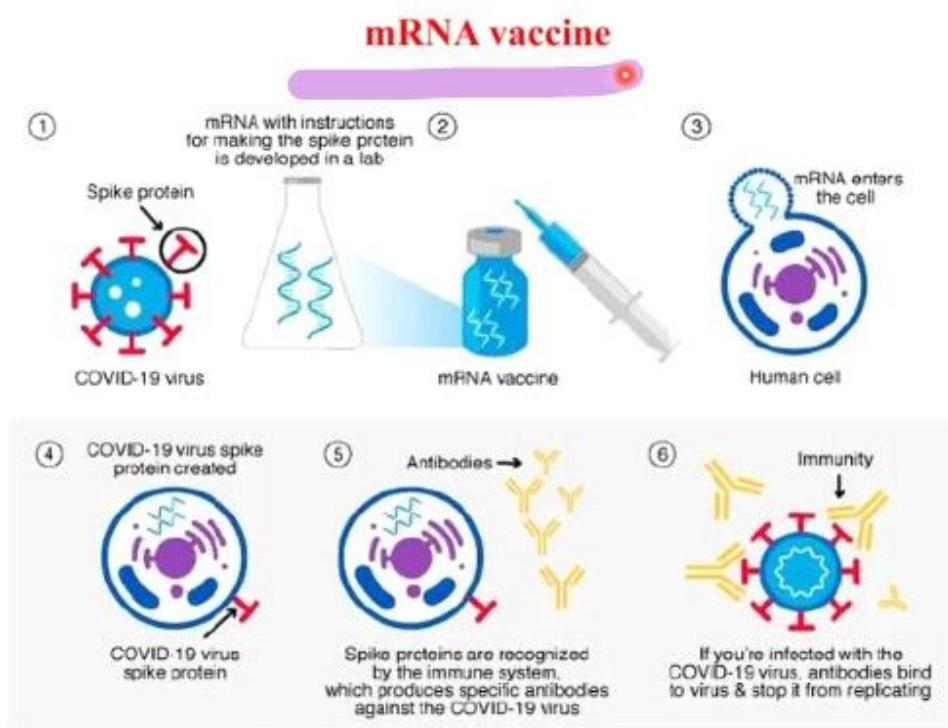
• Types :

- Killed vaccine : dead
- Attenuated vaccines : Inactivated
- Subunit vaccine : spike protein around nucleo-capsid protein,
  - created by recombinant technique
- Vector : plasmids



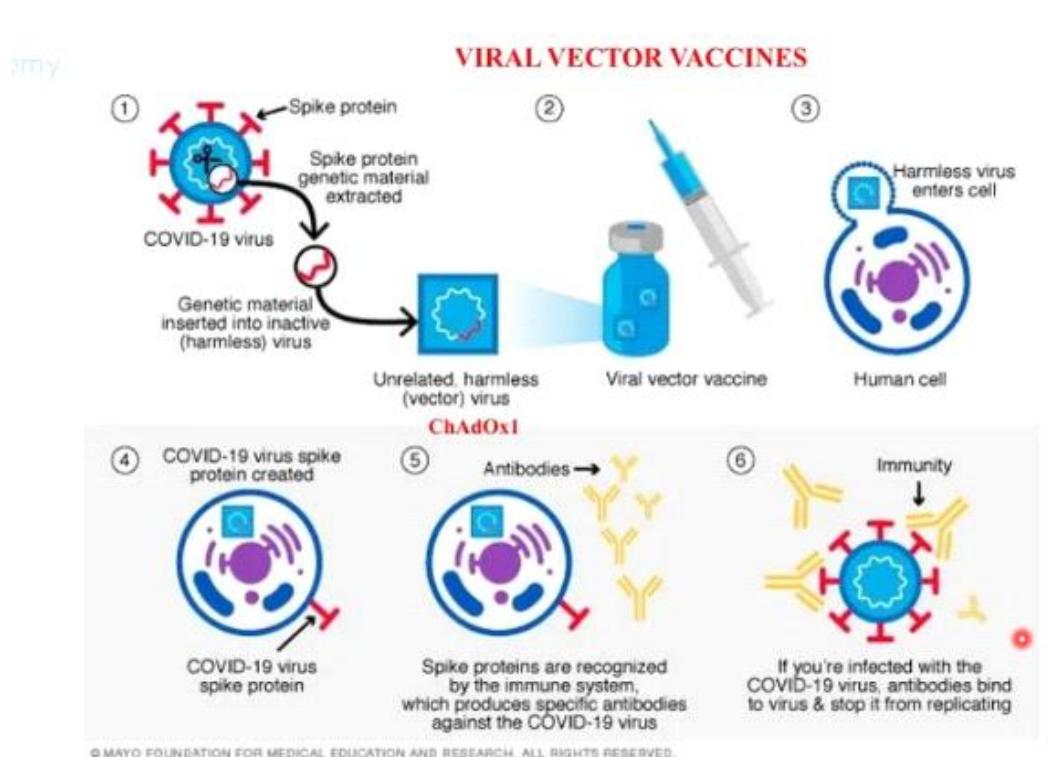
Genetic Material Vaccines

- RNA with instruction to produce the Spike protein (created in lab) is inserted in human cell
- Create spike protein in human -> create antibodies



Viral Vector Vaccines

- chADox1 : harmless to human being
  - Ch : chimpanzee, AD : adeno virus, ox1: number
  - In chADox1 RNA we insert Covid Gene part responsible to create spike protein gene
  - New chADox1 -> enter human bodies -> create antibodies



### Facts

- India's first mRNA Covid-19 vaccine - **GEMCOVAC-19**, created by Pune-based **Gennova Biopharmaceuticals** got emergency approval in June 2022.
- mRNA is a fragile molecule, so researchers put it into a fatty lipid bilayer, which protects it while the vaccine is packaged, shipped and administered. This bilayer easily attaches to our cells once the vaccine is given, which efficiently delivers the mRNA and starts the immunization process.
- India has also approved two more vaccines, **Corbevax** and **Covovax**, under emergency use authorization in December 2021. Both are **Subunit vaccines** and use spike protein of the coronavirus to induce an immune response.
- ZyCov-D** is a “plasmid DNA” vaccine — or a genetically engineered vaccine. DNA encoding the spike protein is chemically synthesized. It is inserted into an identified bacterial plasmid with the help of specific enzymes. **It is the world's first DNA vaccine.** Produced by **Zydus Cadila** with the support of Department of Science and technology and ICMR.

## Intranasal SARS-CoV2 Vaccine

- **Bharat Biotech's COVID-19 recombinant nasal vaccine (iCOVACC)** has been approved by the Ministry of Health's Central Drugs Standard Control Organisation for **primary immunisation** of those aged 18 years and above in emergency situations in **Sep 2022**.
- It is a **replication-deficient** (cannot reproduce in vaccine recipients) **adenovirus vectored vaccine**.

### Why Nasal Vaccine?

- The nasal route has excellent potential for vaccination due to the organized immune systems of the nasal mucosa.
- Non-invasive, Needle-free.
- Ease of administration – does not require trained health care workers.
- Elimination of needle-associated risks (injuries and infections).
- Ideally suits for children's and adults.
- Scalable manufacturing – able to meet global demand.

*What is the basic principle behind vaccine development? How do vaccines work? What approaches were adopted by the Indian vaccine manufacturers to produce COVID-19 vaccines ? (15M, 250 words)*

# L6 Gene Therapy, BT Crops

08 November 2024 08:06 PM

GENE THERAPY	<ul style="list-style-type: none"><li>• Correcting mutated genes, permanent solution</li></ul>
CRISPR	<ul style="list-style-type: none"><li>• CRISPER Cas9 mechanism<ul style="list-style-type: none"><li>• Cas9 : Scissor, nuclease enzyme, cuts the DNA</li><li>• CRISPR : Guider RNA, to guide Cas9 to position of DNA to cut (Artificial)</li><li>◦ Can only bind to the specific mutated gene, pair of mutated gene</li><li>• Cas9 cuts the gene where CRIPR is bonded -&gt; Removed -&gt;</li><li>• Corrected Gene is added by CRISPR</li></ul></li></ul> 
Use	<ul style="list-style-type: none"><li>• Chinese scientist <b>He Jiankui</b> announced that he had used CRISPR-Cas9 to disable copies of the <b>CCR<sub>5</sub> gene in human embryos</b> to prevent the embryos' father from transmitting his HIV infection, implanted genome-edited embryos in the mother's womb for the purpose of reproduction and that live twins were born.</li><li>• Researchers from US, China and South Korea repaired a mutation in human embryos by using a gene-editing tool called CRISPR-Cas9.</li><li>• Clinical trials are under way in China and in the US to use this tool for treating cancer.</li></ul>

### RESEARCHERS DEVELOP AN ENGINEERED 'MINI' CRISPR GENOME EDITING SYSTEM

- CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) is a highly precise gene editing tool that is making breakthroughs in **cancer research and treatment**.
- It works like molecular scissors, cutting out select sections of DNA.
- The researchers at Stanford University developed mini CRISPR system (CasMINI).
- CasMINI despite its smaller size, can genome code just like its regular CRISPR.
- CasMINI's smaller size means it should be easier to deliver into human cells.

**Nobel Prize in Chemistry 2020 to Emmanuelle Charpentier & Jennifer A. Doudna**  
**"for the development of a method for genome editing"**

**Genetic scissors CRISPR/Cas9 : a tool for rewriting the code of life:** Using CRISPR – Cas9, researchers can change the DNA of animals, plants and microorganisms with extremely high precision. This technology has had a revolutionary impact on the life sciences, is contributing to new cancer therapies and may make the dream of curing inherited diseases come true.

- Gene Therapy done in Somatic gene
  - a. Somatic gene therapy:** Treating a genetic disease by correcting the mutation in somatic cells of the patient. Gene editing tool like CRISPR-CAs9 can be used.
  - Advantage:** There are no legal implications.
  - Drawback:** Practically very difficult due to large number of somatic cells to be edited.

- Gene therapy done in embryonic cells
- No legal
- B. Embryonic gene therapy/ Germ line gene therapy:** Treating a genetic disease by correcting the mutation in embryonic cells before birth. Gene editing tool like CRISPR-CAs9 can be used.
  - Advantage:** Practically easier when compared to somatic gene therapy due to lesser number of cells to be edited.
  - Drawback:** Legally not permitted as this could pave the way for "**designer babies**."
- Designer Baby : Updating gene with desired one
  - Example changing colour of baby by updating the skin colour gene
  - Can be risky, not sufficiently tested
  - The feature we have are because of reason,
    - EX : dark skin (UV protection), broad nose (more breath)

## DESIGNER BABY / DESIGNER EMBRYO

**1. Preimplantation embryo scanning for pre-implantation genetic diagnosis** (PGD or PIGD): Scanning the embryonic DNA to identify any mutations that can cause genetic diseases.

**2. Preimplantation gene editing :** Correcting the identified genetic mutations using gene editing tool like **CRISPR- Cas9** so that the genetic disease can be cured in the embryonic stage itself before even the baby is born. (**Embryonic gene therapy**)

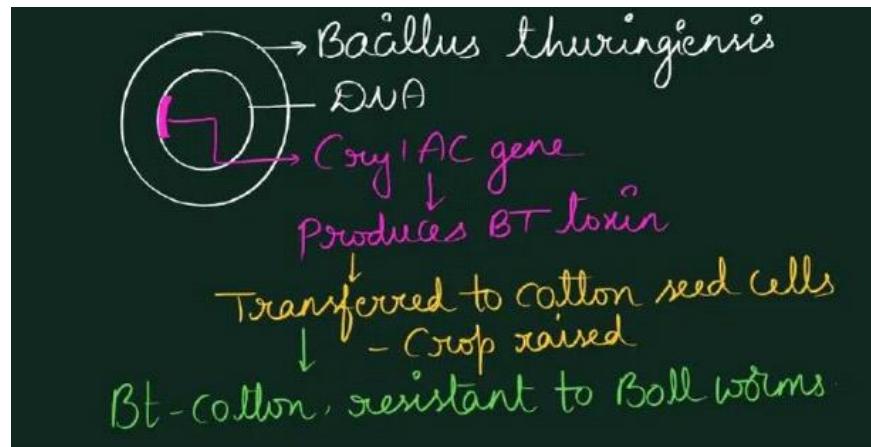
**3. CRISPR – Cas9 mechanism:** **CRISPR** is a guider RNA designed specifically to be complimentary the mutated gene that is to be removed. **Cas-9** is a nuclease enzyme tagged to the CRISPR so that it can remove the mutated gene & a correct copy of the mutated gene can be added in the gap.

Haemoglobins	<ul style="list-style-type: none"> <li>• Haemo (Iron) + Globin (Protein)</li> <li>• Protein : Amino acid chains, joined by peptide bonds, Therefore protein are polypeptide           <ul style="list-style-type: none"> <li>• Hemoglobin are ferroproteins in Red blood cells.</li> <li>• <b>Heme</b> is a large organic molecule having an atom of <b>iron</b>.</li> <li>• The protein part is <b>globin</b>, it is made up of <b>four polypeptide chains (HBF- <math>\alpha 2 \gamma 2</math> &amp; HBA – <math>\alpha 2 \beta 2</math>)</b></li> <li>• The function of hemoglobin is to carry oxygen from the lungs to the body tissues and also to returns carbon dioxide from tissues back to the lungs.</li> <li>• We have different normal hemoglobins in different stages of development, Embryonic haemoglobin, fetal hemoglobin and adult hemoglobin.</li> </ul> </li> <li>• HBF (Foetal haemoglobin)</li> <li>• HBA (Adult Haemoglobin)</li> </ul>
Abnormal Haemoglobin	<ul style="list-style-type: none"> <li>• Sickle Cell Anaemia : RBC change the shape, Difficult to flow</li> <li>• Thalassemia : Absent beta or alpha chain</li> <li>• Lethal and because of Mutated adult haemoglobin</li> </ul> <p><b>Abnormal Hemoglobins:</b></p> <ul style="list-style-type: none"> <li>• Haemoglobin S (beta 6 Glu → Val) mutation.</li> <li>• Hemoglobin C (HbC): (beta 6 Glu → Lys)</li> <li>• Thalassemia: It is a disorder of hemoglobin synthesis. Thalassemia can be divided into - <math>\beta</math> and <math>\alpha</math> thalassemia.</li> </ul>

CASGEVY	<ul style="list-style-type: none"> <li>BCL11 gene prevent production of HBF in adult</li> <li>BCL11 gene is removed using CRIPR/Cas9 in <b>Bone marrow</b> <ul style="list-style-type: none"> <li><b>Somatic Gene Therapy (legal)</b></li> </ul> </li> <li>HBF is start producing in adult suffering from Abnormal Haemoglobin (HBA - Sickle / Thalassemia)           <ul style="list-style-type: none"> <li>HBA is suitable, but HBF is better than absence (none HB)</li> </ul> </li> </ul> <p style="text-align: center;"><b>FDA APPROVES FIRST GENE THERAPIES TO TREAT PATIENTS WITH SICKLE CELL DISEASE &amp; BETA THALASSEMIA</b></p> <ul style="list-style-type: none"> <li><b>Casgevy</b> is a cell-based gene therapy medicinal product using <b>CRISPR/Cas9</b> technology to edit the <b>patient's own blood stem cells</b>.</li> <li>It is a personalised treatment that involves collecting bone marrow stem cells from a patient's blood.</li> <li>CRISPR finds a specific sequence of DNA inside a cell. Using 'molecular scissors' to make precise cuts, it enables adding, removing or altering genetic material at that specific location of the genome of the cells.</li> <li>With Casgevy, stem cells are edited at <b>the BCL11A gene which usually prevents the production of foetal haemoglobin (HbF)</b>.</li> <li>These modified cells are then infused back into the patient, and the <b>reduction of BCL11A gene transcription leads to increase of HbF production</b> thus providing functioning haemoglobin.</li> </ul>
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GM Crops	<p><b>Regulation of GM crops and disputes related to their cultivation in India:</b></p> <p>As per report of <b>International Service for the Acquisition of Agri-biotech Applications</b>, India ranks 5<sup>th</sup> in global cultivation of GM crops. The safety aspects of genetically modified crops are assessed by Genetic Engineering Appraisal Committee (GEAC) (apex body and extra constitutional body) constituted under <b>Environment (Protection) Act, 1986 and Rules, 1989</b>.</p> <p><b>Bt.Cotton, Bt Brinjal &amp; GM Mustard</b> and have been recommended by <b>GEAC to Ministry of Environment, Forests and Climate Change</b>, but <b>Bt. cotton</b> is the only GM crop approved for commercial cultivation in the Country.</p>
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BT Crops	<ul style="list-style-type: none"> <li>BC : Bacillus Thuringiensis (Soil bacteria)</li> <li>Creates seeds plants that release toxin and kills Ball worms, No chemical pesticides required.</li> <li>HYPR : High Yield Pest Resistance Crops</li> </ul>
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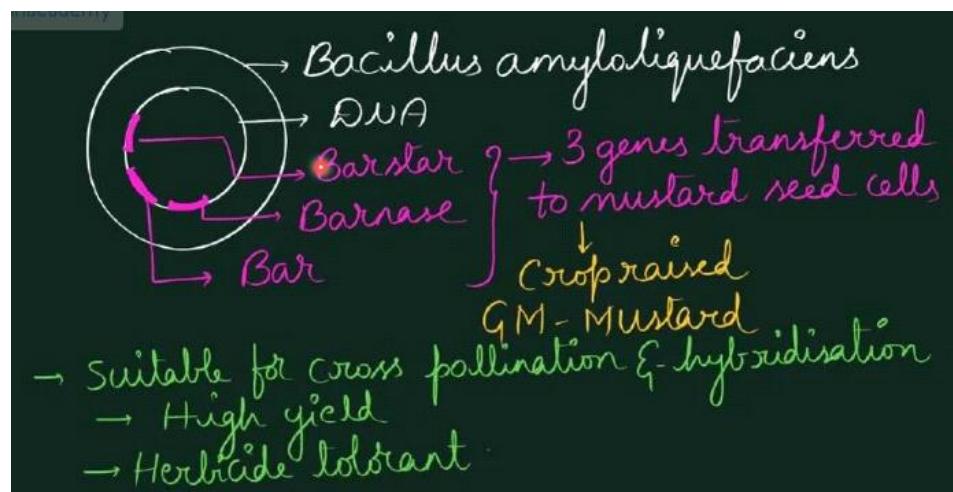


BT Cotton	<ul style="list-style-type: none"> <li>Allowed to grow, cotton is not used in food</li> </ul> <p><b>1. Bt- cotton</b> is made by adding a gene from <b><i>Bacillus thuringiensis</i></b> that produces an insecticide to <b>Bollworms</b> and makes the plant <b>High yield pest resistant (HYPR)</b>.</p> <ul style="list-style-type: none"> <li>Bt cotton was developed with the intention of reducing the usage of pesticides.</li> <li>Researchers at Monsanto, USA developed Bt cotton.</li> <li>The first commercial release was in China and USA in 1996.</li> <li>Introduced in India in 2003, through collaboration between Monsanto and Mahyco (Maharashtra Hybrid seeds company).</li> </ul> <p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>Resistant to boll worms.</li> <li>Reduces the use of pesticides.</li> <li>Results in improvement of yield.</li> <li>The toxin gets activated only in the basic environment in insect gut but not in the acidic gut of higher animals.</li> <li>Promotes multiplication of beneficial insects that are predators of bollworms.</li> </ul> <ul style="list-style-type: none"> <li>BT Cotton seeds are terminator seeds -&gt; used to raise a single crop,       <ul style="list-style-type: none"> <li>Seeds from first crop cannot be used to raise 2nd crop.</li> <li>Done by adding terminator genes (making seeds terminator)</li> <li>Need to purchase the seeds every year (Business interest )</li> </ul> </li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>Seeds are more expensive</li> <li>Ability of the Boll worms to develop resistance to Bt toxin</li> <li>NGOs like Green peace have been voicing against Monsanto's monopoly in the field of GM crops blaming Monsanto for its commercial interests.</li> </ul>
BT Brinjal	<ul style="list-style-type: none"> <li>Not allowed, Poisonous food crop       <ul style="list-style-type: none"> <li>Banned as precaution (It is not toxic to human because of acidic gut (inactive the toxic) )</li> </ul> </li> </ul> <p><b>2. Bt- Brinjal:</b></p> <p>The Bt brinjal has been developed to give resistance against lepidopteron insects, in particular the Brinjal Fruit and Shoot Borer (FSB). University of Agriculture sciences, Dharwad (Karnataka), and Tamil Nadu Agricultural university, in collaboration with Mahyco – Monsanto introduced a Bt - Brinjal variety carrying the gene Cry 1Ac as in Bt - Cotton.</p>

- In 2009 Bt - Brinjal got approval from GEAC and Indian Government, becoming the first GM food crop to be approved in India, but due to concerns over potential health hazards, and other issues on testing methods and duration, a temporary moratorium was imposed on Bt Brinjal in the year 2010.
- The Government of India in 2020 has approved the field trials of indigenous Bt brinjal varieties 'Janak' and 'BSS-793'.
- Both varieties, which are a proprietary product of the government-run Indian Agricultural Research Institute (IARI), contain the 'Bt Cry1Fa1' gene that works by inducing the digestive problems in the 'fruit and shoot borer' insect that attacks the brinjal crop.
- Farmers in Bangladesh have been cultivating Bt Brinjal since 2013.

#### GM Mustard

- Natural Mustard is Self-Pollinated
- We need to make Genetic modify Mustard to make it cross pollinated
  - Cross pollination is suitable for Hybridisation.
  - Hybridisation help in creating variety with more suitable traits, bigger seeds/ High yield
- GM Mustard -> suitable for hybridisation



- Genes uses
  - Barnase : Male sterility, Inactivate Anther -> Make flower female
    - Mustard can be pollinated with pollen of other plant
  - Barstar : Restore male fertility in next generation
    - Guard the pollinated stigma
  - Bar : herbicide tolerant (chemical that kills weeds)

### **3. Dhara mustard hybrid – 11 (DMH-11):**

- There is no natural hybridization system in Mustard. Mustard flowers contain female (Pistil) and male (Stamen) reproductive strictures, making it naturally self pollinating.
- Delhi university in collaboration with Bayer corporation came up with a genetically modified mustard hybrid called DMH -11.
- This GM variety of mustard was developed by introducing 3 genes **Barnase (Causes male sterility), Barstar (Restores male fertility in F1 generation and thus, the ability to produce fertile seeds), and Bar (Confers Herbicide, Glufosinate resistance)** from *Bacillus amyloliquefaciens* (a soil bacteria), making it suitable for hybridization, herbicide tolerant (HT) and high yield.
- GEAC committee approved GM Mustard in **October 2022** (previously approved in 2017) for commercial field cultivation (Need to get Ministry of Environment's approval)

**Dispute:** GM mustard requires almost double the quantity of fertilizer and water. Supreme court of India appointed a Technical Expert Committee (TEC) which in its 2013 report recommended a total ban on herbicide resistant crops as they may lead to negligent usage of herbicides leading to negative health effects.

- Disastrous effect of the spread of herbicide resistance (HT) gene on the normal crop.
- Its consequences on **crop diversity** and a **threat to food security**
- As per apiculturists (Beekeepers), GM crops would decrease **bee population** and hence **honey production**. Beekeepers argue that GM crops give faster yield and fewer flowering days and hence decreases bee population and honey production.
- Activists say this decision is **unscientific** and irresponsible as the researchers behind this didn't provide any **scientific basis** for decision-making.
- GM mustard requires almost double the quantity of fertilizer and water.
- Supreme court of India appointed a Technical Expert Committee (TEC) which in its 2013 report recommended a total ban on herbicide resistant crops as they may lead to negligent usage of herbicides leading to negative health effects.

GM Rubber	<ul style="list-style-type: none"><li>• In June 2021 <b>Rubber Board od India started field trials of world's first genetically modified (GM) rubber in Assam.</b></li><li>• It is the second GM crop to start field trial after Bt. Cotton.</li><li>• Introduced <b>MnSOD gene</b> (Manganese containing superoxide dismutase for the breakdown of oxygen free radical production).</li><li>• Rubber is made from the latex of a tree called <b>Hevea brasiliensis</b>.</li><li>• In 2010 GEAC had given permission to open field trials.</li><li>• Developed in the Biotechnology laboratory at Rubber research Institute of India.</li><li>• GM rubber <b>resists drought, temperature as well as light intensity</b>.</li><li>• <b>Cuts short the maturity period of Rubber leading to early yield.</b></li><li>• Trial permitted as there are no plant species in India that can breed with natural rubber, hence no risk of genes flowing from GM rubber into other native species.</li></ul>
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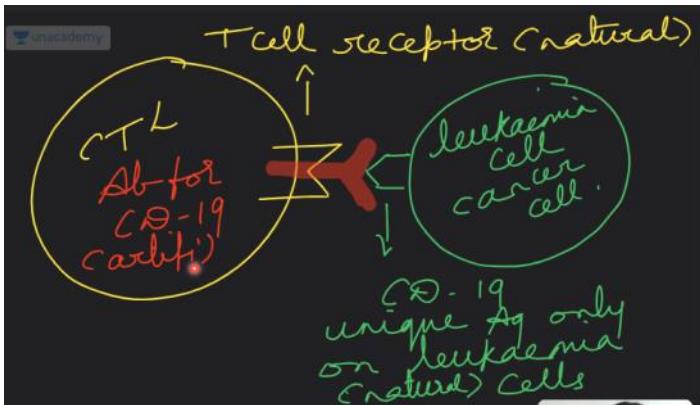
# L7 Transgenic Animals, Cancer

08 November 2024 11:32 PM

Transgenic Animals	<ul style="list-style-type: none"><li>Gene Modified animals</li></ul>
Cows	<ul style="list-style-type: none"><li>Natural cows have 1 casein gene (Milk Protein)<ul style="list-style-type: none"><li>We want to increase the number of casein genes to increase protein content</li></ul></li><li>Adding human casein gene -&gt; cow embryo<ul style="list-style-type: none"><li>Cow will give human milk : suitable for human baby / avoid formula milk</li><li>But milk will not be suitable for calves</li></ul></li></ul> <p><b>TRANSGENIC ANIMALS: Animals whose genetic composition has been altered by the addition of foreign DNA.</b></p> <ul style="list-style-type: none"><li>Diary cows carrying <b>extra copies of two types of Casein genes</b> produce 13% more milk protein and is more nutritious. Currently the milk from these animals is under FDA review.</li><li><b>Cows that produce human milk:</b> The scientists have successfully introduced human genes into 300 dairy cows to produce milk with the same properties as human milk.</li><li>Human milk contains high quantities of key nutrients that can help to boost the immune system of babies and reduce the risk of infections.</li><li>The scientists believe milk from herds of genetically modified cows could provide an alternative to human milk and formula milk for babies, which is often criticised as being an inferior substitute.</li></ul>
Fish	<p><b>TRANSGENIC FISH THAT GROWS FASTER:</b></p> <p>Salmon fish that is genetically modified can grow 6 times faster than wild type because they have extra copies of growth hormone gene.</p> <ul style="list-style-type: none"><li>Fish grow larger and faster</li></ul>
Glowing Animals	<ul style="list-style-type: none"><li>Jelly fish deep sea water : photic zone -&gt; Green Fluorescent Protein (GFP) gene<ul style="list-style-type: none"><li>Add gene to monkey embryo -&gt; glowing monkey babies</li><li>Helps in studying GFP gene transfer -&gt; Visual Tag<ul style="list-style-type: none"><li>Shows confirmation of result of genomic research</li></ul></li></ul></li></ul> <p><b>TRANSGENIC GLOWING MONKEY ANDI:</b></p> <p>ANDI is the first genetically modified rhesus monkey. ANDI was born with an extra glowing gene called green fluorescent protein (GFP). This GFP gene, which is naturally occurring in jellyfish, was taken from a jellyfish and genetically added to ANDI's DNA sequence. OHSU used rhesus monkeys because they share 95% of the same genes as humans.</p>

- Nobel in chemistry (2008) was awarded to a group of US and Japanese researchers who discovered the green fluorescent protein (GFP) in jellyfish and transformed it into one of the most powerful research tools in genomics.
- Although GFP can make glowing kitties (above), glowing bunnies, glowing monkeys and mice (below), it has far more important applications for medical research. The eye-catching protein is **used as a visual tag, linked to other genes or cells.**  
**As a result, scientists can literally see the results of their experiments.**

Cancer Therapy	<ul style="list-style-type: none"> <li>• <b>Tumor:</b> Tumor can be defined as unregulated cell growth. Tumors are of 2 types, <b>Benign and malignant.</b></li> <li>• <b>Malignant tumors are called cancers.</b></li> <li>• In the human body constant cell number is maintained by <b>Cell division (Cell growth) and Apoptosis (Programmed cell death).</b> Cancer can be caused either due to the increase in the rate of cell division or due to the decrease in the rate of Apoptosis.</li> <li>• <b>Proto oncogenes:</b> Genes that regulate and coordinate the cell division and Apoptosis.</li> <li>• <b>Oncogenes:</b> Genes that can cause cancer. They are Mutated (Defective) Proto oncogenes.</li> <li>• <b>Treatment:</b> The regularly used procedures in the cancer treatment are Chemotherapy, Radio therapy and surgery <ul style="list-style-type: none"> <li>• CRISPR Cas9 to silence oncogen</li> <li>• Done after cancer treatment, so that no new cancer cells are formed</li> <li>• Used for localised cancer (ex : breast cancer) <ul style="list-style-type: none"> <li>○ Cannot done on blood cancer, difficult to catch cells</li> </ul> </li> <li>• Legal because it used on small number of cells</li> </ul> </li> </ul>
Example	<p><b>Recent developments in the cancer treatment:</b></p> <p><b>1. Gene silencing using CRISPR cas9:</b> Certain oncogenes – such as the <i>BRCA1</i> gene can cause cancer, they can be cut using CRISPR-Cas9. A major hindrance for this procedure is potential toxicity of existing delivery systems. One way of achieving this is using lipid nanoparticles (LNPs) to deliver CRISPR-Cas9 to the cancer cells.</p> <p><b>2. RNA interference (RNAi) therapy:</b> Si RNA binds to the target mRNA of the oncogene and the associated <b>Argonaute 2 (Ago2)</b> protein degrades the mRNA and thus, silences the expression of oncogene.</p> <ul style="list-style-type: none"> <li>• Anti-sense RNA technology : use to silence any unwanted genes in any organism <ul style="list-style-type: none"> <li>○ Si RNA bind to target gene mRNA and does not allow to produce protein anymore</li> </ul> </li> </ul>

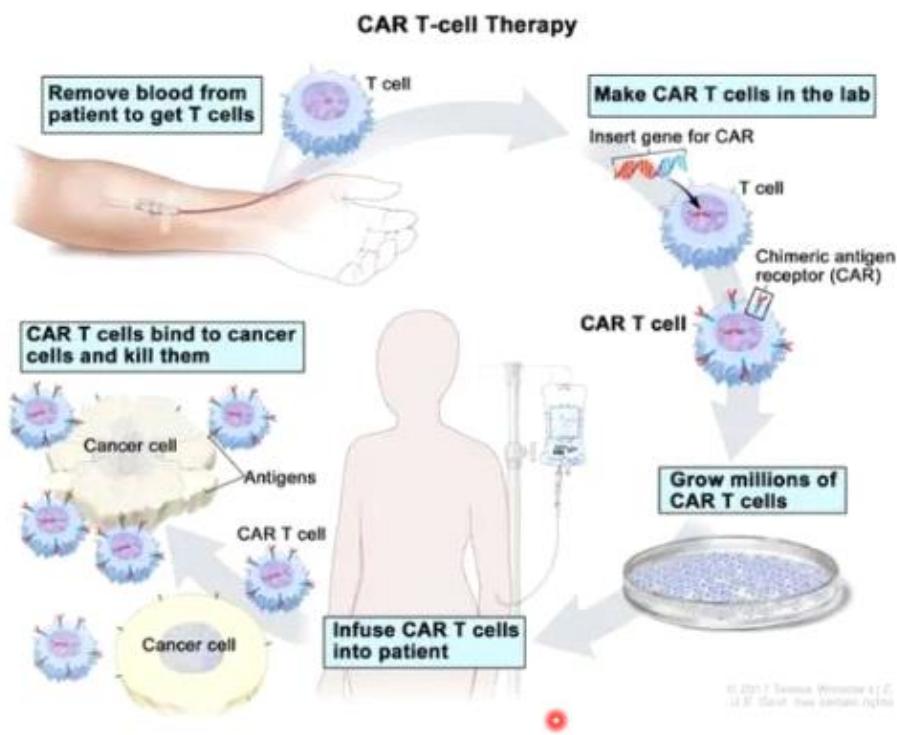
	<ul style="list-style-type: none"> <li>○ Ex : Tomato and Mangoes genes (which make fruit soft on ripening)           <ul style="list-style-type: none"> <li>▪ We can silence the gene by binding mRNA to target gene</li> <li>▪ These are already in market -&gt; easy transport and better shelf life</li> </ul> </li> </ul>
T Cells	<ul style="list-style-type: none"> <li>• Helper T cells: Also known as CD4+ T cells, these cells help activate other immune cells to fight infection. They do this by sending signals to B cells, macrophages, and cytotoxic T cells.</li> <li>• Cytotoxic T cells: Also known as CD8+ T cells, these cells kill infected cells and tumour cells.</li> <li>• Regulatory T cells: These cells regulate or suppress other immune cells when needed.</li> <li>• Natural killer T cells: Also known as NKT cells, these cells can enhance immunity in general.</li> <li>• Mucosal associated invariant T cells: Also known as MAIT cells, these are a type of innate-like T cell.</li> <li>• Gamma delta T cells: These are a type of innate-like T cell</li> </ul>
Immuno Therapy	<p><b>3) Immuno therapy for cancer:</b></p> <p><b>Terminology:</b> There are two important types of Immune cells.</p> <p><b>B cells:</b> Produce antibodies for foreign antigens.</p> <p><b>T cells:</b> Destroy altered self cells like cancer cells.</p> <p><b>CTLA-4 &amp; PD-1</b> functions as brakes on T cells.</p> <p><b>James p. Allison</b> produced antibodies for <b>CTLA-4</b> &amp; <b>Tasuku Honjo</b> produced antibodies for <b>PD-1</b>.</p> <p>Antibodies bind to <b>CTLA-4</b> and <b>PD-1</b> so that they can be inhibited and the T cells can attack on cancer cells.</p> <p><b>Side effects:</b> Auto immunity</p>
CAR T cell Therapy	<ul style="list-style-type: none"> <li>• CD19 (Antigen) only present in leukaemia cancer cell</li> <li>• TCR + CD19 antibody : Chimeric Antigen Receptor CAR</li> </ul>  <p>The diagram illustrates the mechanism of CAR T-cell therapy. On the left, a yellow circle represents a 'CTL' (T cell receptor) containing handwritten text 'Ab for CD-19 (carb)', with an arrow pointing towards a red receptor on the surface. On the right, a green circle represents a 'leukaemia cell cancer cell' containing handwritten text 'CD-19 unique Ag only on leukaemia (natural) Cells'. A green arrow points from the receptor on the CTL towards the CD-19 antigen on the leukaemia cell. The background is black, and the text is written in white and green.</p> <ul style="list-style-type: none"> <li>• Take out CTL from patient, already TCR present</li> <li>• Add CD19 antibodies -&gt; make CAR-T cell -&gt; Inject them back</li> <li>• Now India can make in 40 lakhs (earlier cost crores)</li> </ul> <p style="text-align: center;"><b>CAR T - CELL THERAPY</b></p> <ul style="list-style-type: none"> <li>• In <b>CAR T-cell therapies</b>, <b>T cells</b> are taken from the patient's blood and are changed in the lab by adding a gene for a receptor (called a <i>chimeric antigen receptor</i> or <i>CAR</i>), which helps the T cells attach to a specific cancer cell antigen.</li> </ul>

## CAR T - CELL THERAPY

- In CAR T-cell therapies, T cells are taken from the patient's blood and are changed in the lab by adding a gene for a receptor (called a *chimeric antigen receptor* or *CAR*), which helps the T cells attach to a specific cancer cell antigen. The CAR T cells are then given back to the patient.
- Since different cancers have different antigens, each CAR is made for a specific cancer's antigen. For example, in certain kinds of **leukemia or lymphoma**, the **cancer cells have an antigen called CD19**. The CAR T-cell therapies to treat these cancers are made to attach to the CD19 antigen and will not work for a cancer that does not have the CD19 antigen.

**Side Effects:** The potential side-effects are associated with **cytokine release syndrome** (a widespread activation of the immune system and collateral damage to the body's normal cells) and **neurological symptoms** (severe confusion, seizures, and speech impairment).

**Affordability:** Critics argue that **developing CAR T- cell therapy in India may not be cost-effective** as it will still be unaffordable for most people.



### Stem Cell Transplant

**4. Stem cell transplants:** Done after high intensity chemo or radio therapy to replace the dead blood cells. Stem cells are delivered into the blood stream using central venous catheter (Like blood transfusion). They travel through blood into bone marrow and regenerate the bone marrow damaged due to chemo and radio. The stem cells used for this purpose can be Autologous (Patient's own bone marrow stem cells collected before the treatment and re injected after the treatment), Allogenic (Collected from a suitable donor) or Umbilical cord cells ( If preserved at the time of the birth).

# L8 DNA Profile, Infection, Immunity

09 November 2024

01:28 PM

DNA Profiling	<ul style="list-style-type: none"><li>• Crime scene sample -&gt; extract DNA from crime and suspect -&gt; match both DNA</li><li>• It also provides procedure for the removal of DNA profiles from these indices.</li><li>• It also establishes a DNA regulatory board. Every laboratory that analyses DNA samples to establish the identity of an individual has to be accredited by the board.</li><li>• The bill also proposes a written consent by the individuals be obtained before collection of their DNA samples, however consent is not required for offences with punishment of more than 7 years in jail or death.</li><li>• It states that the DNA samples, DNA profiles and records, will be only used for identification of the person and not for any other purpose.</li><li>• Criminal offences under IPC</li><li>• Civil cases like <u>paternal dispute</u>, ART, Transplantation of human organs, Immigration, emigration, identifying the unidentified human remains, abandoned children etc.</li></ul>
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## Criticism:

- DNA profiling bill is a violation of right to privacy which is recognized as a fundamental right.
- The bill was referred to the **parliamentary standing committee** chaired by Jairam Ramesh, submitted the report in Feb 2021, pointed out that the DNA profiles can **reveal extremely sensitive information** about individuals like pedigree, skin color, behavior, health status, susceptibility to diseases etc. this information can be **misused** for targeted discrimination of marginalized communities.

**DNA FINGER PRINTING / DNA TESTING / DNA PROFILING:**

**1.** DNA will be extracted from a crime scene sample such as saliva, hair, semen, skin, blood etc.

**2. PCR (POLYMERASE CHAIN REACTION):** Invitro DNA replication for the pretest DNA amplification. Enzyme used: DNA polymerase  
Equipment used: Thermal cycler

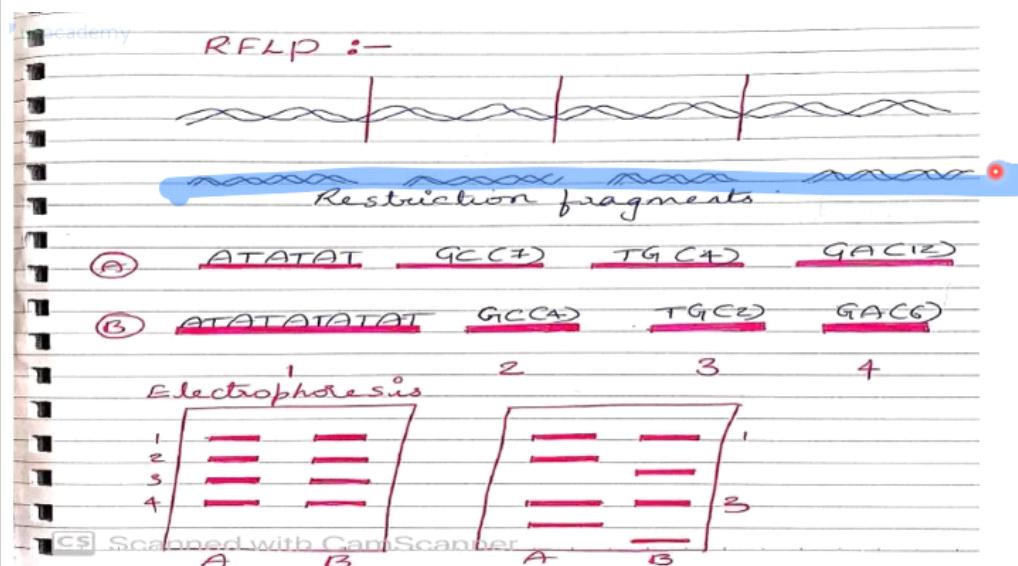
**2. Restriction fragment length polymorphism (RFLP):**

**Restriction endonuclease:** Enzymes that can cut the DNA at a specific interior position.

**Restriction fragments:** Fragments of DNA obtained by cutting with restriction endonucleases. We get several fragments of varying lengths.

As in this technique we analyse the length polymorphism in the restriction fragments between the people, the technique is known as RFLP.

It is also known as **VNTR: Variable Number of Tandem Repeats & as STR: Short Tandem Repeats.**

**3. Gel electrophoresis:**

- A technique used to separate the DNA fragments according to their size.
- DNA fragments are loaded at one end of a gel and electric current is applied to pull them through the gel.
- DNA fragments are negatively charged and moves toward positive electrode. Smaller fragments move faster, and larger fragments move slowly.
- Thus, the restriction fragments gets separated according to their size and forms separate bands. For comparison, different DNA samples will be run side by side on the same gel.
- The band pattern will be transferred to a nylon membrane / nitro cellulose paper by southern blotting.
- In the dark room the nitrocellulose paper is placed against and Xray film. It will record the band pattern. Thererfore the Xray film when developed will have the band pattern.

## DNA TECHNOLOGY (USE AND APPLICATION)

### REGULATION BILL 2019

Introduced in Lok sabha in July 2019.

It seeks to establish a national data bank & regional databanks.

It envisages that every databank will maintain indices like

- Crime scene index
- Suspects' or under trials' index
- Offenders' index
- Missing persons' index.
- Unknown deceased persons' index.

INFECTIONS	<ul style="list-style-type: none"> <li>• Health : A state of complete physical , mental d social well-being.</li> <li>• Pathogen : Disease causing agent. The common infectious agents           <ul style="list-style-type: none"> <li>• include: Bacteria, Viruses, Fungi, Protozoa</li> </ul> </li> </ul>
Prion	<ul style="list-style-type: none"> <li>• Free living infectious protein,</li> <li>• Ex : Kuru, scrapie (sponge form encephalitis (Brain infection - porous)</li> </ul>

Virus	<ul style="list-style-type: none"> <li>• One or more protein and nucleic acid (can be DNA / RNA)</li> <li>• DNA Virus : Plant virus</li> <li>• RNA Virus : Animal virus (including human virus)</li> <li>• Retro Virus : Reverse transcriptase,           <ul style="list-style-type: none"> <li>• Convert RNA -&gt; DNA, and inject the DNA</li> </ul> </li> <li>• Viruses are acellular, and much smaller than bacterial cells (~ 100 nanometers).</li> <li>• They are basically just capsules that contain genetic material.</li> <li>• They come in variety of shapes like helical, spheres, polyhedral or more complex structures.</li> <li>• They either contain <b>DNA</b> or <b>RNA</b> as genetic material, and are known as DNA viruses and RNA viruses, respectively.</li> <li>• <b>Retro virus:</b> Have RNA as genetic material. Uses Reverse transcriptase to get converted to DNA and get inserted in host DNA. Eg: <u>HIV</u>, Human T - lymphotropic virus type -1 HTLV-1 &amp; HTLV – II</li> <li>• <b>RNA virus:</b> Most of the human and animal viruses.</li> <li>• <b>DNA virus:</b> Most of the plant viruses &amp; Herpes, Smallpox, Adeno virus, Hepatitis B</li> <li>• To reproduce, viruses invade cells in host body, hijacking the machinery that makes cells work. Host cells are eventually destroyed during this process.</li> <li>• Antiviral drugs are used in treating viral infections.</li> </ul>
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Disease	Pathogen	Transmission	Systems affected & symptoms
Influenza	Influenza virus A, B, C	Talking, coughing & sneezing	Respiratory Fever, cold
Mumps	Mumps Virus (Paramyxovirus)	Coughing & sneezing	Enlargement of parotid salivary glands
Polio	Polio Virus	Fecal & oral	Spasm of throat & chest muscles, fears from water, paralysis and death
Chicken Pox	Varicella zoster virus	Direct contact, coughing & sneezing	Dark rashes changing into vesicles
Hepatitis	Hep A, B, C, D, E	Food/water (A&E) B, C, &D: Direct contact, blood, or sexual contact	Inflammation of liver, jaundice, loss of appetite, fatigue, Liver cancer

**Ebola****Ebola viral disease:****Caused by Ebola virus****Transmission: Through body fluids of infected animals and people****Symptoms: Unexpected hemorrhage****Diarrhea, headache, fever****Internal/external bleeding**

**Two monoclonal antibodies (Inmazeb and Ebanga)** were approved for the treatment of Ebolavirus infection in adults and children by the US Food and Drug Administration in late 2020.

- Antigen (Epitope) bind with Antibody (Paratope)
- Monoclonal Abs : a clone of antibodies that are specific to a single epitope
- Polyclonal Abs : a clone of antibodies that bind with variety of epitope

**MARBURG VIRUS**

- Marburg virus disease (MVD causes severe, viral haemorrhagic fever in humans.
- The average MVD case fatality rate is around 50%. Case fatality rates have varied from 24% to 88% in past outbreaks depending on virus strain and case management.
- Early supportive care with rehydration, and symptomatic treatment improves survival. There is as yet no licensed treatment proven to neutralize the virus, but a range of blood products, immune therapies and drug therapies are currently under development.
- **Rousettus aegyptiacus**, fruit bats of the **Pteropodidae family**, are the natural hosts of Marburg virus. The Marburg virus is transmitted to people from fruit bats and spreads among humans through human-to-human transmission.
- **Marburg and Ebola viruses** are both members of the Filoviridae family (**filovirus**).

## Monkeypox

- It is a rare **zoonotic disease** that is caused by infection with the **monkeypox virus**.
- It occurs primarily in **tropical rainforest** areas of **Africa** and is occasionally exported to other regions. *pakistan*
- Usually, a **self-limited disease** with the symptoms lasting from 2 to 4 weeks.
- **Symptoms** include fever, rash and swollen lymph nodes and may lead to a range of other medical complications.
- Severe cases can occur - case **fatality** ratio has been around **3–6%**.

### Mode of transmission

**Animal-to-human:** Through direct contact with the blood, bodily fluids, cutaneous or mucosal lesions of an infected animal or eating insufficiently cooked meat from an infected animal.

**Human-to-human:** Through close contact with respiratory secretions, skin lesions of an infected person or contaminated objects.

**Smallpox vaccines** can provide protection against monkeypox.

### Prevention

- Avoid contact with animals
- Isolate sick patients
- Pay attention to hygiene
- Use of smallpox vaccine provides some protection

- Unicellular (1 cell), Prokaryotic (No nucleus)

Bacteria is prokaryotic, single celled organisms visible only under a microscope.

Small, ranging about 1 micrometer in length. They exist in shapes like rods, spheres or spirals.

Disease	Pathogen	Transmission	Systems affected & main symptom
Tuberculosis	<i>Mycobacterium tuberculosis</i>	Air	Respiratory system Cough with blood in sputum
Whooping cough (Pertussis)	<i>Bordetella pertussis</i>	by coughing or sneezing	Respiratory system High-pitched whoop sound during breathing
Pneumonia	<i>Streptococcus pneumoniae</i>	air-borne droplets from cough or sneeze	Respiratory system Pus filled alveoli
Anthrax	<i>Bacillus Anthracis</i>	Through spores and contaminated animal products	Skin and lungs Skin ulcers

## TUBERCULOSIS

~~MIRK~~

- Tuberculosis caused by *Mycobacterium tuberculosis*.
- Common symptoms of active TB are cough with sputum and blood at times, chest pains, weakness, weight loss, fever and night sweats.
- “**Bacillus Calmette–Guérin**” (BCG) is the most widely used vaccine worldwide to prevent TB.
- India is the country with the **highest burden** of both TB (quarter of global cases - ~ 27 lakhs) **and multi-drug resistant TB**. *Super bug*
- India is also the country with the **second highest number** (after South Africa) of estimated HIV associated TB cases.

### **Types of drug-resistant TB:**

- **Multidrug-resistant tuberculosis (MDR-TB):** Resistance to **isoniazid** and **rifampicin**, the two most powerful first-line anti-TB drugs.
- **XDR-tuberculosis (Extensive drug-resistant):** Resistance to **isoniazid and rifampin + any fluoroquinolone + at least one of three injectable second-line drugs** (i.e., amikacin, kanamycin, or capreomycin)
- **TDR-TB (Total drug-resistant):** Resistance to all known TB drugs.
- In 2019, FDA approved **Pretomanid** in combination with **Bedaquiline** and **Linezolid** for the treatment of drug-resistant TB.

### **Tuberculosis – National Strategic Plan (2017-25):**

India is aiming to **eliminate TB** by 2025 (WHO's Global goal is 2030)

“Revised National Tuberculosis program” of India was renamed to **“National Tuberculosis Elimination Program”**

Four **strategic areas**: Detect, Treat, Prevent & Build (network) are 4 pillars of TB elimination. *1st line oral*

#### **Priority areas :**

- Private sector engagement
- Plugging the “leak” from the TB care cascade (i.e., people with TB going missing from care)
- Active case finding among “high risk” groups,
- Preventing the development of active TB in people with latent TB
- Programmatic Management of Drug Resistant TB (PMDT)

**‘TB Harega Desh Jeetega Campaign’**: Launched by Union Minister for Health and Family Welfare in **September 2019**

Aims to improve and **expand the reach of TB care services** across the country by **2022**.

**Nikshay Poshan Yojana**: Launched in April 2018. It's a direct benefit transfer (DBT) scheme to provide nutritional support of Rs. 500/month to TB patients for the entire duration of treatment.

Protozoans are single-celled eukaryotic organisms. Protozoa often spend part of their life cycle outside of humans or other hosts, living in food, soil, water or insects. Some invade humans through the food or the water. Others, such as malaria, are transmitted by mosquitoes.

Disease	Pathogen	Transmission	Systems affected & symptoms
<b>Malaria</b>	Plasmodium species	Anopheles mosquito	Fever, chills, vomiting, headache, anaemia
<b>Kala-Azar (Leishmaniasis)</b>	Leishmania species	Sandfly	Enlarged spleen & liver, skin ulcers, weight loss
<b>Trypanosomiasis (African-sleeping sickness)</b>	Trypanosoma species	Tsetse fly	Fever, headache, muscle & joint pains, sleeping abnormality, coma
<b>Amoebic dysentery (Amoebiasis)</b>	Entamoeba histolytica	Contaminated water/food	Stools with blood, abdominal pain, nausea

Immunity	<ul style="list-style-type: none"> <li><b>Humoral Immunity:</b> B-cells produce antibodies – protection from microbes</li> <li><b>Cell-mediated Immunity:</b> T-cells provide protection against intracellular pathogens, cancers etc.</li> <li><b>Vaccines</b> mimic pathogens and activate the production of antibodies.</li> </ul>
Indra Dhanush Program	<ul style="list-style-type: none"> <li>Launched by the union health minister on <b>25<sup>th</sup> December 2014</b>.</li> <li>Aimed to immunize all <b>children below 2 years</b> as well as all <b>pregnant women</b> against <b>7 vaccine preventable diseases (Diphtheria, whooping cough, Tetanus, Poliomyelitis, Tuberculosis, Measles, and Hepatitis B)</b> in selected districts with ~ 50% unvaccinated children in the country.</li> <li><b>Hemophilus influenza B</b> vaccines are also being provided in selected states.</li> <li>In 2016, four <b>new additional vaccines were added - Rubella, Japanese encephalitis, Injectable polio vaccine, and rotavirus</b>.</li> <li>Originally, the achievement of <b>full immunization under Mission Indra Dhanush to at least 90% coverage was aim to be achieved by 2020</b>.</li> <li><b>Note: Read about Intensified Mission Indra Dhanush 2.0, 3.0, 4.0, 5.0</b></li> </ul>
Antimicrobial Resistance AMR	<ul style="list-style-type: none"> <li>Cure disease, by attacking the antigen</li> <li><b>Antimicrobials or antibiotics</b>, often considered as “magic bullets”, helped mankind in fighting bacterial infections since about a century.</li> <li>Antibiotics <b>work either by</b> damaging bacterial cell wall, protein-building or DNA-copying machinery, or metabolic processes that are specific to bacteria.</li> <li>Given <b>viruses</b> do not have these targets (such as cell wall, protein synthesizing machinery) they cannot be killed by antibiotics.</li> <li><b>Antibiotic resistance</b> occurs when bacteria change in a way that reduces the effectiveness of antibiotics, designed to cure or prevent infections.</li> <li>The bacteria survive and continue to multiply even in presence of an antibiotic, causing more harm.</li> </ul>

Resistance AMR	<ul style="list-style-type: none"> <li>• <b>Antimicrobials or antibiotics</b>, often considered as “magic bullets”, helped mankind in fighting bacterial infections since about a century.</li> <li>• Antibiotics <b>work either by</b> damaging bacterial cell wall, protein-building or DNA-copying machinery, or metabolic processes that are specific to bacteria.</li> <li>• Given <b>viruses</b> do not have these targets (such as cell wall, protein synthesizing machinery) they cannot be killed by antibiotics.</li> <li>• <b>Antibiotic resistance</b> occurs when bacteria change in a way that reduces the effectiveness of antibiotics, designed to cure or prevent infections.</li> <li>• The bacteria survive and continue to multiply even in presence of an antibiotic, causing more harm.</li> <li>• There is a growing concern of antimicrobial resistance (AMR) posing a challenge to global healthcare system.</li> </ul>
National Action Plan for AMR	<p>In April 2017, Indian government launched <b>National Action Plan (NAP) on AMR, based on the Global Action Plan (GAP)</b>.</p> <p><b>Strategic priorities</b></p> <ul style="list-style-type: none"> <li>✓ Improving awareness and understanding of AMR through effective communication, education and training</li> <li>✓ Reducing the incidence of infection through effective infection prevention and control</li> <li>✓ Optimizing the use of antimicrobials</li> <li>✓ Promoting investments for AMR activities, research and innovations</li> <li>✓ Strengthening India's contributions towards global efforts to contain AMR.</li> </ul>

	<ul style="list-style-type: none"> <li>India launched “<b>Red Line campaign</b>” in 2016, began <b>marking prescription-only antibiotics</b> with a <b>red line</b> to curb their irrational use and create awareness on the dangers of taking antibiotics without being prescribed.</li> <li>In 2019, the government <b>banned use of Colistin</b>, which is a “last-resort antibiotic” being used in fish and livestock industries.</li> <li>In 2020, <b>Ministry of Environment, Forest and climate change</b> published <b>draft standard limits for antibiotic residues in pharmaceutical industry effluents</b>.</li> <li>A strong political will, inter-sectoral co-ordination between public and private sectors and comprehensive strengthening of the healthcare systems are necessary to contain AMR issue in India.</li> </ul>
Probiotic	<ul style="list-style-type: none"> <li>Friendly micro biome <ul style="list-style-type: none"> <li>Probiotics are live microorganisms that are intended to have health benefits when consumed or applied to the body.</li> <li>They can be found in yogurt and other fermented foods and dietary supplements.</li> <li>Useful microbes, especially, bacteria help digest food, destroy disease-causing organisms, or produce vitamins.</li> <li>Many of the microorganisms in probiotic products are the same as or microorganisms that naturally live in our bodies.</li> <li>Probiotics may contain a variety of microorganisms.</li> <li>The most common are <ul style="list-style-type: none"> <li><b>Bacteria: <i>Lactobacillus</i> and <i>Bifidobacterium</i>.</b></li> <li><b>Yeast such as <i>Saccharomyces boulardii</i>.</b></li> </ul> </li> </ul> </li> <li>Pre Biotic Food : they support growth of friendly bacteria <ul style="list-style-type: none"> <li>Ex : Fibre rich food</li> </ul> </li> </ul>
Biofilms	<ul style="list-style-type: none"> <li>Biofilms are <b>slimy layers of microorganisms</b> that stick to wet surfaces.</li> <li>They may cause up to 80 percent of infections in humans.</li> <li>Biofilms are resistant to <b>antibiotics, disinfectants</b>, and the <b>human immune system</b>.</li> <li>Ultra-fine plastic particles in waste can become 'hubs' for antibiotic-resistant bacteria and pathogens to grow.</li> <li>Certain strains of bacteria show <b>elevated antibiotic resistance</b> by up to 30 times when living in biofilms that form on <b>microplastics</b> (such as those used in medical implants).</li> <li>Biofilms imply <b>major challenges for the food industry</b> because they allow bacteria to bind to a range of surfaces, including rubber, plastic, glass, stainless steel, and even food products.</li> </ul>

**National Nutrition Mission 2018 / POSHAN Abhiyaan  
‘Prime Minister’s Overarching Scheme for Holistic Nutrition’.**

- Malnutrition is a significant issue in India and contributes to **mortality and morbidity** by reducing immunity to infections.
- Launched on **8<sup>th</sup> March 2018** on the occasion of international women's day.
- It is backed by **National nutrition strategy** prepared by the NITI Aayog with the goal of attaining "**Kuposhan mukt Bharat**" / **malnutrition free India by 2022**.
- A flagship programme of the **Union Ministry of Women and Child Development** (MWCD) to achieve improvement in nutritional status of **Children from 0-6 years**, Adolescent Girls, Pregnant Women and Lactating Mothers.

# L9 Space Orbits

10 November 2024 12:07 AM

Major Event	<p><b>1957:</b> First artificial satellite Russian Sputnik 1 launched.</p> <p><b>1958:</b> Explorer 1, first US satellite launched.</p> <p><b>1962:</b> Indian National Committee for Space Research (INCOSPAR) formed by the Department of Atomic Energy under the leadership of Dr. Vikram Sarabhai</p> <p><b>1969:</b> Indian Space Research Organization (ISRO) formed under Department of Atomic Energy.</p> <p><b>1972:</b> Department of Space (DoS) established and ISRO brought under it.</p> <p><b>1975:</b> First Indian satellite, <b>Aryabhata</b>, launched into space April 19. It was completely designed in the country and launched from a Russian facility.</p> <p><b>1979:</b> <b>Bhaskara-I</b>, an experimental remote sensing satellite for earth observations, launched from Russia into LEO.</p> <p><b>1993:</b> PSLV carried out its first mission, became the Indian space mission's most reliable workhorse.</p> <p>For the next 20 years, it launched various satellites for historic missions such as the Chandrayaan and Mangalyaan. PSLV remains a favourite among various organizations as a launch service provider.</p>
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Orbits	<p><b>How Do Objects Stay in Orbit?</b></p> <p>An object in motion will stay in motion unless something pushes or pulls on it. This statement is called Newton's first law of motion. Without gravity, an Earth-orbiting satellite would go off into space along a straight line. With gravity, it is pulled back toward Earth. A constant tug-of-war takes place between the satellite's tendency to move in a straight line, or momentum, and the tug of gravity pulling the satellite back.</p> <p>An object's <b>momentum</b> and the <b>force of gravity</b> have to be balanced for an orbit to happen. If the forward momentum of one object is too great, it will speed past and not enter into orbit. If momentum is too small, the object will be pulled down and crash. When these forces are balanced, the object is always falling toward the planet, but because it's moving sideways fast enough, it never hits the planet.</p> <p>Orbital velocity is the speed needed to stay in orbit. At an altitude of 150 miles (242 kilometers) above Earth, orbital velocity is about 17,000 miles per hour. Satellites that have higher orbits have slower orbital velocities.</p>
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Low earth Orbit LEO	<ul style="list-style-type: none"> <li>A low Earth orbit (LEO) is, as the name suggests, an orbit that is relatively close to Earth's surface.</li> <li>It is normally at an altitude of less than 1000 km but could be as low as 160 km above Earth – which is low compared to other orbits, but still very far above Earth's surface.</li> <li>Unlike satellites in GEO that must always orbit along Earth's equator, Low earth orbits can be tilted. This means there are more available routes for satellites in LEO, which is one of the reasons why LEO is a very commonly used orbit.</li> <li>LEO's close proximity to Earth makes it useful for several reasons. It is the orbit most commonly used for satellite imaging, as being near the surface allows it to take images of higher resolution.</li> <li><b>It is also the orbit used for the International Space Station (ISS), as it is easier for astronauts to travel to and from it at a shorter distance.</b></li> <li>Satellites in this orbit travel at a speed of around 7.8 km per second; at this speed, a satellite takes approximately 90 minutes to circle Earth, meaning the ISS travels around Earth about 16 times a day.</li> <li>However, individual LEO satellites are less useful for tasks such as telecommunication, because they move so fast across the sky, communications satellites in LEO often work as part of a large combination or constellation, of multiple satellites to give constant coverage.</li> </ul>
Geo Stationary Orbit GEO	<p style="color: red;"><b>Geo synchronous (GSO) / Geo stationary orbit (GEO)</b></p> <ul style="list-style-type: none"> <li>Satellites in geostationary orbit (GEO) circle Earth above the equator from west to east following Earth's rotation – taking 23 hours 56 minutes and 4 seconds – by travelling at exactly the same rate as Earth.</li> <li>This makes satellites in GEO appear to be 'stationary' over a fixed position.</li> <li><b>If such orbit circles exactly above the equator, it is called Geostationary and if it is inclined, it is called Geosynchronous.</b></li> <li>In order to perfectly match Earth's rotation, the speed of GEO satellites should be about 3 km per second at an altitude of 35 786 km.</li> <li>This is much farther from Earth's surface compared to many satellites.</li> </ul>

	<ul style="list-style-type: none"> <li>• GEO is used by satellites that need to stay constantly above one particular place over Earth, such as telecommunication satellites. <u>This way, an antenna on Earth can be fixed to always stay pointed towards that satellite without moving.</u></li> <li>• Also used for India's navigation satellites.</li> <li>• It can also be used by weather monitoring satellites, because they can continually observe specific areas to see how weather trends emerge there.</li> <li>• Satellites in GEO cover a large range of Earth so, as few as three equally-spaced satellites can provide near global coverage. This is because when a satellite is this far from Earth, it can cover large sections at once.</li> </ul>
Medium Earth Orbit MEO	<ul style="list-style-type: none"> <li>• Medium Earth orbit comprises a wide range of orbits anywhere between LEO and GEO.</li> <li>• It is similar to LEO in that it also does not need to take specific paths around Earth, and it is used by a variety of satellites with many different applications.</li> <li>• It is very commonly used by navigation satellites &amp; some communication satellites.</li> </ul>
Geo Transfer Orbit GTO	<p><b>Geostationary transfer orbit (GTO)</b></p> <p>Memo</p> <ul style="list-style-type: none"> <li>• Transfer orbits are a special kind of orbit used to get from one orbit to another.</li> <li>• A GTO is highly elliptic. Its <u>perigee</u> (closest point to Earth) is typically as high as low Earth orbit (LEO), while its <u>apogee</u> (furthest point from Earth) is as high as geostationary / geosynchronous orbit. That makes it a <b>Hohmann transfer orbit</b> between LEO and GSO.</li> <li>• Using this system, the satellite is placed into a low earth orbit with an altitude of around 180 miles. Once in the correct position in this orbit rockets are fired to put the satellite into an elliptical orbit with the perigee at the low earth orbit and the apogee at the geostationary orbit as shown. When the satellite reaches the final altitude the rocket or booster is again fired to retain it in the geostationary orbit with the correct velocity.</li> </ul>
Polar orbits	<ul style="list-style-type: none"> <li>• 1 type of LEO , 160km - 1000km</li> <li>• Direction N-S / S-N, inclination is near to 90 to the equator</li> </ul>

### 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.
- Satellites in a polar orbit do not have to pass the North and South Pole precisely; even a deviation within 20 to 30 degrees is still classed as a polar orbit.
- ***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 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 – for example, passing the city of Paris every day at noon exactly.

# L10 Launch vehicle and fuels

10 November 2024 12:50 AM

ISRO Satellite Launcher	unacademy Satellite Launchers					
	 <b>SLV-3</b>	 <b>ASLV</b>	 <b>PSLV-XL</b>	 <b>GSLV Mk II</b>	 <b>GSLV Mk III</b>	
	Height : 22.7m Lift-off weight : 17 t Propulsion : All Solid Payload mass : 40 kg Orbit : Low Earth Orbit	Height : 23.5m Lift-off weight : 39 t Propulsion : All Solid Payload mass : 150 kg Orbit : Low Earth Orbit	Height : 44m Lift-off weight : 320 t Propulsion : Solid & Liquid Payload mass : 1860 kg Orbit : 475 km Sun Synchronous Polar Orbit (1300 kg in Geosynchronous Transfer Orbit)	Height : 49m Lift-off weight : 414 t Propulsion : Solid, Liquid & Cryogenic Payload mass : 2200 kg Orbit : Geosynchronous Transfer Orbit	Height : 43.43 m Lift-off weight : 640 t Propulsion : Solid, Liquid & Cryogenic Payload mass : 4000 kg Orbit : Geosynchronous Transfer Orbit	
SLV 3	<b>1. Satellite Launch Vehicle-3:</b> <ul style="list-style-type: none"><li>(SLV-3) was India's first experimental satellite launch vehicle, which was an <b>all solid, four stage vehicle</b> weighing 17 tons with a height of 22m and capable of placing 40 kg class payloads in Low Earth Orbit (LEO).</li><li>While building upon the experience gained from the SLV-3 missions, ISRO developed the "<b>Augmented Satellite Launch Vehicle</b>" (ASLV), designed to augment the payload capacity to 150 kg for Low Earth Orbits (LEO). <b>It is a five stage, all-solid propellant vehicle.</b></li><li>Solid fuel : great thrust but once ignited cannot be stopped<ul style="list-style-type: none"><li>Ignition can be stopped till fuel is exhausted</li></ul></li><li>Shut Down both SLV and ASLV</li></ul>					

### **Polar Satellite Launch Vehicle (PSLV):**

- It is the third generation launch vehicle of India.
- It is the first Indian launch vehicle to be equipped with liquid stages.
- **It is a four-staged launch vehicle with first and third stage using solid rocket motors and second and fourth stages using liquid rocket engines.**
- It also uses strap-on motors to augment the thrust provided by the first stage and depending on the number of these strap-on boosters, the PSLV is classified into its various versions like **core-alone version (PSLV-CA)** with no strap-on boosters, **PSLV-G with six strap-on boosters** (9 tons each), and **PSLV-XL variant with 6 strap-on boosters** (12 tons each).
- New variants such as **PSLV-DL** (2 strap on motors) & **PSLV-QL** (4 strap on motors) are also being used.
  - Liquid Fuel : lesser thrust but gives control to switch off ignition when not needed
    - Inertia takes care while we don't need extra push to keep in the orbit
- **PSLV is designed mainly to deliver the “remote-sensing” satellites** with lift-off mass of up to about 1750 Kg to Sun-Synchronous circular polar orbits.
- After its first successful launch in October 1994, PSLV emerged as the reliable and versatile **workhorse launch vehicle** of India by launching the satellites of lower lift-off mass of up to about 1400 Kg to GEO transfer orbit (GTO). Besides, the vehicle successfully launched two spacecrafts – Chandrayaan-1 and Mars Orbiter Spacecraft.

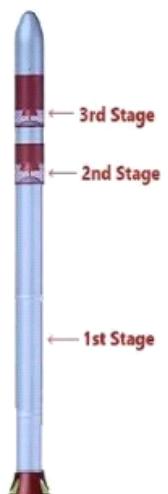
### **3. Geosynchronous Satellite Launch Vehicle (Fat boy):**

- (GSLV) is the fourth generation launch vehicle developed by India. Two versions of the GSLV are being developed by ISRO.
- **The first version, GSLV Mk-II**, has the capability to launch satellites of lift-off mass of up to 2,500 kg to the GTO and satellites of up to **5,000 kg** lift-off mass to the LEO.
- GSLV MK-II is a **three-staged vehicle with first stage using solid rocket motor, second stage using Liquid fuel and the third stage, called Cryogenic Upper Stage, using cryogenic engine.**

- **GSLV Mk III**, chosen to launch **Chandrayaan – 2** spacecraft and will be used to carry **Gaganyaan**.
- For one of its recent launch, ISRO redesignated GSLV-MK III to **LVM-III** (Launch Vehicle – Mark III)
- **It is a three-stage heavy lift launch vehicle developed by ISRO**. The vehicle has **two solid strap-on boosters (S200 strap-ons)** on either side of its core. Each carry 204 tons of composite solid propellant and their ignition results in vehicle lift off. Considered as stage 1
- **Stage 2 is L110 liquid stage**
- It has a **cryogenic upper stage (C25)**.
- It is designed to carry 4-ton class of satellites into Geosynchronous Transfer Orbit (GTO) or about 10 tons to LEO, which is about twice the capability of GSLV Mk II.

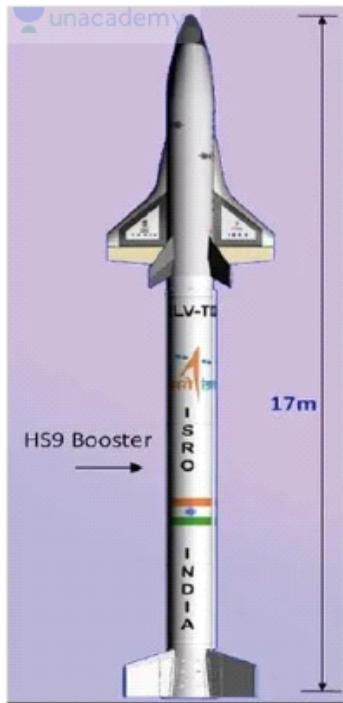


SSLV	<ul style="list-style-type: none"> <li>• D3 test covered recently (last test)</li> </ul> <p> <b>Small Satellite Launch Vehicle (SSLV)</b></p> <ul style="list-style-type: none"> <li>• Low-cost alternate to launch small satellites</li> <li>• Produced through New space India Limited (NSIL, Nodal agency for SSLV)</li> <li>• <b>3-Stage Solid propulsion</b></li> <li>• Pay load capacity of 300 kg to Sun synchronous orbit &amp; LEO 500 kg to Low earth orbit.</li> </ul> <p><b>Planned launches:</b></p> <ul style="list-style-type: none"> <li>• In March 2022, ISRO has successfully conducted ground testing of SSLV's solid booster stage-SS1, completing the ground testing of all 3 stages.</li> <li>• <b>SSLV-D1 (demonstration)</b> launch has taken place in August 2022, but failed due to a sensor failure and placed <b>Earth Observatory satellite (EOS)-2 and a student satellite into a wrong orbit</b>.</li> <li>• <b>The second developmental flight of SSLV, SSLV-D2 is successfully launched.</b></li> </ul> <ul style="list-style-type: none"> <li>• 1st test : Ground test</li> <li>• 2nd test : D1 -&gt; Flight test (Failed)</li> </ul>
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- 3rd test : D2 -> Demonstration

RLV



### Reusable Launch Vehicle (RLV)

- ISRO is also working on a **reusable launch vehicle (RLV)** is to achieve low cost, reliable and on-demand space access.
- RLV-TD (technology demonstration) was successfully flight tested in 2016 from Sriharikota High Altitude Range (SHAR) validating the critical technologies such as autonomous navigation, guidance & control, reusable thermal protection system and re-entry mission management.
- ISRO tested the landing capabilities of RLV TD, It was taken to a height 4.5 km by an Indian Air Force (IAF) **Chinook helicopter and & dropped** the from there.

#### **Other Agencies Using RLV or Partial RLV:**

- Reusable spacecraft have been around for a while; the NASA space shuttles have completed numerous human space flight missions.
- With its **Falcon 9 and Falcon Heavy rockets**, SpaceX has been demonstrating partially reusable launch systems since 2017.
- **Starship** is a system of fully reusable launch vehicles that SpaceX is also developing.

Source: The Hindu, 3 April , 2023.

ISRO  
Sounding  
Rocket

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AGNILET    • Private Rocket

## AGNILET: World's first single-piece 3D-printed rocket

- On 4<sup>th</sup> November 2022, Chennai-headquartered space-tech **start-up Agnikul** had successfully test-fired its **single-piece 3D-printed engine, Agnilet**.
- It is the **world's first single-piece 3D-printed rocket engine** fully **designed and manufactured in India**, which was successfully **first test-fired at IIT Madras in 2021**.
- The current test was conducted at Thumba Equatorial Rocket Launching Station (**TERLS**), at Vikram Sarabhai Space Center (**VSSC**), Thiruvananthapuram **as part of MOU signed between ISRO and Agnikul Cosmos Pvt. Ltd.** to provide opportunity for Indian space start-ups to use facilities of ISRO **through (Indian National Space Promotion and Authorization Centre) IN-SPACE**.
- This engine is going to be used in **Agniban, a two-stage rocket** with 100 kg payload capacity to orbits around 700 km high (low Earth orbits). It is going to use **semi cryogenic engine** that run on **Kerosene as fuel and Liquid oxygen as oxidizer**.

Vikram S

Funacademy

## Vikram-S: India's first privately made rocket launched (Mission Prarambh)

- **Vikram** is a family of small lift launch vehicles being developed by Hyderabad based startup, **Skyroot Aerospace**. — *Company*
- It became the **first Indian company** to be authorised for launching a rocket **by Indian National Space Promotion and Authorisation Centre (IN-SPACe)**.
- Skyroot has been developing **4 variants of the Vikram rocket**, named after Dr. Vikram Sarabhai.
- **Vikram-S, a sounding rocket** (used for probing the upper atmospheric regions and for space research with their suborbital flights). was launched by **Skyroot Aerospace** on 16<sup>th</sup> Nov 2022, from the **sounding rocket launch complex** at Satish Dhawan Space Centre. The Mission titled '**Prarambh**' carried **three payloads**. It marks the **first launch** of launch vehicle built **by a private company** in India. It reached an **altitude of 89.5 km**. It was fuelled by **3-stage all solid** engine.
- Sounding : Probing (testing) the upper atmosphere upto 9.5 km
  - Sub orbital launches
  - Do not orbit the earth, gives a trail of white tracks
  - To collect the atmospheric sample from upper atmosphere and come back
- ROHINI Serie, 100 of rocket are in the series
  - ISTO souding rocket

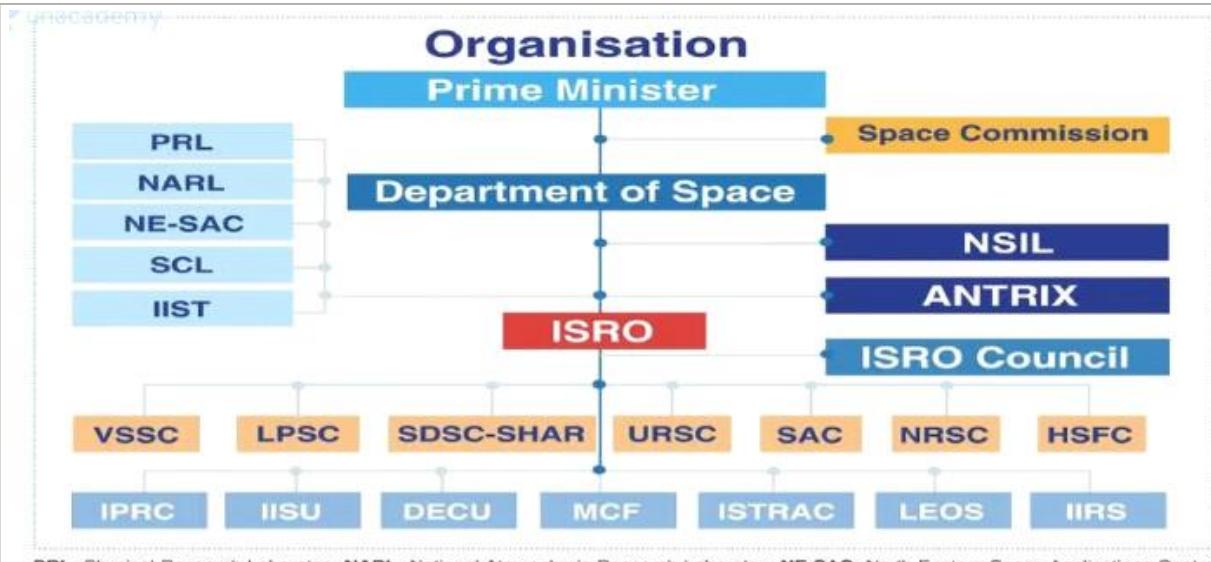
## Vikram - 5 – sounding.

- ② **Vikram-I** can carry 480 kilograms of payload to Low Earth Orbit.
- **Vikram-II** is equipped to lift off with 595 kilograms of cargo.
  - **Vikram-III** can launch with an 815 kg to 500 km Low Inclination Orbit.
  - Skyroot's first privately developed, fully cryogenic rocket engine, Dhawan-I, for its Vikram II was successfully test fired in 2021.
  - **Skyroot Aerospace test-fired its 3D-printed Dhawan II engine.** The engine was developed by the company **for its updated version of, Vikram II.**
  - Dhawan-II is completely indigenous and used a super alloy for 3D printing the engine, which reduced the manufacturing time by 95%. It will use Liquid Natural gas (LNG) and Liquid Oxygen (LoX) as propellants.
  - **LNG is more than 90% methane and is considered the rocket fuel of the future.**
  - The engine development was partly supported by NITI Ayog's ANIC-ARISE program which promotes technologies including the use of green rocket propellants.
  - ANIC ARISE Progeam
    - By Niti Aayog : To promote green Propellants

FUELS	
Solid	<p><b>Solid propellant:</b></p> <ul style="list-style-type: none"> <li>• They consist of <b>mixture of solid compounds</b> (both fuel and oxidizer) that burn at a rapid rate after ignition.</li> <li>• The fuel is usually <b>organic material</b> (hydroxyl-terminated polybutadiene) or powdered aluminum.</li> <li>• The <b>oxidizer</b> is most often <b>ammonium perchlorate</b>.</li> <li>• Solid rocket motors once ignited burn their fuel until it is exhausted.</li> </ul>
Liquid	<p><b>Liquid propellant:</b></p> <ul style="list-style-type: none"> <li>• Liquid fuels can range from ordinary <b>kerosene</b>, which can be used at ground temperature, to <b>liquid hydrogen</b>, which must be maintained at extremely cold temperatures.</li> <li>• In order to burn, liquid rocket fuel must be <b>mixed in the combustion chamber</b> of a rocket engine with an oxidizer. <b>Liquid Oxygen</b> is commonly used as oxidizer.</li> <li>• Liquid engines can be turned off after ignition and provide better control than solid fuels.</li> <li>• Liquid Hydrogen : it is liquid at low temp (-252°C)           <ul style="list-style-type: none"> <li>○ It is a cryogenic fuel but still called Liquid Fuel</li> <li>○ Bc Engine used is liquid engine (cannot take the benefit of cryogenic fuel)               <ul style="list-style-type: none"> <li>▪ Liquid hydrogen will be used as liquid fuel only</li> </ul> </li> <li>○ Benefit of liquid hydrogen is renewable and low pollutant</li> </ul> </li> </ul>

**Cryogenic Engines:**

- Cryogenic rocket stage is **more efficient** and **provides more thrust** for every kilogram of propellant it burns compared to solid and liquid propellant rocket stages.
- **Liquid Hydrogen** and **Liquid Oxygen** are commonly used as cryogenic propellants.
- Cryogenic stage is **technically a very complex system** compared to solid or liquid propellant stages due to its use of **propellants at extremely low temperatures** and other designing requirements.
- Oxygen liquifies at -183 deg C and Hydrogen at -253 deg C.



**PRL:** Physical Research Laboratory **NARL:** National Atmospheric Research Laboratory **NE-SAC:** North Eastern Space Applications Centre **SCL:** Semi-Conductor laboratory **IIST:** Indian Institute of Space Science and Technology **ISRO:** Indian Space Research Organisation **Antrix:** Antrix Corporation Limited **VSSC:** Vikram Sarabhai Space Centre **LPSC:** Liquid Propulsion Systems Centre **SDSC:** Satish Dhawan Space Centre **URSC:** U R Rao Satellite Centre **SAC:** Space Applications Centre **NRSC:** National Remote Sensing Centre **HSFC:** Human Space Flight Centre **IPRC:** ISRO Propulsion Complex **IISU:** ISRO Inertial Systems Unit **DECU:** Development and Educational Communication Unit **MCF:** Master Control Facility **ISTRAC:** ISRO Telemetry, Tracking and Command Network **LEOS:** Laboratory for Electro-Optics Systems **IIRS:** Indian Institute of Remote Sensing **NSIL:** NewSpace India Limited

# L11 Satellites, Moon Missions

10 November 2024 02:20 PM

Satellites	<p>These are manufactured objects or spacecraft that orbit celestial bodies like planets or the moon. They are used for many purposes, including</p> <ul style="list-style-type: none"><li>• <b>Communication:</b> Satellites can receive signals from Earth and retransmit them back using a transponder. Satellite communication technology can be used for internet access, especially in remote areas.</li><li>• <b>Weather forecasting:</b> Satellites can be used to forecast weather.</li><li>• <b>Navigation:</b> Satellites can be used for navigation.</li><li>• <b>Broadcasting:</b> Satellites can be used for broadcasting.</li><li>• <b>Scientific research:</b> Satellites can be used for scientific research.</li><li>• <b>Earth observation:</b> Satellites can be used to observe Earth.</li></ul>
Communication Satellites	<ul style="list-style-type: none"><li>• Every Satellite is communication satellite<ul style="list-style-type: none"><li>• If satellite stops communication -&gt; satellite retired</li></ul></li><li>• 1 way communication : TV Broadcast<ul style="list-style-type: none"><li>• TV Channel -&gt; signals -&gt; satellite -&gt; TV Antenna</li></ul></li><li>• 2 way communication : Video conference</li><li>• Transponder : Transmit + Receive</li></ul> <p><b>The Indian National Satellite (INSAT) system</b></p> <ul style="list-style-type: none"><li>• One of the largest domestic communication satellite systems in Asia-Pacific region</li><li>• Established in <b>1983</b> with commissioning of <b>INSAT-1B</b>.</li><li>• <b>9</b> communication satellites placed in <b>Geo-stationary orbit (5 operational now)</b>.</li></ul> <p><b>GSAT (Geosynchronous satellites)</b></p> <ul style="list-style-type: none"><li>• India's indigenously developed communication satellites.</li><li>• First launch in 2001.</li><li>• Launched by GSLV or foreign launchers (mostly Ariane-5).</li><li>• Over 20 GSAT satellites of ISRO have been launched, out of which, 14 are operational.</li></ul>

They contain instruments like transponders (A wireless communication & monitoring device that picks up and responds to a signal) serving in various bands for TV broad casting, cameras, Radiometers (Detects and measures electromagnetic radiation) for Meteorological imaging.

#### **Applications:**

Telecommunication, Television broadcasting, Satellite news gathering, Meteorology (Weather forecasting), Disaster warning, Search and Rescue operation services.

#### **Theme based communication satellites:**

- ‘EDUSAT’(GSAT-3), India’s first thematic satellite dedicated exclusively for educational services.
- Telemedicine.

Remote Sensing

## **REMOTE SENSING SATELLITES (IMAGING)**

- Starting with IRS-1A in 1988, ISRO has launched many operational remote sensing satellites.
- Today, India has one of the largest constellations of remote sensing satellites in operation. Currently 13 operational satellites are in Sun synchronous orbit & 4 in Geostationary orbit.
- The satellites use variety of instruments to provide necessary data in diversified fields.

#### **(i) Land/water resources applications**

- RESOURCESAT series and RISAT series

#### **(ii) Ocean/atmospheric studies**

- OCEANSAT series, INSAT-VHRR (Very High-Resolution Radiometer), INSAT-3D, Megha-Tropiques and SARAL

#### **(iii) Large scale mapping applications**

- CARTOSAT series

- Remote sensing satellite RADAR -> emits radio waves
- Waves hits surface to be studied -> reflected back radio waves
- RADAR will read reflected radio waves and analyse to understand the nature of surface
  - Composition / Colour / Moisture etc
- Active radar : Emit radio waves and study reflected radio wave
- Passive radar : Study the radio wave emitted by the surface itself
- SAR Synthetic Aperture Radar : Cover large area
  - Take multiple images while moving ahead , taking multiple photos of same area
  - which increase the actual aperture area to KM<sup>2</sup>
- Beam Radar : fixed and oscillating, project beam of RW, cover small area

## Remote Sensing - Applications

### Agriculture

- Crop area estimation
- Crop production Forecast
- Crop health / damage assessment
- Soil mapping
- Horticulture development

### Rural Development

- National Drinking Water Mission
- Wastelands Mapping/ Updation
- Watershed Development & Monitoring
- Land Records Modernization Plan

### Urban Development

- Urban Mapping of Major Cities
- Master/ Structure Plans
- Comprehensive Development Plans

### Cartography

- Visualization of spatial information.
- Large Scale Mapping

### Resources & Environment

- Forest Cover & Type mapping
- Wetland Inventory & Conservation plans
- Biodiversity Characterization
- Desertification Status mapping
- Snow & Glacier studies

### Disaster Management Support

- Realtime analysis of natural disasters like Flood, Cyclone, Drought, Landslide, Earthquake and Forest Fire
- R&D Studies on Early warning Systems, Decision Support Tools

### Geology & Mineral Resources

- Landslide Hazard Zonation
- Mineral/ Oil Exploration, Mining Areas,
- Seismo-tectonic Studies

### Ocean and Meteorology

- Ocean State Forecast (OSF)
- Regional Weather prediction

Bands	<ul style="list-style-type: none"> <li>• Low Frequency to High frequency bands</li> </ul> <table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr><td style="text-align: center; padding: 2px;">HF Band</td><td style="text-align: center; padding: 2px;">3 to 30 MHz</td></tr> <tr><td style="text-align: center; padding: 2px;">VHF Band</td><td style="text-align: center; padding: 2px;">30 to 300 MHz</td></tr> <tr><td style="text-align: center; padding: 2px;">UHF Band</td><td style="text-align: center; padding: 2px;">300 to 1000 MHz</td></tr> <tr><td style="text-align: center; padding: 2px;">L Band</td><td style="text-align: center; padding: 2px;">1 to 2 GHz</td></tr> <tr><td style="text-align: center; padding: 2px;">S Band</td><td style="text-align: center; padding: 2px;">2 to 4 GHz</td></tr> <tr><td style="text-align: center; padding: 2px;">C Band</td><td style="text-align: center; padding: 2px;">4 to 8 GHz</td></tr> <tr><td style="text-align: center; padding: 2px;">X Band</td><td style="text-align: center; padding: 2px;">8 to 12 GHz</td></tr> <tr><td style="text-align: center; padding: 2px;">Ku Band</td><td style="text-align: center; padding: 2px;">12 to 18 GHz</td></tr> <tr><td style="text-align: center; padding: 2px;">K Band</td><td style="text-align: center; padding: 2px;">12 to 27 GHz</td></tr> <tr><td style="text-align: center; padding: 2px;">Ka Band</td><td style="text-align: center; padding: 2px;">27 to 40 GHz</td></tr> </tbody> </table> <ul style="list-style-type: none"> <li>• Narrow band : less range of frequencies</li> <li>• Broad band : More range of frequencies</li> </ul>	HF Band	3 to 30 MHz	VHF Band	30 to 300 MHz	UHF Band	300 to 1000 MHz	L Band	1 to 2 GHz	S Band	2 to 4 GHz	C Band	4 to 8 GHz	X Band	8 to 12 GHz	Ku Band	12 to 18 GHz	K Band	12 to 27 GHz	Ka Band	27 to 40 GHz
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NISAR

- NASA-ISRO Synthetic Aperture Radar.
- It will be the first satellite mission to use two different radar frequencies (L-band and S-band) to measure changes in our planet's surface.
- NASA will provide the mission's **L-band Synthetic Aperture Radar** and ISRO will provide **S-band Synthetic Aperture Radar**.
- This allows the mission to observe a **wide range of changes**, from the flow rates of glaciers and ice sheets to the dynamics of earthquakes and volcanoes, biomass, natural hazards, sea level rise, and groundwater etc.
- Likely to be launched by GSLV in **2024 from India** after final assembly at **UR RAO Space centre into a sun synchronous orbit from Satish Dhawan Space Centre .**

Navigation Satellite

- NAVIC System : Indian GPS



## NAVIGATION SATELLITES

**Navigation:** The process of accurately ascertaining one's position and planning and following a route”

**Indian Regional Navigational Satellite System (IRNSS):** independent Indian Satellite based positioning system for critical national applications. Objective is to provide Reliable Position, Navigation and Timing services over India and its neighborhood, 1500 kilometers around the Indian mainland.

- **9 satellites launched, one unsuccessful, eight** satellites are currently in orbit (3 in Geo stationary orbit and remaining in Geosynchronous orbits).
- The IRNSS constellation is known as **Navigation with Indian Constellation (NavIC)**
- **IRNSS-1I** is the latest (eighth) member of the **NavIC** system, launched on 12<sup>th</sup> April, 2018, into Geosynchronous orbit.
- ISRO has recently revealed its plans to add new navigation satellites in Medium Earth Orbits to increase coverage.

The IRNSS will help India enter the club of select countries which have their own positioning systems. Following countries have global coverage:

- **USA's GPS (31 satellites in a constellation)**
- **Russia's GLONASS (over 24 satellites)**
- **European Union's Galileo (Over 24 satellites)**
- China's **BeiDou** (Full global services launched in July 2020 with constellation of **35 satellites**)
- Japan's **Quasi Zenith (QZSS)** regional system (planned to launch **7 satellites**).

The system was developed partly because access to foreign government-controlled global navigation satellite systems is not guaranteed in hostile situations, as happened to the Indian military in 1999 when the United States denied an Indian request for Global Positioning System (GPS) data for the Kargil region, which would have provided vital information. The Indian government approved the project in May 2013.

### Navigation satellites - Applications

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

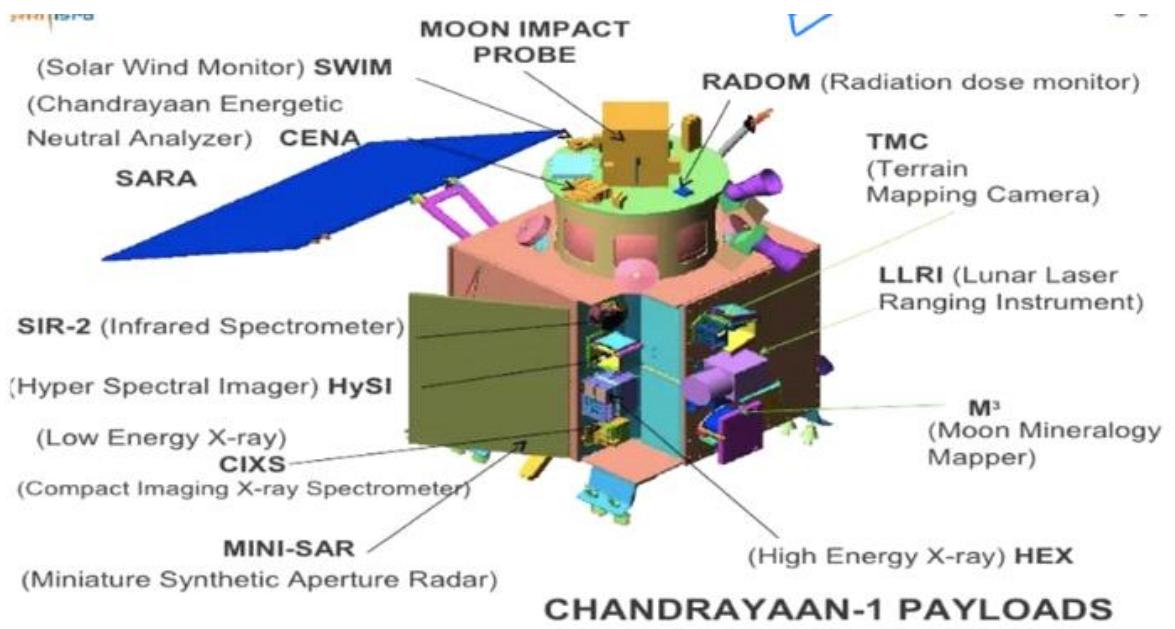
GAGAN

- Satellite bassed Navigation of flights

## GPS Aided Geo Augmented Navigation (GAGAN)

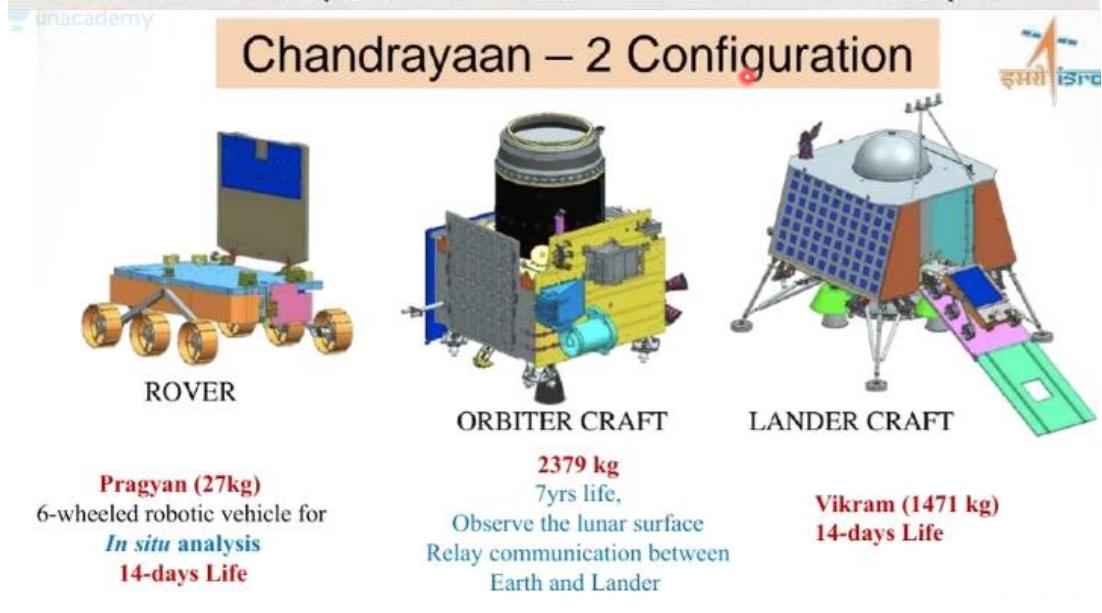
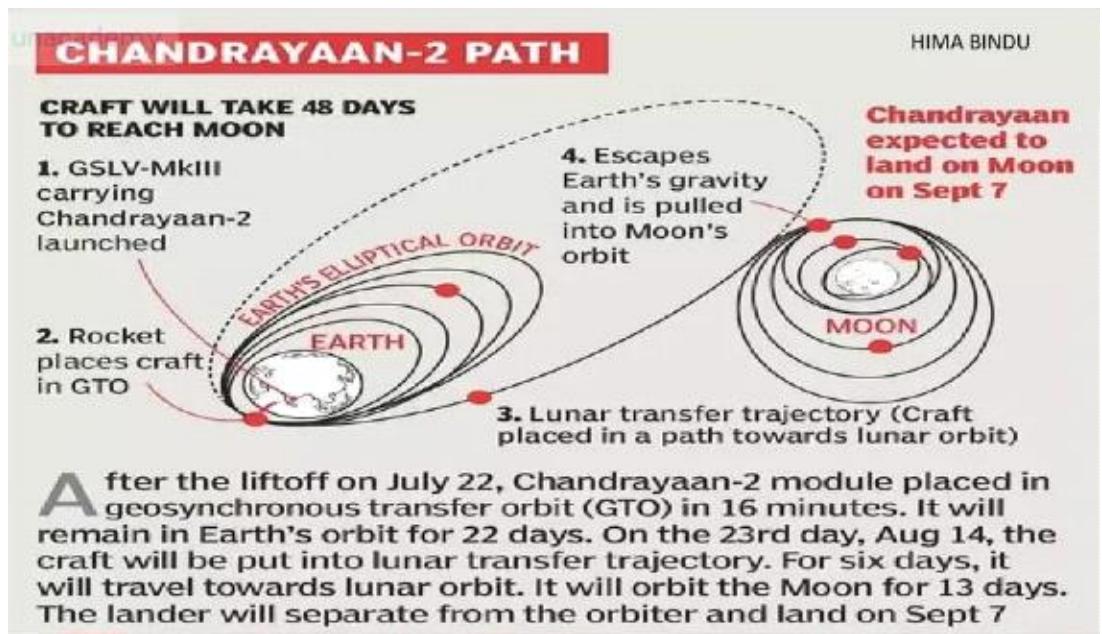
- Developed by **ISRO** and **Airports Authority of India (AAI)** to deploy **satellite-based augmentation system (SBAS)** for civil aviation applications.
- Replace ground-based navigation systems using radars.
- More efficient use of available airspace.
- GAGAN GEO coverage extends from **Africa to Australia** and has expansion capability for seamless navigation services across the region.
- GAGAN is already operational through **GSAT-8, GSAT-10, and GSAT 15** satellites.

**Uses:** Additional accuracy, availability, and integrity necessary for all phases of flight.

Moon Missions	
Chandrayan 1	<ul style="list-style-type: none"> <li>• Moon Probe           <ul style="list-style-type: none"> <li>• Launched on <b>22nd October 2008</b>.</li> <li>• India became the <b>4<sup>th</sup> country</b> (USA, RUSSIA, JAPAN) to land a probe on the moon.</li> <li>• <b>Distance:</b> 386,000 km from the earth</li> <li>• <b>PSLV-XL (C11)</b> (320-ton lift-off weight)</li> <li>• <b>Cost:</b> \$ 80 million (~400 cr)</li> <li>• The mission included a lunar orbiter and an impactor.</li> <li>• <b>Expected duration:</b> 2 years , Lasted for ~ 10 months.</li> <li>• Confirmed water ice on the surface using NASA's instrument, Moon mineralogy mapper, M<sup>3</sup>.</li> <li>• <b>Carried 11 scientific instruments</b> (payloads), 5 from ISRO, remaining from other countries.</li> <li>• <b>Findings:</b> confirmed the presence of lunar waters, lunar caves, tectonic activity, Faults and fractures.</li> </ul> </li> </ul>  <p><b>CHANDRAYAAN-1 PAYLOADS</b></p>

## Chandrayan 2

- Launched on **22<sup>nd</sup> July 2019**.
- **GSLV Mk III-M1**
- **Cost : ~ 1000 Cr**
- 3 parts: **Orbiter, Lander and Rover**.
- Could have become the **first-ever mission** to land a rover near **the lunar south pole** (Unexplored).
- Lander crashed during the **soft landing**.
- Only US, Russia and China have been able to soft-land spacecraft on lunar surface so far.



**CHANDRAYAAN-1**  
**Oct 2008****ORBITER:** 100km from  
lunar surface**11 PAYLOADS**

5 from India, 3 from Europe

2 from USA, 1 from Bulgaria

**WHAT IT DID**

Discovery of water

Mapping of chemicals, 3D  
topography**PSLV**Spacecraft mass: **1.4T****CHANDRAYAAN-2**  
**July 2019 (targeted)****ORBITER:** 100km from  
lunar surface**VIKRAM LANDER**

Softlanding near south pole

**PRAGYAN ROVER**

In-situ experiments

**13 INDIAN PAYLOADS**

8 on Orbiter, 3 on Lander

2 on Rover + 1 passive

experiment from NASA

Expanding Lunar Exploration

**GSLV MKIII**Spacecraft Mass: **3.8T**

Source: ISRO Indian Express

- Chandrayaan-2 was initially supposed to be a collaboration between India and Russia.
- However, **Russia withdrew from designing the lander-rover** for Chandrayaan-2 leading India to develop it independently.
- Also, **four astronauts** who will be part of India's first crewed space mission: Gaganyaan have been trained in Russian facilities.

Source: IE, 16 Aug 2023.

South Pole of  
Moon**Why ISRO want to explore the Moon's South Pole:**

**Water Resources:** The south pole region is believed to have water molecules in substantial amounts, possibly trapped as ice in the permanently shadowed craters. Exploring and confirming the presence of water is essential for future human missions and the potential utilization of lunar resources.

**Scientific Discoveries:** The extreme environment and the presence of permanently shadowed regions provide a preserved record of the Moon's history and the early Solar System.

**Clues to Earth's History:** The Moon is thought to have formed from debris generated by a giant impact between a Mars-sized object and the early Earth. By studying the lunar south pole, scientists can gain insights into the materials and conditions that existed during the formation of the Earth-Moon system.

**Technological Advancements:** By undertaking missions to this region, ISRO can develop and demonstrate innovative technologies for soft landing, navigation, resource utilization, and long-duration operations that can be applied in future space missions.

- Colonize the moon

Chandrayan 3

- Chandrayaan-3 is **India's third moon mission** and is a follow-up of Chandrayaan-2 (2019) which aimed to **land a rover on the lunar South Pole**.
- It aims to be the world's first mission to **soft-land** near the lunar South Pole.

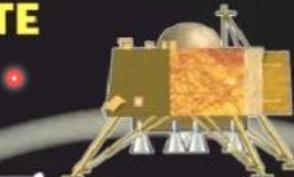
**About the Mission:****The Mission will have three major modules-**

- The **Propulsion module** (will carry the lander and rover configuration till 100 km lunar orbit).
- Lander module** (capability to soft land and deploy Rover).
- Rover** (will carry out in-situ chemical analysis of the lunar surface).

Unlike Chandrayaan-2, it **will not have an orbiter** and its **propulsion module will behave like a communications relay satellite**.

## INDIA'S THIRD DATE WITH THE MOON

India will launch its third mission, Chandrayaan-3, to the moon in an attempt to land on its surface in 2020-21. The mission will target a soft-landing near the lunar South Pole later this year or early next year



### MISSION COST

Chandrayaan-2	₹250cr	₹360cr	₹610cr	₹960cr
Chandrayaan-3	Lander-rover	Launch rocket		Hindustan Times

### Chandrayaan-3 payloads:

#### The propulsion module:

- It has **Spectro-polarimetry of Habitable Planet Earth (SHAPE)** payload to look for changes that a life supporting atmosphere make to the star light that is passing through it, thereby analysing possibility of life in nearby planets.

#### The Lander payloads:

- **Radio Anatomy of Moon Bound Hypersensitive ionosphere and Atmosphere (RAMBHA)** – to measure near surface plasma density and its changes with time.
- **Chandra's Surface Thermophysical Experiment (ChaSTE)** to measure the thermal conductivity and temperature.
- **Instrument for Lunar Seismic Activity (ILSA)** for measuring the seismicity around the landing site.
- **Langmuir Probe (LP)** to estimate the plasma density and its variations.
- A passive **Laser retroreflector array** from NASA to help accurately measure the distance between Earth and moon.

#### The Rover payloads:

- **Alpha Particle X-ray Spectrometer (APXS) and Laser Induced Breakdown Spectroscopy (LIBS)** for deriving the elemental composition in the vicinity of the landing site.

Chandrayaan - 3 landed on Moon on 23<sup>rd</sup> August. Rover separated. And lost contact after 14 days.

#### Global Collaborations:

- ISRO-NASA successfully confirmed the presence of water from the data taken by Chandrayaan-1.
- Indo-Japan collaboration, LUPEX aims to send a lander and rover to the Moon's south pole around 2024.
  - X ray and Gamma ray induce ionisation -> can induce mutation
  - Ionisation can also happen because of Light energy or Heat energy

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### **Findings of Chandrayaan 3:**

- Chandrayaan-3 ‘unambiguously confirmed’ the presence of sulphur in the lunar surface near south pole. Other elements like Aluminum (Al), Calcium (Ca), Iron (Fe), Chromium (Cr), Titanium (Ti), Manganese (Mn), Silicon (Si), and Oxygen (O) are also detected. The space agency further added that the search for Hydrogen (H) is underway.
- 2. 4-meter diameter crater on Moon's surface
- Temperature recorded on the Lunar surface is 50-70°C and at a depth of 8cm (-)10°C
- Vikram lander studied the Moon's Ionosphere to provide insights into developing future communication technology suitable for Moon.
- Vikram lander detected seismic activity which could be either due to a moon quake or an Asteroid hit.
- Pragyan Rover covered 100 meters distance of Lunar terrain.
- Found that near surface plasma environment (Charged particles) to be relatively sparse means it will not cause much disturbance to radio communication.
- Vikram lander performed a hop experiment indicating that the space craft could be used to bring samples back in future.

Russia Luna 25

The chart compares the Chandrayaan-3 mission (India) and the Luna-25 mission (Russia). It includes details such as launch date and time, rocket type, launch site, launch mass, payload mass, landing site, travel duration, landing date, and mission duration. Both missions are set to land on the Moon's South Pole.

Chandrayaan-3	Luna-25
Jul 14   9:05 UTC	Aug 10   23:10 UTC
LVM3 M4	Rocket
Satish Dhawan Space Centre, India	Vostochny Cosmodrome, Russia
3,900 kg	Launch Mass
1,752 kg + 26 kg	Payload Mass
Lander Rover	31 kg
South Pole (69.367621 S, 32.348128 E)	Landing Site
19 days + 5 days + 18 days	Days to travel to moon
Earth Orbit Earth to Moon Moon Orbit	5 days + 7 days
Aug 23	Earth Orbit Moon Orbit
14 Days	Landing Date*
	Aug 22
	Mission Duration
	1 Year

### **RUSSIA'S LUNA 25**

- The race to send a spacecraft to the moon has taken an exciting turn as **Russia's Luna 25 mission**, launched on a Soyuz rocket on August 11, 2023, aims to soft-land on Moon's south pole a few days before India's Chandrayaan-3.
- Luna 25 marks Russia's return to lunar exploration after 47 years**, aiming to reclaim its reputation in space exploration.
- Russia's space agency, **Roscosmos asserts that Luna 25's landing would not impact Chandrayaan-3**, as their landing regions are distinct.

Chang e4

### **China's Chang'e-4 Mission**

- On **January 2<sup>nd</sup>, 2019**, China has successfully landed a robotic spacecraft on the **far side of the Moon**, the first ever such landing.
- Previous Moon missions have landed on the Earth-facing side, but this is the first successfully landing on the unexplored far side.
- It is carrying **instruments to analyse** the unexplored region's **geology**, as well to **conduct biological experiments**.
- The area where the probe has landed faces away from Earth, meaning it is free from radio frequencies. As a result, it is not possible for a lunar rover to communicate directly with ground control.
- Hence, China launched a **dedicated satellite (Queqiao)** orbiting to relay information from the rover to Earth.

## New International Moon missions

- NASA's **VIPER rover**: Planned to be launched on the **Moon's south pole** in 2023 to study water ice.
- **South Korea** launched **Danuri** (also known as the **Korean Pathfinder Lunar Orbiter or KPLO**) to the **Moon** on **August 5, 2022**, to study the Moon's surface and help plan future missions to the lunar poles.
- **Beresheet2**: Israeli non-profit organization, **SpaceIL**'s plan to the Moon targeting **2024** to conduct scientific experiments.

unacademy

## NASA's ARTEMIS MISSION

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Artemis is the ambitious plan of NASA to relaunch its human missions to Moon after 5 decades

- The Artemis program comprises of **three missions**:
- **Artemis I**, launched on **16th November 2022**, is an uncrewed mission, with human models to test the functioning of the rocket and effects on Human body.
- NASA's SLS rocket carried Orion spacecraft into space to **travel past the moon** and cover 1.3 million miles before ending its 42-day **journey back to earth**.
- **Artemis II** will be the **first crewed flight test** of the SLS rocket and the Orion spacecraft around the Moon taking humans to their farthest point yet in space.
- **Artemis III** will make history by landing humans on the Moon.
- With this Mission, NASA is planning to establish **long-term presence on Moon** by setting up a human base camp, a series of nuclear reactors, and a mineral mining operation.
- It is going to be stepping stone of its journey to Mars and then further exploration of deep space.

# L12 Interplanetary and Deep Space

10 November 2024 05:51 PM

INTER PLANETARY MISSIONS	
ISRO Mangalyaan MOM	<ul style="list-style-type: none"><li>• ISRO Mars Orbital mission 2013<ul style="list-style-type: none"><li>• <b>Launch vehicle</b> : PSLV XL (C25) (1350 Kg)</li><li>• Launched on <b>5<sup>th</sup> Nov 2013</b></li><li>• <b>Cost</b>: \$ 75 million (~ 450 crore)</li><li>• <b>Payload</b>: 1350 kg</li><li>• Mangalyaan traveled for ~300 days, covering ~ 680 mn kilometers, and reached Martian orbit in <b>September 2014</b>.</li><li>• <b>Objective</b>: To study the <b>composition of Mar's SAM (Surface – Atmosphere – Minerals)</b>, using 5 different payloads.</li><li>• It made India the 4<sup>th</sup> space agency to orbit mars after ROSCOSMOS, NASA, ESA &amp; the first nation to send a satellite into Martian orbit on its first attempt.</li><li>• The Mars Color Camera (MCC) has produced more than 1000 images and published a <b>Mars Atlas</b>.</li><li>• ISRO is planning another orbiter mission (MOM-2) as the Mars Orbiter craft has attained end-of-life.</li></ul></li></ul>
ISRO Shukrayaan	<ul style="list-style-type: none"><li>• ISRO Venus Future mission<ul style="list-style-type: none"><li>• ISRO is also planning a <b>mission to Venus</b>.</li><li>• Both the Earth and Venus <b>share similarities</b> in size, mass, density, bulk composition and gravity.</li><li>• ISRO is planning to send <b>an orbiter that will be placed</b> around 400 km <b>over Venus</b> to conduct research and understand its formation, its atmosphere and its interaction with the solar wind.</li><li>• The mission is expected to be <b>launched by 2024</b> and expected to orbit for ~ 4 years.</li><li>• ISRO has been soliciting ideas for instruments for Venus mission since 2018.</li><li>• The flagship instrument will be a <b>synthetic aperture radar</b> to examine the Venusian surface covered by thick clouds.</li></ul></li></ul>

**MARS missions****NASA**

**Perseverance** Rover  
**MAVEN** Orbiter  
**InSight** Lander  
**Curiosity** Rover  
**MARS Reconnaissance** orbiter  
**Odyssey** orbiter (working for two decades)

**European Space Agency**

**ExoMars Trace Gas Orbiter**  
**Mars Express**

**BepiColombo**

**European & Japanese** collaborative mission to **Mercury**. Launched in **October 2018** and expected to reach Mercury in 2025.

**Akatsuki**

Japan's first interplanetary mission actively studying **Venus's** atmosphere.

**Juno**

NASA's mission exploring **Jupiter** (Reached Jupiter in 2016).

Nasa  
Perseverance

- NASA Rover Mission 2020
- Biosignature (life support - organic compounds)
  - It is a **NASA'S MARS ROVER**, launched on 30<sup>th</sup> July 2020
  - It reached on: 18<sup>th</sup> Feb 2021
  - Took 7 months and traveled ~ 480 million Km.
  - It is part of NASA's **Mission 2020** to collect **samples** from Mars.
  - Landing site: **Jezero Crater**
  - It uses the Mars **Reconnaissance Orbiter** (designed to study geology and climate on Mars, reached MARS in 2006) to send images back to Earth.
  - Samples will be studied to learn if life has ever existed on Mars.
  - An experimental helicopter called **Ingenuity, a small drone** was sent along with Perseverance to test if helicopter can fly in Mars' atmosphere.
  - In December 2021, NASA announced that Perseverance detected Carbon containing organic compounds on Martian rocks – indicating past life on MARS, but it needs to be confirmed through sample verification in future.

HOPE Al Amal

**HOPE (Al-Amal)**

- United Arab Emirates' (UAE's) first-ever interplanetary mission
- This orbiter/probe, developed by UAE scientists in the USA and was launched on **19<sup>th</sup> July 2020** from the Tanegashima Space Centre in Japan.
- Has successfully entered **orbit around Mars** in **February 2021**.
- UAE became **the fifth country** to reach the Red Planet, joining NASA, the Soviet Union, the European Space Agency and India.

Tianwen 1

**Tianwen-1 (Questions to heaven)**

- China's first Mars mission, launched on **23<sup>rd</sup> July 2020**.
- A robotic spacecraft, consisting of an **orbiter, lander and rover**.
- Has successfully entered orbit around Mars in February 2021 and landed a rover (**Zurong**) in May 2021 on a massive plain in the northern hemisphere known as **Utopia Planitia**.
- China became the **second only country**, after USA to land a rover on MARS.

JUICE	<ul style="list-style-type: none"> <li>• JUNO Mission : Jupiter</li> <li>• JUICE Mission : Jupiter's Moon (Ganymede, Callisto, Europa)           <ul style="list-style-type: none"> <li>• Icy moon -&gt; water presence -&gt; life supporting</li> </ul> </li> </ul> <p style="text-align: center;"><b>EUROPEAN SPACE AGENCY SET TO LAUNCH JUPITER ICY MOONS EXPLORER (JUICE)</b></p> <ul style="list-style-type: none"> <li>• Recently, the European Space Agency is set to launch the Jupiter Icy Moons Explorer (Juice) mission to explore Jupiter and its icy moons, namely <b>Ganymede, Callisto, and Europa</b>.</li> <li>• Two other spacecraft have examined Jupiter: NASA's Galileo probe, which orbited the gas giant between 1995 and 2003, and NASA's Juno, which has been circling the planet since 2016.</li> <li>• <b>Launched from French Guiana on an Ariane 5 launcher.</b> The mission is set to reach Jupiter in 2031.</li> <li>• The spacecraft was constructed by <b>Airbus Defence and Space</b>, a division of the Airbus group.</li> </ul> <p><b>Main Objectives:</b></p> <ul style="list-style-type: none"> <li>• To create detailed maps of the moons' surfaces and look beneath them to probe the potential habitable environments by analyzing the water bodies underneath.</li> <li>• To create a comprehensive picture of Jupiter by trying to understand its origin, history, and evolution.</li> <li>• To explore Jupiter's complex environment in depth, and study the wider Jupiter system as an archetype for gas giants across the Universe.</li> <li>• The focus will be on Ganymede (the largest moon in the Solar System, which generates its magnetic field).</li> <li>• <b>The three moons, Ganymede, Callisto, and Europa, are believed to hold immense amounts of water, potentially making them habitable.</b></li> <li>• <b>Juice isn't equipped to detect life</b> but can find out whether there could be necessary conditions, such as water, biological essential elements, energy, and stability, to sustain life.</li> </ul>
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DEEP SPACE MISSION	<ul style="list-style-type: none"> <li>• Far in space missions</li> </ul>
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## VOYAGER TWIN SPACECRAFT

- The twin Voyager 1 and 2 spacecrafts **launched in 1977** are continuing to explore where nothing from Earth has flown before.
- The **primary mission**, **Voyager 1** was the exploration of **Jupiter and Saturn**.
- Voyager 2 went on to explore **Uranus and Neptune** and is still the only spacecraft to have visited those outer planets.
- In **August 2012**, **Voyager 1** made the **historic entry into interstellar space** (the region between stars), crossing the **Heliopause** (The boundary between solar wind and interstellar wind). The interstellar space is filled with material ejected by the death of nearby stars millions of years ago.
- **Voyager 2** entered **interstellar space** on **November 5, 2018** and scientists hope to learn more about this region.
- Voyager's power supply comes from a **radioisotope thermoelectric generator (RTG)** which turns heat from the decay of radioactive material into electricity to power the space craft.
- Twin Voyagers are likely to run out of power within **5 years**.
  - NASA kept the Voyager in the energy saving mode, about to complete the fuel
    - Nuclear fuel : radioactive decay
    - Plutonium 238, byproduct of nuclear weapons
      - In atom bomb we use plutonium 239
  - Farthest man-made object

ISRO Nuclear  
Engines

## ISRO, BARC JOIN HANDS TO DEVELOP NUCLEAR ENGINES FOR ROCKETS

- Recently, the Bhabha Atomic Research Center (BARC) and the Indian Space Research Organization (ISRO) began working together to develop **radio thermoelectric generators (RTGs)**, a novel strategy meant to overcome the limitations of traditional chemical engines for interplanetary travel.
- **Chemical engines** work well for satellite thrusters, but they are **inadequate for deep space travel** due to fuel limitations and lack of solar power in distant regions.
- **RTGs** have been successfully employed by US spacecraft such as the **Voyager**, **Cassini** and **Curiosity**, to power missions with exceptional achievements.

### **Radio Thermoelectric Generators (RTGs):**

- **Radioisotope Heater Unit (RHU)** utilize radioactive materials, such as **Plutonium-238 or Strontium-90**, to emit heat as they decay over time.

- This heat is harnessed and converted into electricity by the **RTG component**.
- This conversion takes place through a **thermocouple**, a material that generates voltage when subjected to a temperature gradient.
- The voltage produced by the thermocouple is **utilized to charge batteries onboard the spacecraft**.
- These batteries, in turn, power various systems, including propulsion mechanisms, enabling interplanetary travel.

#### **Advantages of RTGs for Space Missions:**

##### **Independence from Solar Proximity:**

- Unlike solar-powered systems, **RTGs operate effectively regardless of the spacecraft's distance from the sun**.
- This characteristic **eliminates constraints related to launch windows and planetary alignment**.

##### **Reliability and Consistency:**

- RTGs offer a consistent and reliable source of power, essential **for sustaining prolonged deep space missions**.
- The gradual decay of radioactive materials ensures a **continuous supply of heat and electricity**.

##### **Bhabha Atomic Research Centre:**

- BARC is **India's premier nuclear research facility** based in Mumbai, Maharashtra.
- It is a **multi-disciplinary research center** with core mandate to sustain **peaceful applications of nuclear energy**, primarily for power generation.

Source: BL, 16 July 2023.

Nuclear Powered Rocket

#### **NUCLEAR-POWERED ROCKET**

- NASA collaboration with the United States Defense Advanced Research Projects Agency (DARPA) is seeking a **nuclear propulsion system**, a nuclear reactor that utilizes the energy derived from the **fission of uranium atoms that could potentially cut down the travel time to Mars by half**.
- This ambitious initiative, known as the **Demonstration Rocket for Agile Cislunar Operations (DRACO)** and the launch is scheduled for late 2025 or early 2026.

##### **Significance:**

**Minimized Exposure:** The potential risks associated with extended space travel, such as radiation exposure and isolation, could be mitigated through **quicker journeys**.

**Military Applications:** Nuclear propulsion can facilitate **rapid maneuvers of military satellites** in Earth's orbit.

**Concern:**

- **Safety Concerns:** Accidents or malfunctions could release radioactive material into space or back to Earth. Such incidents could have severe environmental and health consequences.
- **Launch Risks:** There is always a chance of a launch failure or explosion, leading to the dispersion of radioactive material over a wide area.

**Historical Context of Nuclear Propulsion:**

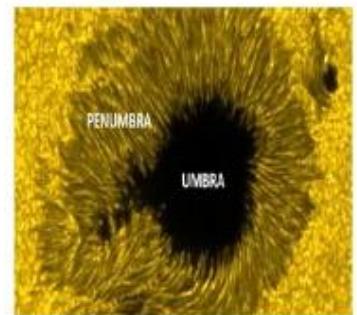
- Projects like **Orion, Rover, and NERVA** explored nuclear-powered propulsion systems, although these initiatives were not fully realized.
- Notably, **Project Orion** considered using **atomic bomb explosions** for acceleration, while Project **NERVA** aimed to develop a **nuclear-thermal engine** akin to the DRACO engine.

# L13 Sun Probes

10 November 2024 08:27 PM

Solar Flares	<ul style="list-style-type: none"><li>• Solar Flared : High Energy rays (x rays and gamma rays)<ul style="list-style-type: none"><li>• <b>Solar flares</b> are highly energetic phenomena that happen when the energy stored in the sun's magnetic structures called sunspots is converted into light and heat energy. This causes the emission of high energy electromagnetic waves like radio waves, <b>x-ray radiation</b>, Gamma rays. They travel at a speed of light. Takes 8 mins to reach Earth.</li><li>• There are <b>five categories of solar flare</b> according to their brightness in the x-ray wavelengths, which include <b>A, B, C, M, and X</b>; each class is at least ten times more potent than the one before it.</li><li>• (<b>Current:</b> Recently, the Sun emitted an <b>X1.0 -class solar flare</b>, disrupting radio communications over parts of the United States and the Pacific Ocean).</li></ul></li></ul>
Solar Winds / CME	<ul style="list-style-type: none"><li>• Solar Winds : High Energy Particles emitted by the sun (electron and alpha particles)</li><li>• Coronal Mass ejection<ul style="list-style-type: none"><li>• Coronal : outer most layer of the suns atmosphere, plasma emission</li><li>• The <b>solar wind</b> is a stream of charged particles released from the outer most layer of the Sun's atmosphere called the corona. This mostly consists of electrons, protons and alpha particles with kinetic energy between 0.5 and 10 keV.</li><li>• A <b>coronal mass ejections (CME)</b> are significant release of plasma and accompanying magnetic field from the Sun's corona into the solar wind. They can harbour energies exceeding that of a million atomic bombs. Take 1-3 days to reach Earth.</li><li>• Solar flares occur in active regions and are often, but not always, accompanied by coronal mass ejections.</li></ul></li></ul>
Solar Storms / Geomagnetic storms	<ul style="list-style-type: none"><li>• SW, SF and CME they drag some parts of suns magnetic field toward earth or other planets<ul style="list-style-type: none"><li>• It distorts and disturbs the earth magnetic field</li></ul></li></ul>

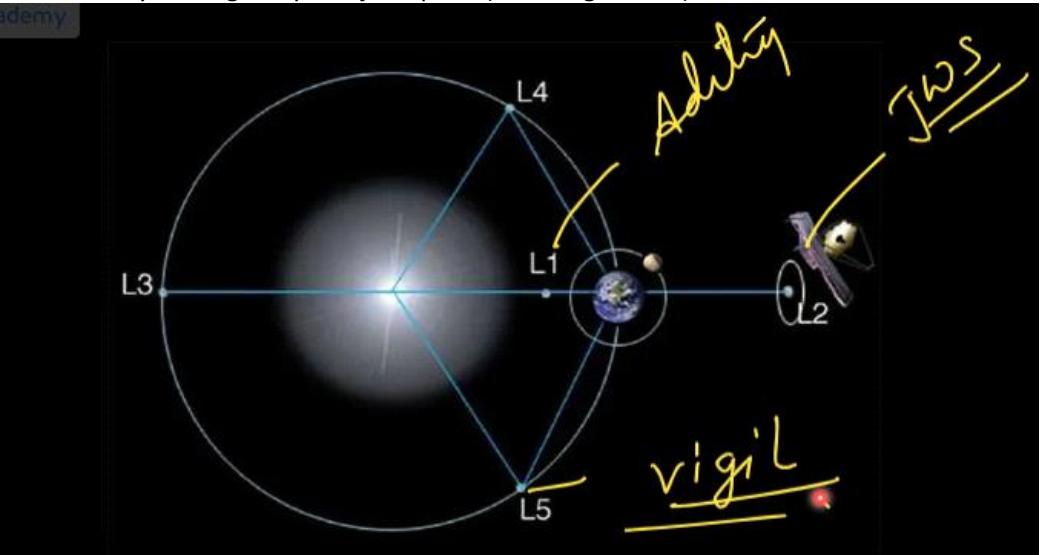
- The **Solar magnetic cycle** that works in the deep interior of the Sun creates regions that rise to the surface and appear like dark spots. These are **sunspots**.
- Solar magnetic cycle:** Every 11 years or so, the Sun's magnetic field completely flips. This means that the Sun's north and south poles switch places.
- One way to track the solar cycle is by counting the number of sunspots. The beginning of a solar cycle is a **solar minimum**, or when the Sun has the least sunspots. Over time, solar activity—and the number of sunspots—increases.
- They typically consist of a **dark region** called the '**umbra**', which is surrounded by a **lighter region** called the '**penumbra**'.
- Geomagnetic storm:** Major disturbance of **Earth's magnetosphere** due to the **heliospheric magnetic field (HMF)** that is dragged out from the solar corona by the **solar wind**. They are categorised as **G1, G2, G3, G4, G5** in the increasing order of their intensity.
- Solar storms** occur when sun emits huge bursts of energy in the form of solar flares and Coronal mass ejections. *Solar storms can last only a few minutes to several hours, but the effects of geomagnetic storms can linger in the Earth's magnetosphere and atmosphere for days to weeks.* They are categorised as **S1, S2, S3, S4, S5** in the increasing order of their intensity
- (Note: *Magnetosphere is that area of space, around a planet, that is controlled by the planet's magnetic field.*)
- The interplanetary magnetic field (IMF) or heliospheric magnetic field (HMF), is the component of the solar magnetic field that is dragged out from the solar corona by the solar wind flow to fill the Solar System.)*



Effect of solar storm	<ul style="list-style-type: none"> <li>Aurora Borealis (Polar lights / Northern Lights)</li> <li>Judging by data from the <b>NASA DSCOVR satellite</b>, the scientists observed a <b>steep jump in transverse magnetic fields, density and speeds of the plasma wind</b> that are tell-tale signatures of the arrival of a <b>coronal mass ejection shock front</b>. (The shock wave of travelling mass)</li> <li>The energy, radiation and high energy particles emitted by flares can affect Earth bound objects and life on Earth – it can affect the <b>electronics within satellites</b> and <b>affect astronauts</b>. International Space station ISS could also have been affected.</li> <li>Intermittent satellite navigation (GPS) problems.</li> <li>Very powerful Earth-directed coronal mass ejections can cause failure of power grids and affect oil pipelines and deep-sea cables.</li> <li>They can also cause spectacular <b>aurorae in the high-latitude</b> and <b>polar countries</b>.</li> <li>The last major blackout due to a coronal mass ejection recorded was in 1989.</li> </ul>
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### Predicting Solar Storms:

- The process of prediction takes place in two steps: First the researchers analyse the possibility of a strong solar flare from **an active region** – that is, **clusters of sunspots** using a machine learning algorithm which has been developed in CESSI, IISER Kolkata.
- The second step is estimating the time of arrival on Earth of coronal mass ejections and forecasting the geomagnetic storm.
- If there is an associated flare, its position on the Sun is used to extract the location of origin of the CME. The location of the source of the CME and the velocity are used as inputs in a model called **the Drag Based Ensemble Model** to calculate the **CME arrival times and speed**.

Solar Probes	<ul style="list-style-type: none"> <li>To keep an eye on Sun to study Solar winds, Solar flares, etc</li> </ul>
Lagrange point	<ul style="list-style-type: none"> <li>Lagrange Point : An object in 5 Lagrange point is subjected to 3 forces</li> <li>Earth Gravity + Sun gravity + object speed (centrifugal force)</li> </ul> 
ISRO Aditya L1 Mission	<ul style="list-style-type: none"> <li>Launched on 2<sup>nd</sup> September 23, reached the orbit on 6<sup>th</sup> January 24.</li> <li>A 400-Kg Space craft will be launched using <b>PSLV-XL</b> (PSLV – C57) in an orbit around the <b>Lagrange point 1 (L1)</b> of the Sun-Earth system.</li> <li><b>Lagrange points</b> are the positions where the centrifugal force due to the velocity of orbiting satellite &amp; the gravitational force / centripetal forces of two large bodies, Sun and earth balance each other. There are 5 such points in Sun-Earth system.</li> <li>It is placed at 1.5 million kms away from earth to provide continuous <b>view of the Sun</b> without any occultation due to <b>eclipses</b>.</li> <li>It carries <b>7 payloads like electromagnetic, particle and magnetic field detectors</b> to study Solar corona (Visible and near infrared rays), Sun's Photosphere (soft and hard X-ray) &amp; Chromosphere (UV) solar emissions.</li> <li>4 payloads directly view the sun to make round the clock imaging and 3 payloads carryout in-situ studies of particles and fields at L1.</li> <li>Solar winds, preflare and flare activities, dynamics of space weather, propagation of particles &amp; fields, Coronal mass ejections.</li> </ul>
NASA Parker	<p><b>'Parker Mission' is a probe launched by NASA to study the Sun.</b></p>

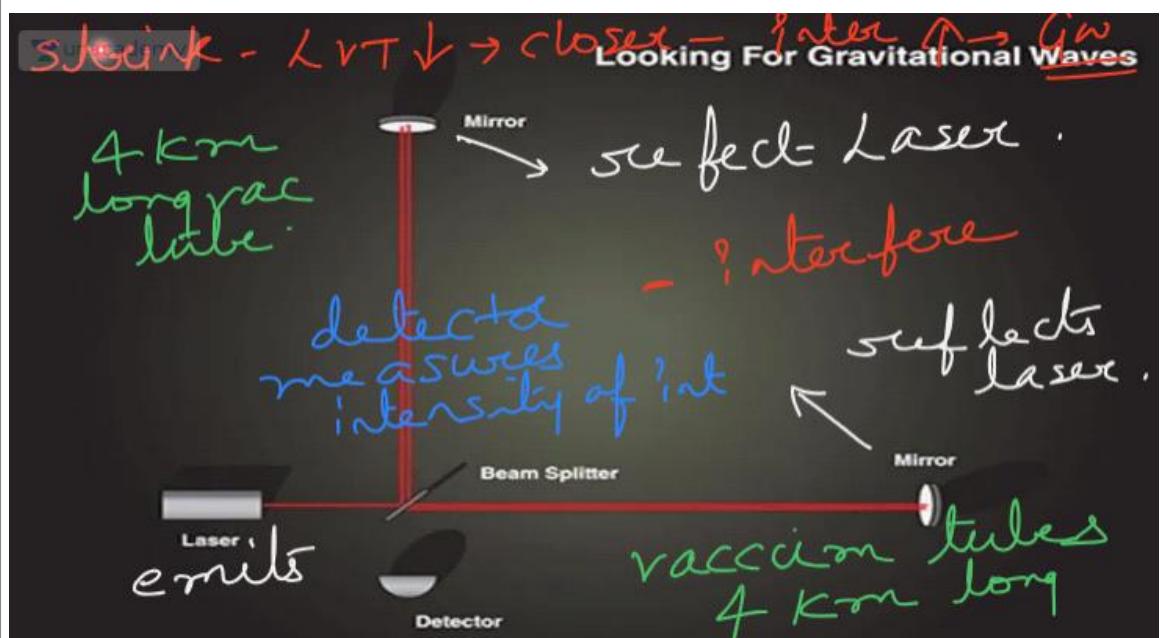
Probe	<ul style="list-style-type: none"> <li>Launched using <b>Delta-IV Heavy rocket</b> in <b>August 2018</b>. Cost: \$ 1.5 bn</li> <li>Over the course of <b>seven years</b>, Parker will make <b>24 loops</b> around the Sun - getting as close as about <b>6 million km</b> away from the Sun of <b>150 million km</b>.</li> <li><b>First-ever</b> mission to "<b>touch</b>" the Sun (as per NASA, the probe in December 2021 <b>flew through the Sun's upper atmosphere – the corona – and sampled particles and magnetic fields</b>).</li> <li>This probe is considered to be the fastest man made object with speeds around 190 km/s.</li> </ul> <p><b>Key objectives:</b></p> <ul style="list-style-type: none"> <li><i>in situ</i> measurements and imaging.</li> <li>Understanding of the corona and expanding our knowledge of the origin and evolution of the solar wind.</li> <li>To forecast changes in Earth's space environment that affect life on Earth.</li> </ul>
European Vigil Mission	<p style="text-align: center;"><b>The European Space Agency's (ESA) Vigil mission (formerly known as Lagrange)</b></p> <ul style="list-style-type: none"> <li>It's the first of its kind mission, with the aim of monitoring the unpredictable and active Sun and help protect the Earth from its outbursts.</li> <li>Solar flares, coronal mass ejections, geomagnetic storms, and other space weather incidences will be monitored by <b>ESA Vigil</b>.</li> <li>Monitoring of the space incidences will help in predicting the timing of its arrival on Earth and any effect it might have on infrastructure.</li> <li>This mission plans to position two spacecraft in the L1 and L5 Lagrangian points.</li> <li>The spacecraft at L1 is to provide observations of the solar wind speed, density, temperature and dynamic pressure, charged particle environment and the direction and strength of the interplanetary magnetic field.</li> <li>The spacecraft at L1 would also monitor the solar corona and measure solar energetic particles that may be associated with solar flares and the onset of coronal mass ejections.</li> <li>The spacecraft at L5 would complement measurements made from L1 by providing a side-view of the propagation of plasma clouds emitted by the Sun toward Earth.</li> <li>The spacecraft at L5 would monitor of the solar disk and corona and carry out measurements of the interplanetary medium.</li> </ul>

# L14 Gravitational Waves, Missions, Privitisation

11 November 2024 06:38 PM

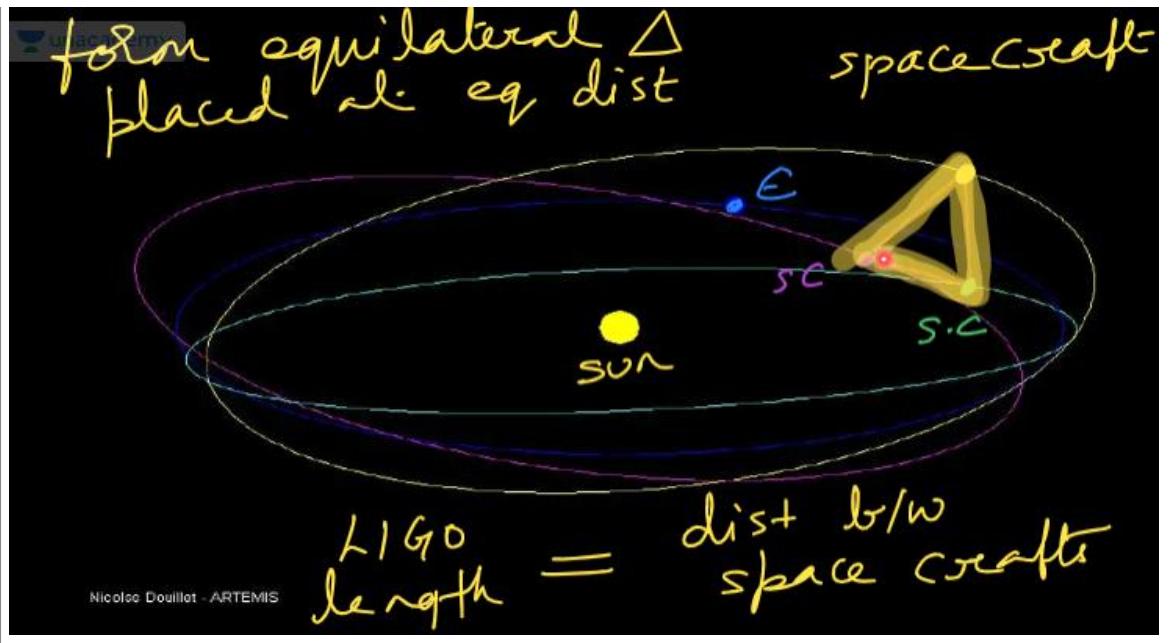
Gravitational Waves	<ul style="list-style-type: none"><li>• Space Time Fabric : filled with matter,</li><li>• With 3 dimension ( length + breadth +depth) + 4th dimension (time)<ul style="list-style-type: none"><li>• Time is one dimension / component / part of space.</li></ul></li><li>• To travel in the time, it is must to travel in the space<ul style="list-style-type: none"><li>• Any material having mass cannot travel at speed of light</li></ul></li><li>• If there is any vehicle which can travel faster than speed of light -&gt; you can go back into past</li><li>• You can go in past or future.</li><li>• what was before big bang<ul style="list-style-type: none"><li>• Time occur when matter occur</li><li>• No matter no time</li><li>• Before big bang does not exist a<ul style="list-style-type: none"><li>◦ No Matter was present , no time , no before present</li></ul></li></ul></li><li>• Gravity force : Space Time warping of space time fabric because of mass</li><li>• Causes : Disturbance in space time fabric, Ex : Stars Explodes, Black hole colide</li><li>• To study the black holes we need to check for gravitational waves</li><li>• Studying gravitation waves can help us understand part of universe that doesn't emit electromagnetic waves or bend EM waves. Like Black hole and any unknown entity.</li></ul>
LIGO	<p><b>LIGO (Laser Interferometer Gravitational-Wave Observatory):</b></p> <ul style="list-style-type: none"><li>• Einstein predicted gravitational waves about 100 years ago.</li><li>• Gravitational waves can be caused when stars explode or when two black holes merge or when two large bodies orbit each other.</li><li>• In 2015, scientists detected gravitational waves for the very first time.</li><li>• They used a very sensitive instrument called <b>LIGO (Laser Interferometer Gravitational-Wave Observatory)</b>.</li><li>• These gravitational waves happened when two black holes crashed into one another.</li><li>• The collision happened 1.3 billion years ago &amp; the ripples reached earth in 2015.</li><li>• When a gravitational wave passes by Earth, it squeezes and stretches space. LIGO can detect this squeezing and stretching.</li><li>• Each LIGO observatory has two “arms” that are each more than 4 kilometers long.</li></ul>

- A passing gravitational wave causes the length of the arms to change slightly. The observatory uses lasers, mirrors, and extremely sensitive instruments to detect these tiny changes.
- Detection of gravitational waves was a very important event in science. Before this our understanding of the universe was only from studying waves of light. Now we have a new way to learn about the universe—by studying waves of gravity.
- Gravitational waves will help us learn many new things about our universe.



- LIGO project operates three gravitational-wave (GW) detectors. Two are at Hanford in the state of **Washington**, USA, and one is at Livingston in **Louisiana**, USA.
- Currently these observatories are being upgraded to their advanced configurations (called Advanced LIGO).
- The proposed **LIGO-India project** aims to move one Advanced LIGO detector from Hanford to India.
- LIGO-India project is envisaged as an international collaboration between the LIGO Laboratory and Indigo (A consortium of Indian gravitational wave physicists).
- *The Union cabinet on 6<sup>th</sup> April 2023 approved the project at an estimated cost of Rs 2600 crores. The facility's construction is expected to be completed by 2030.*
- *LIGO India will work in tandem with the twin LIGO observatories in USA.*
- LIGO lab would provide the complete design and all the key detector components. Indian scientists would provide the infrastructure to install the detector at a suitable site in India and would be responsible for commissioning it.

Other Earth Based Detectors	<ul style="list-style-type: none"> <li><i>VIRGO detector is a 3 km interferometer in Italy.</i></li> <li><i>The KAGRA observatory is an underground 3 km interferometer in Japan.</i></li> <li><i>They are managed by VIRGO collaboration and KAGRA collaboration, respectively.</i></li> <li><i>LIGO-VIRGO-KAGRA (LVK) collaboration: These detectors need to be operating simultaneously around the globe to localize a source of gravitational waves anywhere in the sky.</i></li> </ul>
Space Based detectors	<ul style="list-style-type: none"> <li>LIGO's success has led to ESA's plans of a future mission possibly by 2034. The project is called <i>Evolved Laser Interferometry Space Antenna / New Gravitational Wave Observatory (eLISA/NGO) - or just LISA for short.</i></li> <li>The first step to ESA's space-based observatory has been taken. LISA Pathfinder, which was a test-phase mission, ends on July 18, 2017, having shown its technology works in space.</li> </ul>
LISA	<p><b>Laser Interferometer Space Antenna (LISA)</b></p> <ul style="list-style-type: none"> <li>The <b>Laser Interferometer Space Antenna (LISA)</b> is a proposed space probe to detect and accurately measure gravitational waves from astronomical sources.</li> <li>LISA would be the first dedicated space-based gravitational wave detector.</li> <li>The LISA concept has a constellation of three spacecraft arranged in an equilateral triangle with sides 2.5 million km long, flying along an Earth-like heliocentric orbit.</li> <li>LISA will observe gravitational waves by measuring differential changes in the length of its arms, as sensed by laser interferometry. (work by merging two or more sources of light to create an interference pattern, which can be measured and analysed.) Each of the three LISA spacecraft contains two telescopes, two lasers and two test masses</li> <li>(each a 46 mm, roughly 2 kg, gold-coated cube of gold/platinum), arranged in two optical assemblies pointed at the other two spacecraft</li> <li>Studying gravitational waves gives enormous potential for discovering the parts of the universe that are invisible by other means, such as black holes, the and other yet unknown, objects. LISA will complement our knowledge about the beginning, evolution and structure of our universe.</li> <li>The LISA project started out as a joint effort between NASA and the European Space Agency (ESA). However, in 2011, NASA announced that it would be unable to continue its LISA partnership with the European Space Agency due to funding limitations.</li> </ul> <p><i>form equilateral <math>\triangle</math> placed at eq dist spacecraft</i></p>



SPACE MISSION	
GAGANYAAN	<ul style="list-style-type: none"> <li>• <b>First-ever manned space mission of India</b> – announced on 15<sup>th</sup> Aug, 2018.</li> <li>• Expected launch - in 2023</li> <li>• Budget: <b>10,000 cr.</b></li> <li>• India to become <b>fourth country</b> in the world to send manned missions to space after USA, Russia and China.</li> <li>• Planning to send 3 <b>astronauts</b> (using <b>GSLV Mk-III</b>) into <b>LEO</b> (300-400km). They can see India from space while conducting experiments on <b>microgravity</b>.</li> <li>• Two unmanned test missions (delayed to 2023) will be launched before the final manned mission.</li> <li>• A humanoid robot (<b>Vyom mitra</b>) will be part of unmanned missions.</li> <li>• Recently, ISRO has successfully integrated Vyom mitra with a computer ‘brain’ to enable it to ‘<b>read</b>’ <b>control panels</b> aboard the unmanned test flights and communicate with its voice with the ISRO ground stations.</li> <li>• Human rated LVM III</li> </ul>

# Gaganyaan Mission



- Crew Module return to earth
  - Thermal protection system : protection from earth dense atmosphere friction
  - Parachute : slow down the entry and reduce speed
  - Land into water body -> recover from water body
  - Pad abort : in case of explosion -> pod pushed away
- ISRO has begun work on the manned mission in 2004.
- Many of the critical technologies required for human spaceflight have already been validated through various tests
  - ✓ Space Capsule Recovery Experiment (from water bodies)
  - ✓ Crew Module Atmospheric Re-Entry Experiment (CARE) in Dec-2014.
  - ✓ Pad Abort Test (An ISRO launch escape system test of its crew module).
- **Four Indian Air Force fighter pilots completed training in Moscow**  
Gagarin Research & Test Cosmonaut Training Center (GCTC) (Glavkosmos)
- **Spacesuits are being made by Defence Bioengineering and Electromedical Laboratory (DEBEL)**, an Indian defence laboratory under the DRDO.

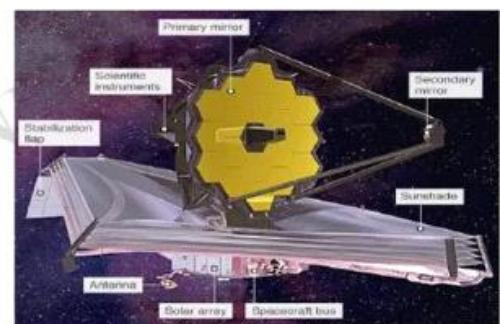
## SPACE STATION FOR INDIA

- ISRO is planning to setup its own space station in about a decade.
- It would be similar to the **International Space Station (ISS)** but smaller in size weighing about **20 tonnes**.
- It would be placed **in a low earth orbit** ( $\sim 400$  km).
- The preliminary plan for the space station is to accommodate astronauts for up to **15-20 days** in space to conduct microgravity experiments.
- It may take about **5 to 7 seven years** to construct, **details** will only **emerge after the Gaganyaan Mission** is complete.
- China is also planning a large space station in the Lower Earth Orbit.

James Webb Space Telescope

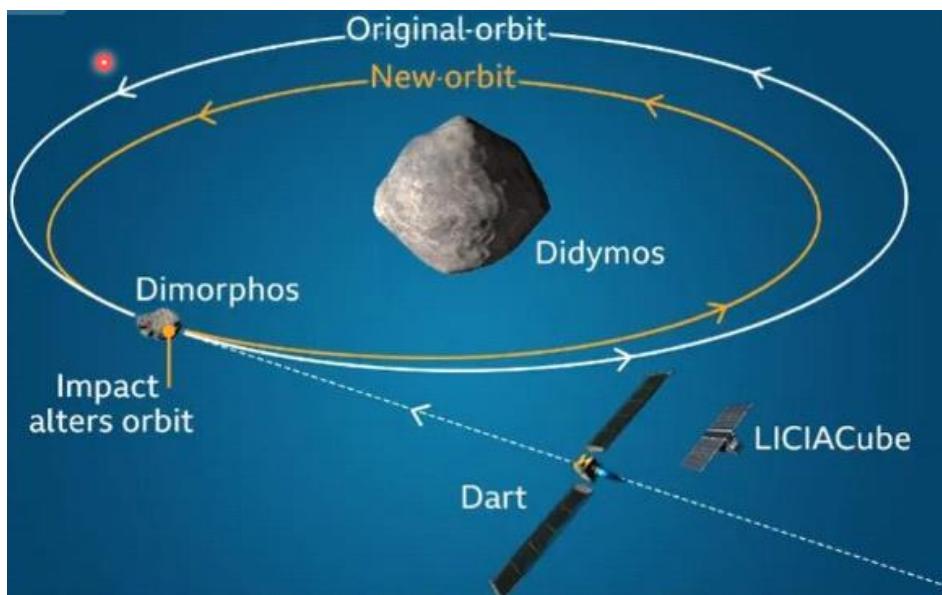
### JAMES WEBB SPACE TELESCOPE

- Next Generation Telescope - successor to the **Hubble Space Telescope**.
- Developed by **NASA**—in collaboration with **the Canadian Space Agency and the European Space Agency** (Cost: \$9.7 billion).
- It will be the **largest and most powerful telescope** ever built for use in space.
- Launched on **25th December 2021** by the **Ariane 5 rocket** from European Space Agency's Spaceport in French Guiana.
- Maximum Life span estimated to be **10 years**.
- After a 29 day-long journey, the spacecraft will arrive at **Lagrangian point 2** (nearly **1.5 million km** from Earth).
- The gravitational forces of the Sun and the Earth can nearly hold a spacecraft at this point, so that it takes relatively little rocket thrust to keep the spacecraft in orbit around L2.
- It will have a much **larger primary mirror** than Hubble (2.7 times larger in diameter & 6 times larger in area), giving it **more light-gathering power**.
- It has **infrared instruments** with longer wavelength coverage and **greatly improved sensitivity** than Hubble.
- Biggest feature is a **tennis court sized** five-layer **sunshield** that attenuates heat from the sun more than a million times.
- The telescope recently captured a clear image of the planet Uranus and its rings. (April 2023)



## NASA's DART (Double Asteroid Redirection) Test

- On September 27, 2022, NASA conducted DART (Double Asteroid Redirection Test).
- It is a mission to demonstrate **Kinetic impact/Kinetic kick** method to **deflect an asteroid** by changing its motion.
- For this test, NASA targeted Asteroid pair **Didymos** and its moonlet **Dimorphos**.
- **LICIACube (Light Italian CubeSat for Imaging Asteroids)** was launched from earth along side the DART impactor to take pictures of the Asteroid before & after the collision.
- DART collided with the Dimorphos (just 160 meters wide) at a speed of **23,760 kilometers per hour**, and **changed its angular momentum** and moved it in to a closer orbit to Didymos – causing deflection.
- This method is expected to **save the world** in future by safely **deflecting a killer asteroid** on its course towards earth.



- PSLV DL : Vehicle Model
- PSLV C44 : One of the version of Vehicle

## PSLV-C44 mission

- **PSLV C-44** served as a test for a new variant of the launch vehicle, the **PSLV-DL**, which has **two strap-on motors**.
- It will make use of the final stage of rocket as an experimental orbital platform for **Kalamsat**, world's smallest student satellite, built by Chennai based school students. It will continue orbiting the earth at a distance of 450km above it for six months, maybe more.
- PSLV C44 also carried an imaging and surveillance satellite called **Microsat for the Defence Research and Development Organisation (DRDO)**.
- **Microsat** was targeted in **Anti-satellite test (ASAT), Mission Shakti**.

- Star Exploded -> emits x-rays -> other object will push/pull/reflect/refract x-rays
  - Polarity (Direction) will change -> Detector will detect the changes

- Understand the source of x-rays and object in the path

## **X-RAY POLARIMETER SATELLITE (XPOSAT)**

Indian Space Research Organisation (ISRO) launched its pioneering polarimetry mission, **XPoSat on January 1.**

The primary objective of the XPoSat mission is to study the “polarisation” of astronomical X-rays to understand about the astronomical X-ray sources such as **black holes and neutron stars—the collapsed cores of massive stars etc.**

**XPoSat carries two payloads in its low Earth orbit:**

**1. POLIX (Polarimeter Instrument in X-rays):** Designed to make observations in the energy band of 8-30 keV, POLIX is expected to observe around 40 bright astronomical sources of various categories during its planned five-year mission lifespan.

**1. XSPECT (X-ray Spectroscopy and Timing):** Utilizing spectroscopy, XSPECT studies the electromagnetic spectrum generated by different matter, further enhancing the mission’s observational capabilities.

The XPoSat mission complements NASA’s polarimetry satellite, **Imaging X-ray Polarimetry Explorer (IXPE), launched in 2021.** While IXPE focuses on measurements in the energy range of **2-8 keV**, **XPoSat extends this spectrum to 2-30 keV.** The collaboration between these two satellites enables coordinated observations, offering a comprehensive view across a wide energy spectrum.

Note: (**Polarisation:** An electromagnetic wave such as light consists of a coupled oscillating electric field and magnetic field which are always perpendicular to each other; by convention, the "polarization" of electromagnetic waves refers to the direction of the electric field).

NISAR	<ul style="list-style-type: none"> <li>• NASA-ISRO Synthetic Aperture Radar.</li> <li>• It will be the <b>first satellite mission to use two different radar frequencies</b> (L-band and S-band) to measure changes in our planet’s surface.</li> <li>• <b>NASA will provide the mission’s L-band Synthetic Aperture Radar and ISRO will provide S-band Synthetic Aperture Radar.</b></li> <li>• This allows the mission to observe a <b>wide range of changes</b>, from the flow rates of glaciers and ice sheets to the dynamics of earthquakes and volcanoes, biomass, natural hazards, sea level rise, and groundwater etc.</li> <li>• Likely to be launched by GSLV in <b>2024 from India</b> after final assembly at <b>UR RAO Space centre into a sun synchronous orbit from Satish Dhawan Space Centre .</b></li> </ul>
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Space Debris	<ul style="list-style-type: none"> <li>• Kessler's syndrome effect : More debris will be created if debris divide into multiple pieces</li> <li>• Problem is not size, Problem is speed</li> <li>• Will create problem in the future : space exploration will be difficult</li> </ul>
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	<ul style="list-style-type: none"> <li>Space debris is the <b>collection of defunct man-made objects</b> in space — old satellites, spent rocket stages and fragments from disintegration and collisions.</li> <li>It is estimated that there are about <b>half a million pieces</b> of man-made substances orbiting the Earth.</li> <li>These space debris can really be dangerous as they travel at high speeds, which turns even tiny pieces of junk into deadly shrapnel that can damage satellites, space shuttles and even space stations.</li> <li><b>Kessler effect/syndrome:</b> Proposed by NASA scientist <b>Donald J. Kessler</b> in 1978 - proposed that a chain reaction of exploding space debris can end up making space activities and the use of satellites impossible for generations.</li> </ul>
ISRO Steps	<ul style="list-style-type: none"> <li>ISRO is a member of “<b>Inter-Agency Space Debris Coordination Committee</b>” (IADC), which makes global efforts to reduce man-made and natural space debris. They <b>exchange information on space debris among member space agencies</b> and alert a respective space agency when any satellite of that space agency is in danger due to space debris.”</li> <li>ISRO also banks on its sophisticated “<b>Multi-Object Tracking Radar (MOTR)</b>”, operational since 2015, to track space debris.</li> <li>In 2019, ISRO initiated ‘<b>Project NETRA</b>’ (NEtwork for space object TRacking and Analysis) – an early warning system in space to detect debris and other hazards to Indian satellites.</li> <li>On 14<sup>th</sup> December 2020, ISRO inaugurated a dedicated <b>space situational awareness (SSA) Centre at ISRO Telemetry, Tracking and Command Network (ISTRAC)</b> in Bangalore under project NETRA.</li> <li>The project NETRA with an estimated to cost of ₹400 crore, will give India its own capability in <b>space situational awareness (SSA)</b> like the other space powers — which is used to ‘predict’ threats from debris to Indian satellites.</li> <li>Under “NETRA”, ISRO is planning to <b>set up several observational facilities: connected radars, telescopes, data processing units and a control Centre.</b></li> </ul>

Initial focus seems to be on debris in the **Low Earth Orbit**, eventually ISRO wants to track **the debris in GEO** where the communication satellites operate.

**Need:**

- Currently there are 15 functional Indian communication satellites in the GEO, 13 remote sensing satellites in LEO & 8 navigation satellites in MEO. Protecting them is important for India.
- This would make India a part of international efforts towards tracking, warning about and mitigating space debris.

Efforts to cleanup

**SPACE DEBRIS –  
INTERNATIONAL EFFORTS TO CLEANUP**

1. “**RemoveDEBRIS**” has been deployed from the International Space Station (ISS) that can **capture and deorbit the debris**.
2. **European Space Agency** with Swiss startup company “**Clear Space**” is building a spacecraft equipped with **four robotic arms** to capture debris and drag it into Earth’s atmosphere. This mission, known as **ClearSpace-1**, is expected to **launch by 2025**.
3. NASA's Space Debris Sensor orbits the Earth on the International Space Station.
4. The United Nations has established the Committee on the Peaceful Uses of Outer Space (COPUOS).

Privatisation  
Space Activities

- Department of Space announced **Cabinet approval** on reforms to boost private participation in space activities on **24 June, 2020**.
- GOI announced the establishment of a new autonomous body - **Indian National Space Promotion and Authorization Centre (IN-SPACe)** that will take "decisions to regulate and permit activities in the space sector - a **facilitator**, and also a **regulator**.
  - ❖ ISRO will be the main body for all the missions.
  - ❖ IN-SPACE acts as a channel between private and government space sectors.
  - ❖ NSIL works as marketing arm for ISRO
- Private companies can now **produce their own satellites and rockets** and use ISRO's launch facility to launch them **for a fee**.
- A large part of manufacturing and fabrication of rockets and satellites has also begun in the private sector through **NSIL**.
  - ISRO R&D New Design -> In-Space -> Authorise a private company to manufacture
  - NSIL will get the manufacturing by company authorised by In-Space

NSIL & ANTRIX

- NSIL and ANTRIX have same role
  - ANTRIX had some bad name , ISRO created new corporation to do business

## **NSIL & ANTRIX corporation**

- An agreement between **Antrix corporation** and Bengaluru based startup **Devas multimedia** was signed in 2005 under which Antrix agreed to build, launch and operate two satellites and lease our 90% of satellite transponder capacity to Devas which had planned to use it to offer hybrid satellite and terrestrial communication services throughout India.
- The deal included **70MHz of S-band spectrum** (Restricted for the use by **security forces and government telecom entities like MTNL and BSNL**) which was priced at 1000 crore. A media expose claimed that incurred heavy loss to the national exchequer (Treasurer or the treasury itself).
- The controversial deal was cancelled later.
- The long legal battle between Antrix and Devas ended up in the supreme court in 1<sup>st</sup> Jan 2022 which ordered the winding up of the startup.
- **NSIL** is considered to be a move to protect the space industry in India from the consequences of the **Devas-Antrix mess**.

NSIL

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## **New Space India Limited**

- It is a new commercial arm of ISRO, incorporated on **6 March 2019** (under the Companies Act, 2013) is a wholly owned Government of India company, under the administrative control of Department of Space (DOS).
- NSIL will have role in the following:
  - Production of **Polar Satellite Launch Vehicle (PSLV)** and Small Satellite Launch Vehicle (SSLV) through industry;
  - Building of Satellites (both Communication and Earth Observation) as per user requirements.
  - Transfer of technology developed by ISRO centres/ units and constituent institutions of Dept. of Space;
  - Marketing spin off technologies and products/ services emanating out of ISRO activities

ISRO is also willing to provide place for private players to build their **own launchpad** within the Sriharikota launch station.

Space X

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## **SPACE X**

- **Space Exploration Technologies Corporation (Space X)** is an **American aerospace manufacturer** and **space transportation** services company.
  - It was founded in 2002 by **Elon Musk**.
- Crew Dragon spacecraft**
- Space X has contract with NASA for **Cargo and crew transportation** to and from the **International Space Station**.
  - On 30<sup>th</sup> May 2020, **Crew dragon Demo-2 mission** took Two NASA astronauts to ISS. It was the first crewed test flight of the crew dragon space craft and the falcon 9 rocket.
  - **SpaceX Crew -1 mission:** On 16<sup>th</sup> November 2020, **SpaceX** launched **four astronauts** (3 Americans + 1 Japanese) to the International Space Station in the first operational crewed flight of a “**Crew dragon, resilience**”, **spacecraft on a Falcon 9 rocket**. It was the first full-fledged taxi flight for NASA by a private company.

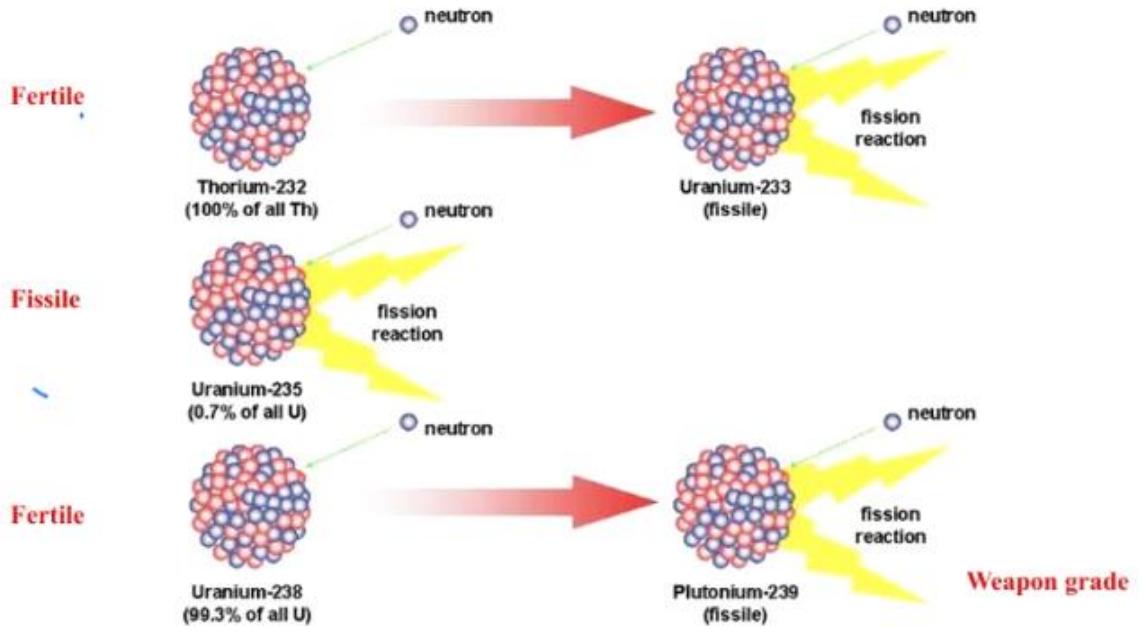
- SpaceX broke the **world record** of the greatest **number of satellites** carried by a single rocket as by sending **143 payloads** into space on **24<sup>th</sup> Jan 2021**.
- With this it broke the record of **ISRO's 104 satellites** being launched in one go in February 2017.
- The reusable **Falcon 9** rocket carried **133 commercial** and government spacecraft and **10 Starlink satellites** to space - part of the company's **Small Satellite Rideshare Programme**.
- (**Note:** Starlink is a satellite internet constellation being constructed by SpaceX providing satellite internet access)

Space Race	 <p><b>Space Race</b></p>  <table border="0"> <tr> <td style="text-align: center;">             Jeff Bezos  <b>(Blue Origin)</b> </td><td style="text-align: center;">             Richard Branson  <b>(Virgin Galactic)</b> </td></tr> <tr> <td style="text-align: center;">VS</td><td></td></tr> <tr> <td style="text-align: center;">2000</td><td style="text-align: center;"><b>Founded</b></td><td style="text-align: center;">2004</td></tr> <tr> <td style="text-align: center;">July 20, 2021*</td><td style="text-align: center;"><b>Launch Date</b></td><td style="text-align: center;">July 11, 2021</td></tr> <tr> <td style="text-align: center;">Above 100km*</td><td style="text-align: center;"><b>Flight Altitude</b></td><td style="text-align: center;">Above 80km</td></tr> <tr> <td style="text-align: center;">10 minutes*</td><td style="text-align: center;"><b>Duration</b></td><td style="text-align: center;">10 minutes</td></tr> <tr> <td style="text-align: center;">4 minutes</td><td style="text-align: center;"><b>Weight-Lessness</b></td><td style="text-align: center;">3-4 minutes</td></tr> </table> <p><b>SpaceX (Elon Musk) Inspiration-4</b></p> <p>On 16th September 2021 flew the automated <b>Crew Dragon</b> with <b>four civilian astronauts</b> to an altitude of 575 km.</p> <p>They spent three days circling the earth.</p>	 Jeff Bezos <b>(Blue Origin)</b>	 Richard Branson <b>(Virgin Galactic)</b>	VS		2000	<b>Founded</b>	2004	July 20, 2021*	<b>Launch Date</b>	July 11, 2021	Above 100km*	<b>Flight Altitude</b>	Above 80km	10 minutes*	<b>Duration</b>	10 minutes	4 minutes	<b>Weight-Lessness</b>	3-4 minutes
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# L15 Nuclear Fission

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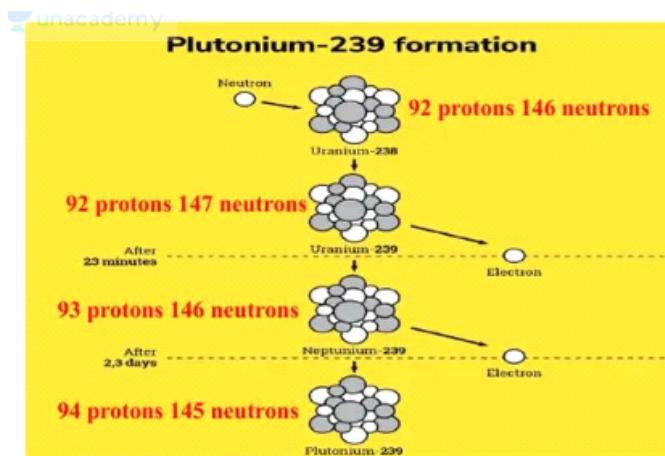
Nucellar Fission	<p>academy</p> <h2>Nuclear Fission</h2> <p>It is the process by which a <b>heavy atomic nucleus</b> splits into <b>two or more lighter nuclei</b>. It releases large amounts of energy.</p> <p>Example:</p> $^{235}_{92}\text{U} + {}^1_0\text{n} \longrightarrow {}^{141}_{56}\text{Ba} + {}^{92}_{36}\text{Kr} + 3 {}^1_0\text{n}$ <ul style="list-style-type: none"><li>The neutron induced fission of <math>^{235}\text{U}</math> isotope releases an average of <b>200 Mega electron volts (MeV) energy per atom</b>.</li><li>This process is behind <b>atom bomb</b> and is being employed in <b>nuclear reactors</b> to generate power.</li></ul>
Type of Radioactivity	<ul style="list-style-type: none"><li><b>Fissile materials</b> can fission by absorbing a neutron with very low kinetic energy. Simply adding the neutron adds enough energy for it to fission. This is due to the odd number of neutrons in the nucleus which will ‘rearrange’ themselves to release the energy. U-235, Pu-239, Pu-241 are all fissile. They have even number of protons and odd number of neutrons. Atoms favour even number of neutrons and protons. Therefore, isotopes with odd number of neutrons gain 1 to 2 MeV of energy by absorbing a neutron.</li><li><b>Fertile materials</b> are materials that can be transformed (technically this is called transmuted) into fissile materials by the bombardment of fast neutrons <math>&gt; 1\text{MeV}</math>, inside a reactor. E.g., U-238, Pu-240, Th- 232. This is because of even number of neutrons in the nucleus.</li><li><b>Isotopes:</b> Two or more <u>types of atoms</u> that have same atomic number (No. of protons) and position in the periodic table but different mass number (No. of nucleons) due to different no. of neutrons</li></ul>



- Fissile + slow n → fission
- Fertile material + slow n → nothing
- Fertile material + fast n → undergo transmutation (Conversion into fissile material)
  - Fissile material + slow n → fission

#### Fertile Enrichment

- Beta decay : neutron → proton + electron
  - Increase the number of proton , change the atomic number
  - Hence new atom is created
- Enrichment : Increasing the fissile material percentage
  - Centrifuge the material -> both get separated -> create the new mixture



beta decay of a neutron transforms it into a proton by the emission of an electron accompanied by an antineutrino.

- **Uranium enrichment:** Most of the natural uranium is fertile material . Concentrating the fissile material (Uranium-235) from the natural / mined uranium is known as Uranium enrichment.
- One method of achieving it is by centrifugation.
- Enriching to 20% purity for using as fuel in nuclear reactors, but 90% enrichment is required for generating weapon grade uranium.
- Thus, enriched uranium and plutonium are weapon grade.

Natural Uranium :	U238 (99.3%) + U235 (0.7%)
Enriched Uranium :	U235 (>0.7%)
Reactor Grade Uranium :	U235 (4-20%)
Weapon Grade :	U235 (>90%)

- Iran's sophisticated Uranium enrichment capabilities became the subject of intense international negotiations and sanctions between 2002 & 2015.
- Negotiations between the P5+1 & Iran yielded Joint comprehensive plan of action (JCPOA) in July 2015, a comprehensive 25year nuclear agreement limiting Iran's nuclear capacity in exchange for sanctions relief.

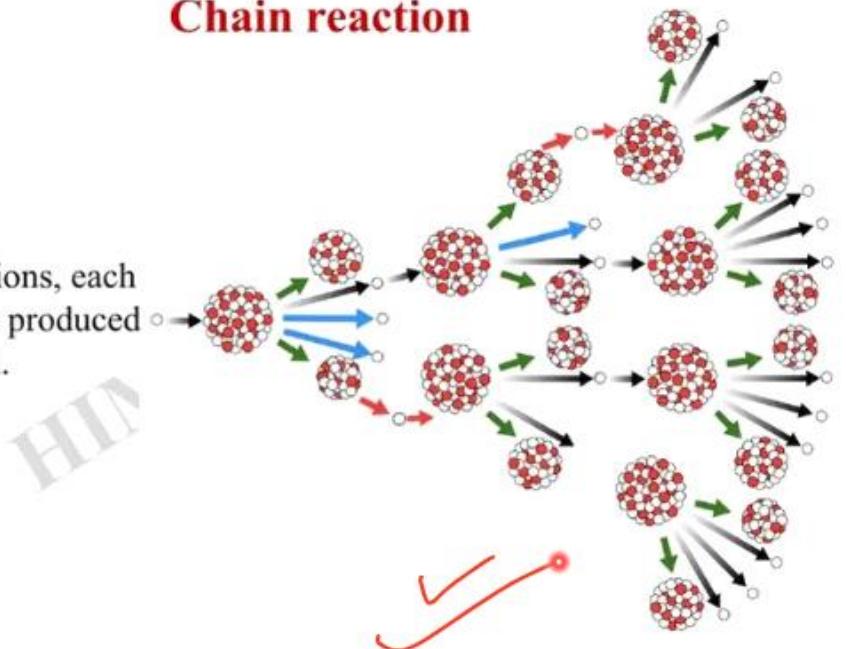
**(Note:** The **P5+1** refers to the UN Security Council's five permanent members, the P5; namely **China, France, Russia, the United Kingdom, and the United States; plus, Germany**. The P5+1 is often referred to as the **E3+3** by European countries. It is a group of six world powers which, in 2006, joined together in diplomatic efforts with Iran regarding its nuclear program).

- On 16<sup>th</sup> Jan 2016, all nuclear related sanctions on Iran were lifted.
- But Mr. Trump withdrew the U.S from the deal in an effort to force Iran to negotiate a new accord. U.S decision was criticized by all other parties to JCPOA and in 2018 the International Atomic Energy Agency, IAEA's report concluded that Iran's stockpiles of Uranium and heavy water and implementation of protocols were in compliance with the agreement.
- In July 2019 Iran breached the 3.67% cap on Uranium enrichment & on 4<sup>th</sup> January 2021, announced that it resumed enriching Uranium to 20% purity at Fordo facility.

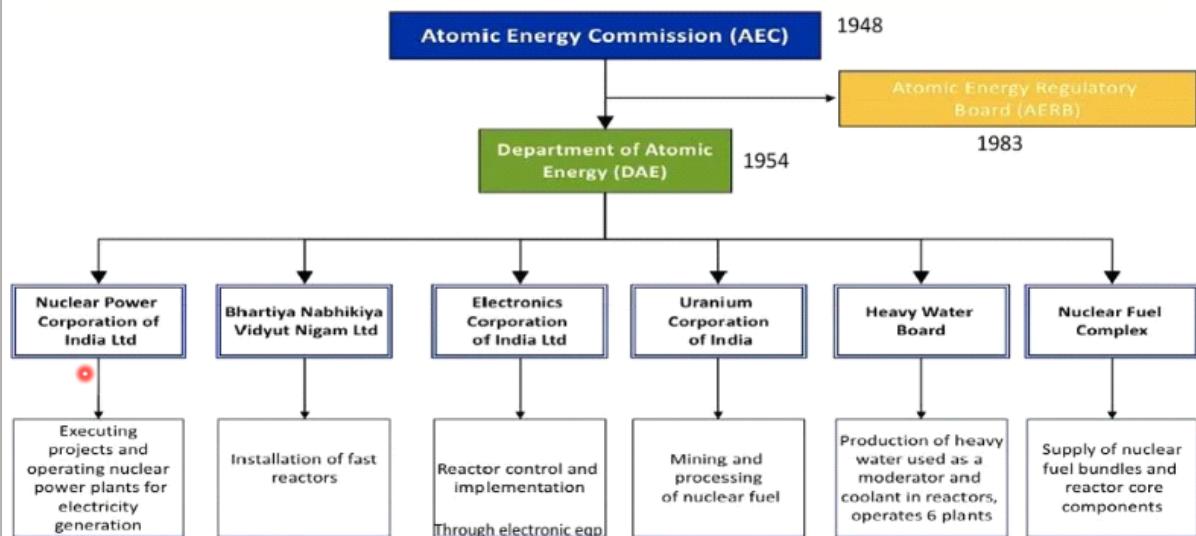
#### Chain Reaction

### Chain reaction

Series of nuclear fissions, each initiated by a neutron produced in a preceding fission.



## The Atomic Energy Commission (AEC) is solely responsible for managing nuclear power in India



### Nuclear Reactor

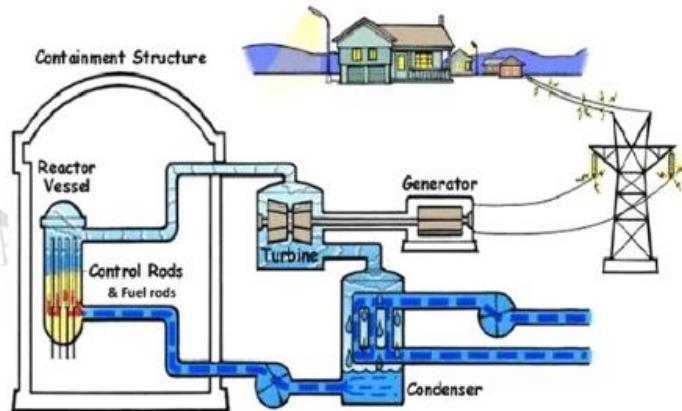
**Fuel:** Fissile material like U-235, Plutonium-239.

**Moderator:** To slow-down neutrons. E.g., Water or Heavy water.

**Coolant:** To absorb heat from the reaction. E.g., Water

**Controller:** To stop the reaction by absorbing neutrons / Control the rate of fission. E.g., Cadmium or Boron.

**Containment:** Safety barrier (made of concrete/steel) to prevent heat & radioactivity exposure.

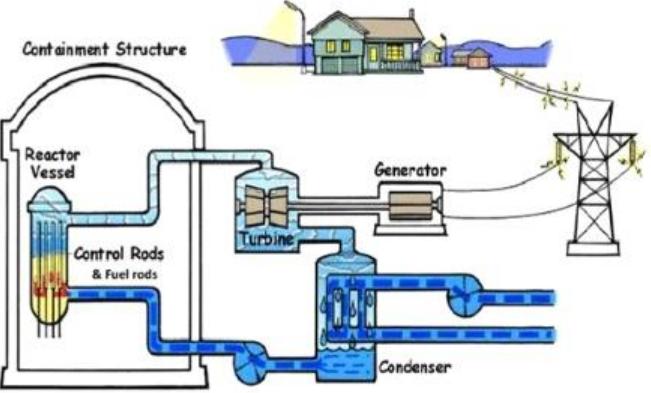
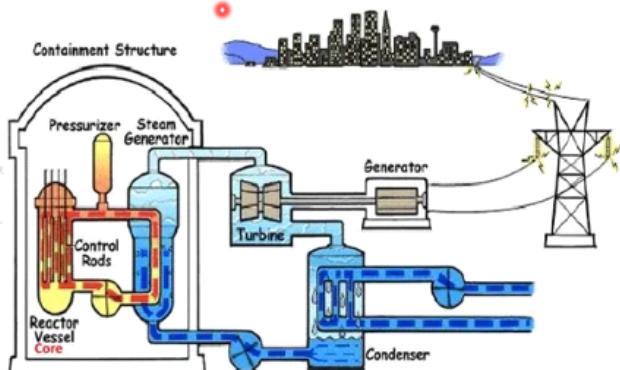
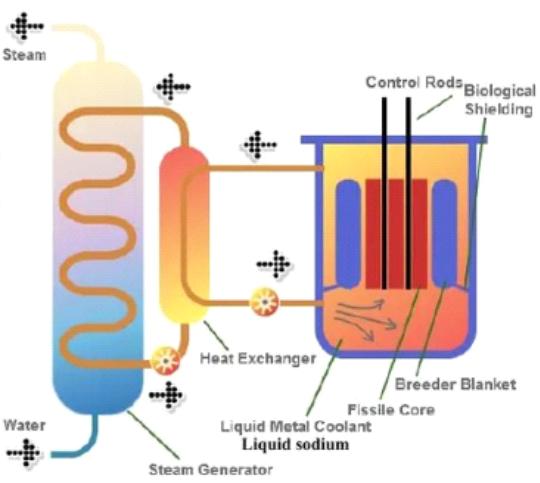


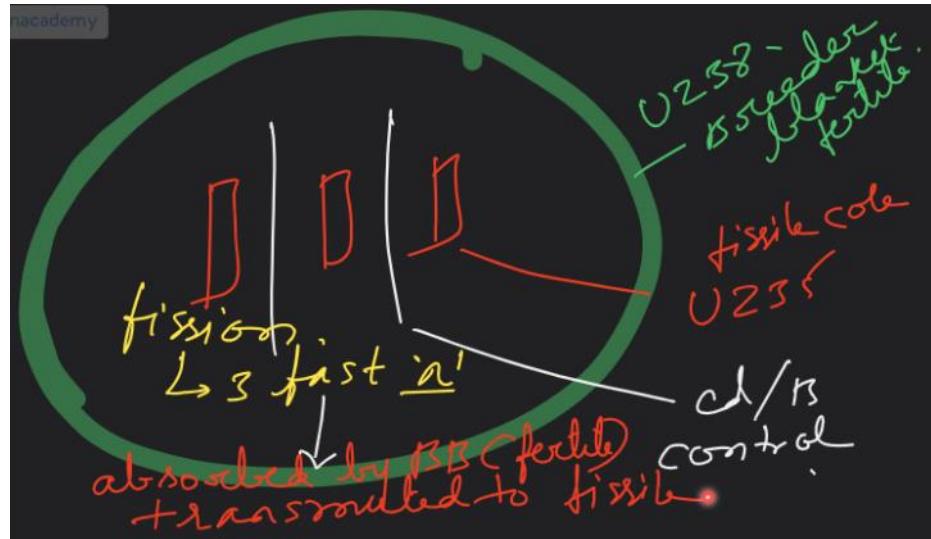
### Types of Reactor

Reactor	Fuel	Coolant	Moderator
<b>Boiling Water Reactor</b>	Enriched Uranium	Water	Water
<b>Pressurized Water Reactor</b>	Enriched Uranium	Water	Water
<b>Pressurized Heavy Water Reactor</b>	Natural Uranium	Heavy Water	Heavy Water
<b>Fast Breeder Reactor</b>	Plutonium, Uranium & Thorium <i>(U-238 TR-232)</i>	Liquid Sodium	None

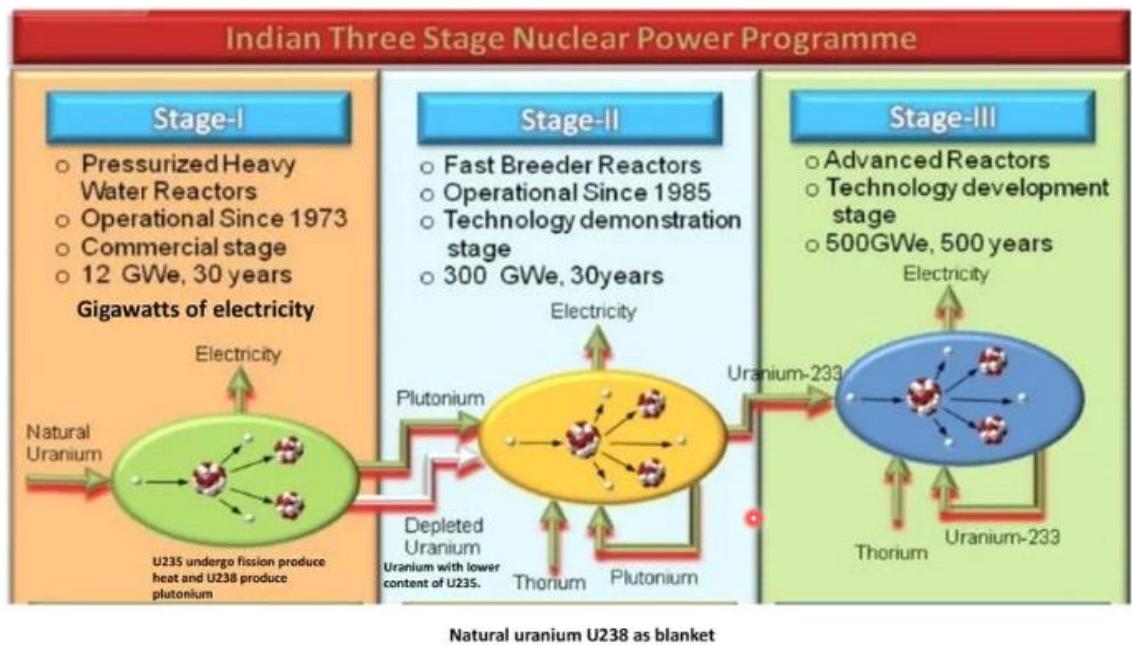
### Boiling water

- Simple water or heavy water steam is used to tur turbine

Reactor	<p><b>Fuel:</b> Fissile material like U-235, Plutonium-239.</p> <p><b>Moderator:</b> To slow-down neutrons. E.g., Water or Heavy water.</p> <p><b>Coolant:</b> To absorb heat from the reaction. E.g., Water</p> <p><b>Controller:</b> To stop the reaction by absorbing neutrons / Control the rate of fission. E.g., Cadmium or Boron.</p> <p><b>Containment:</b> Safety barrier (made of concrete/steel) to prevent heat &amp; radioactivity exposure.</p> 
Pressurised water reactor	<ul style="list-style-type: none"> <li>Pressure -&gt; water start boiling at higher temperature             <ul style="list-style-type: none"> <li>More heat energy -&gt; More kinetic energy -&gt; More Electric energy</li> </ul> </li> </ul> <p><b>Pressurized Water Reactor</b></p> <ul style="list-style-type: none"> <li>The water in the reactor is pressurized.</li> <li>As the pressure gets higher, the boiling point of water increases.</li> <li>At high pressures, the water can operate at extremely high temperatures without boiling to steam.</li> <li>Higher pressures allow for greater power output.</li> <li>If heavy water is used as both moderator &amp; coolant, it is called “<b>Pressurized Heavy Water Reactor</b>”.</li> </ul> 
Fast Breeder reactor	<ul style="list-style-type: none"> <li>Breeding (Producing) -&gt; Fissile material (By Transmutation)</li> <li>Liquid Sodium is used as Coolant (Bad Moderator) -&gt; Does not slow down neutron as water does             <ul style="list-style-type: none"> <li>Even low quality uranium can be used</li> </ul> </li> <li>Reactors those <b>produce more fissile fuel</b> than they consume, while generating energy using <b>fast neutrons</b>.</li> <li><b>Weak moderator</b> such as <b>liquid sodium</b> is used as coolant, hence no slowing down of neutrons.</li> <li>Fast neutrons are readily <b>captured</b> by fertile material in blanket, producing more fissile material.</li> </ul> <p><b>Breeder Blanket</b> : Fertile material that can breed or produce fissile material</p> 



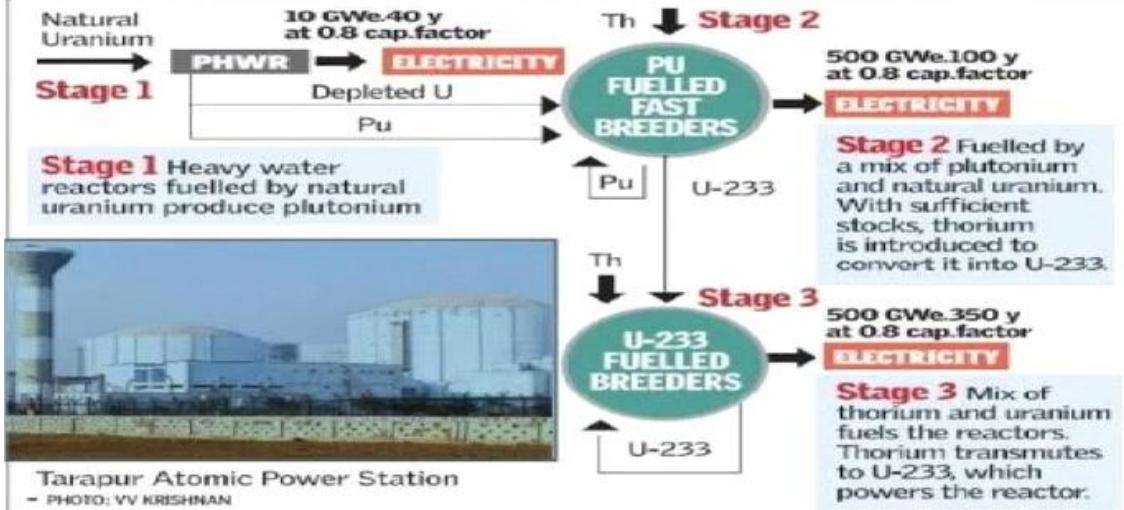
### Indian Nuclear Programme



Stage I	<ul style="list-style-type: none"> <li>Development</li> <li>U235 → Fission</li> <li>U238 → P239</li> </ul>
Stage II	<ul style="list-style-type: none"> <li>Technology Demonstration stage</li> <li>Uses P239 and Depleted U235</li> <li>Adding Thorium from outside</li> <li>Recently core loading happened</li> </ul>
Stage III	<ul style="list-style-type: none"> <li>Th 232 + n → U233 from stage II</li> <li>Adding thorium from outside → Again convert into U233</li> </ul>

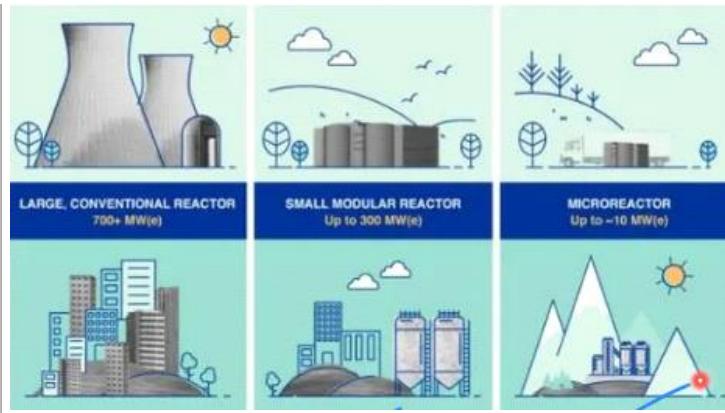
## INDIA'S THREE-STAGE NUCLEAR PROGRAMME

Homi Bhabha envisioned India's nuclear power programme in three stages to suit the country's low uranium resource profile



- Purpose : Thorium is available in India, Final target to depend on Thorium 232
  - Depend on fissile material U233
  - Not to depend on other country for nuclear fuel

<b>Small Modular reactors SMRs</b>	<p>Small modular reactors (SMRs) are advanced nuclear reactors that have a power capacity of up to 300 MW(e) per unit, which is about one-third of the generating capacity of traditional nuclear power reactors. SMRs, which can produce a large amount of low-carbon electricity, are:</p> <ul style="list-style-type: none"> <li>Small – physically a fraction of the size of a conventional nuclear power reactor.</li> <li>Modular – making it possible for systems and components to be factory-assembled and transported as a unit to a location for installation.</li> <li>Reactors – harnessing nuclear fission to generate heat to produce energy.</li> </ul> <p><b>Advantages of SMRs</b></p> <ul style="list-style-type: none"> <li>Many of the benefits of SMRs are inherently linked to the nature of their design – small and modular. Prefabricated units of SMRs can be manufactured and then shipped and installed on site, making them more affordable.</li> <li>They can be deployed incrementally to match increasing energy demand.</li> <li>Microreactors, which are a subset of SMRs designed to generate electrical power typically up to 10 MW(e) will be better suited for regions inaccessible to clean, reliable and affordable energy.</li> <li>Microreactors could serve as a <u>backup power supply</u> in emergency situations or replace power generators that are often fuelled by diesel, for example, in rural communities or remote businesses.</li> <li>The passive systems / auto turnoff options eliminate or significantly lower the potential for unsafe releases of radioactivity to the environment and the public in case of an accidents.</li> <li>Power plants based on SMRs may require less frequent refuelling, every 3 to 7 years, in comparison to between 1 and 2 years for conventional plants. Some SMRs are designed to operate for up to 30 years without refuelling.</li> <li>For India, which aims to achieve net-zero emissions by 2070, SMRs can play a pivotal role.</li> <li>The transition to clean energy requires Critical Minerals for technologies like lithium-ion batteries, leading to concerns about geopolitical risks and environmental impacts. SMRs offer an alternative, as they require low-enriched uranium, which is more widely distributed than critical minerals.</li> </ul>
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Indian Development	<ul style="list-style-type: none"> <li>Nuclear energy is the <b>fifth-largest source of electricity for India</b> which contributes about 3% of the total electricity generation in the country.</li> <li>India has over <b>23 operating nuclear reactors in 7 power plants</b> across the country which produces <b>7480 MW of nuclear power including the recent Kakrapar Atomic Power Project (KAPP-3)</b>, India's first 700 MWe unit, and the biggest indigenously developed variant of the PHWR, that has also been connected to the grid in January- 2021.</li> <li><b>19 reactors are Pressurised Heavy Water Reactors (PHWRs) and 4 are Light Water Reactors (LWRs).</b></li> </ul> <p><b>Recent Developments:</b></p> <p>Government allowed Joint Ventures with PSUs to <b>enhance India's nuclear program</b>. As a result, the <b>Nuclear Power Corporation of India Limited (NPCIL)</b> is now in two joint ventures with the <b>National Thermal Power Corporation Limited (NTPC)</b> and the <b>Indian Oil Corporation Limited (IOCL)</b>.</p> <p><b>Expansion of Nuclear Installations:</b></p> <ul style="list-style-type: none"> <li>In the past, <b>India's nuclear installations were mostly located in South India</b> or in Maharashtra and Gujarat in the west.</li> <li>However, the government is now <b>promoting its expansion to other parts of the country</b>. As an example, the upcoming <b>nuclear power plant in Gorakhpur town of Haryana</b>, which will become operational in the near future.</li> </ul> <p><b>India's Indigenous Move:</b></p> <ul style="list-style-type: none"> <li>The world's first thorium-based nuclear plant, "<b>Bhavni</b>," using <b>Uranium-233</b>, is being set up at <b>Kalpakkam in Tamil Nadu</b>. This plant will be <b>entirely indigenous and will be the first of its kind</b>.</li> <li>The experimental thorium plant "<b>Kamini</b>" already exists in Kalpakkam.</li> </ul>
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## **India's plans to expand nuclear energy share**

- As per ministry of power, nuclear energy will soon emerge as one of the most important sources of alternative or clean energy for the increasing power demand of India.
- India is counting on its nuclear program to help meet its commitments under **Paris agreement** (adopted by 196 parties at COP 21 in Paris) to reduce 35% emissions intensity by 2030.
- The nuclear power plants have so far generated about 755 billion units of electricity, saving about 650 million Tons of CO<sub>2</sub> emission in the country.
- Several measures to enhance the generation from nuclear power plants in the country were taken - including administrative approval and financial sanction for 10 indigenous 700 MW pressurized heavy water reactors.
- “in-principle” approval was given for setting up of six advanced pressurized water nuclear power reactors at Jaitapur in Maharashtra, with 1,650 MW each, with cooperation from France will make it the largest power generating site with a total capacity of 9,900 MW.
- The government has also amended the Atomic Energy Act to enable joint ventures of public sector companies to set up nuclear power projects.
- From the present nuclear power capacity of 6,780 MW, it is expected to be increased to 22,480 MW by 2031 on completion of projects.
- Given the issues associated with nuclear power, it is debatable if nuclear power is still a viable choice for India.
- Cost for establishing nuclear reactors has increased by at least by 4-fold in last decade.
- Delays in completion of proposed projects and per unit cost of nuclear power compared to decreasing costs of renewable energy.
- Vulnerability to disasters & wars (in the context of threat felt to reactors in Ukraine – explosions near **Zaporizhzhia and Chernobyl** powerline cuts).

# L16 Nuclear Fusion and Indian Nuclear Policy

12 November 2024

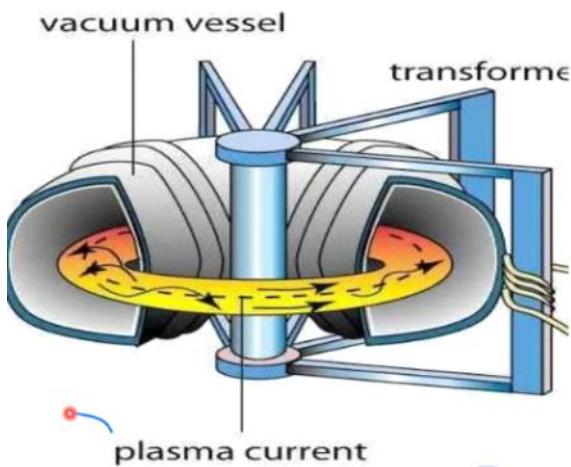
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Nuclear Fusion	<h2 style="color: red;">Nuclear Fusion</h2> <p>It is the process where <b>two lighter nuclei</b> combine to form a <b>heavy nucleus</b>.</p> <p>The diagram illustrates the fusion of two light nuclei. On the left, a deuterium nucleus (one proton and one neutron) and a tritium nucleus (one proton and two neutrons) are shown approaching a central point. In the center, a large yellow sphere represents the resulting helium nucleus (two protons and two neutrons). A single blue sphere labeled 'Neutron' is shown below the central point. A large red arrow points away from the central point towards the bottom right, labeled 'Energy'. Small arrows indicate the direction of approach of the deuterium and tritium nuclei.</p> <p>~ 4 times more energy compared to uranium fission is released.</p> <ul style="list-style-type: none"><li>• Unlimited Hydrogen in the atmosphere</li><li>• Product is Helium (safe), neither carbon issue nor radioactive waste<ul style="list-style-type: none"><li>◦ No pollution, 100% clean</li></ul></li><li>• Disadvantage :<ul style="list-style-type: none"><li>◦ Need very high activation energy<ul style="list-style-type: none"><li>▪ Nucleus are +ve charged, repel each other</li><li>▪ Need lot of energy to push them together to facilitate the fusion</li></ul></li><li>◦ High heat generated</li></ul></li><li>• Stars and sun are example of natural fusion</li><li>• Activation energy : Gravitational force, total mass exerts inward pressure to fuse material</li><li>• Hydrogen bombs</li><li>• Activation energy : atom bomb (fission bomb) heat energy</li><li>• No commercial fusion reactor have been created : high Activation energy</li><li>• Only experimental models are there</li></ul>
Fusion Reactor	<ul style="list-style-type: none"><li>• High activation energy is necessary for the fusion as both the positively charged nuclei repel each other, however when the fusion takes place more energy is released than invested. The reaction is exergonic.</li><li>• In stars, the enormous pressure and energy of gravity provides the activation energy.</li><li>• In <b>Hydrogen bomb</b> the activation energy is provided by the explosion of a fission bomb to heat the reactants to a temperature of about <math>10^8</math> K.</li><li>• This technology when used in fusion reactors offers great promise as Deuterium and tritium are available in unlimited amounts, the technology is environment friendly as end product is Helium, there is no radioactive radiation, Huge amount of energy can be obtained from a small amount of fuel.</li></ul>

International Thermonuclear Experimental reactor ITER

- **ITER** is an experimental **fusion reactor** facility under construction in Cadarache, South of **France** to prove the feasibility of nuclear fusion for future source of energy.
- **ITER partners** are the European Union, China, **India**, Japan, South Korea, Russia and the United States of America.
- European Union being the host party contributes **45%** while the rest of the parties contribute **9% each**. Most of these contributions are through '**in-kind**' procurement of **ITER components**.
- India formally joined the ITER Project in 2005 and the ITER Agreement between the partners was signed in 2006.
  
- **ITER Organization (IO)** is the **central team** responsible for **construction** at site and operation, while the ITER partners created their own **domestic agencies** to deliver their commitments to ITER.
- It has a **five-year assembly phase** and plans to reach its **maximum power output by 2035**.
- Assembly of reactor began in July 2020.
- **ITER-India** (under **Institute for Plasma Research-Gujarat**) partner **L&T**, delivered **Cryostat**, whose function is to provide cooling to the fusion reactor and to keep very high temperatures at its core under control.

ITER Function



- Plasma current: Highly ionised state of matter that is flowing,
  - Plasma to get high heat as activation energy
  - Heat to high temperature : by injecting high energy neutral particle beam
  - Or high frequency radio waves
  - Composition : Deuterium + Tritium Mixture
  - Kept in motion : to not touch the wall
    - Using strong electromagnets, that repel it in all direction
- Exergonic : 500 Mw outout for 50 Mw input
  - Output should be 10 times the activation energy

	<ul style="list-style-type: none"> <li>The reaction takes place in deuterium, tritium plasma that is ionized, consisting of electrons released by the atoms and of deuterium and tritium nuclei.</li> <li>The activation energy is provided by heating the plasma to a temperature of about <b>100 million degrees centigrade</b>, by injecting high energy neutral particle beam or radio frequency waves from outside which get absorbed in the plasma.</li> <li>Under these conditions, nuclei can overcome repulsive forces and fuse, releasing huge amount of heat energy.</li> <li>At this temperature the wall of the reactor would melt therefore the plasma is kept in motion in ring shaped magnetic field.</li> <li><b>ITER</b> has been designed to produce <b>500 megawatts of output power for 50 megawatts of input power for up to 400seconds.</b></li> <li>The ITER has been designed for developing and testing the necessary technologies for energy production but not for industrial energy production.</li> <li>Another 2000-megawatt reactor has been proposed for continuous energy production.</li> </ul>
US Lab	<p><b>U.S LAB MAKES HEADWAY IN NUCLEAR FUSION ENERGY</b></p> <ul style="list-style-type: none"> <li>So far, fusion devices that show a net energy gain have not been demonstrated in labs.</li> <li>An experiment at the U.S National Ignition Facility (NIF) comes close to demonstrating this. In this lab, using laser beams, tiny pellets of deuterium and tritium (heavier isotopes of hydrogen) have been fused to form helium and release energy that very nearly matches the amount of energy input using the lasers.</li> <li>To be functional, a reactor has to produce an output that is at least tens of times the input energy. The NIF has been trying to achieve this for nearly a decade.</li> <li>The amount of laser energy used in this experiment is 1.9 megajoule (MJ) &amp; the <b>amount of fusion energy produced in these experiments was approximately 1.3 MJ</b> which is now for the first time comparable to amount of laser energy input.</li> </ul>
JET Joint European Torus	<p><b>A NEW RECORD IN NUCLEAR FUSION ENERGY</b></p> <ul style="list-style-type: none"> <li><b>Joint European Torus (JET)</b>, a fusion experiment facility at U.K set a new record for the amount of energy released in a sustained fusion reaction.</li> <li>They generated <b>59 mega joules</b> of heat - equivalent to about 14 Kg of TNT (Trinitrotoluene - explosive) - during a 5 sec of fusion which is more than <b>double the previous record</b> achieved in 1997 by the same facility.</li> <li>JET, a doughnut-shaped <b>tokamak</b> fusion reactor contains <b>plasma</b> (highly ionized gases) which are heated to 150 million °C inside a vacuum [10 x hotter than the center of sun].</li> <li><b>Note: Watt = 1 joule per second.</b></li> </ul>

## China's Artificial Sun Broke a Record for Longest Sustained Nuclear Fusion

- The China's "artificial sun" project called **EAST** (Experimental Advanced Superconducting Tokamak) is an advanced nuclear fusion experimental research reactor located at the Institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP) in Hefei, China.
- In Jan 2022, it set a world record for reaching temperatures **five times hotter than the Sun (70 million degree Celsius) and staying there for 17 minutes.**
- Earlier, in May 2021, EAST had set a similar record when it ran for 101 seconds at 120 million degree Celsius.
- The Sun's core, in contrast, reaches temperatures of 15 million degree Celsius (27m degree F).
- It brings scientists closer to realising their dream of creating a near-unlimited source of clean energy.
- In 2020, **South Korea's KSTAR reactor set a new record by maintaining a plasma temperature of over 100 million degrees Celsius for 20 seconds.**

### Benefits of Nuclear Energy

- **Reliability** – Nuclear Power is a highly reliable, almost as good as other fossil fuel energy forms like coal, gas etc. Once established they can continuously generate energy.
- **Low Fuel Cost** – Large amounts of Nuclear Energy can be produced from the fission of radioactive elements like uranium. The costs of nuclear fuel is relatively low compared to other energy sources like coal and gas.
- **Long term usage** – Nuclear Plants also have long lives of between **40-60 years** which means that they are extremely profitable once constructed within reasonable costs
- **No Greenhouse Gas Emissions/Air Pollution** – Nuclear electricity does not produce any **greenhouse gas emissions** or cause air pollution from the combustion of fossil fuels unlike coal, oil or gas.
- **Huge Potential** – Nuclear Energy Potential is almost infinite compared to the limited and peak features of other forms of energy like wind, geothermal, oil, gas and others.

- **Cost** - Establishments of nuclear power plants is an expensive deal.
- **Safety issues** - If nuclear energy is not generated adhering to the highest standards of safety, there is possibility of catastrophic accidents such as Chernobyl and Fukushima. These disasters are of concern for all those adopting nuclear power generation.
- **Nuclear waste Management** – Waste produced at various stages of electricity generation is radioactive and therefore must be carefully managed and disposed.
- **Health** - Exposure to radioactive fallout would lead to an increased risk of genetic disorders, developmental issues, cancers etc.
- Nuclear material like plutonium can be used to produce highly destructive **nuclear weapons**.
- **Terror threats** - Nuclear installations could also become targets for terrorist attacks.

A nuclear catastrophe occurred at the **Chernobyl Nuclear Power Plant** in Ukraine on April 26, 1986

# WORLD'S WORST NUCLEAR DISASTER



An explosion at reactor #4 caused large quantities of radioactive particles to be released from the core

Contaminated an area of about 1,00,000 sq km

20% of Belarus	8% of Ukraine	0.5-1% of the Russian Federation
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1,35,000 people were evacuated from settlements around the reactor

Radioactive elements such as **Iodine-131, Cesium-137, and Strontium-90** were disseminated

31 direct deaths were reported & **thousands suffered cancer-causing side effects**

**NF** news trucks



## Japan's Nuclear disaster

- Following a major **earthquake** and **tsunami** disabled the power supply and cooling of three reactors at **Fukushima Daiichi, Japan**, causing a **nuclear accident** beginning on **11 March 2011**.
- **Cores** of the reactors **melted**, releasing large amount radioactivity.
- Although there have been **no immediate deaths** or cases of radiation sickness, at least 16 workers injured due to explosions and over **100,000 people** were **evacuated** from their homes as a preventive measure.
- Official figures show that there have been 2313 disaster-related deaths among evacuees from Fukushima.

- Primary objective:** To achieve economic, political, social, scientific and technological development **within a peaceful and democratic framework**
- Building and maintaining a **credible minimum deterrent**.
  - A "No First Use" posture; nuclear weapons to be used only "in retaliation against a nuclear attack on Indian territory or on Indian forces anywhere".
  - Nuclear retaliation to a first strike will be "massive" and designed to inflict "unacceptable damage".
  - Nuclear retaliatory attacks to be authorized only by civilian political leadership through the Nuclear Command Authority.
  - Nonuse of nuclear weapons against **nonnuclear weapon states**.
  - Continuance of strict controls on export of nuclear and missile related materials and technologies.
  - Participation in FMCT (Fissile material cutoff treaty) negotiations, **continued moratorium on testing**.

(Note: The Fissile Material Cut off Treaty (FMCT) is a proposed international treaty to prohibit the further production of fissile material for nuclear weapons or other explosive devices. The treaty has not been negotiated and its terms remain to be defined. According to a proposal by the United States, fissile material includes high-enriched uranium and plutonium (except plutonium that is over 80% Pu-238). According to a proposal by Russia, fissile material would be limited to weapons-grade uranium (with more than 90% U-235) and plutonium (with more than 90% Pu-239). Neither proposal would prohibit the production of fissile material for non-weapons purposes, including use in civil or naval nuclear reactors.

- India to retain option of retaliating with nuclear weapons in the event of a major attack against it with **biological or chemical weapons**.
- Continued commitment to goal of nuclear weapon free world, through global, verifiable and nondiscriminatory disarmament.
- USA : fissile material content > 80 % (More strict : Final)
- Russian : fissile material content > 90 %

**India conducted two nuclear tests:**

- **Pokhran-1:** Known as "Smiling Buddha", took place on 18<sup>th</sup> May 1974 – Tested a fission bomb.
- **Pokhran-2:** With the code name "Operation Shakti", took place on 11<sup>th</sup> and 13<sup>th</sup> May 1998. Conducted multiple tests including a fusion bomb and a couple of fission bombs.

**International Atomic Energy Agency (IAEA).**

- India has a site-specific safeguards agreement with the **International Atomic Energy Agency (IAEA)**.
- As of 2019, 14 Indian nuclear reactors that use **imported uranium** are under safeguards of IAEA.
- IAEA was **established in 1957** as the "World's Atoms for Peace" organization within United nations family, to promote **safe, secure, and peaceful uses of nuclear technology**.

Nuclear  
Suppliers Group

**The Nuclear Suppliers' Group** is a 48-nation body, which monitors and controls the export of materials or technology that can be used to create nuclear weapons.

- Brought in 1974—*in response to the Indian nuclear test (smiling Buddha)*.
- It is a *Multilateral export control regime*.
- It is *Not a formal organization, and its guidelines are not binding*. Decisions, including on membership, are made by consensus.
- *Membership: 48 supplier states*

Admission of new members is done through consensus. India has been attempting formally joining it since over a decade. India received a special waiver in 2008 from NSG to conduct nuclear commerce. Even though India has the backing of the majority of the group's members, China has been blocking its entry for India not being a signatory of “**Non-Proliferation Treaty**” (NPT).

**Benefits to India if it enters the NSG:**

Membership will *increase India's access to state-of-the-art technology* from the other members of the Group. Access to technology and being allowed to produce nuclear equipment will give a **boost to the Make in India program**. That will, in turn, boost the **economic growth** of our country.

- Indian advantage : access to new technology, export and import technologies
- China has objection : India not signed NPT Non Proliferation treaty

Non  
Proliferation  
Treaty

- India is not nuclear weapon state : tested in 1974 (after 1964 year are not NWS)
- Signing NPT means : we will not be allowed to possess nuclear weapon
- Nuclear Weapon state can delegitimize proliferation

## **TREATY ON THE NON-PROLIFERATION OF NUCLEAR WEAPONS (NPT)**

- Opened for signature in 1968, the treaty entered into force in 1970 (monitored by IAEA).
- The treaty defines nuclear-weapons states as those that have built and tested a nuclear explosive device before 1<sup>st</sup> January 1967.
- Five states are recognized by NPT as Nuclear weapon states, USA, Russia, UK, China, France
- It delegitimizes proliferation (production & transfer) of nuclear weapons, fissile materials and related technology by the nonnuclear weapon states while the NWS can continue to possess nuclear weapons.

Questions

**1Q. Give an account of the growth and development of Nuclear Science and technology in India. What is the advantage of fast breeder reactor program in India (2017, 15M, 250 words)**

**2Q. With growing energy needs should India keep on expanding its nuclear energy program. Discuss the facts and fears associated with nuclear energy. (2018, 15M, 250 words)**

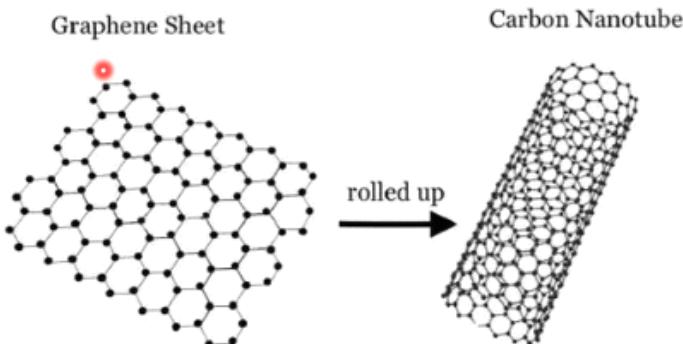
# L17 Nanotechnology

12 November 2024 01:23 AM

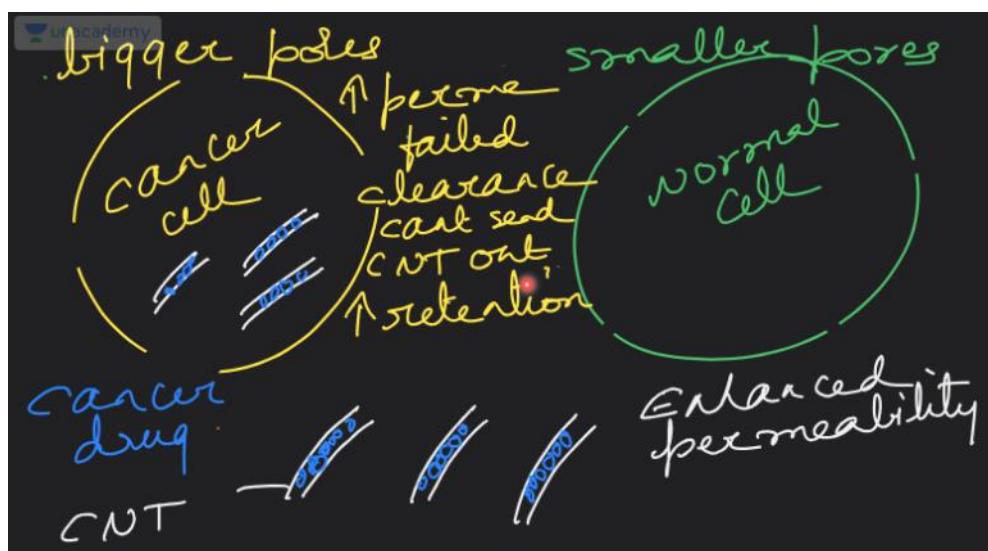
Nano Technology	<ul style="list-style-type: none"><li>• Any tech dealing with nano particles or nano material</li><li>• Any material of size 1-100 nm</li></ul>
Properties	<p><b>Nanomaterials</b> exhibit <b>unique properties</b>, such as</p> <ul style="list-style-type: none"><li>– Size (<b>1-100 nm</b>)</li><li>– Optical ( Changes in color, transparency)</li><li>– Electrical ( Changes in conductivity)</li><li>– <b>Physical</b> ( Changes in hardness, melting point)</li><li>– Chemical (Changes in reactivity, reaction rates)</li></ul> <p><b>Optical Properties Examples: Gold</b></p> <ul style="list-style-type: none"><li>• Bulk gold appears <b>yellow</b> in color</li><li>• <b>Nanosized</b> gold appears <b>red</b> in color</li></ul> <p><b>Reason:</b> The particles are so small that electrons are not free to move about as in bulk gold (Quantum confinement). As the movement of electrons is restricted, the particles react differently with light.</p>
Graphene / Fullerene / Carbon Nanotube	<ul style="list-style-type: none"><li>• Allotropes : Differ in special arrangement of same atom</li></ul> <p style="text-align: center;"><b>GRAPHENE &amp; FULLERENE</b></p> <ul style="list-style-type: none"><li>• There are four major allotropes of carbon; graphene, fullerene, and the other two are <u>diamond</u> and <u>graphite</u>.</li><li>• <b>Graphene</b> is a flat sheet of carbon atoms arranged in hexagons.</li><li>• <b>Fullerenes</b> are molecules of carbon in the shape of spheres, ellipses and tubes.</li><li>• A <b>fullerene</b> is an <u>allotrope of carbon</u> whose molecule consists of <u>carbon</u> atoms connected by single and double bonds so as to form a closed or partially closed mesh, with fused rings of five to seven atoms.</li><li>• The molecule may be a hollow <u>sphere</u>, <u>ellipsoid</u>, <u>tube</u>, or many other shapes and sizes.</li><li>• The family is named after <b>buckminsterfullerene (C<sub>60</sub>)</b>, the most famous member, which is named after <u>Buckminster Fuller</u>.</li><li>• Buckminsterfullerenes (C<sub>60</sub>) are spherical carbon allotropes where 60 atoms are assembled in pentagons and hexagons, in a geometry similar to a soccer ball.</li></ul>

## Carbon nanotubes

- Carbon nanotubes (CNTs) are **cylindrical molecules** that consist of **rolled-up sheets** of single-layer carbon atoms (graphene).
- They are **100 times stronger than steel** but **only one sixth of its weight**.
- They are also **good thermal and electric conductors**, unlike its constituent carbon.

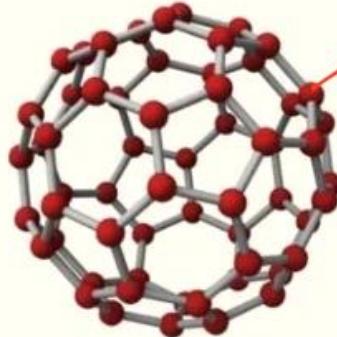


- The unique properties of CNTs such as ease of cellular uptake, high drug loading, render them useful for cancer therapy.
- Cancer is one of the most challenging diseases of modern times because its therapy involves distinguishing normal healthy cells from affected cells.
- Here, CNTs play a major role because phenomena such as EPR, allow CNTs to distinguish normal cells from affected ones.
- **The enhanced permeability and retention (EPR) effect** is the property which small sized nanoparticles and macromolecular drugs can accumulate more in tumor than in normal tissues. The EPR effect is generally due to the larger pore size of cancer cells and poor lymphatic clearance of tumours.



- The closed fullerenes, especially  $C_{60}$ , are also informally called **buckyballs** for their resemblance to Soccer balls.
- Nested closed fullerenes have been named **bucky onions**.
- Cylindrical fullerenes are also called carbon nanotubes or buckytubes.

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Why Nano gold is red

#### **Quantum confinement:**

- Quantum confinement is change of electronic and optical properties like **increase in band gap** when the material is of sufficiently small size - typically 10 nanometers or less.
- The bandgap increases as the size of the nanostructure decreases.***

**Band gap:** Valence band and conduction band are two different energy levels separated by certain amount of energy, this energy difference is called band gap.

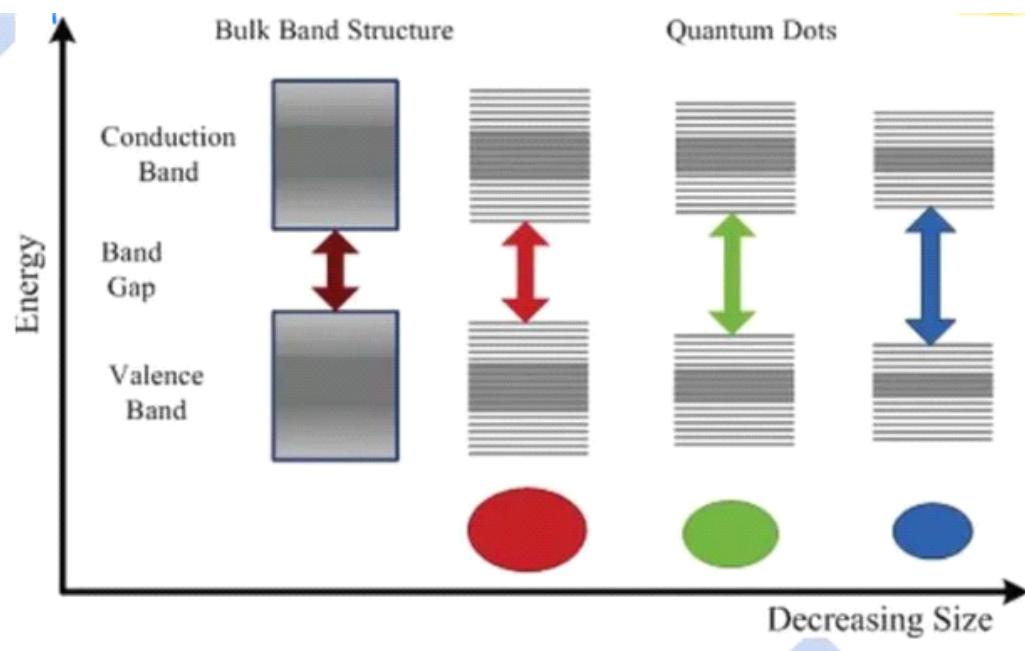
***Band gap is inversely proportional to size of the quantum dot.***

dc1910@gmail.com  
1844

Property	Valance band	Conduction band
External excitation	Electrons move out of VB	Electrons reach CB
Energy state	Low energy	High energy

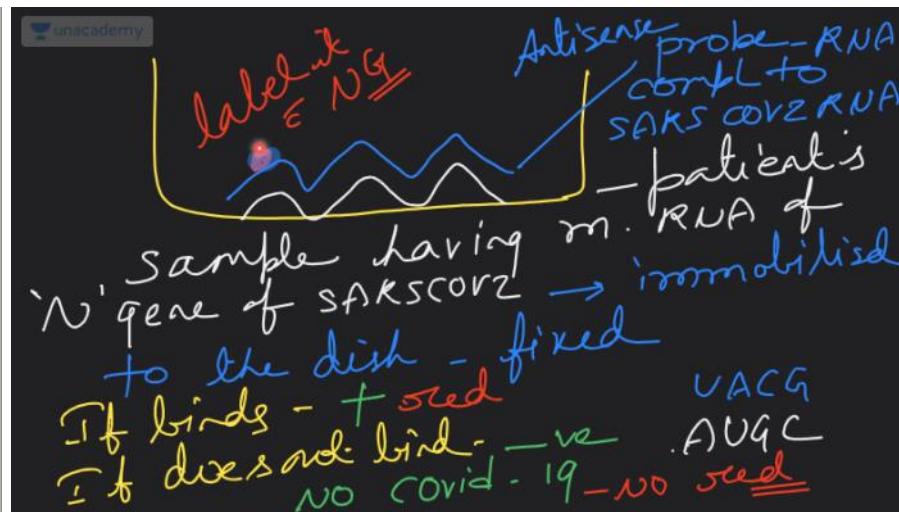
#### **Applications:**

- Quantum dot televisions (QLED) for better colors and high resolution.
- Labelling Biological molecules invitro & In vivo for diagnostic purposes.
- Incorporate in inks and polymers used in Paper currency to combat counterfeiting.
- Used in solar panels to minimize their size and increase surface area.
- Quantum dots** are used by NASA to help boost the performance of solar cells.
- Band Gap increases when size decrease
- Quantum Confinement :
  - Quantum : smallest unit of matter (Sub atomic particles - electron)
  - Confinement : electron confined due to small size
  - Need more energy to push them to conduction band



- Red Colour : less energy big wavelength wave
- Blue Colour : High energy low wavelength wave

	<ul style="list-style-type: none"> <li>• Quantum dots are small, semiconducting nano crystals / nanoparticles, made up of elements like Silicon, Cadmium selenide, cadmium sulfide etc.</li> <li>• They range in size from 2-10 nm. 1nm = 2 silicon atoms</li> <li>• These semiconducting material can absorb light &amp; when they release that energy they transform it to a different colour of light.</li> <li>• The colour depends on size and material of the quantum dot.</li> <li>• The larger the size of the dot the lower the energy of the light waves resulting in redder light, The smaller the dot the bluer the light will be.</li> <li>• This phenomena is due to quantum confinement.</li> </ul>
Biochemical Sensor	<p>Visualizing the changes by using colour property</p> <p><b>Biochemical sensors:</b></p> <p>Sensor - sensing or detecting something</p> <p>Sensing happens through a reaction <i>b/w RNAs Ag-Sb<sup>-</sup></i></p> <p>Should be able to see the reaction</p> <p>Nano sensors indicate the reaction through color</p>



### Application of Quantum Dots



## Applications in Healthcare



- In diagnosis of infections and cancers:** Antibodies attached to carbon nanotubes are being prepared to detect **cancer cells** in the blood stream.
- Drug delivery systems:** Nanoparticles are used to deliver drugs, radiation & light emitting substances to specific types of cells (such as cancer cells).
- Gene therapy:** Nanoparticle based **gene delivery** systems.
- Nanorobots** could be programmed to enter blood stream and perform complicated **surgeries** in human body. They are 2 types.
  - Controlled nanorobots: Instructed from outside and relays information to outside. E.g., Pillcam by Medtronic is an ingestible pill camera that can relay information about patient.
  - Autonomous nanorobots – Can operate on their own without external control.
- Bandages containing **silver nanoparticles** are effective in killing disease causing microbes due to their antimicrobial properties.

## SARS CoV2 Diagnosis & Disinfection

- Researchers from the **University of Maryland, USA**, have developed a diagnostic test based on **nano gold particles** capped with DNA antisense sequence specific for N-gene (nucleocapsid phosphoprotein) of SARS-CoV-2, which bind specifically to the viral RNA and detect positive **COVID-19 cases** within **10 minutes** of obtaining the isolated RNA samples.
- Nanomaterial based **handsanitisers** and **disinfectants** have also been developed to kill microorganisms during **Covid-19 pandemic** as .
- Antimicrobial properties of nano particles:** Metal oxide (iron oxide) or positively charged metal (Silver) Nanoparticles  $\rightarrow$  Attach to the negatively charged cell membrane  $\rightarrow$  penetrate into the cell  $\rightarrow$  Trigger the production of reactive oxygen species (ROS)  $\rightarrow$  Destroy the cell structures through oxidation.

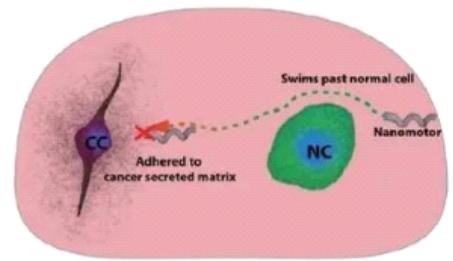
### Hepatitis C diagnosis:

- Researchers at **BITS Pilani, Hyderabad campus**, have developed a **gold nano particle-based diagnostic kit**, which is **cheaper and quicker** for **early-stage detection of Hepatitis-C infection**.
- New method uses a specific sequence in the probe which is universal to all genotypes of Hepatitis C.
- The probe is tagged to nanogold nanoparticles for visualisation.
- If the sample is HCV positive, the probe binds to the stabilised viral RNA, retaining the red colour of nano gold. Thus, red colour indicate positive result.

Health  
Sector  
Research

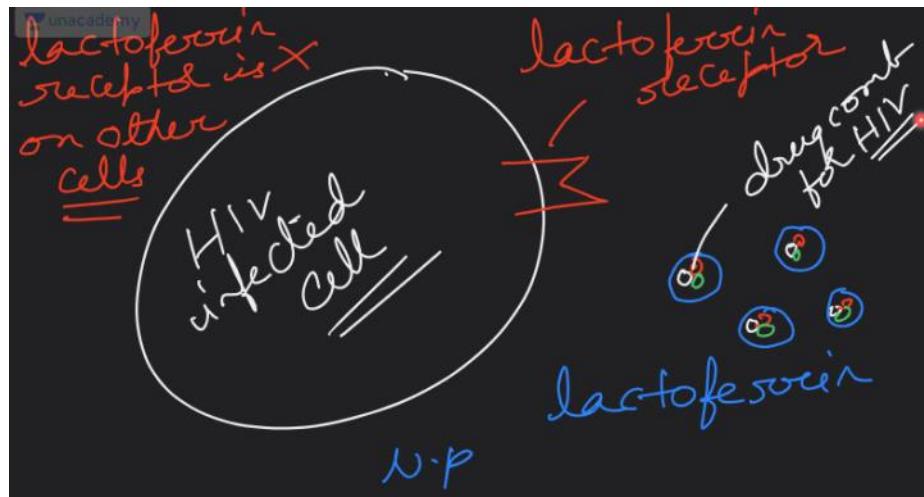
### IISc Bengaluru researchers discover **nanomotors can lead to early detection of cancer cells**

- A team of researchers at the Indian Institute of Science (IISc) in Bengaluru has discovered that nanomotors can help in early detection of cancer cells.
- The researchers used magnetically-driven nanomotors for the study,
- 'Nanomotors Sense Local Physiochemical differences in Tumour Microenvironments'.
- Nanomotors get stuck when they encounter cancer cells which are coated with negatively charged sugars, but not with normal cells.



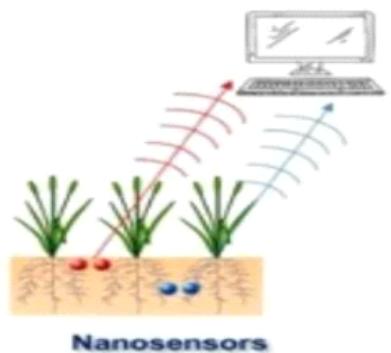
### University of Hyderabad scientists get patent for nano HIV drug combination efficacy enhancers

- Scientists recently developed **lactoferrin nanoparticles** encapsulating a combination of drugs that can be used in treatment of HIV.
- These nanoparticles allow drug cargo to be delivered through lactoferrin receptors expressed on HIV infected cells.

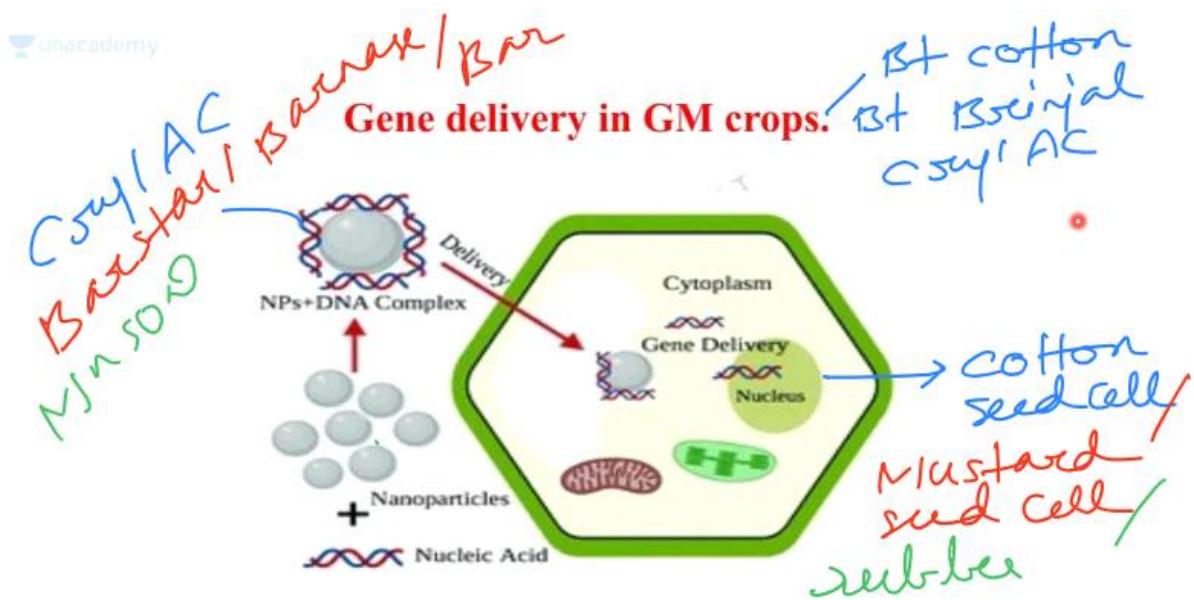


### Nano Tech in Agriculture

- Nano sensors dispersed in the field can detect **plant viruses** and the **level of soil nutrients**. **Nanoparticle mediated** material delivery to plants and advanced biosensors for precision farming can revolutionize the field of agriculture.



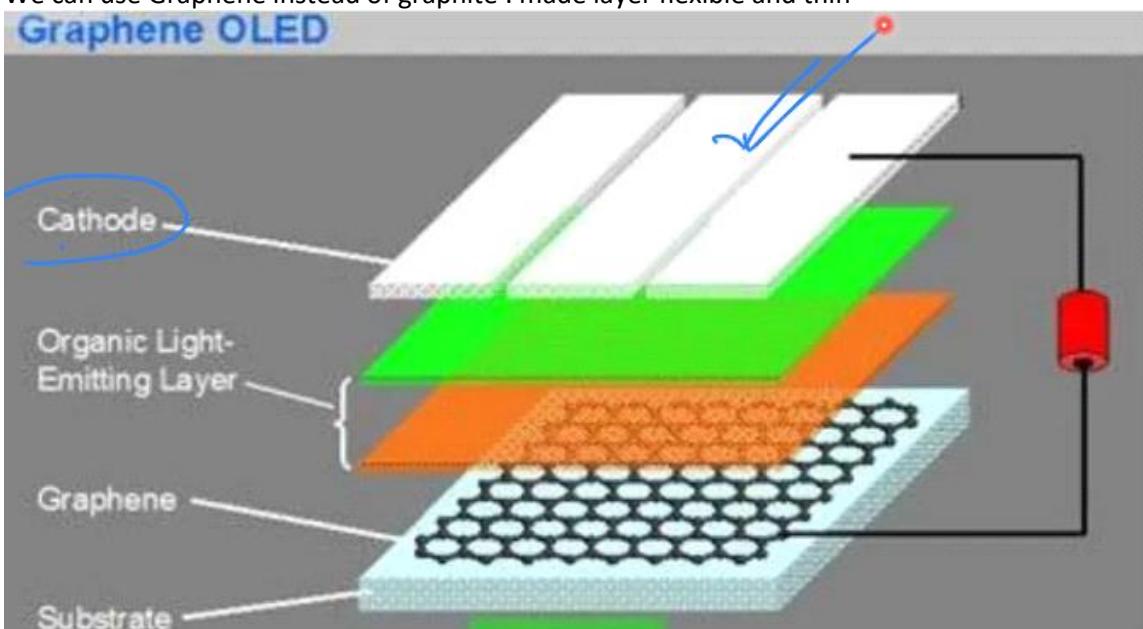
Nano encapsulated **slow-release fertilizers** and **pesticides** have also become a trend to save fertilizer consumption and to minimize environmental pollution.



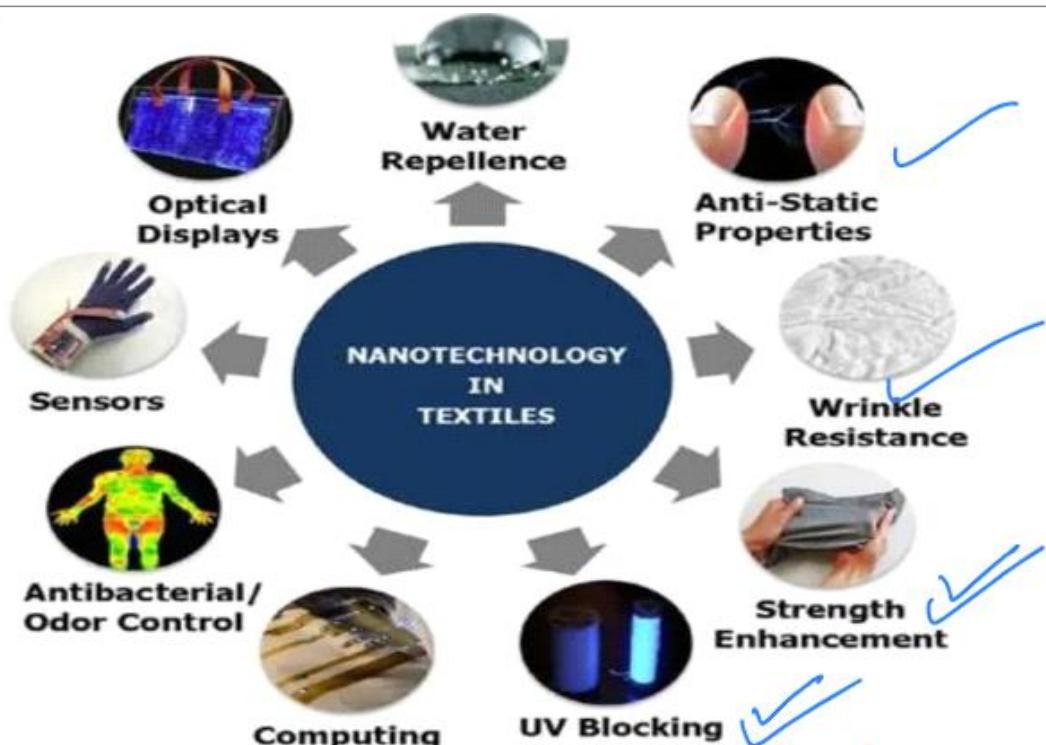
	<ul style="list-style-type: none"> <li>• Pesticides: Nanopesticides can be used for efficient crop protection.</li> <li>• Sensors: Nanosensors can monitor plants for growth, nutrients, pests, soil conditions and plant hormones using antibodies, enzymes or nucleic acids in the probes.</li> <li>• Nanomaterials: Nanomaterials like carbon, silica, silver etc., can be used to monitor plant diseases.</li> <li>• Food processing: Edible nano coatings can be used on perishable foods like fruits, vegetables, meat, and fish to extend their shelf life. These coatings can also provide flavor, color, and enzyme to the product.</li> <li>• Soil enhancement: Nanomaterials can improve soil quality by improving the functionality of soil microbiome.</li> <li>• Plant stress tolerance: Nanomaterials can promote plant stress tolerance by stimulating detoxification pathways.</li> <li>• Gene transfer: A nano particle-based gene delivery can be used to make the GM crops.</li> </ul> <p>• Nano Particle -&gt; plants -&gt; stimulate Detoxification</p>
Nano urea	<ul style="list-style-type: none"> <li>• Prime Minister of India inaugurated the World's first Nano Urea Liquid plant in May 2022 in Gujarat.</li> <li>• It is essentially liquid urea in the form of a nanoparticle.</li> <li>• It has been developed at <b>Indian Farmers Fertiliser Cooperative Limited's</b> (IFFCO) <b>Nano Biotechnology Research Centre</b> (NBRC) at Kalol, Gujarat.</li> <li>• Half a litre of Nano urea with the cost of Rs 240 can substitute a bag of urea that comes for ~ Rs 300 after heavy subsidy (international market price Rs 3500 - 4000)</li> <li>• It is sprayed directly on the leaves and gets absorbed by the plant's stomata.</li> <li>• Upon penetration, nanoparticles reach plant parts and release nutrients in a controlled manner, thereby reducing usage as well as wastage into the environment.</li> <li>• While conventional urea is effective just for 30-50 % (and rest contaminate soil and water) in delivering nitrogen to plants, the effectiveness of the nano urea liquid is over 80%.</li> </ul> <p><b>Benefits:</b></p> <ul style="list-style-type: none"> <li>• Improves yield, soil health and nutritional quality of crop</li> <li>• It has also been tested for biosafety and toxicity.</li> <li>• Reduces the import cost on urea</li> </ul>
Nano Tech in Energy Sector	<h3 style="color: red; text-align: center;">Applications in 'Energy Sector'</h3> <ul style="list-style-type: none"> <li>• Nanotechnology can be useful at different levels - from energy generation, storage to usage.</li> <li>• Superconducting <b>Carbon nanotube cables</b> for energy distribution.</li> <li>• Nanomaterials can improve <b>capacity and safety of lithium-ion batteries</b>, through high-performance electrode materials.</li> <li>• In 2019, Scientists from <b>IIT-Kharagpur</b> designed "<b>Piezoelectric Nanogenerators</b>" that can <b>produce electricity</b> through <b>body movements</b> such as walking, speaking, swallowing etc.</li> </ul> <p><b>(Piezo electric effect:</b> Ability of certain materials to generate an electric charge in response to applied mechanical stress)</p>

## LITHIUM-ION BATTERIES:

- Rechargeable batteries that power electric vehicles, laptops and mobile phones.
- Lithium ions move **from negative electrode (Typically Graphite) to the positive electrode (Intercalated Lithium compound) during discharge and back when charging.** The battery consists of an electrolyte that allows the movement of ions.
- India, through a newly-floated state-owned company **Khanij Bidesh India Ltd**, has inked a pact with **an Argentine firm** to jointly **prospect lithium in Argentina**, a country that has the **one of the largest reserves** of Lithium in the world.
- **Khanij Bidesh India Ltd** was incorporated in August 2019 by three state-owned companies, **NALCO, Hindustan Copper and Mineral Exploration Ltd**, with a specific mandate to **acquire strategic mineral assets such as lithium and cobalt abroad.**
- Plan is also to explore options in **Chile and Bolivia**, two other top lithium-producing countries.

Nano tech in Electronic	<ul style="list-style-type: none"><li>• Drastic <b>reduction in size</b> of components in electronic equipment such as Nano transistors, nano processors, nano storage devices, resulted in small and highly efficient phones, computers etc.</li><li>• Researchers at Stanford University have successfully developed brand new concept of <b>organic light-emitting diodes (OLEDs)</b> with a few nanometre of <b>Graphene as transparent conductor / transparent electrode.</b></li><li>• This paved the way for inexpensive mass production of OLEDs on large-area low-cost flexible plastic substrate, which could be rolled up like wallpaper and virtually applied to anywhere you want.</li><li>• <b>NOTE:</b> OLED is an LED in which electroluminescent layer is a film of organic compound (Any compound that contains Carbon-Hydrogen bonds) that emits light in response to an electric current. This organic layer is situated between two electrodes, typically at least one of these electrodes is transparent.</li></ul>
Nano Tech in OLED	<ul style="list-style-type: none"><li>• LED : Light Emitting Diode, electroluminescent layer</li><li>• OLED : Organic LED : Compound containing carbon Hydrogen Bonds</li><li>• Both of them uses Graphite</li><li>• We can use Graphene instead of graphite : made layer flexible and thin</li></ul>  <p>The diagram illustrates the structure of a Graphene OLED. It shows a cross-section of the device with the following layers from top to bottom: a blue oval labeled 'Cathode', a green layer labeled 'Organic Light-Emitting Layer', an orange layer labeled 'Graphene', and a grey layer labeled 'Substrate'. A red wire connects the Cathode to a red battery symbol, and another red wire connects the Graphene layer to the same battery symbol, indicating the flow of electrical current through the device.</p>

Nano Tech in Textile



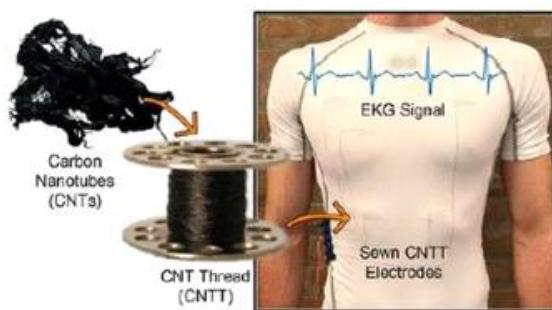
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HIMA BINDU



Roger Federer's Wilson tennis Rackets are made up of graphite with carbon nanotubes

## 'Smart Shirt' Developed by American Researchers Can Monitor Heart Rate



- CNT embedded into the shirt, transmit the information of electrical activity through Bluetooth technology to a computer – collecting **ECG** without
- The threads can comfortably move with the wearer, and be washed, stretched and worn repeatedly without breaking down.
- In future they can be used as antennas to **track the location of military personnel**.

Bhabha Kavach

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### Bhabha Kavach

- The **Bhabha Atomic Research Centre's (BARC)** next-generation bulletproof jacket for the **Indian armed forces**.
- They are **cheaper** and much **lighter**.
- Weighs **6.6 kg** in comparison to the 17-kg jackets in use
- Cost is **₹70,000**, compared to 1.5 lakh for a similar strength jacket in the international market.
- Designed to protect our soldiers against AK-47 (hard steel bullets)
- Made using extremely hard **boron carbide** ceramics, **hot-pressed** with **carbon nanotubes** and composite polymer.



Misc. Application

- Lightweight but strong vehicles (cars, trucks, airplanes, boats, and space crafts) with significant **fuel savings**.
- **Self cleaning textiles:** Nano material coated on the clothes, when exposed to light, release a burst of energy that degrades organic matter and stains.
- Superior household products such as **degreasers** and **stain removers**; Water filters, air purifiers; durable and washable paints etc.
- Dust-repellent, water-repellent, rust-resistant coatings for vehicles are already in the market.

- Clear **nanoscale films** on eyeglasses, computer and camera displays, windows, and other surfaces.
- Water- and residue-repellent, antireflective, self-cleaning, antifog, antimicrobial, scratch-resistant glass.
- Nanoscale **titanium dioxide** and **zinc oxide** have been used for years in **sunscreen** to provide protection from the sun while **invisible** on the skin.

Issues	
Health issues	<ul style="list-style-type: none"> <li>• Nanoparticles appear to get <b>absorbed easily</b> when they encounter the tissues or the fluids of the body. These absorbed nanoparticles <b>reach the sites</b> like liver, blood cells, heart etc.</li> <li>• With decrease in particle size, in many nanomaterials the <b>production of free radicals</b> increases, resulting in <b>toxicity</b>.</li> <li>• Titanium dioxide, cobalt, nickel, polystyrene etc. are responsible for <b>respiratory toxicity</b>.</li> <li>• Nanoparticles can cross the blood brain barrier which is responsible for <b>brain toxicity</b>.</li> <li>• <b>Titanium dioxide</b> nanoparticles that are widely used in sunscreens and cosmetics, shown to cause <b>lung cancer</b> in rats.</li> <li>• Studies have also shown that some carbon nanotubes can also cause the onset of <b>mesothelioma</b> – cancer previously thought to be only associated with asbestos exposure.</li> <li>• Nano Particle -&gt; release free radical -&gt; oxidation -&gt; damages</li> </ul>
Environmental Issue	<ul style="list-style-type: none"> <li>• Scientific studies show that some nanomaterials are toxic to commonly used environmental indicators such as <b>algae, fishes</b> etc.</li> <li>• Studies have also found that carbon nanomaterials like <b>Fullerenes</b> and multi walled nanotubes - <u>delayed rice flowering</u>, significantly <u>affecting the yield</u> of exposed rice plants.</li> <li>• Exposure to carbon nanotubes also makes <b>wheat plants</b> more vulnerable to <u>uptake of pollutants</u>.</li> <li>• Use of nanopesticides /fertilizers can increase <b>chemical pollution</b>.</li> <li>• Manufacturing <u>nanomaterials</u> and <u>nano-devices</u> is extremely <b>energy-intensive</b>, requires <b>large amount of water and energy</b>, which is not desirable.</li> <li>• Studies on carbon nano fibre production found that their <b>potential to contribute</b> to <u>global warming</u>, <u>ozone layer depletion</u>, <u>environmental or human toxicity</u> by multiple fold than conventional materials.</li> </ul>

Social And Legal Issue	<ul style="list-style-type: none"> <li>Nanotechnology can enhance the gap in the society / '<b>nano-divide</b>' due to the reasons like <b>affordability</b>.</li> <li>Nanotechnology has the capability to produce <b>new weapons</b>, thus leading to new security challenges.</li> <li>As this technology resulted in small but powerful devices like cameras, they can collect the information of customers without their knowledge, leading to <b>privacy issues</b>.</li> <li>Legal issues with respect to <b>patent applications</b> is another challenge due to lack of a standardized definition of nanomaterials.</li> <li>Also, the <b>inherently multidisciplinary nature</b> of nanotechnology presents significant challenge in <b>proper evaluation</b> of <b>patent applications</b> and in granting the patents.</li> <li><b>Inaccurately assessing an invention's novelty due to lack of experts</b> with knowledge in variety of areas associated with this field.</li> </ul>
Ethical Issue	<ul style="list-style-type: none"> <li>Ignoring the <b>negative consequences</b> of nanomaterials for gaining <b>commercial benefits</b>.</li> <li>Governments allowing applications of nanomaterials without having a good understanding of harmful effects of them on other life forms.</li> <li>Nanomaterial use as <u>undetectable weapon</u> in warfare, and the incorporation of <u>nano-devices as performance enhancers</u> in human beings.</li> <li>If nanodevices happened to be expensive, they cannot be accessed by poor.</li> <li>Ingredient can be falsified as nano size, They can just write composition without size</li> </ul>

Government Initiative	<ul style="list-style-type: none"> <li>Important</li> </ul>
NSTI	<p style="color: red; font-weight: bold;">Nanoscience and Nanotechnology Initiative (NSTI)</p> <ul style="list-style-type: none"> <li>NSTI was launched in <b>October, 2001</b> under the <b>Department of Science and Technology</b>.</li> <li><b>Aim</b> is to create <b>research infrastructure</b> and <b>promote basic research</b> in nanoscience and nanotechnology.</li> <li>It focused on various issues relating to infrastructure development, <u>basic research</u> and <u>application oriented</u> programmes in nanomaterial including drugs/drug delivery/gene targeting etc.</li> <li>In <b>2001-2002</b>, the DST set up an Expert Group on "Nanomaterials: Science and Devices".</li> </ul>

## Nano mission of India

- A **Mission on Nano Science and Technology** (Nano Mission) was launched by the DST to foster, promote and develop all aspects of nanoscience and nanotechnology which have the potential to benefit the country.
- Allocation of **Rs. 1000 crore** for 5 years in the **11<sup>th</sup> Five Year Plan**.
- The Mission is steered by a **Nano Mission Council** (NMC) under the Chairmanship of **Prof. CNR Rao**.

### Objectives

- **Basic Research Promotion** – Funding of basic research and creation of centres of excellence.
- **Infrastructure Development for Nano Science Research** – Establishing shared facilities across the country with **expensive equipment** like **Atomic Force Microscope (AFM)** and **Scanning Tunneling Microscope (STM)** etc.

Others

- **Nano Applications and Technology Development Programmes:**
  - To catalyze applications and technology development programmes leading to manufacture of products and devices.
  - To promote application-oriented R&D Projects,
  - Establish Nano Applications and Technology Development Centres, Nano-Technology Business Incubators etc.
  - Special efforts to involve the industrial sector into nanotechnology R&D directly or through Public Private Partnership (PPP) ventures.
- **Human Resource Development:**
  - Providing **effective education and training** to researchers and professionals in diversified fields related to nanotechnology.
  - Launch of M.Sc./M.Tech. programmes, create national and overseas post-doctoral fellowships in universities, etc.
- **International Collaborations:**
  - Exploratory visits of scientists, organization of joint workshops and conferences and joint research projects with other countries.
  - Access to sophisticated research facilities abroad, establish joint centres of excellence and academia-industry partnerships at the international level.

Recognizing the success of Nano Mission, the Union Cabinet accorded approval for continuation of the Nano Mission in its Phase-II during the **12th Plan period** (2012-17) with an allocation of **Rs. 650 crore**.

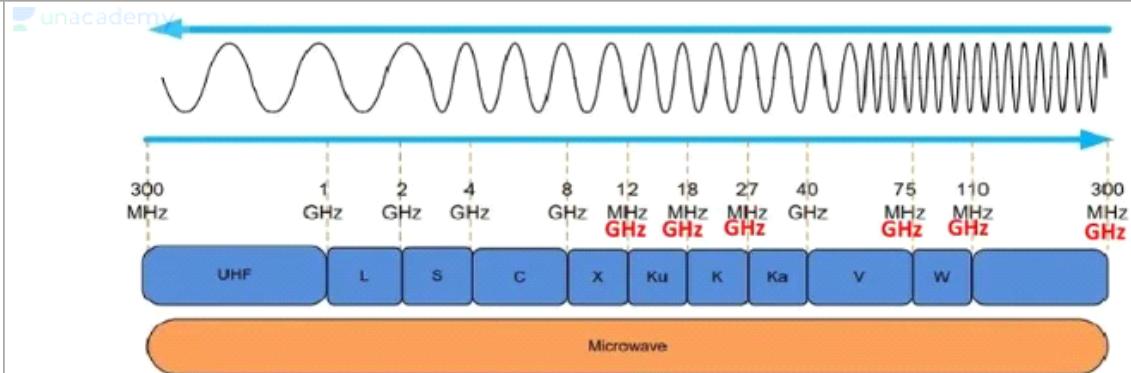
## Other initiatives

- **Indian Nanoelectronics Users Programme (INUP)**
  - It was initiated by (Ministry of Electronics and information technology) MeitY - being implemented at **Centre of Excellence in Nanoelectronics (CEN)** at **IISc and IIT Bombay**
  - Provided **access to state-of-the-art nanofabrication facilities** for undertaking research and skill development in Nanoelectronics.
  - About **400 researchers** are being imparted hands-on training in Nanofabrication at these centres every year.
- **DST** has launched bilateral joint- research projects with more than 25 countries and multilateral research projects

# L18 Information and Communication

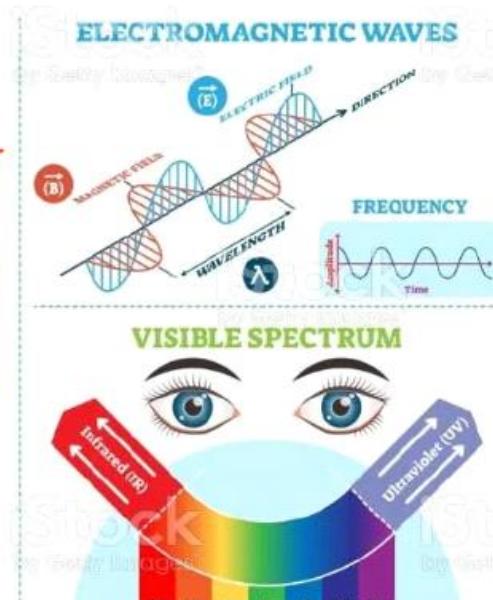
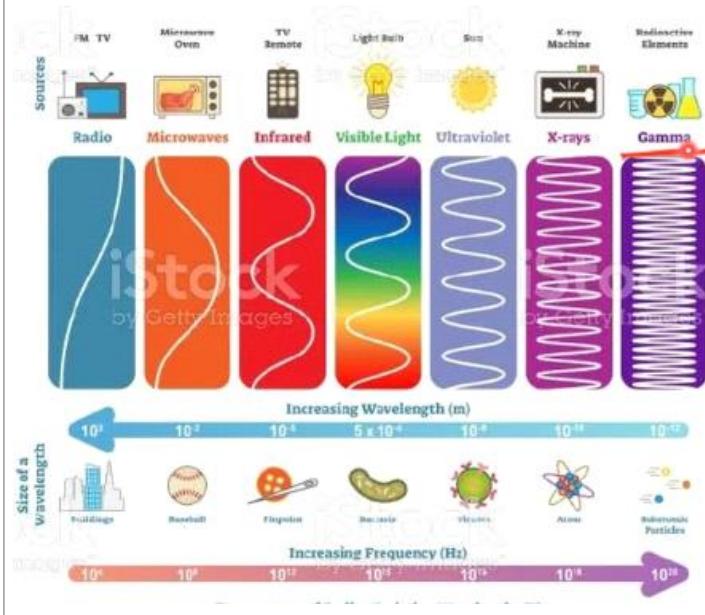
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## Waves Spectrum



- **Microwave** is a form of electromagnetic radiation with wavelengths with frequencies ranging between 300 MHz and 300 GHz. Microwave region overlap with highest frequency radio waves.
- **Millimeter waves** are electromagnetic waves typically defined to lie within the **frequency range of 30–300 GHz**.
- Radio waves are a type of electromagnetic waves with frequency range 3 kilohertz up to 300 gigahertz. (Kilo<Mega<Giga<tera<Peta)

## ELECTROMAGNETIC SPECTRUM



**SHORT RANGE DEVICES**

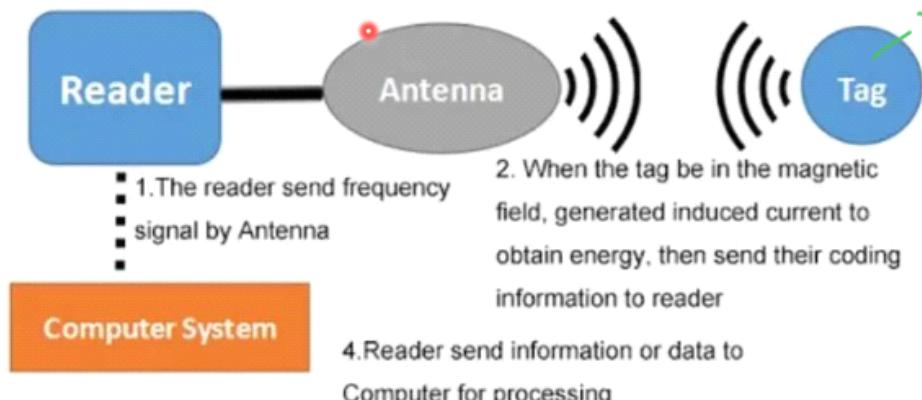
- **Short Range Devices** are radio devices whose transmitted power and their range is low.
- They have a low risk of interference with other radio services.
- Short Range Devices include many different types of wireless equipment, such as
  - **Closed-circuit television (CCTV)**, TV system in which signals are not publicly distributed but are monitored primarily for surveillance and security purpose. It uses radio waves to transmit the video images recorded by cameras to a limited set of monitors through radio waves.
  - **Wireless Local Area Networks (WLAN)** that interconnects computers within a limited area such as residence, school, laboratory, university etc. through radio waves.
  - **Remote controllers** that use radio waves to control distant switches.
  - Alarms and **movement detectors/motion sensors** that use RADARS that emit radio waves will reflect off walls and objects.
  - **Bluetooth, RFIDs etc.**
- Also called radio waves device

- RFID :Radio frequency Identification, Ex : Fast tag

**Radio-frequency identification, RFID**

- RFID is an acronym for “**radio-frequency identification**”
- Radio Frequency Identification (RFID) refers to a wireless system comprised of two components, tags and readers. The reader is a device that has one or more antennas that emit radio waves and receive signals back from the RFID tag. Tags communicate their identity and other information to nearby readers such as making required payments at toll gate.

3. Reader Collecting information and decoding



RFID tag data can be read outside the line-of-sight, whereas barcodes must be aligned with an optical scanner.

### **Applications**

- Asset tracking, Personnel tracking.
- Controlling access to restricted areas, Employee ID Badges.
- Supply chain management.
- RFID being used in FASTag- **Electronic Toll Collection on Toll Plazas** on National Highways.
- **Indian Railways** is using RFID tags to **track wagons and coaches**.
- **Vadodara Municipal Corporation (VMC)** in Gujarat, is tagging cattle with RFID tags to deal with Cattle menace in the city.
  
- Optical Scanner -> RFID -> GPS tracking (In Future)
  - Issue with GPS : Privacy + Enormous amount of data (Big data)

Bluetooth	<ul style="list-style-type: none"> <li>• Wireless technology developed in 1990s.</li> <li>• It uses radio waves as a medium.</li> <li>• Works for <b>short-range</b> (typically about 10 m distance)</li> <li>• It is a <b>high speed</b> (&lt; 1 Mbps, 25 Mbps in 4<sup>th</sup> gen) &amp; low-powered</li> </ul> <p><b>Uses:</b></p> <ul style="list-style-type: none"> <li>• File (data) transfer between devices.</li> <li>• Bluetooth headset (voice transfer)</li> <li>• Bluetooth mouse/Key pad etc.</li> </ul>
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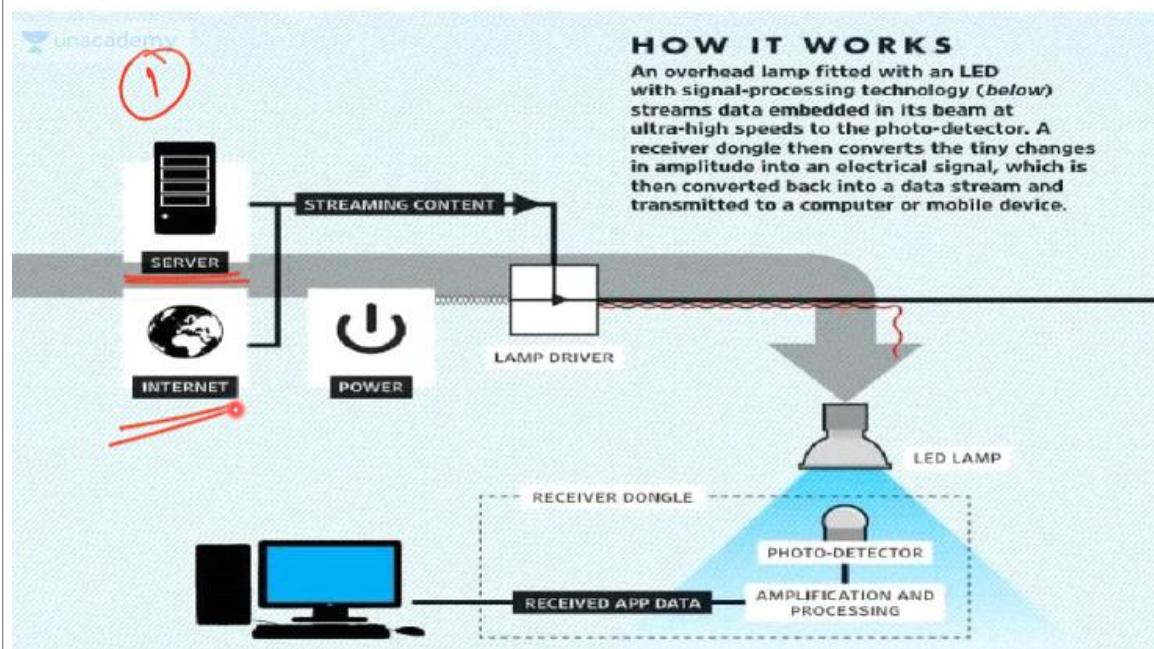
Long Range Device	
WIFI	<ul style="list-style-type: none"> <li>• Instead of using wired connections like Ethernet, Wi-Fi uses radio waves to transmit information at specific frequencies.</li> <li>• Initially developed in 1990s.</li> <li>• It allows devices <b>to connect to internet</b>.</li> <li>• Can offer high-speed Internet.</li> <li>• Range <b>100 m</b></li> <li>• <b>Speeds:</b> Can go up to ~ 250 Mbps (Megabits per second)</li> </ul>

- It is a form of optical communication in which unguided visible, infrared (IR), or ultraviolet (UV) light is used to carry a signal. It is generally used in short-range communication.
- **Optical communication**, also known as **optical telecommunication**, is communication at a distance using light waves as a medium to carry information.

## VISIBLE LIGHT COMMUNICATION TECHNOLOGY

### Light fidelity, Li-Fi

- Li-Fi is a wireless technology invented in **2011**.
- Makes use of visible light in place of radio waves (**Optical wireless communication**) to transmit binary data in the form of light pulses.
- A preferred communication technique because of its high bandwidth and immunity to interference from electromagnetic sources.
- Can transmit data up to **100 Gbps** - more than 100 times the speed of Wi-Fi and much higher than Bluetooth (~ 1 Mbps).
- **Light bulbs (LED lamps)** are used as wireless routers.
- It accommodates a **photo-detector** to receive light signals and a **signal processing element** to convert the data into 'streamable' content.



# L19 Supercomputers, AI, Robot, Blockchain

13 November 2024 01:16 AM

Super Computer

- Parallel Computing : Many Computer (Processor) working together
- Pratyush : Indians fastest and First Multi Petaflops supercomputer
  - to improve weather and climate forecast

## SUPERCOMPUTERS

- Supercomputers are **high-performance computers**.
- They work on a concept called "**parallel computing**", wherein an array of **processors** stacked together to perform high computational tasks.
- Supercomputers can do in minutes or hours what regular computers do in days, months or years.

### Types of super computers:

#### Cluster Computing:

A Computer Cluster is a local network of two or more **homogenous computers**. A computation process on such a computer network i.e., cluster is called Cluster Computing.

#### Grid Computing:

Grid Computing can be defined as a network of **homogenous or heterogenous** computers working together over a long distance to perform a task that would rather be difficult for a single machine.

- With a theoretical peak performance of **1102 peta Flops**, USA's **Frontier** is the world's fastest supercomputer as of November 2022.
- Currently, the most powerful supercomputer of India is **Param Siddhi**. It ranks **102** as of new list released in 2022.
- The supercomputer is a single system with more than 285,000 CPU cores and 10,000 GPUs. On top of that, each GPU server has 400 gigabits per second of network connectivity.

(Note: Graphics processing unit is a specialized processor that can process many pieces of data simultaneously, making them useful for machine learning, video editing, and gaming applications.

GPUs may be integrated into the computer's CPU or offered as a discrete hardware unit).

**FLOP: Floating point operations per second** - a direct mathematical measurement of a computer's performance. **Tera: One trillion, Peta: Quadrillion** (1000 trillion/million billion)

	<b>Cluster computing</b>	<b>Grid computing</b>
	<b>Nodes</b> must be homogenous i.e. they should have same type of hardware and operating system.	<b>Nodes</b> may have different Operating systems and hardwares. Machines can be homogenous or heterogenous.
	Computers in a cluster are dedicated to the same work and perform no other task.	Computers in a grid contribute their unused processing resources to the grid computing network.
	Computers are located close to each other.	Computers may be located at a huge distance from one another.
Application	<p>Supercomputers are designed for <b>calculation-intensive tasks</b> such as problems involving</p> <ul style="list-style-type: none"> <li>• <u>Quantum mechanics</u></li> <li>• Weather forecasting</li> <li>• climate research</li> <li>• Simulation of airplanes in wind tunnels, simulation of the detonation of nuclear weapons, and research into nuclear fusion</li> <li>• Molecular modeling (computing the structures and properties of chemical compounds, biological molecules, drugs)</li> <li>• Modelling the spread of the <u>Covid-19</u> and predicting the pandemic peak using mathematical models.</li> </ul>	
Indian Super Computer	<p>Supercomputers are designed and assembled in India by “<u><b>Center of Development for Advance Computing (CDAC)</b></u>”</p> <p><b>Pratyush &amp; Mihir:</b></p> <ul style="list-style-type: none"> <li>• In 2018, India announced the release of India’s fastest supercomputer (As of January 2018), Pratyush, an array of computers that can deliver a <b>peak power of 6.8 petaflops</b> along with another supercomputer, Mihir.</li> <li>• The machines are installed at two government institutes:  <b>4.0 petaflops</b> facility at <b>Indian Institute of Tropical Meteorology (IITM)</b>, Pune  <b>2.8 petaflops</b> facility at the <b>National Centre for Medium Range Weather Forecast</b>, Noida.</li> </ul> <p>Primarily be used for supporting research for “<b>improving weather and climate models</b>”.</p>	

## National Supercomputing Mission

- National Supercomputing mission (NSM), aims to enable various institutes across country with supercomputer infrastructure to aid R&D community for Scientific and Societal applications.
- It was launched in 2015 to enable India to leapfrog to the league of world class computing power nations.
- The Mission is steered jointly by the **Department of Science and Technology** (DST) and **Department of Electronics and Information Technology** (DeitY), and implemented by **Centre for Development of Advanced Computing** (C-DAC) and the **Indian Institute of Science** (IISc), Bangalore.
- C-DAC is responsible to design, develop, deploy and commission of supercomputers under the build approach of Mission.
- The Mission plans to build and **deploy 24 facilities** with cumulative compute power of more than 64 Petaflops. Till now C-DAC has deployed 11 systems at various institutes in India.
- Estimated cost of the mission is **Rs.4500 crore**
- Mission duration : **Seven years.**
- The mission envisages empowering our **national academic and R&D institutions** in the country by installing a vast **supercomputing grid** comprising of more than **73 indigenous super computers**.
- MoUs have been signed with **14 premier institutions** of India for establishing supercomputing infrastructure with assembly and manufacturing in India, including IITs, NITs, National Labs and IISERs.

### Progress:

- In **December 2018**, the government awarded French technology firm “**Atos**” the contract to build over 70 supercomputers.
- **1<sup>st</sup> phase** is completed, **2<sup>nd</sup> phase** was expected to be completed by Sep 2021 and third phase has begun.
- Supercomputing infrastructure has already been installed in more than 10 premier institutions.
- NSM’s first supercomputer named **Param Shivay** has been installed in IIT-BHU, Varanasi, in 2019. It has **837 TeraFlop** High-Performance Computing (HPC) capacity.
- The **second supercomputer, Param Shakti (1.66 PetaFlop)** has been installed at IIT-Kharagpur.
- The **third system, Param Brahma (797 Tera Flop)**, has been installed at IISER-Pune.

- **Param Yukti** (838 Tera Flop) supercomputer at Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore & a 650 teraflops supercomputer at **IIT Hyderabad**.
- **PARAM Sanganak** was set up at **IIT Kanpur** with a peak computing power of 1.3 Petaflops.
- **Param Siddhi:** A high performance computing-artificial intelligence (HPC-AI) supercomputer has been created and installed in C-DAC (**Fastest in India as of Nov 2020 & Ranked 63 in Top 500 in 2020**), with a peak speed of **5.267 petaflops** and **4.6 petaflops** sustained speed. P 4
- **Recently, Param Pravega (3.33 PetaFlop)**, supercomputer installed in January 2022 at IISc-Bangalore. **It is the largest in any Indian academic institution.**
- **Param Ganga** a **1.66 PetaFlop** installed at IIT-Roorkee in March 2022.
- **Param Ananta** Supercomputer was installed at IIT Gandhinagar in May 2022 with a peak performance of **838 Tera Flops**.
- As of now, **15 supercomputers** have been installed across the nation with aggregate computing capacity of **24 petaflops**

Connection used	<ul style="list-style-type: none"> <li>• Trinetta : Connection, inter node communication</li> <li>• Rudra : Server</li> </ul> <ul style="list-style-type: none"> <li>○ The next-generation indigenous HPC interconnect called “<b>Trinatra</b>” has been designed and developed by CDAC for efficient <u>inter-node communication between computer nodes within a cluster</u>.</li> <li>○ India’s first indigenous server platform called ‘<b>Rudra</b>’ is also initiated.. A wide spectrum of sectors, including high performance computing (HPC) systems, hyperscale data centres, edge computing, banking and commerce, oil and gas industry and health care, can benefit from the indigenously built server.</li> <li>○ <b>Note:</b> Server is a computer or system that provides resources, data, services or programs to other computers known as clients, over a network.</li> </ul>
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# ARTIFICIAL INTELLIGENCE

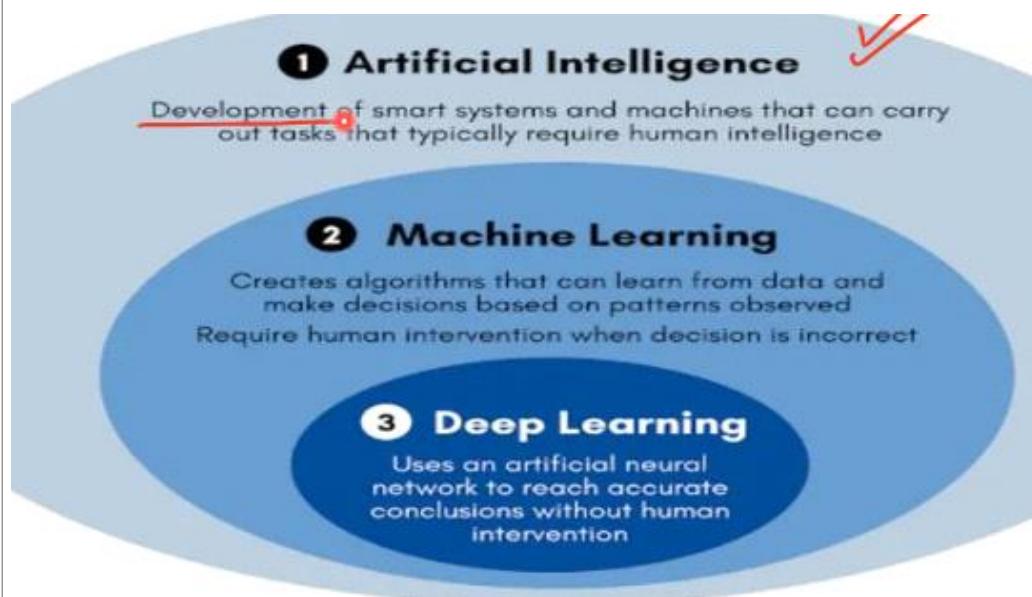
“Ability of machines to perform cognitive tasks like thinking, learning, problem solving and decision making”.

## Machine Learning:

- Without being explicitly programmed, it enables self-learning from data and then applies that learning without the need for human intervention.
- Machine learning finds patterns in data and uses them to make predictions.

## Deep Learning:

- It is a technique for implementing Machine Learning in a much deeper or more sophisticated level.
- It was inspired by the structure and function of the brain, specifically the interconnecting of many neurons. Artificial Neural Networks (ANNs) are algorithms that are based on the biological structure of the brain.



## Neural network:

- An artificial neural network (ANN) is a computing system designed to simulate the way the human brain analyzes and processes information. It is the foundation of artificial intelligence (AI) and solves problems that would prove impossible or difficult by human or statistical standards.
- The basic unit of computation in a neural network is the neuron, often called a node or unit. It receives input from some other nodes, or from an external source and computes an output. Thus, Nodes contain data and can link to other nodes.

Biological Neural Network	Artificial Neural Network
Dendrites	Inputs
Cell nucleus	Nodes
Axon	Output

Machine learning is a subfield of artificial intelligence. Deep learning is a subfield of machine learning, and neural networks make up the backbone of deep learning algorithms. In fact, it is the number of node layers, or depth, of neural networks that distinguishes a single neural network from a deep learning algorithm, which must have more than three.

#### Deepfakes

- Deepfakes are fake digital content in the form of images, videos or audios.
- Deepfakes are created using a technique called generative adversarial networks (GANs), which involve **two competing neural networks: a generator and a discriminator**.
- The generator tries to create fake images or videos that look realistic, while the discriminator tries to distinguish between the real and the fake ones.
- The generator learns from the feedback of the discriminator and improves its output until it can fool the discriminator.
- Deepfakes are a part of **AI-Deep Synthesis**, which uses technologies, including deep learning and augmented reality.
- **Data synthesis:** Synthesising artificial data that can mimic the real-world data
- **AI-Deep Synthesis, also known as deepfake:** is a technology that can generate or manipulate image, audio, or video content that appears realistic but is not authentic.

#### Deepfake Regulation:

- India does not have specific laws or regulations that ban or regulate the use of deepfake technology.
- **The IT Act, 2000 and IT Rules, 2021** stipulate that social media intermediaries are responsible for promptly removing deepfake videos or photos and failure to do so can result in imprisonment for up to three years or a fine of Rs 1 lakh.
- **Rule 3(1)(b)(vii):** This rule mandates social media intermediaries to ensure that users do not host any content impersonating another person.
- **Rule 3(2)(b):** It requires such content to be removed within 24 hours of receiving a complaint against it.
- **Sections 67 and 67A of the Information Technology Act (2000)** have provisions that may be applied to certain aspects of deep fakes, such as defamation and publishing explicit material.
- **According to Section 66D of the IT Act, 2000**, individuals who deceive others by impersonating using a communication device or computer resource can face imprisonment for up to three years and a fine of up to one lakh rupees.

AI Regulation	<ul style="list-style-type: none"> <li>◦ <b>Section 500 of the Indian Penal Code (1860)</b> provides punishment for defamation.</li> <li>◦ <b>The Digital Personal Data Protection Act</b>, provides some protection against the misuse of personal data.</li> <li>◦ In November 2022, the <b>Ministry of Electronics and Information Technology (MeitY) issued its first advisory</b> to social media platforms asking them to identify and remove deepfake videos being circulated online.</li> <li>◦ On December 26th, MeitY released a second advisory targeted specifically at curbing the spread of misinformation through deepfakes. The advisory directs social media platforms to adhere to the Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Rules, 2021. It asks them to make users aware of the ban on publishing fake content under the IT Rules.</li> <li>◦ <b>The Fact Check Unit under PIB</b> was established under IT rules 2021, in November 2019 with a stated objective of acting as a deterrent to creators and disseminators of fake news and misinformation.</li> </ul>
AI in India	<ul style="list-style-type: none"> <li>• <b>In June 2018</b>, the Indian government defined a national policy on AI in a <b>working paper</b> titled, “<b>National Strategy for Artificial Intelligence “AIforAll.”</b></li> <li>• This paper identified <b>five focus areas</b> where AI is envisioned to help fulfilling the societal needs:</li> <li>• <b>Healthcare</b>: increased access &amp; affordability of quality healthcare.</li> <li>• <b>Agriculture</b>: enhanced farmers’ income, increased farm productivity and reduction of wastage.</li> <li>• <b>Education</b>: improved access &amp; quality of education</li> <li>• <b>Smart Cities and Infrastructure</b>: efficient and connectivity for the rapidly growing urban population.</li> <li>• <b>Smart Mobility and Transportation</b>: smarter and safer modes of transportation and better traffic and congestion problems.</li> </ul> <p><b>Challenges:</b></p> <p>There are several barriers that need to be addressed to realize the goal of “AI for all”.</p> <ol style="list-style-type: none"> <li>1. Lack of broad based expertise in research and application of AI</li> <li>2. Absence of enabling data ecosystems – access to intelligent data</li> <li>3. High resource cost and low awareness for adoption of AI</li> <li>4. Privacy and security, including a lack of formal regulations around anonymisation of data</li> <li>5. Absence of collaborative approach to adoption and application of AI.</li> </ol>

- In 2020, Union government has launched a National Program for the youth, “**Responsible AI for Youth**”, aiming at **students from Government schools** to empower the youth to become AI ready and help reduce the skill gap, while finding solutions that can bring in social impact.
- Government also launched “**National Artificial Intelligence (AI) Website**”, a **one stop digital platform** for AI related developments in India, sharing of resources such as articles, startups, investment funds in AI, companies and educational institutions related to AI in India etc.

*+ read more*

On March 7, 2024, the **Union Cabinet approved the IndiaAI Mission** with an outlay of Rs 10,372 crore for the next five years, under which the government will allocate funds towards subsidising private companies looking to set up AI computing capacity in the country, among other things.

### **Challenges:**

There are several barriers that need to be addressed to realize the goal of “AI for all”.

1. Lack of broad based expertise in research and application of AI
2. Absence of enabling data ecosystems – access to intelligent data
3. High resource cost and low awareness for adoption of AI
4. Privacy and security, including a lack of formal regulations around anonymisation of data
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GPAI

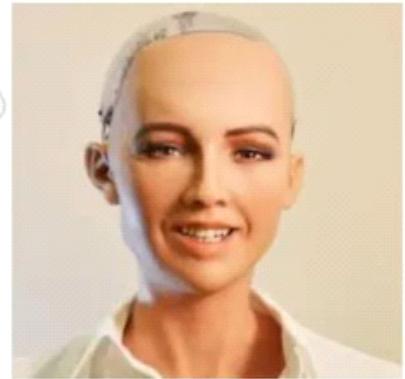
### **The Global Partnership on Artificial Intelligence (GPAI)**

- The Global Partnership on Artificial Intelligence is an **international initiative to promote the responsible use of AI** that supports **human-centric development** and **democratic values**.
- It is a **congregation of 25 member countries**, which along with **India** includes the United States, United Kingdom, European Union, Canada, Australia, Italy, Denmark, and Singapore, among others.
- It is the first of its kind initiative which **aims to bridge the gap between theory and practice on AI** and to **better understand the challenges and opportunities** around AI using the experience and diversity of participating countries.
- **India assumed the chair** of the GPAI for **2022-23** at the meeting of the body in Tokyo in **November 2022**. This signifies how world today perceives India as a trusted technology partner.

ROBOTICS	<ul style="list-style-type: none"> <li>“Robot” is “an electromechanical device” with multiple degrees-of-freedom that is programmable to accomplish a variety of tasks.</li> <li>Robots are of <b>different types</b>.</li> <li><b>Fixed robots</b> are mostly industrial robotic manipulators that work in well-defined environments performing specific repetitive tasks.</li> <li><b>Mobile robots</b> are expected to move around and perform tasks in uncertain environments. They can operate in terrestrial, aquatic, or air with legs or wheels.</li> <li><b>Humanoid robots</b> are professional service robots built to mimic human motion and interaction.</li> </ul>								
Application	<table border="1"> <tbody> <tr> <td> <b>Healthcare</b>            Providing high-quality medical care  <ul style="list-style-type: none"> <li>■ Diagnosis</li> <li>■ Treatment</li> <li>■ Surgery assistance</li> </ul>  </td> <td> <b>Restaurants</b>            Automating end-to-end restaurant service  <ul style="list-style-type: none"> <li>■ Cooking</li> <li>■ Serving</li> <li>■ Bartending</li> </ul>  </td> <td> <b>Hotels and Accommodations</b>            Performing routine customer service tasks  <ul style="list-style-type: none"> <li>■ Reservations</li> <li>■ Concierge</li> <li>■ Housekeeping</li> </ul>  </td> <td> <b>Public Infrastructure</b>            Supplementing security and maintenance personnel  <ul style="list-style-type: none"> <li>■ Surveillance</li> <li>■ Information services</li> <li>■ Cleaning</li> </ul>  </td> </tr> <tr> <td> <b>Retail</b>            Assisting customers and managing inventory  <ul style="list-style-type: none"> <li>■ Point of sale</li> <li>■ Stocking</li> <li>■ Shopping assistance</li> </ul>  </td> <td> <b>Logistics</b>            Enabling self-operating warehousing and shipping systems  <ul style="list-style-type: none"> <li>■ Loading/ unloading</li> <li>■ Picking</li> <li>■ Packing</li> <li>■ Stowing</li> <li>■ Palletizing</li> </ul>  </td> <td> <b>Homes</b>            Working on daily domestic tasks  <ul style="list-style-type: none"> <li>■ Cleaning</li> <li>■ Maintenance</li> <li>■ Cooking</li> </ul>  </td> <td> <b>Space</b>            Conducting unmanned exploration of space  <ul style="list-style-type: none"> <li>■ Research</li> <li>■ Exploration</li> </ul>  </td> </tr> </tbody> </table>	<b>Healthcare</b> Providing high-quality medical care <ul style="list-style-type: none"> <li>■ Diagnosis</li> <li>■ Treatment</li> <li>■ Surgery assistance</li> </ul> 	<b>Restaurants</b> Automating end-to-end restaurant service <ul style="list-style-type: none"> <li>■ Cooking</li> <li>■ Serving</li> <li>■ Bartending</li> </ul> 	<b>Hotels and Accommodations</b> Performing routine customer service tasks <ul style="list-style-type: none"> <li>■ Reservations</li> <li>■ Concierge</li> <li>■ Housekeeping</li> </ul> 	<b>Public Infrastructure</b> Supplementing security and maintenance personnel <ul style="list-style-type: none"> <li>■ Surveillance</li> <li>■ Information services</li> <li>■ Cleaning</li> </ul> 	<b>Retail</b> Assisting customers and managing inventory <ul style="list-style-type: none"> <li>■ Point of sale</li> <li>■ Stocking</li> <li>■ Shopping assistance</li> </ul> 	<b>Logistics</b> Enabling self-operating warehousing and shipping systems <ul style="list-style-type: none"> <li>■ Loading/ unloading</li> <li>■ Picking</li> <li>■ Packing</li> <li>■ Stowing</li> <li>■ Palletizing</li> </ul> 	<b>Homes</b> Working on daily domestic tasks <ul style="list-style-type: none"> <li>■ Cleaning</li> <li>■ Maintenance</li> <li>■ Cooking</li> </ul> 	<b>Space</b> Conducting unmanned exploration of space <ul style="list-style-type: none"> <li>■ Research</li> <li>■ Exploration</li> </ul> 
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## Sophia

- Developed by "**Hanson Robotics**" (Hong Kong), lead by AI developer **David Hanson** (2016).
- Through "**Artificial Intelligence**", it has developed to hold eye contact, recognize faces and understand human speech.
- It is able to answer certain questions and to make simple conversations on predefined topics.
- Sophia became **first humanoid robot** to become a **full citizen of a country** (Saudi Arabia).



## Vyommitra

- A "half-humanoid" being developed by the ISRO
- prototype for a half-humanoid that will eventually fly to space on an unmanned mission later this year. This will serve as a test of ISRO's preparedness for its manned mission Gaganyaan.
- It is built to mimic crew activity inside the crew module of Gaganyaan.
- It can attain launch and orbital postures, responding to the environment, generating warnings, operating switches, monitoring of the crew module, receiving voice commands, responding via speech (bilingual).



## **FEDOR was first humanoid robot to be sent to space by Russia in 2019.**

The robot's main purpose is to be used in operations that are especially dangerous for humans onboard spacecraft and in outer space.

## Robonaut 2:

- Developed by NASA.
- It's a humanoid sent to the international space station in 2011 to help astronauts with various tasks. It can grasp objects, flip switches and high-five crew members after successfully performing tasks.
- Can take over simple, repetitive, or especially dangerous tasks.

## Bandicoot

Developed by “Genrobotic Innovations” from Kerala, a spider-shaped robot to “clean sewers and manholes” been deployed in Kerala, Tamil Nadu, Andhra Pradesh, Telangana, Gujarat, and Haryana.



## During Covid-19

- Robots are in demand during this contagious disease outbreak- globally, they are being used in sample collection, patient monitoring, performing cleaning services in hospitals.
- **Maitri**, a robot developed by a Vijayawada based firm of Andhra Pradesh, is being used to serve food, water and medicines in hospitals.
- **Drones** are being used to decontaminate the containment zones by spraying chemicals, rush test samples to laboratories, and monitoring the implementation of quarantine measures.

Robotics in India	<ul style="list-style-type: none"><li>• Enterprises are increasingly turning to robots to save manpower and cost.</li><li>• The adoption of robots has been <b>slow in India</b>.</li><li>• <b>2021 statistics</b> show that India has only <b>4 robots for every 10,000 workers (called 'robot density')</b> while the <b>global average is 126</b>.</li><li>• <b>South Korea</b> has the <b>highest robot density</b> of 932, with Singapore, Japan, Germany following it. USA (255) is in 7th and China in 9th (246) positions.</li><li>• With more firms <b>investing in digitization</b>, the levels are set to increase in India.</li><li>• Sales of industrial robots in India reached a new record of <b>4,771 new units</b> installed in 2018, an <b>increase of 39 percent</b> compared to the previous year (2017: 3,412 units), as per “<b>International Federation of Robotics (IFR)</b>” report published in October, <b>2019</b>.</li><li>• While the <b>automotive industry</b> has seen the highest adoption, the demand for robots is growing in general industry as well.</li></ul>
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- A “Blockchain” is a digital, distributed transaction ledger, with identical copies maintained on multiple computer systems controlled by different entities.
- Satoshi Nakamoto, a pseudonymous person or persons developed **digital cryptocurrency**, **bitcoin**, and authored the bitcoin white paper, (A **white paper** is a report or guide that informs readers concisely about a complex issue) using block chain technology.
- Nakamoto was the first to solve the double-spending problem for digital currency using this peer-to-peer network.
- To this decentralized database, new information is added in the form of a “block.”
- This new block is linked to a “chain” of previously created blocks.
- Each block contains some data, a unique ID called hash and the hash of the previous block.
- Data in the block depends on the type of blockchain. E.g., in Bitcoin block chain contains information like sender, receiver and the number coins.
- Changing some thing in the block changes its hash which makes all the next blocks in the chain invalid.
- The chance of changing the hashes of all next blocks is minimised by “proof of work”, a mechanism where a mathematical puzzle to be solved for adding each new block, slows down the creation of new blocks.
- Thus, It would require **massive amounts of computing power** to access every block of a certain blockchain and alter them all at the same time.
- Because they aren’t stored in a central location, blockchains don’t have a single point of failure.

**Cryptocurrencies**

- “Virtual/ Digital currencies, like Bitcoin, use blockchain technology platform.
- It allows cryptocurrencies to operate without the need for a central authority.
- Reduces the risk and eliminates processing/transaction fees.
- It also bypasses govt control over currency

**Voting**

- Citizens can cast votes the same way they initiate other secure transactions and validate that their votes were cast—or even verify the election results.

	<p><b>In banking sector</b></p> <ul style="list-style-type: none"> <li>It can provide wide range of benefits, including lower costs, fewer errors and frauds.</li> </ul> <p><b>Healthcare</b></p> <ul style="list-style-type: none"> <li>Secure transfer of patient database (medical records), prescriptions, and medicine supply chain management can happen through blockchain technology.</li> </ul> <p><b>Land registrations</b></p> <ul style="list-style-type: none"> <li>By securing a unique and non-corruptible record on a blockchain and validating changes to the status of that record across owners, a reliable land record can be created.</li> </ul>
NFT	<ul style="list-style-type: none"> <li><b>NFT : Non Fungible tokens (Non Exchangeable Tokens)</b> <ul style="list-style-type: none"> <li><b>Non-fungible tokens (NFTs)</b> are cryptographic assets on a <b>blockchain</b> with unique identification codes and metadata (Data about data E.g., Metadata for a music file might include the artist's name, the album, and the year it was released) that distinguish them from each other. They cannot be replicated.</li> <li>NFTs can represent real-world items like artwork and real estate.</li> <li>NFTs are ideal for creating <b>digital version</b> of collectibles like art, real estate identities etc.</li> <li>"<b>Tokenizing</b>" / <b>Digitising</b> these real-world tangible assets makes buying, selling, and trading them more efficient while reducing the probability of fraud.</li> <li>NFTs can also function to represent individuals' identities, property rights, and more.</li> <li>Unlike <b>cryptocurrencies</b>, they cannot be traded or exchanged at equivalency. This differs from <b>fungible tokens like cryptocurrencies</b>, which are identical to each other and, therefore, can serve as a medium for commercial transactions.</li> </ul> </li> </ul>

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## Challenges & Issues

- Lack of awareness of the technology.
- Resistance to change from traditional/centralized methods and the loss of control can be deeply unsettling.
- For Bitcoin total running costs associated with validating and sharing transactions on the public ledger are estimated to be as much as \$600 million a year.
- Due to their complexity and their encrypted, distributed nature, blockchain transactions can take a while to process.
- Privacy and the security of the data stored and accessible on the shared ledger.
- Scalability is an issue for public blockchains like bitcoin that are enormously growing.
- Large Computational power/power consumption.
- Lack of regulation.

# L20 Internet, 5G, 6G

16 November 2024 02:59 PM

INTERNET	<b>THE EVOLUTION OF THE INTERNET (WEB 1 TO WEB 5)</b>																
	<p>The Block Head (TBH), Dorsey's Bitcoin business division, is working on Web 5.0, which aims to create an additional decentralised web that places people in charge of their data and identity.</p> <table border="1"><thead><tr><th>Web 1.0</th><th>Web 2.0</th><th>Web 3.0</th><th>Web 5.0</th></tr></thead><tbody><tr><td>Read Only</td><td>Read and Write</td><td>Read, Write and Own</td><td>Read, Write and Own</td></tr><tr><td>Static</td><td>Centralized</td><td>Decentralized</td><td>Decentralized</td></tr><tr><td>onymous</td><td>onymous</td><td>Anonymous</td><td>onymous</td></tr></tbody></table>	Web 1.0	Web 2.0	Web 3.0	Web 5.0	Read Only	Read and Write	Read, Write and Own	Read, Write and Own	Static	Centralized	Decentralized	Decentralized	onymous	onymous	Anonymous	onymous
Web 1.0	Web 2.0	Web 3.0	Web 5.0														
Read Only	Read and Write	Read, Write and Own	Read, Write and Own														
Static	Centralized	Decentralized	Decentralized														
onymous	onymous	Anonymous	onymous														
	<p><b>(i) Web 1.0 (1989 – 2005)</b></p> <ul style="list-style-type: none"><li>• Web 1.0 is the first generation of the internet referred to as the “read-only” or “static” web.</li><li>• Users could not interact with the website; they could only read its content.</li></ul> <p><b>(ii) Web 2.0 (2004-to-date)</b></p> <ul style="list-style-type: none"><li>• It is regarded as the social web or the read-and-write web.</li><li>• Facebook, Google, Twitter, WordPress, and Instagram are all Web 2.0 applications.</li><li>• On Web 2.0, users had identities. However, the issue with Web2 is <b>“centralization.”</b></li><li>• These companies collect users’ data and sell it for targeted advertisements, enriching only themselves and without the users’ consent.</li></ul> <p><b>(iii) Web 3.0 (2021-to-date)</b> ↗</p> <ul style="list-style-type: none"><li>• The third generation of the web, known as Web 3.0, strongly emphasizes decentralization.</li><li>• It enables users to not only read and write but also become owners of the internet through cryptocurrencies.</li><li>• Web 3 keeps users’ identities anonymous.</li><li>• It allows users to control their data, thus eliminating the centralization and exploitation of data.</li></ul> <p><b>(iv) Web 5.0 (2022)</b></p> <ul style="list-style-type: none"><li>• Web 5.0 aims to improve upon Web 2.0 and Web 3.0.</li><li>• <b>Web2+ Web3= Web5</b></li><li>• In Web 2.0 users have an identity that is managed by an authority.</li><li>• And in Web 3.0, users access decentralized platforms where they are anonymous and own their data.</li><li>• Web 5.0, on the other hand, will give users identities and allow them to access decentralized platforms where they have total control of their data.</li></ul>																
Virtual Reality	<ul style="list-style-type: none"><li>• Virtual reality (VR) refers to a computer-generated simulation in which a person can interact within an artificial three-dimensional environment using electronic devices, such as special goggles with a screen or haptic gloves fitted with sensors. In this simulated artificial environment, the user can have a realistic-feeling or experience.</li></ul>																

- Software creates **virtual worlds** that are experienced by users through devices such as **goggles, headphones, and special gloves**.
- Together, the user can view and interact with the virtual world as if it is real.

### **Applications**

- Virtual reality has several applications, most common one being in entertainment and gaming, also in developing tools for sales, education, and training.

### **Education**

- VR can be used in schools for adapting education through virtual experience of the situations.
- They can also be taken on virtual field trips, for example, to museums, taking tours of the solar system and going back in time to different eras.
- VR can also be particularly beneficial for students with special needs, such as autism.

### **Medical:**

- Due to its interactive nature, medical and dental students have begun using VR to practice surgeries and procedures. Immersive touch through haptic gloves gives them a hands on experience.
- It allows for **a consequence free learning** environment, inflicting harm while practicing on real patients is eliminated.

### **Sports:**

- Virtual reality can be used by coaches and players to train more efficiently across a range of sports, as they are able to watch and experience certain situations repeatedly and can improve each time.

### **Military:**

- The military uses it for **flight simulations, battlefield simulations, vehicle simulation and virtual boot camp**, among other things.
- VR is a **completely immersive, visual and sound-based experience**, which can safely **replicate dangerous training situations** to prepare and train soldiers, without putting them at risk until they are ready for combat.

Augmented Reality	<ul style="list-style-type: none"> <li>• AR : Superimposition of computer-generated images on existing environments" to make them more realistic.</li> </ul> <p><b>In medicine:</b> Helps in generating more realistic imaging of organs, tumors etc, for improved accuracy in surgeries.</p> <p><b>Military use:</b> The <b>Heads-Up Display (HUD)</b> is the typical example of augmented reality when it comes to military applications of the technology. A transparent display is positioned directly in the fighter pilot's view. Data typically displayed to the pilot includes altitude, airspeed and the horizon line in addition to other critical data.</p>
Metaverse	<ul style="list-style-type: none"> <li>• AR + VR + Block Chain ( Crypto + NFTs)</li> <li>• "Metaverse" became a buzzword after Facebook changed its name to "Meta" in October 2021.</li> <li>• The metaverse, is originally conceived by the American writer, Neil Stephenson (1992) in his science fiction novel "Snow Crash".</li> <li>• It refers to a virtual world where people can socialize, work, and play.</li> </ul> <p>• A super-platform convenes sub- platform: social media, online video ease-of-life apps, all games,</p>

accessible through the same digital space and sharing the same digital economy.

- The idea is to create a more Immersive internet, in which technologies like AR and VR are used to spend our time engaging in virtual spaces and experiences rather than the physical world.
- It requires collaborative efforts by multiple stakeholders.
- It is projected to be the future of the internet, although timelines are unclear.

## JPMORGAN - THE FIRST BANK IN METAVERSE

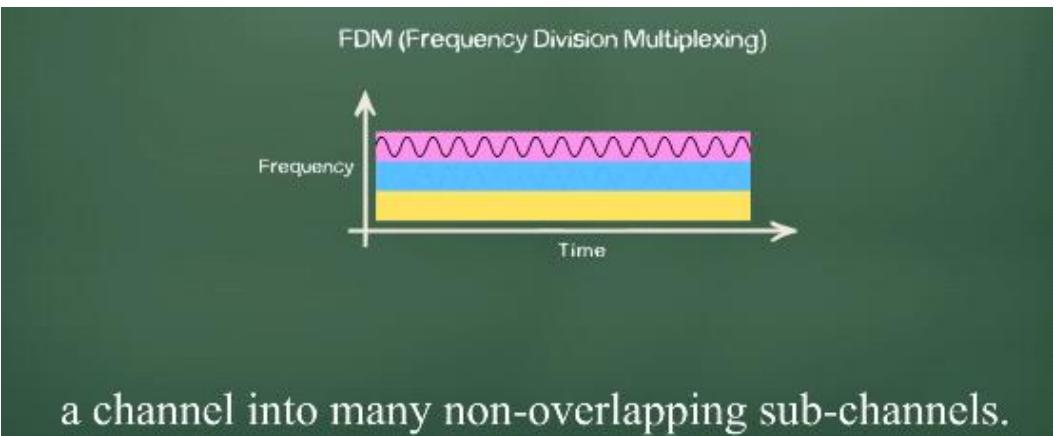
- JPMorgan is the world's first bank to set up shop in the **Metaverse**.
- The largest bank in the US has opened a lounge in the blockchain-based world **Decentraland** (**virtual destination for digital assets backed by Ethereum blockchain**).
- Users can create their virtual avatars, build virtual spaces and roam in the lounge christened '**Onyx Lounge**'.
- The lounge also features a digital image of the bank's **CEO Jamie Dimon**.
- Metaverse marketplaces combine the capabilities of Virtual reality, Blockchain and **NFT (Non-Fungible Tokens)** – units of data on blockchain like photos, videos associated with digital files)
- In the economics of the metaverse (Called '**metanomics**') — there are opportunities in almost every market area like virtual Shopping, private clubs and Real estate and more.
- In January 2022, Samsung opened a version of its New York store in Decentraland, and in November 2021, Barbados established a metaverse embassy.
- Metaverse real estate is a booming market and digital plots of land continue to remain highly sought after.

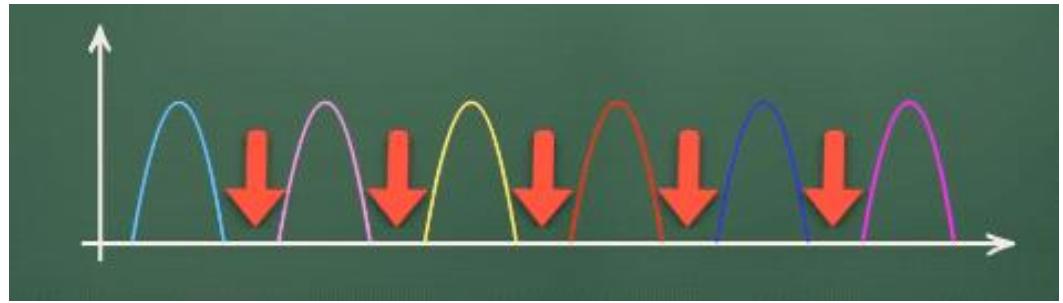
Communication Technology	1991 	1998 	2008 	2020? 
		 Internet access	 Internet access 	 Internet access  Ultra HD & 3-D video  Smart home
	<b>2G Frequencies</b>	<b>3G Frequencies</b>	<b>4G Frequencies</b>	<b>5G Frequencies</b>
	GSM 2G Upto 1.9 Ghz	HSDPA 3G Upto 2.1 Ghz	LTE 4G Upto 2.5 Ghz	IoT 5G Upto 95 Ghz

- 5G is a fifth-generation communication technology.
- With its new Radio interface, along with other new technologies, that utilizes much **higher radio frequencies** to transfer exponentially more data.

	<b>4G</b>	<b>5G</b>
<b>Theoretical maximum Speed</b>	1 Gbps	Up to 20 Gbps
<b>Latency (Response time)</b>	50 milli second	1 milli second

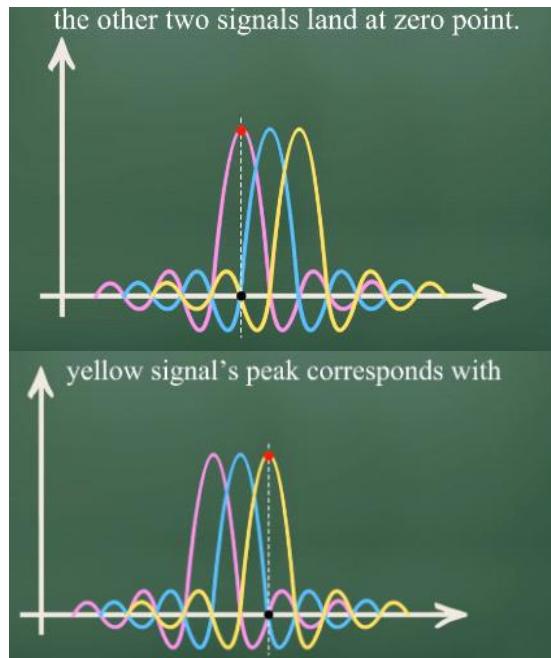
- 5G uses **millimetre wave spectrum**, {Milli meter waves are electromagnetic (Radio) waves. Millimeter wave spectrum is the band of spectrum between 30 GHz and 300 GHz. Wedged between microwaves and infrared waves, this spectrum can be used for high-speed wireless communications} - 2.5 gigahertz (GHz) for 4G LTE Pro and 3.5GHz to tens of gigahertz into the millimeter wave (mmWave) spectrum for 5G
- 4G is reaching **the technical limits** of how much data it can quickly transfer,” 5G can eliminate this congestion problem &
- Like 4G LTE, 5G is also “Orthogonal frequency-division multiplexing (OFDM) and will use the same mobile networking principles. However, 5G interface will further enhance OFDM to deliver a much higher degree of flexibility and scalability.
- **OFDM:** Multiplexing the signals in a way that the peak of one signal is at the null of the other signal, allowing more data transmissions in a particular band width. At the receiving end the demultiplexer would separate them.
- This enables **more devices to be used within the same geographic area**.
- While 4G can support about **4,000 devices per square kilometre**, 5G will support around one million/ Sq Km.
- 5G uses Milli meter wave spectrum : 30 GHz to 300 GHz

5G Importance	<ul style="list-style-type: none"> <li>• High Frequency RW (MM waves) -&gt; High Speed</li> <li>• More Bandwidth</li> <li>• OFM : No overlap</li> <li>• Network Slicing : No wastage of spectrum</li> <li>• Massive MIMO : More connection from one cell phone tower</li> </ul>
Frequency Division Multiplexing	<p>• FDM :</p>  <p>a channel into many non-overlapping sub-channels.</p>



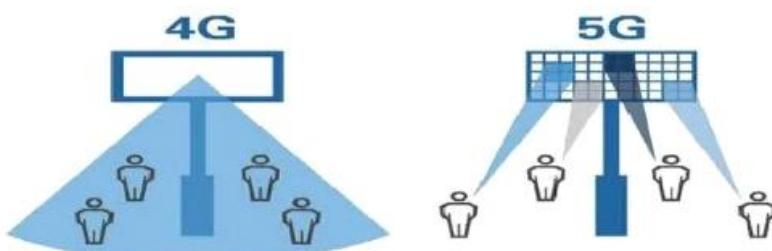
- OFDM : orthogonal FDM

- OFDM is a very popular multiplexing method used for many of the latest wireless and telecommunication standards
- Peak of signal comes at zero of other signal



#### Network Slicing

- “**Network slicing**” is a network architecture that enables the multiplexing of independent virtual networks on same physical network infrastructure to provide different amounts of resources to different types of traffic. It allows only the functions necessary to support particular customers and particular market segments.
- **Ericsson 5G RAN slicing** is designed to secure dynamic radio source allocation and prioritisation for different slices.

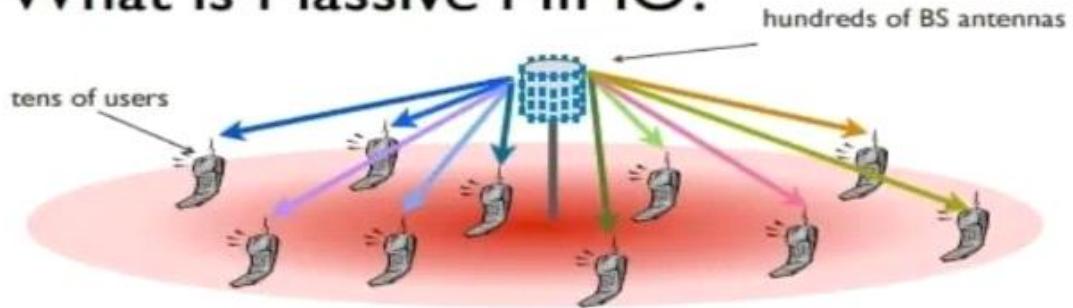


#### MIMO

- MIMO : Multiple input and Multiple output
- By using large number of antenna element

- 5G also uses a new digital technology called **Massive MIMO** (multiple input multiple output), improving coverage, speed and capacity.
- 5G uses ‘massive’ MIMO (multiple input, multiple output) antennas that have very large numbers of antenna elements or connections to send and receive more data simultaneously.
- **Each antenna panel at cell towers contains hundreds of antennas.**
- Every modern mobile device has two or more cellular antennas onboard to enable the magic of MIMO.

## What is Massive MIMO?



- A very large antenna array at each base station
- An order of magnitude more antenna elements in conventional systems
- A large number of users are served simultaneously
- An **excess** of base station (BS) antennas

### 5G Application

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#### 5G - Applications

The primary use of the technology will go beyond **delivery of services on personal mobiles** devices such as faster streaming/download speeds. Expected to form the backbone of emerging technologies such as the Internet of Things (IoT) and machine to machine communications, thereby supporting a much larger range of applications and services, including

- Tele/robotic surgery and
- AR/VR applications
- Smart city and smart transport infrastructure
- Implementation of sensor-embedded network that will allow real time relay of information across fields such as manufacturing, consumer durables and agriculture.
- Enable driverless cars
- Real time data analytics.

With 5G, it is possible to have many more devices working, reliably, securely and uninterrupted in the same area.

## 5G Launch in India

- 5G services was launched by Prime Minister Narendra Modi on **October 1st 2022**, during the 6th edition of India Mobile Congress (IMC), after being postponed for 2 years.
- **South Korea, USA and China** were ahead of other countries in launching 5G commercially and over 70 countries have already launched 5G as of mid 2022.
- 5G services are going to be available in various Indian cities in phase wise manner.
- **Jio emerged as the top bidder** in India's **5G spectrum auction in July 2022**, acquiring **24,740 MHz of spectrum (out of the 72,098 MHz of spectrum offered across 10 bands)** worth **Rs 88,078 crore**. It took the most expensive 700MHz band that can provide 6-10 km of signal range and forms a good base for 5G in all telecom 22 circles in the country. A single tower can cover more area if 700MHz is used.
- **Airtel was the second-highest bidder** with 19,867 MHz of spectrum in various bands worth Rs 43,084 crore.
- Vodafone and Adani group stood third and fourth in the auction.

]

## 6G TECHNOLOGY

In telecommunications, 6G is the sixth-generation standard currently under development for wireless communications technologies supporting cellular data networks. It is the planned successor to 5G and will likely be significantly faster.

### **Key features of 6G technology:**

- 1. Speed and sensitivity to obstacles:** Terahertz radiation (0.3 THz to 3 THz) and millimeter waves (30 to 300 GHz) are much shorter than the waves used by 5G thus, they can carry the data faster. However, they are much more sensitive to obstacles than the microwave frequencies (about 2 to 30 GHz) used in 5G and Wi-Fi, which are more sensitive than the radio waves used in 1G, 2G, 3G and 4G.
- 2. Multiband ultrafast speed transmission.**
- 3. Band width:** Band width is the width of the frequency band (Highest frequency – lowest frequency) more band width in 6G (95GH – 3 TH) would allow for spectacular data rates. 6G is expected to give a speed of 1 Terabyte of data per second (1TBPS) while 5G delivers 10 - 20 gigabytes of data per second (10 – 20 GBPS).
4. Latency: latency of one-microsecond in 6G while 5G is 1 millisecond latency

**5. Extreme Massive MIMO:** In 2022, Indian Institute of Technology Hyderabad (IITH) announced a demonstration of the Extreme Massive MIMO (Multiple-Input Multiple-Output), a technology that is being considered for 5G-advanced and 6G deployment. Extreme massive MIMO refers to next-generation technology that uses very large antenna arrays. This is expected to show a 3-fold improvement over the state-of-the art 5G massive MIMO technology.

**6. “Network slicing”** is a network architecture that enables the multiplexing of independent virtual networks on same physical network infrastructure to provide different amounts of resources to different types of traffic. It allows only the functions necessary to support particular customers and particular market segments.

**7. Use of Artificial Intelligence:** AI will be used to improve the performance of 6G networks by dynamic radio source allocation and prioritisation for different slices. This not only leads to economic use of band width but also to energy efficient communication.

**8. Security:** AI-driven algorithms can continuously learn and adapt to new threats, ensuring the network's resilience against evolving cyber-attacks.

9. 6G communication includes **OWC (Optical wireless communication)** and **Lifi (Light fidelity)**

Spectrum	<p>The diagram illustrates the Electromagnetic Spectrum and the 6G Spectrum. The spectrum ranges from Non-ionising radiation (700 MHz to 300 GHz) to Ionising radiation. Key frequency bands include 2.4 GHz, 2.6 GHz, 3.4 - 3.8 GHz, 5 GHz, 26 GHz, 40 GHz, 66 GHz, 95 GHz, 430-750 THz, 30 PHz, 3 EHertz, and 300 EHertz. The 6G experimental spectrum is highlighted between 95GHz and 300 GHz. Below the spectrum, icons represent various applications: Terrestrial TV, 2.4 GHz wifi, Existing mobile airwaves (2G 3G 4G), Current and planned 5G airwaves, 5 GHz wifi, Possible future 5G airwaves, Visible light, Ultraviolet, X-rays, and Gamma rays. A note states: "Radio frequencies needed for common household items to work, from televisions to microwave ovens (usually between 300 and 3000GHz), produce radiation which is classified as non-ionising. This means that it does not have sufficient energy to break chemical bonds or remove electrons, as opposed to ionising radiation, which occurs at much higher frequencies and is generally considered to be hazardous to humans. (Source: International Commission for Non-Ionizing Radiation Protection (ICNIRP))". A Hertz (Hz) key provides conversions: kHz = <math>10^3</math> Hz, MHz = <math>10^6</math> Hz, GHz = <math>10^9</math> Hz, THz = terahertz = <math>10^{12}</math> Hz, PHz = petahertz = <math>10^{15}</math> Hz, GHZ = gigahertz = <math>10^9</math> Hz, EHZ = exahertz = <math>10^{18}</math> Hz.</p>
Application of 6G	<p><b>1. Healthcare:</b></p> <ul style="list-style-type: none"> <li>• Robotic surgeries, conducting surgeries in remote areas through video conference with specialists.</li> <li>• Fully AI-enabled ambulances that are connected to the other medical infrastructure.</li> <li>• Wearable health devices, providing continuous, real-time monitoring and data analysis for personalized healthcare.</li> <li>• The vast data rates of 6G will support the massive data requirements of genomic sequencing, biometric analysis, and other research areas, driving forward medical science at unprecedented speeds.</li> </ul> <p><b>2. Agriculture:</b> It would help create an intelligent predictive system using IoT and AI/ML approaches to anticipate yield, irrigation schedule, pesticide schedule, and crop health information.</p> <p><b>3. Transportation/Air Mobility:</b> For Urban Air Mobility (UAM), 6G will be necessary. These electric vertical take-offs and landing (eVTOL) would be extremely useful in peak hour traffic &amp; for drones.</p> <p><b>4. Education:</b> 6G could be used to transform education by allowing students to interact with virtual teachers and classmates, virtual tours to museums, historic places, solar system etc., through AR, VR &amp; metaverse and access high-quality educational resources from anywhere in the world.</p> <p><b>5. Advanced technologies:</b> 6G network helps in advanced technologies like Edge computing, IOT, Smart cities, High performance computing &amp; big data analysis.</p> <p><b>6. Space exploration:</b> 6G aims to seamlessly integrate satellite networks, enhancing global connectivity and enabling better management of flying objects in space and high-altitude platforms. 6G could be used to enable new space exploration applications, such as real-time control of space robots and vehicles, and high-resolution imaging of distant planets and stars.</p>

## unacademy INDIA'S VISION TO BE A FRONT-LINE CONTRIBUTOR IN DEVELOPMENT OF 'IMT 2030'

**International Telecommunication Union (ITU)**, the specialised agency for Information and Communication Technologies of United Nations has approved the 6G Vision Framework. India, through Department of Telecommunications, Ministry of Communications played a key role in framing the Framework.

Prime Minister had released India's 6G Vision "**Bharat 6G Vision**" document on March 23, 2023, which envisages India to be a front-line contributor in design, development and deployment of 6G technology by 2030.

The 6th Generation or 6G Technology has been named '**IMT 2030**' (International Mobile Telecommunications) by ITU.

India has recently secured more than 127 patents on 6G from global institutions.

### **BHARAT 6G PROJECT:**

India is gearing up to roll out high-speed 6G communication services by 2030 and has set up a **Bharat 6G project** to identify and fund research and deployment of the next-generation technology in the country, according to a vision document unveiled by the Prime Minister.

- While, technically, 6G does not exist today, it has been conceived as a far superior technology promising internet speeds up to 100 times faster than 5G.
- In order to facilitate coordination between excavation agencies and the owners of underground utilities and prevent damage to utilities as a result of digging, the government has also released the "Call Before You Dig (CBuD)" app.
- India's 6G project will be implemented in two phases, the first one from 2023 to 2025 and the second one from 2025 to 2030.
- The government has also established an apex council to oversee the project and concentrate on matters like standardization, identifying the spectrum for 6G usage, developing an ecosystem for gadgets and systems, and determining funding for R&D, among other things.
- New technologies like terahertz communication, radio interfaces, tactile internet (Low latency, high reliability, and high security internet) artificial intelligence, new encoding techniques, will be a major area of focus for the council.

# L21 Quantum Computing, Cloud

17 November 2024 12:50 AM

QUANTUM COMPUTERS	<ul style="list-style-type: none"><li>• Uses Magnetic Field and direction of electron magnetic field as bits of modern computer</li><li>• 0 : Aligned e- 1 : Unaligned e-</li><li>• Classical computer : 0001101011101 Quantum Computer : <math>\uparrow \downarrow \uparrow \uparrow \uparrow \downarrow \downarrow \downarrow \uparrow \downarrow</math></li></ul> <p><b>Quantum:</b> Smallest possible discrete unit of any physical property such as energy or matter.</p> <p>✓ Quantum computers uses qubits instead of classical bits, 0&amp;1</p> <ul style="list-style-type: none"><li>• <b>Qubits</b> can be 0&amp;1 at the same time <math>\rightarrow</math></li><li>• There are several physical objects that can be used as qubits. E.g., <b>A single photon, an electron or a nucleus.</b></li><li>• Electrons have magnetic field; they are like tiny bar magnets. When we place them in a magnetic field, they will align with the magnetic field just like the needle of the compass aligns with the earth's magnetic field. This is the lowest energy state. (Spin down = let's compare it to classical bit 0)</li><li>• They can also align in a position exactly against the magnetic field. This is highest energy state. (Spin up = like classical bit 1)</li><li>• The quantum objects can be in both states at once called quantum superposition.</li><li>• It is giving up the precise values 0 &amp; 1 and allowing some uncertainty.</li><li>• A classical bit is 1 or 0 like heads/tails, but qubits exist in a fluid nonbinary identity. They can exist in a super position with some probability of being heads or tails.</li></ul> <ul style="list-style-type: none"><li>• In Quantum, Qubits can be <math>\uparrow</math>, <math>\downarrow</math> and <math>\uparrow \downarrow</math> (neither down nor up)<ul style="list-style-type: none"><li>• <b>Quantum Super Position</b> : Condition of uncertainty,</li><li>• Has probability of attaining a particular direction</li><li>• In quantum we have unlimited possibilities of probability.</li></ul></li><li>• Advantage :<ul style="list-style-type: none"><li>• Super computer can generate a password (Quantum Key) that no one can guess</li><li>• Quantum Key Distribution :<ul style="list-style-type: none"><li>○ Key generated by quantum computer -&gt; distributed among the parties</li><li>○ If others try to hack or guess the QC can make it wrong</li></ul></li></ul></li></ul>
Application	<p><b>Applications:</b></p> <ul style="list-style-type: none"><li>• Quantum uncertainty can be used to create private keys / security codes for encrypting messages sent from one location to another. Hackers cannot copy the key perfectly due to the quantum uncertainty.</li><li>• Health care and medicine. The design and analysis of molecules for drug development is challenging because exactly describing and calculating all the quantum properties of all atoms in the molecules is computationally difficult even for a supercomputer but a quantum computer can do it better as it operates using the same quantum properties as the molecule it is trying to simulate. Thus, quantum computers are more efficient in modelling biochemicals and biochemical reactions.</li></ul>
Teleportation	<ul style="list-style-type: none"><li>• Quantum Entanglement : Quantum particles (Electron) re connected together</li><li>• Can be used for Quantum Internet</li></ul>

 **Teleportation** of information without physically transmitting information. Scientists confirmed that the information could be passed between photons on computer chips even when the photons were not physically linked. Quantum particles can get entangled across space and time in such a way that when we change something about one particle, it can impact the other particle. This creates a channel for teleportation. Scientists are trying for quantum internet.

- **Albert Einstein** said that quantum mechanics should allow two objects to affect each other's behavior instantly across vast distances, He called it **"Spooky action at a distance"**
- They have the potential to **process exponentially more data** compared to classical computers.
- Such algorithms would be useful in **solving complex mathematical problems or** predicting multiple particle interactions in **chemical reactions**.

#### Comparison

##### **Comparison with regular computers:**

- Quantum computers are not comparable to regular computers. They work on different principles.
- Quantum computers are not faster or better than super computers in all matters, but they are particularly efficient in certain complex tasks.
- Quantum computers do exceptionally well in problems that require calculation of probabilities of many possible different combinations.
- Regular browsing or simple calculations may be even faster on a regular computer than a quantum computer.

## Issues & Challenges

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- Not everybody is convinced that quantum computers are worth the effort.
- Some mathematicians believe there are **obstacles that are practically impossible** to overcome, putting quantum computing forever out of reach.
- Some companies, such as IBM and Google, claim we might be close, as they continue to cram more qubits together and build more accurate devices.
- Quantum research in India is “solid on the theoretical side, but we **need to build infrastructure and experimental facilities**”

## National Mission on Quantum Computing

- With an aim to spearhead scientific breakthroughs and boost quantum technology-led economic growth, India, in the **Budget 2020-21** has announced a “**National Mission on Quantum Technologies and Applications**”
- Allocated a budget of **Rs. 8000 cr** for a period of **5 years**.
- It is to be implemented by the **Department of Science and Technology**.

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### India's first Quantum Computer Simulator toolkit launched

- In August 2021, the Ministry of Electronics and Information Technology (MeitY), launched the country's first ‘Quantum Computer Simulator (QSim) Toolkit’.
- Quantum simulators are software programs that run on classical computers.
- QSim is a first-of-its-kind toolkit to be indigenously developed and is intended to be a vital tool in learning and understanding the practical aspects of programming using Quantum Computers.
- It is a collaborative initiative brought together by **IISc Bangalore, IIT - Roorkee and C-DAC** to address the challenges of advancing the Quantum Computing research in India.
- QSim assists researchers in doing necessary experiments to run on actual Quantum Hardware.

### UNION CABINET GIVES NOD FOR ₹6,003 CRORE QUANTUM MISSION

- Recently, the union cabinet chaired by the Prime Minister has approved the National Quantum Mission (NQM) to aid scientific and industrial research and development in quantum technology.

#### National Quantum Mission:

- It'll be implemented by the **Department of Science & Technology (DST)** under the **Ministry of Science & Technology**.
- The **mission planned for 2023-2031** aims to seed, nurture, and scale up scientific and industrial R&D and create a vibrant & innovative ecosystem in Quantum Technology (QT).
- With the launch of this mission, **India will be the seventh country to have a dedicated quantum mission** after the US, Austria, Finland, France, Canada and China.

	<p><b>Features of NQM:</b></p> <ul style="list-style-type: none"> <li>• It will target developing intermediate scale quantum computers with 50-100 physical qubits in 5 years and 50-1000 physical qubits in 8 years.</li> <li>• The mission will help develop magnetometers with high sensitivity for precision timing (atomic clocks), communications, and navigation.</li> <li>• It will also support design and synthesis of quantum materials such as superconductors, novel semiconductor structures and topological materials for fabrication of quantum devices.</li> <li>• The mission will help in developing Satellite based secure quantum communications between ground stations over a range of 2000 km within India.</li> <li>• Long distance secure quantum communications with other countries.</li> <li>• Inter-city quantum key distribution over 2000 km.</li> <li>• Multi-node Quantum network with quantum memories</li> </ul>
Steps for QC development	<ul style="list-style-type: none"> <li>• Four Thematic Hubs (T-Hubs) would be set up in top academic and National R&amp;D institutes on the domains of Quantum Technology: <ul style="list-style-type: none"> <li>◦ Quantum computation</li> <li>◦ Quantum communication</li> <li>◦ Quantum Sensing &amp; Metrology</li> <li>◦ Quantum Materials &amp; Devices</li> </ul> </li> </ul> <p><b>Significance:</b></p> <ul style="list-style-type: none"> <li>• This will accelerate QT led economic growth and make India one of the leading nations in the development of Quantum Technologies &amp; Applications (QTA) ranging from healthcare and diagnostics, defense, energy and data security.</li> <li>• It will work towards indigenously building quantum-based computers which are far more powerful and are able to solve the most complex problems in a highly secure manner.</li> </ul> <p><b>Quantum Technology:</b></p> <ul style="list-style-type: none"> <li>• Quantum technology is a field of science and engineering that deals with the principles of quantum mechanics, which is the study of the behavior of matter and energy at the smallest scale.</li> <li>• Quantum mechanics is the branch of physics that describes the behavior of matter and energy at the atomic and subatomic level.</li> </ul> <p><b>Quantum key distribution:</b></p> <ul style="list-style-type: none"> <li>• QKD, also called <b>Quantum Cryptography</b>, is a mechanism to develop secure communication.</li> <li>• It provides a way of distributing and sharing secret keys that are necessary for cryptographic protocols.</li> <li>• The conventional cryptosystems used for data-encryption rely on the complexity of mathematical algorithms, whereas the security offered by quantum communication is based on the laws of Physics.</li> </ul>

## CLOUD COMPUTING

- It is the **delivery of computing services**—including servers, storage, databases, networking, software, analytics, and intelligence—**over the Internet** (“the cloud”) to offer faster innovation, flexible resources, and economies of scale.
- **Examples** of cloud computing used in day today life are **Facebook, YouTube, Dropbox, and Gmail** etc.
- Many cloud computing providers such as Google, Microsoft, Yahoo, IBM and Amazon are moving towards escalation in the usage of various cloud services.

### 3 major Types of Cloud services:

- **Software as a Service (SaaS):** Software can be accessed online without the need for downloading E.g., email services like Gmail, Hotmail and Microsoft office 365, Microsoft outlook etc. (email, calendar and files in one spot). Their user interface can be **customized** as per the need.
- **Infrastructure as a Service (IaaS):** Storage, network, operating system, virtual machines etc. (Google drive)
- **Platform as a Service (PaaS):** Platform on which user can deploy their own software and coding E.g. Google Cloud platform (GCP), Amazon web services (AWS) and Microsoft's Azure.

## Indian Cloud Computing

### 'GI Cloud' - 'MeghRaj'

- It is an initiative by government of India, launched in 2014.
- It is to increase the usage of cloud technology in providing government services.
- The focus of this initiative is to **accelerate delivery of e-services** in the country while optimizing ICT spending of the Government.

### **AIRAWAT' Platform To Boost AI**

- NITI Aayog is working to set up **India's first AI-specific cloud computing infrastructure** called '**AIRAWAT' (AI Research, Analytics and Knowledge Assimilation platform).**

## Benefits of Cloud computing

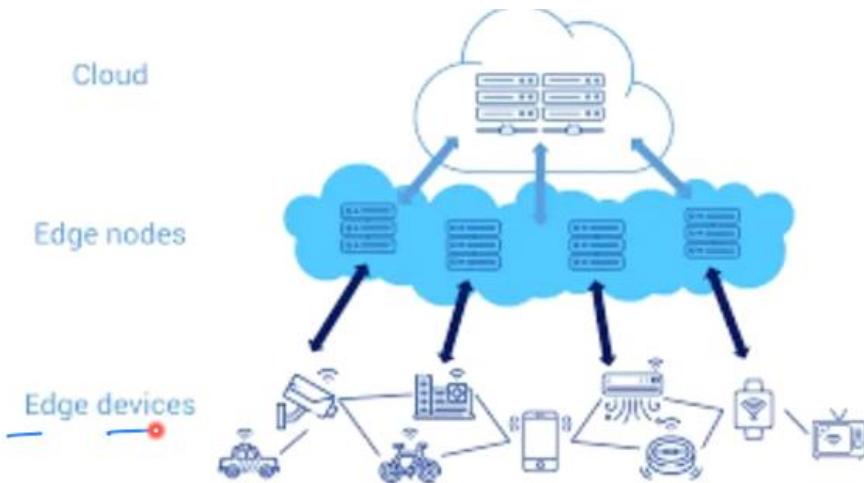
- **Cost Saving:** In cloud computing users have to only pay for the services they consumed. Maintenance cost is low as user do not need to purchase the infrastructure.
- **Flexibility:** Cloud computing is scalable. The rapid scale up and down in the operations of a business may require quick adjustment of hardware and resources. In order to manage this variations, cloud computing provide flexibility.
- **Modifiable:** Applications hosted in cloud can be modified internally without too much concern of the end users. Change in one place would reflect in all the places inherently and it would be consistent.
- **Enhanced Security:** Cloud computing provide high security through the ~~data encryption~~, strong access controls, key management, and security intelligence.

## Issues in Cloud computing

- Security Concerns – Despite reasonable measures provided on cloud platforms, sensitive information stored on cloud can be stolen by hackers.
- Need to meet several Legal requirements.
- Maintaining the integrity of information on cloud

### EDGE Computing

- It refers to **bringing computing closer to the source of the data**.
- Bringing computation and data storage closer to the sources of data. **It minimizes** the need for **long distance communications** between client and server. It improves response time and saves bandwidth.
- **Edge computing** is about processing data locally, and **cloud computing** is about processing data in a data center or public cloud." ( E.g., mobile computing, Internet of things, In vehicles)
- In edge computing, data is processed by the device itself or by a local computer or server, rather than being transmitted to a data centre.
- Due to the increased use of technologies like IoT, AR/VR, robotics, machine learning that require **service provisioning** closer to users, edge computing helps solve the key challenges of bandwidth, latency, resiliency (dealing with failures in cloud platforms), and data security.



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### Difference between IOT & EDGE COMPUTING

- If the bus allows riders to swipe a card that informs the driver if the person has enough credits on their card to allow them entry.
- On a traditional system, the card is swiped and the data is then transmitted (via a wireless connection) to a centralized hub, where the computing is taken care of.
- The centralized server checks the user account, discovers they do have enough funds on their account, and transmits a response to the originating system, without having the bus to sync to a centralised server & compute data by itself, **it's simply an IoT device.**
- If, however, we add syncing to a centralized server to the localized computer, **it IoT Edge Computing.** In the IoT/Edge Computing environment, The passenger enters and swipes their card. The Edge Computing device has already synced to the centralized server and contains an updated database of information, so it immediately checks the user's account and arrives at an affirmative answer, so the rider is allowed on the bus.
- The Edge Computing example is much faster than the traditional example because it doesn't have to transmit any data during the transaction.

## INTERNET OF THINGS IOT

## INTERNET OF THINGS (IOT)

It can be defined as “**the network of physical objects**—“things”—that are embedded with sensors, software, and other technologies for the **purpose of connecting** and **exchanging data** with other devices and systems over the internet.

- In 1999, **Kevin Ashton coined the term** ‘Internet of Things’.
- It is made up of devices – from **simple sensors** to **smartphones** and **wearables** connected together.
  - **Wearables** – Smartwatches, Smart glasses, fitness bands etc.
  - **Homes** – connecting household appliances to the network.
  - **Cars** – vehicles that are connected to the internet.
  - **Cities** – smart meters which analyse usage of water, gas, electricity etc.
- Between the capital city of New Delhi and Varanasi in Uttar Pradesh, the **Vande Bharat Express** – India’s first semi high-speed train – uses a **collision-avoidance system** comprising sensors and other IoT devices to prevent accidents due to human error or equipment failure.
- In Kohima, data collected from sensors and other IoT devices is being used to manage street lighting, ensure public safety and deliver a slew of citizen services.
- In agriculture, Tea Tantrum, a supplier of wellness and premium teas in India, is using IoT technology to **monitor moisture content** and **maintain the ingredient proportions** of some of its products.
- The Indian IoT market is expected to reach **US\$9.28 billion by 2025** from US\$4.98 billion in 2020, driven mostly by changes in enterprise behaviour triggered by the COVID-19 pandemic and verticals' focus on automation are driving the market.

## BIG DATA

- It refers to the data that is large, contains diverse sets of information that grow at ever-increasing rates.
- The different types of data originate from sensors, devices, video/audio, networks, applications, social media etc. in real time and at a very large scale.

### Features of Big data:

- **Volume:** Big data is larger, with more complex data sets, usually acquired from new data sources. High volumes of unstructured data of unknown value, such as Twitter data feeds or sensor-enabled equipment.
- **Velocity:** It is the rate at which data is received and become available.
- **Variety:** Data comes in variety of data types, such as text, audio, and video.
- **Value:** Data has intrinsic value.
- **Veracity:** It is about how accurate or truthful a data set is and how much can one rely on it.

## Uses of Big Data

- **Product Development:** Companies like Netflix and Amazon use big data to anticipate customer demand.
- **Customer Experience:** Data can be gathered from social media, web visits, and other sources to improve the interaction experience and maximize the value delivered.
- **Predictive maintenance:** By analyzing the indications of potential issues (like mechanical failures in vehicles) before the problems happen, organizations can deploy maintenance more cost effectively and maximize parts and equipment uptime.
- **Fraud and Compliance:** Big Data helps in identifying patterns in data that indicate fraud and aggregate large volumes of information to make regulatory reporting much faster.
- **Financial trading:** Big data can be used to estimate the rates of return and probably outcomes on investments.
- **Dealing with Pandemics like COVID-19:** Big data is generated through the accumulation of all the data related to the disease from around the world. Mathematical modeling of such data is being used to identify geographical hotspots, create death prediction models, provide estimates regarding testing and the need for testing supplies, and guide decision-making among policymakers, health care providers, and other key stakeholders.

## Issues/Challenges with Big Data

- This is a **new set of complex technologies** in the **nascent stages** of development and evolution.
- Some of the commonly faced issues include **inadequate knowledge** about the technologies involved, **data privacy**, and **inadequate analytical capabilities** of organizations.
- Huge amount of data creates problems such as its **storage** and **retrieval**.
- **Unstructured data** with increase in the number of data formats, **complicates the information** and the amount of time needed to organize the data by '**Data Scientists**' (Professionals who are skilled in organizing and analyzing massive amounts of data).
- Finding the "**needle in the haystack**" – identifying the key information from the massive data is always **challenging** and **time consuming**.
- This data is made available from numerous sources, and therefore has **potential security problems**.



### DIGITAL INDIA PROGRAMME

## DIGITAL INDIA PROGRAMME

- The Digital India programme was launched by the Prime Minister of India on **1<sup>st</sup> July 2015**.
- **Aim:** To transform India into a **digitally empowered society**.
- An **umbrella program** that covers **multiple ministries and departments**, **coordinated** by the **Department of Electronics and Information Technology** (DeitY).



## Nine-pillars of Digital India



9 Pillars	<p><b>1. Broadband highways –</b></p> <ul style="list-style-type: none"> <li>• Connecting villages to a <b>national optical fibre network</b>.</li> <li>• Virtual network operators / Mobile virtual network operators (Reseller of network services) be leveraged for urban connectivity infrastructure.</li> <li>• A national information infrastructure for government. E.g. Interconnecting government offices.</li> </ul> <p><b>2. Universal access to mobile connectivity –</b> To improve <b>mobile network penetration</b> and fill the connectivity gaps across the country. I.e., universal access to mobile phones with network facility.</p> <p><b>3. Public internet access programme –</b> Increase the number of <b>common service centres</b> across the country and make them viable and convert <b>post offices</b> into <b>multi-service centres</b>.</p> <p><b>4. e-Governance –</b> Reforming government through technology. E.g. Use of online repositories like school certificates, voter ID cards so that citizens need not submit them in physical form.</p> <p><b>5. e-Krantि –</b> Is a <u>national e-Governance plan</u> to <u>accelerate e-Governance</u> across India. Several projects already in various stages of implementation for the <b>electronic delivery of services</b>. E.g., <b>e-Education, e- Health care, etc.</b></p> <p><b>6. Information for all –</b></p> <ul style="list-style-type: none"> <li>• <b>Open Data platform and online hosting of information &amp; documents</b> to facilitate open and easy access to information for citizens.</li> <li>• <b>Government shall pro-actively engage through social media</b> and web based platforms to inform citizens. E.g., <b>MyGov.in</b> has already been launched as a medium to exchange ideas/ suggestions with Government. It will facilitate 2-way communication between citizens and government through a “<b>Discuss</b>”, “<b>Do</b>” and “<b>Disseminate</b>” approach.</li> <li>• <b>Online messaging</b> to citizens on special occasions/programs would be facilitated through emails and SMSes.</li> </ul>
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**7. Electronics manufacturing** – A target of **net zero imports** in electronics by 2020, with focus on microprocessor fabrication, Set top boxes, mobiles, consumer & Medical electronics, Smart energy meters, smart cards and micro-ATMs.

**8. IT for jobs** – Training youth with skills required for jobs in the IT/IT Enabled Services sector.

**9. Early harvest programmes** – Projects that can be implemented in a **short period** of time, including **WiFi for all universities, public WiFi hotspots, Biometric attendance systems** for central government, SMS based weather information and disaster alerts and the national portal for lost and found children, schoolbooks to be e books etc.

**Initiative**

**NOTABLE INITIATIVES UNDER DIGITAL INDIA PROGRAM**

- Free and Open Source Software (FOSS) presents an alternative model to build digital technologies for population scale. Unlike proprietary software, everyone has the freedom to edit, modify and reuse open-source code.
- This results in many benefits — reduced costs, no vendor lock-in, the ability to customise for local context, and greater innovation through wider collaboration.
- Indian government encourages open source instead of proprietary technology for government applications.
- Many solutions launched by the government including **Digilocker, Diksha, Aarogya Setu**, the Covid-19 vaccination platform **CoWIN** — built on open-source digital platforms.

**1. Digital Locker System:**

Minimize the usage of **physical documents** and enable sharing of **e-documents** across agencies. The sharing of the e-documents will be done through **registered repositories** thereby ensuring the authenticity of the documents online.

**2. BHIM (Bharat interface for money) app & new modified version BHIM 2.0:**

- Ministry of Electronics and Information Technology (MeitY) has launched a new version of BHIM app i.e., BHIM 2
- Developed by National payments corporation of India.
- It is a unified payment interface (UPI) that allows real time fund transfer.
- New version supports 16 Indian languages.
- Includes features like **donation gateway, linking multiple bank accounts, gifting money etc.**
- Uses 3-point authentication (Mobile number, device ID and UPI PIN) and fingerprint based biometric verification of transaction via Aadhaar to prevent fraudulent transactions.
- BHIM app can replace existing mobile wallets and comparatively reliable option for bank-to-bank transfer.

### **3. Aadhaar cards:**

- An identity platform - one of the key pillars of 'Digital India'.
- The largest biometrics-based identification system in the world.
- Every resident of the country is provided with a **unique identity** or Aadhaar number.
- Used as a **basis/primary identifier** to roll out **several Government welfare schemes** and programmes for effective service delivery thereby promoting transparency and good governance.
- **Aadhaar is 'Open Application Programming Interfaces (APIs):** This is government's approach to promote software interoperability for all e-governance applications and systems.
- The Unique Identification Authority of India (UIDAI) allows third party developers to access Aadhaar card number and related information. For e.g., it is used for e-KYC purpose.
- (Note: In API, **application** stands for any software with a distinct function. **Interface** is a contract of services between two applications).

### **4. Pradhan Mantri Gramin Digital Saksharta Abhiyan (PMGDISHA)**

- To make citizens **digitally literate**.
- The project is expected to be **one of the largest initiatives** of the country with an **overall target of training 6 crore students reaching 40% of rural households**, covering one household from every eligible family.
- The government has accepted 250,000 Gram Panchayats to register at least 200-300 candidates each.

### **5. Jandhan-Aadhaar- Mobile[ JAM] initiative**

Bank accounts, Mobile numbers and Aadhar cards of Indians are linked to **directly transfer subsidies** to intended beneficiaries and ~~eliminate~~ intermediaries and leakages. It provided a **digital identity** to **more than a billion Indian citizens**.

The **DIKSHA platform** offers teachers, students and parents engaging learning material relevant to the prescribed school curriculum. Teachers have access to aids like lesson plans, worksheets and activities, to create enjoyable classroom experiences. Students understand concepts, revise lessons and do practice exercises. Parents can follow classroom activities and clear doubts outside school hours.

## 6. BharatNet Project

- The project was originally started in 2011 as **National Optical Fibre Network (NOFN)**, renamed as **BharatNet** in 2015.
- The project is being implemented by **Bharat Broadband Network Limited (BBNL)** under the **administrative control of Telecom ministry**. The project is seen as a **major breakthrough** for the success of digital India initiative.
- The program aims to use **domestically manufactured products** for the entire project.
- **The total cost** of the project is expected to be more than **72000 crores**.

### Phases of Bharat Net project and revised plan

- The **first phase** of the project **completed** in Dec 2017, covering 1,22,908 Gram panchayats.
- The Bharat Net **phase 2** is aimed at providing broadband **connectivity to all 2.5 lakh gram panchayats**.
- 1,56,223 Gram Panchayats have been made service ready by 31st May, 2021.
- In June 2021, the Central government had revised BharatNet program to expand the coverage to all inhabited villages in the country, with initial approval to 16 states.

Smart Cities  
Mission

### SMART CITIES MISSION 2023

Prime Minister Narendra Modi launched the Smart Cities Mission in India on June 25, 2015. The project aims to improve the quality of life for people living in India and drive economic growth. Almost 31% of the population of India lives in cities, and they contribute 63% of the GDP, as per the data collected in Census 2011. By 2030, around 40% of India's will be living in cities and contribute 75% to the GDP. This mission of the government of India promises to improve the quality of life in 100 cities and towns.  
*National Smart Cities Mission Convention to be Held from 27th Sep to 29th Sep 2023 in Indore*

### FEATURES OF SMART CITY MISSION IN INDIA

- It promotes mixed land use as per the area. With the mission, the states will have more flexibility to use the land for various purposes. However, fulfilment of environmental safeguards will be taken care of.

- It aims to expand housing opportunities for everyone.
- Smart Cities Mission visions to reduce congestion, ensure security, reduce air pollution and promote interaction and local economy. New way for pedestrians are built for walkers and cyclists to reduce accidents.
- Development of playgrounds, parks, open gyms and other recreational spaces is another objective.
- More transport options are promoted.
- To bring transparency and accountability in governance, more online services are launched.
- Identity is provided to the city based on the education sector, health sector, local cuisine, sports, culture, art, furniture etc.
- Smart Solutions are applied to infrastructure and services for area development.

### SMART SOLUTION OF SMART CITIES MISSION

- Public information and grievance redressal
- Electronic service delivery
- Video crime monitoring
- Waste to compost, Waste to energy and fuel
- Smart meters and management for water and electricity
- Leakage identification, Water quality monitoring
- Renewable source of energy, Energy efficiency and green buildings
- Intelligent Traffic management system
- Tele-medicine
- Trade facilitation centers, Skill Development Centers.

### SMART CITIES MISSION HIGHLIGHTS

Items	Cost / Number
Cities	100
Total Projects	7,742
Total Cost of Projects	Rs. 1,81,561 Cr.
Completed Projects to Date	5,002
Cost Involved in Completed Projects	Rs. 92, 561 Cr.
Ongoing Projects	2,740
Cost Involved in Ongoing Projects	Rs. 89,000 Cr.

### FINANCING OF SMART CITY MISSION IN INDIA:

In total, the government has funded a sum of Rs 7,20,000 crore. On average Rs 100 crore per city over the five years. The scheme will be operated as a Centrally Sponsored Scheme (CSS) on a 50:50 model between centre & state government or Union Territories.

### INTEGRATED COMMAND AND CONTROL CENTERS:

- Under the Smart Cities Mission, inter alia, ICCC (Integrated Command and Control Centers) have been operationalized in all the 100 Smart Cities, which have been envisaged to act as the brain and nerve center of the enabling cities with a decision support system for enhancing quality of life for its citizen.
- These ICCC are playing important role in ensuring better monitoring and efficiency in areas like traffic management, solid waste management, Surveillance, water distribution management, grievance redressal, management of the COVID-19 pandemic etc.

## Challenges

- Slow roll-out of Wi-Fi hotspots and the slow internet speeds.
- Most small and medium scale industry is struggling to adapt to modern technology.
- Entry level smartphones have limited capabilities for smooth internet access, and the outreach of the ‘smartphones’ is limited.
- There is an absence of enough skilled manpower in digital technology.
- Lack of user education and there are limited facilities to train personnel.
- India needs over one million cybersecurity experts to check and monitor the growing menace of digital crime.

e- Governance

Academy

## e-governance

Application of information and communication technologies in governance process is referred to as “**Electronic governance**”

### Kinds of interactions in e-governance

- Within government (Govt-Govt & Govt-Employees)
- Govt-Citizens
- Govt-Business

### Reasons for Opting e-Governance

- Governance has become very complex
- Increase in citizens’ expectations from the government

### Benefits

Less corruption, increased transparency, greater convenience, revenue growth, and or cost reductions.

## Examples of e-governance projects

### UMANG (Unified Mobile Application for New-age Governance):

- Developed and operated by **National e-Governance Division (NeGD) of Ministry of Electronics & IT**
- Launched in **2017** to bring **all government services on a single mobile app.**
- Single, unified, secure, multi-channel, multi-platform, multi-lingual, multi-service mobile app, powered by a robust back-end platform providing access to high impact services of various organization (Central and State).
- About **660 services from 127 department & 25 states**, including utility payments are live and more are in pipeline.

- **National Scholarships Portal (NSP):** The portal is a one-stop solution to implement end-to-end disbursement of the scholarship to the beneficiaries. The process includes student registration, application, approval and disbursement. 76 schemes of 22 Ministries/Departments of the Government are being on-boarded on the portal.
- **Computerization of Land Records:** In collaboration with National informatics centre, NIC. Ensuring that landowners get computerized copies of ownership, crop and tenancy and updated copies of Records of Rights (RoRs) on demand.
- **e-Mandi:** The Government has launched e-Mandi portal to make to reduce the role of intermediaries and benefit small and marginal farmers.
- **mKisan Portal:** This is a unified platform using which officials and scientists can send targeted text and voice-based advisories to the farmers on a host of issues related to agriculture and its allied sectors.

e-  
Authentication

### e-authentication, 2FA & MFA

The **process of electronic verification** of the identity of an entity.

It provides a **simple, convenient and secure way** for the

- Users to access government services via internet/mobile
- As well as for the government departments and agencies to assess the authenticity of the users.

Electronic authentication is accomplished based on the following factors:

- **Knowledge** - something the user knows (e.g. user name, password, PIN, secret questions and answers, etc.);
- **Possession** - something the user has (e.g. digital signature, smart card, etc.);
- **Be/ Inherence** - something the user is (e.g. biometric fingerprint, iris pattern, etc.); or a combination of the above.

#### Three kinds of authentication mechanisms:

- **Single Factor Authentication:** An authentication mechanism that utilizes only one of the various factors (e.g., a user using username and password for accessing an application).
- **Two Factor Authentication:** An authentication mechanism where a combination of two factors is used (e.g., username and password as first factor and One Time Password (OTP) / A token, material device that is used to access secure systems. Common forms include a dongle, card, or RFID chip).
- **Multi-factor Authentication:** An authentication mechanism where two or more factors are used with one of the factors **necessarily being the “Third Factor – ‘Be’** which is something the user is (e.g., a user providing Aadhaar number (first factor – “Knowledge”) and biometrics (third factor – “Be”) to authenticate oneself).

Application  
Programming  
Interface API

- (Note: In API, **application** stands for any software with a distinct function. **Interface** is a contract of services between two applications).

#### Types of API:

- Open APIs, which any developer can access.

### **Types of API:**

- Open APIs, which any developer can access.
- Partner APIs, which only authorized developers may access.
- Internal APIs, which only internal teams may access.
- Composite APIs, which combine multiple APIs

## CYBER CRIMES

**Cybercrime** is any crime that takes place **primarily online**.

As per **cybercrime website of Indian government**, cybercrime is “any unlawful act where computer or communication device or computer network is used to commit or facilitate the commission of crime”.

### **Types of cyberattacks:**

- **Malware:** refers to **malicious software**, used by the attacker to compromise the confidentiality, availability and integrity of data.  
**Common types of malware** are viruses, worms, trojans, spyware, ransomware, adware etc. E.g., ‘**Pegasus**’ is a malware created by an Israeli firm and used on WhatsApp platform to spy on journalists and human rights activists in India in 2019.
- **Ransomware** – Ransomware is a malware where your computer or device is locked until you pay a sum of money (e.g.: **WannaCry** in 2017)
- **Phishing:** a technique aiming to **steal private information** from users by **pretending as a trustful source**, lures an individual to open a mail or message, tricks the victims in to opening a **malicious link** which can lead to installation of malware that can reveal sensitive information.
- **Hacking:** Identifying **weakness** in computer systems or networks to **gain access** by skilled computer programmers. E.g.: Using **password cracking algorithm** to gain access to a system
- **Identity theft:** It involves **acquiring key pieces of someone's identifying information** to impersonate them and commit various **crimes in that person's name**.
- **DDoS (Distributed Denial of Service):** It is a type of attack where the attacker **floods the victim** (e.g., server, website etc.) with **several connection requests** until the network gets trafficked and **unable to function, causing denial of service for the targeted resource**.
- **Cyberbullying** – It is also a Cybercrime where computers, tablets, or mobile phones are used to send, post, or share private, negative, or false information about someone without their consent to cause embarrassment or humiliation.
- **Crypto jacking** – Here, the attacker breaks into a person's computing device to extract money from the target in the form of cryptocurrency without their consent or knowledge.
- **Cyber Espionage** – Cyber espionage occurs when an attacker illicitly gains access to a company's or government's sensitive data or intellectual property.

Example

### Some Examples of cybercrimes in news:

- **Sim Swap fraud:** Bangalore – in the name of upgrading sims from 3G to 4G – gained access to the smart phone and to bank accounts.
- Government ID database, **Aadhaar**, reportedly suffered multiple breaches that potentially compromised the records of all 1.1 billion registered citizens. It was reported in **January 2018** that criminals were selling access to the database.
- The **Kudankulam nuclear power plant** was hacked using malware designed for data extraction linked to a group that is known to have ties to two **North Korean backed groups**.
- There has been a steep rise in the use of **malware** by a Chinese group called **Red Echo** to target **India's power sector**. Red Echo used malware called **ShadowPad**, which gains access servers.
- The Chinese hacker group known as **Stone Panda** had “identified gaps and vulnerabilities” in the IT infrastructure and supply chain software of **Bharat Biotech & Serum Institute of India**.

Indian Laws

### Laws Against Cybercrime in India

In addition to setting up a **legal framework through IT Act, 2000** and **National cyber security policy in 2013**, India launched following initiatives to control cybercrimes:

#### Government Initiatives to prevent Cyber Security

- ❖ Indian Cyber Crime Coordination Centre (I4C)
- ❖ Indian Computer Emergency Response Team (CERT-In)
- ❖ Cyber Surakshit Bharat initiative
- ❖ National Cyber Crime Reporting Portal
- ❖ Cyber Swachhta Kendra
- ❖ National Cyber Security Coordination Centre (NCCC)
- ❖ “National Critical Information Infrastructure Protection Centre”
- ❖ “Information Security Education and Awareness Project” (ISEA)

Digital Personal Data Protection

### DIGITAL PERSONAL DATA PROTECTION ACT - 2023

#### Applicability:

- The Bill applies to the processing of digital personal data within India where such data is collected online, or collected offline and is digitised.
- It will also apply to the processing of personal data outside India if it is for offering goods or services in India.

#### Obligations of data fiduciary:

- ❖ Build reasonable security safeguards to prevent a data breach
- ❖ Inform the Data Protection Board of India and affected persons in the event of a breach
- ❖ Erase personal data as soon as the purpose has been met and retention is not necessary for legal purposes
- ❖ Personal data must be used by **Data fiduciaries** (those who collect the data) only in a manner that is **lawful, fair, transparent** and limit its use to the intended purpose.

**Data Principal's** (those who provide the data) **consent must** be obtained before collecting their data. Data Principals can **withdraw the consent**, demand for **correction and erasure** of the data.

- The bill allows the Government to notify the ‘**Significant Data Fiduciary**’ based on, among other things, the **volume and sensitivity** of Personal Data processed by it.
- Data cannot be “stored perpetually by default” and **storage should be limited** to a fixed duration.
- It has also **relaxed rules on cross-border data flows** that could bring relief to the big tech companies, alongside a **provision for easier compliance requirements** for **start-ups**.
- Bill only prescribes **monetary penalties** for breaches and non- compliances with **no criminal liabilities**, as well as no penalties that are directly linked to the turn-over or revenue of the Data Fiduciary in question.
- A **Data Protection Board of India** is proposed to be set up by the Central Government to enforce the provisions of the DPD Bill.
- Like in the previous version, the Centre has been empowered to exempt its agencies from adhering to provisions of the Bill in the interest of **sovereignty and integrity** of India, **security of the state**, maintenance of public order or preventing incitement to any cognizable offence.

*Lok*

#### **Background:**

- Aug 2017 - Privacy as a fundamental right (Article 21) was reaffirmed **in Justice KS Puttaswamy vs Union of India case by SC**.
- July 2018 - **Justice Srikrishna committee** released draft personal data protection Bill and report.
- Dec 2019 - “**Personal Data Protection Bill**” was introduced in Parliament in and has been referred to a **Joint Parliamentary Committee** for detailed examination.
- Dec 2021 – JPC released its report and a new version of the bill which is withdrawn in Aug 2022.
- Nov 2022 – MEITY released draft Digital Personal Data Protection Bill for public consultation.
- August 9, 2023, the Rajya Sabha “unanimously” passed the **Digital Personal Data Protection Bill (DPDP), 2023**
- 11<sup>th</sup> August - received the assent of the President

# L23 Defence Missile, Sub, Ships, Anti Ballistic

17 November 2024 03:17 PM

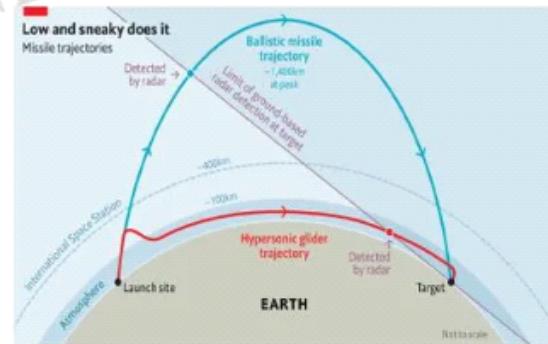
DRDO	<ul style="list-style-type: none"><li>• DRDO was established in 1958.</li><li>• It works under “Department of Defence Research and Development” under Ministry of Defence.</li><li>• It works towards <b>enhancing self-reliance</b> in Defence Systems and undertakes design &amp; development leading to <b>production of world class weapon systems</b> as per the requirements of the three defence services.</li><li>• DRDO has a network of <b>over 50 laboratories</b> working in various areas of defence technology.</li><li>• It also provides ample spinoff benefits to the society at large thereby contributing to the <b>nation building</b>.</li></ul>
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MISSILES	<ul style="list-style-type: none"><li>• Sub Sonic : less than speed of sound</li><li>• Super Sonic : 1.2 -5 Mach</li><li>• Hypersonic : &gt; 5 Mach</li></ul> <p><b>NOTE:</b></p> <p><b>Air breathing engines:</b> Uses atmospheric Oxygen in the combustion of fuel so that oxidizer need not be added along with the fuel. This reduces the total propellant required. In such engines the atmospheric air is compressed by a <u>rotary compressor like Turbofan</u>.</p> <p><b>Ramjet:</b> A variant of air breathing Jet engine that does not include a <b>rotary compressor (Turbofan)</b>, rather it uses the engine's forward movement to compress the incoming air (Works at subsonic speeds)</p> <p><b>Scramjet:</b> It is an innovation on Ramjet in which combustion chamber is specially designed to operate under hypersonic airflow.</p> <p><b>Dual mode Ramjet:</b> A type of jet engine where a Ramjet transforms into a Scramjet over Mach 4-8 range. Thus, it can efficiently work in subsonic and supersonic speeds.</p>
Ballistic Missiles	<ul style="list-style-type: none"><li>• Guided by rocket till 50%, other 50% on gravity</li><li>• </li></ul>

## Ballistic missiles:

**Ballistic missile**, a rocket-propelled self-guided strategic-weapons system that follows a **ballistic** trajectory to deliver a payload from its launch site to a predetermined target. **Ballistic missiles** can carry conventional high explosives as well as chemical, biological, or nuclear munitions.

- Under the guidance of **Dr. Kalam**, India developed several ballistic missiles as part of **The Integrated Guided Missile Development Programme (IGMDP)**.
- Strategic missiles are the missiles that can attack bigger targets like a city.



- Tactical : Small damage area, no need of approval
- Strategic : damage large are, need govt approval

### unacademy Surface to Surface

#### Short Range Ballistic Missiles (SRBMs)

Missile name	Range	Payload
Prithvi-I	150 km	1,000 kg
Prithvi-II	250 km	500 kg
Prithvi-III	350 km	1000 kg
Agni-I	1000 km	1000 kg

#### Inter Continental Ballistic missiles (ICBM)

Agni-V	5000 km	1500 kg
<b>Submarine launchable Ballistic missiles (SLBM)</b>		
K-15	750 km	500 kg
Sagarika		
K-4	3000 km	1000 kg

#### Intermediate Range Ballistic Missiles (IRBMs)

Missile name	Range	Payload
Agni-II	2000 km	1,000 kg
Agni-III	3000 km	500 Kg
Agni-IV	4000 km	1000 Kg

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## Agni V

- India's first **intercontinental ballistic missile (ICBM)**.
- It is a **three-stage surface to surface** missile that uses **solid propellant**.
- It can carry **1.5 ton** of **nuclear warheads** with a target range over **5,000 km**.
- It can attain the **speed of 24 Mach**.
- Unlike other missiles of the series, Agni-5 is the **most advanced** in terms of navigation and guidance, warhead and engine, can hit the targets with high precision.
- Agni 5 was test fired on 27<sup>th</sup> October 2021 from APJ Abdul Kalam island.

## AGNI - P

- India reportedly has been working to develop **multiple independently targetable re-entry vehicles (MIRVs)**.

- India reportedly has been working to develop **multiple independently targetable re-entry vehicles** (MIRVs).
- It is the 6<sup>th</sup> missile in the Agni series.
- In December 2021, DRDO successfully test fired **Agni-P** from Abdul Kalam island
- Agni P is a new generation advanced variant of Agni class missiles.
- It is canisterised missile with range capability between 1000 -2000 Km.
- Canisterisation of missiles reduces the time required to launch the missile while improving its storage and mobility.
- It plugs the range gap between Agni I & II
- (*Note: Agni VI with a range of 11,000 – 12000 km is under development.*)
- This is a three-stage solid fuel missile with Maneuverable reentry vehicle (MaRV) capability that delivered the warheads in two separate locations.
- MaRV is a type of ballistic missile whose warhead is capable of autonomously tracking ground targets.

### 3. AGNI – V MISSILE WITH MIRV TECHNOLOGY

- Defence Research and Development Organisation (DRDO) conducted first successful flight test of **indigenously developed Agni-5 missile with Multiple Independently Targetable Re-Entry Vehicle (MIRV) technology**.
- The flight test named **Mission Divyastra** was carried out from Dr APJ Abdul Kalam Island in Odisha. Various Telemetry and radar stations tracked and monitored multiple re-entry vehicles.
- Agni V is India's first **intercontinental ballistic missile (ICBM)** developed by DRDO.
- It is a **three-stage** surface to surface missile that uses **solid propellant**.
- It can carry **1.5 ton of warheads** with a target range over **5,000 km**.

- A MIRV is a ballistic missile designed for exo-atmospheric deployment, housing multiple warheads, each capable of targeting distinct targets spaced 100s of kilometres apart.
- While primarily associated with intercontinental ballistic missiles equipped with thermonuclear warheads, the concept extends to an **intermediate variant, the Multiple Re-entry Vehicle (MRV) missile**, disperses multiple warheads without individual targeting.

#### Advantages of MIRV:

- It can release multiple warheads and thereby reduces the number of missiles and launch facilities required.
- With the MIRV, the **effectiveness of an anti-ballistic missile system** that relies on intercepting individual warheads is also reduced.

**What other countries have MIRV:**

- USA, UK, France- have MIRV technology on their Submarine-Launched Ballistic Missile (SLBM).
- China- has MIRVed on Intercontinental Ballistic Missile (ICBM)
- Russia- has both MIRVed ICBMs and SLBMs.
- Pakistan is also believed to be experimenting with MIRV technology.

**Key Features of Agni-V**

- Weight - 50,000 kilograms
- Height - 1.75 meters
- Diameter - 2 meters
- It carries 1650-kilogram warhead atop three-stage rocket powered by solid fuel.
- MIRV Capacity – 2-12 warheads

- Speed - 25 Mach, 8.5 km per second or 29,401 km per hour.
- Equipped with advanced navigation systems including a ring laser gyroscope inertial navigation system (NavIC) and satellite guidance.
- Launch flexibility from mobile launchers.

**Agni-V Trajectory and Thermal Resilience:**

- As it re-enters the Earth's atmosphere, temperatures soar beyond 4,000 degrees Celsius. Yet, the missile's indigenously developed heat shield maintains internal temperatures below 50 degrees Celsius, ensuring operational integrity.

Cruise  
Missile

- These missiles don't follow the laws of gravity and their path is controlled throughout their journey period.
- These missiles are **self-navigating** and fly at **extremely low altitudes** to avoid being caught by radars.
- Level of **accuracy** in these missiles is extremely high.
- These are **Tactical missiles** that are used in the battle field.

Type	Name	Range	Payload Capacity
Subsonic Cruise Missiles	Nirbhay	750-1000 km	500 kg
Supersonic Cruise Missiles	BrahMos (Mach 2.8)	290 km Extended to 450 km	300 kg
Hypersonic Cruise Missiles	BrahMos-II (Mach 7) (Under development)	750 km 400 – 600 km	1000 kg ----

## Nirbhay

- It is an indigenously developed **subsonic missile**, with a speed of **0.7 Mach**.
- It has a range of ~ **800 km** (Long range)
- The missile is powered by a **solid rocket booster** and a **turbofan** (air breathing) **engine**.
- It can also be **launched from multiple platforms** including aircraft, land-based vehicles/launchers, ships and submarines.
- Carry **conventional warheads** and is also said to be **nuclear capable**.
- It is capable of **deep penetration** to strike **high-value targets** with **precision**.
- With **sea-skimming** and **terrain-hugging capability**, the missile can stay under enemy radar to **avoid detection**.
- It was **in news** as one of its test conducted in October 2020 had to be aborted due to an unexpected problem.

## BrahMos

- It is a medium-range **supersonic cruise missile** – built by **India** with the help of **Russia** (Named after **Brahmaputra** river + **Moskva** (Russian) river)
- It is **multiplatform launchable** - can be launched from land or submarines/warships or fighter jets.
- It uses **2-stages**, first **solid stage** and second being the **liquid ramjet**.
- It boasts to be **fastest supersonic missile** in the world (Mach 2.8).
- A hypersonic version BrahMos – II with speed of Mach 7-8 is also under development & **expected to be deployed by 2025**.
- The **2.5-tonne** missile has a strike range of nearly **300 kilometres**.

## Shaurya

- Tested in **October 2020** from Abdul Kalam island.
- New indigenously-developed **hybrid missile**, that attains 7.5 Mach speed.
- Like a **ballistic missile**, it is powered by solid fuel, but can guide itself up to the target like a **cruise missile**.
- Medium-Range (750 km)
- Land variant of K-15 Sagarika
- Surface to Surface missile
- **Two-stage** missile that uses **solid propellants**
- Can carry conventional or Nuclear warheads (up to 1000 kg)

## Other missiles

### SURFACE TO AIR MISSILES

Missile name	Range	Payload
Trishul	9 km	5 kg
Akash	30 km	50 kg
Maitri	15 km	10 kg
Barak-8	70 km	60 kg

### ANTI-TANK GUIDED MISSILE

NAG	4 - 7 km	8 kg
HeliNa	7 - 10 km	8 Kg

HeliNa: Helicopter launched Nag Missile

HeliNA (Army version), (Dhruvastra – Indian Air Force version of HeliNa)

### AIR TO AIR MISSILES

Astra Mk-1	110 km	15 kg
Astra Mk-2	160 km	Under development

## Akash – NG (New Generation)

- It is a new variant of the Akash missile - **surface-to-air Missile**, tested in July 2021.
- It can strike targets with an **extended range up to 70 km** and fly at a speed of up to **Mach 2.5**.
- Developed by Defence Research & Development Laboratory (**DRDL**), Hyderabad.
- Primarily designed for the IAF with an aim of **intercepting high maneuvering aerial threats** that have low Radar Cross Section (RCS), which is the electromagnetic signature of the object.

## STAND-OFF ANTI-TANK MISSILE (SANT)

- Indigenously made **helicopter launched missile**
- It has been tested in **December 2021** by DRDO and Indian Air Force at Pokhran test range.
- Designed and developed by **Research Centre Imarat (RCI)** in coordination with other DRDO Laboratories.
- It is a fourth-generation **upgraded variant of HELINA** missile.
- The missile is equipped with a state-of-the-art **Milli Meter Wave (MMW) Active Radar seeker** which provides high precision strike capability in all weather conditions.
- Can neutralize targets in a **range up to 10 km**.

Rudram I	<ul style="list-style-type: none"> <li>Also known as '<b>New Generation Anti Radiation Missile</b>', is India's first indigenous <b>anti-radiation missile</b>.</li> <li>Successfully flight tested from a <b>Sukhoi-30 MKI in October 2020</b></li> <li>Designed to detect, track and neutralize the enemy's radar, communication assets and other radio frequency sources, which are generally part of their air defence systems.</li> <li>It is an <b>Air to Surface missile that can be launched from 500 m to 15 km height and hit the targets in range of more than 100 km</b>.</li> <li>Once it locks on the target, it is capable of striking accurately even if the radiation source switches off in between.</li> </ul>
Anti Satellite Missile	<p>inacademy</p> <h3 style="color: red; text-align: center;">Anti-satellite missile (ASAT) test</h3> <ul style="list-style-type: none"> <li>ASAT, code name "<b>Mission Shakti</b>", is a technology mission carried out by <b>DRDO with ISRO</b>.</li> <li>Test date: <b>27<sup>th</sup> March 2019</b></li> <li>Ballistic missile targeted an ISRO's live satellite (<b>MICROSAT</b>) in LEO (~300 km)</li> <li>It used "<b>kinetic kill</b>" technology.</li> <li>India became the <b>4<sup>th</sup> country</b> to do so after USA, Russia and China.</li> <li>It successfully demonstrated India's capability to <b>interdict and intercept</b> a satellite in outer space based on complete <b>indigenous technology</b>.</li> </ul> <p><b>Issues:</b></p> <ul style="list-style-type: none"> <li>Space debris, Space weaponization.</li> <li>Need for such a test is questioned by other countries.</li> <li>India's commitment to <b>Outer space treaty 1967</b>, that prohibits countries from placing in to orbit around the earth "any objects carrying nuclear weapons or any other kinds of weapons of mass destruction".</li> </ul> <p>cademy</p> <h3 style="color: red; text-align: center;"><u>RUSSIA'S NEW ANTI-SATELLITE MISSILE TEST</u></h3> <ul style="list-style-type: none"> <li>In November 2021, Russia launched a missile that destroyed its own satellite (Kosmos 1408), a large spacecraft that orbited the Earth roughly 480 km away.</li> <li>The breakup of the satellite created at least 1,500 pieces of trackable fragments, according to the US State Department, as well as thousands of smaller pieces that cannot be tracked.</li> <li>All of those pieces are in low Earth orbit, moving at thousands of miles an hour and posing a threat to any objects that might cross their path.</li> <li>Initially, that even included the International Space Station, with crew members on board forced to take shelter in their spacecrafts as the debris cloud from the satellite passed by the ISS a couple of times.</li> <li>International norms are urgently needed to prevent future tests like this and to keep Earth's orbits as safe as possible.</li> </ul>

- A Russian satellite, Kosmos 2499 broke apart in the month of January depositing space debris in Earth's orbit according to US Space Force's 18<sup>th</sup> space defense squadron which tracks all man-made objects in Earth's orbit. (Feb 2023)
- It is believed as second breakup of the satellite and it could be the breakup of already broken parts.

#### Mysteries associated with the satellite:

- Kosmos 2499 was not in the launch manifest according to RussianSpaceWeb.com.
- The Ghost satellite created suspicions that it was a platform to test the technology that would allow space craft to attack and disable satellites.

IGMDP / Nuclear Triad

#### **IGMDP (Integrated Guided Missile Development Program)**

- It was approved by the Government of India in 1983 and completed in March 2012.
- The 5 missiles developed under this program are:
  - **Prithvi:** Short range surface to surface ballistic missile.
  - **Agni:** Ballistic missiles with different ranges, Agni (1,2,3,4,5)
  - **Trishul:** Short-range, low-level surface to air missile.
  - **Nag:** 3<sup>rd</sup> generation anti-tank missile.
  - **Akash:** Medium range surface to air missile.

**Nuclear triad**, a three-sided military-force structure consisting of **land-launched** nuclear missiles, **nuclear-missile-armed submarines**, and strategic **aircraft** (e.g. **Rafale**, **Brahmos**) with **nuclear bombs** and missiles.

SUBMARINES

- **Submarines** are self-propelled vessels that are designed and built to perform underwater operations.
- The Indian Navy currently operates **Sixteen diesel-electric powered** submarines (including the Scorpene) and **two nuclear powered submarines** — INS Arihant (SSBN, a ballistic missile submarine) and INS Chakra (SSN, a nuclear-powered one) leased from Russia.
- India's submarine fleet is based at **two locations**: Visakhapatnam on the east coast and Mumbai on the west coast.
- Of the 16 conventional submarines India currently possesses, only half are operational at any given point of time.

#### **NOTE:**

INS – Indian Naval Ship

SS – Submarine ship

SSN – Submarine Ship Nuclear

Nuclear Powered Sub

- Fission Powered Vehicle, Launch Ballistic Missiles or short range attack purpose
- No need of snorkel

- Always make sound because of coolant pumping
  - Can be detected by SONAK
- Waste disposal and dispose decommissioned nuclear submarine is difficult



**1. Arihant class:** Nuclear powered Ballistic missile submarines (SSBN) – carry long distance missiles, these are being developed and built indigenously under the **Advanced Technology Vessel (ATV) Project**

- Presently only one – INS Arihant is operational.
- Second – INS Arighat – Completed advanced sea trials & is all set to be commissioned.

**2. Akula Class:** Nuclear powered attack submarines (SSNs) – short range attacks.

**India signed an agreement with Russia** to get an Akula Class nuclear powered attack submarine, christened as **Chakra-3**, on lease. It is currently being refitted in Russian shipyard as per Indian specifications.

**INS Chakra II is also a Russian Akula class** nuclear powered attack submarine commissioned into service in India in April 2012 & decommissioned in 2021.

Diesel-Electric Sub	<ul style="list-style-type: none"> <li>• Diesel Combustion -&gt; Heat generated -&gt; Converted into Electricity -&gt;           <ul style="list-style-type: none"> <li>◦ Charge Batteries -&gt; Power Submarines</li> <li>◦ Need of Snorkel : To breathe oxygen for combustion</li> <li>◦ Absolutely silent : Do not produce sound while on battery               <ul style="list-style-type: none"> <li>▪ Uneducable by SONAK (sound detection)</li> </ul> </li> </ul> </li> <li>• <b>Diesel-Electric submarines</b> run on diesel and electricity. They have a large network of batteries which are charged by the diesel generator. They <i>snorkel</i>, which means, travelling just below the surface of the water (This makes them vulnerable to detection). Once they charge their batteries, they dive into the ocean and run silently on battery power with the diesel generators shut down.</li> <li>• The problem was overcome by applying <b>nuclear power to produce the ‘true submarine’</b> but this solution is expensive. It also presents problems in the disposal of nuclear waste products and eventually the boats themselves. And the nuclear reactors cannot be shut down when not needed.</li> <li>• <b>Air-independent propulsion (AIP), or air-independent power</b>, is any marine propulsion technology that allows a non-nuclear submarine to operate without access to atmospheric oxygen (by surfacing or using a snorkel).</li> <li>• AIP can augment or replace the diesel-electric propulsion system of non-nuclear vessels.</li> </ul>
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- In AIP, **Liquid oxygen** (LOX) is stored in tanks on board the submarine and sent to the diesel engine for combustion. (Or)
- The **combustion of ethanol and oxygen** under high pressure is used to **generate steam**. The steam generated is the working fluid and is used to **run the turbine**.
- Modern non-nuclear submarines are potentially stealthier than nuclear submarines; although some modern submarine reactors are designed to rely on natural circulation, most naval nuclear reactors use pumps to circulate constantly the reactor coolant, generating ~~some~~ amount of detectable noise.
- Non-nuclear submarines running on battery power or AIP, on the other hand, can be virtually silent
  
- The **Scorpène-class submarines** are a class of **diesel-electric** attack submarines jointly developed by the French Naval Group and the Spanish company Navantia.
- It features diesel propulsion and an additional air-independent propulsion (AIP). It is now marketed as the Scorpène 2000.
- They are the most sophisticated submarines, capable of undertaking multifarious missions including anti-surface ship warfare, anti-submarine warfare, intelligence gathering, mine laying, and area surveillance.
- The **Scorpene class is the Indian Navy's first modern conventional powered submarine series** (diesel-electric), weighing 1,500 tonnes ad can go up to depths of 300m.
- The Navy is looking to install **Air Independent Propulsion (AIP) modules** on all the Scorpene submarines to enhance endurance.

Projects

## PROJECT 75 (INDIA)

- Project 75 (I) is a follow up of project 75. Under the P75I , the Indian Navy intends to build **six advanced Diesel-electric submarines** under Ministry of Defence's **Strategic Partnership model**, which aims to build indigenous capabilities.
- IN 2020, the government approved ~~Mazagon Docks & Larsen & Turbo (L&T)~~ as the **Indian Strategic Partners (SP)** and five potential Foreign **Original Equipment Manufacturers (OEM)**.
- The submarines will feature **advanced air-independent propulsion** systems for longer submerge duration and substantial increase in their operational range.
- They are capable of **anti-surface** and **anti-ship warfare missions** equipped with a vertical launch system (VLS) to enable them to carry **Brahmos supersonic cruise missiles**.

- They also have advanced stealth capabilities like noise and acoustic suppression.
- Defence Acquisition Council (DAC) on 31st Jan 2019 gave formal approval to execute the Navy's Project-75I (P75I) worth ₹45,000 crore
- Aims at providing a significant boost to the 'Make in India' programme.
- Under the program, the submarines must be made up of **65 percent** indigenous material.
- Stating the terms and conditions in the Request For Proposal (RFP) for the construction of six advanced submarines under Project-75I as unrealistic, **France, and later Russia have withdrawn** from the project, leaving the future of the project in uncertainty.

**Project 75** that was launched in 2005 to build **Six Scorpene** (diesel-electric) **submarines of Kalvari class**.

1. INS Kalvari (commissioned in 2017),
2. INS Khanderi (commissioned in Sep 2019),
3. INS Karanj (commissioned in March 2021),
4. INS Vela (commissioned in Nov 2021),
5. **INS Vagir (Commissioned in Jan 2023)**, and
6. **INS Vagsheer (launched in April 2022 expected to be commissioned in 2023)**

RADAR / SONAR

-  **RADAR (RADIO DETECTION AND RANGING)** is a detection system that uses radio waves to determine the distance (*ranging*), angle, or velocity of objects.
- ❖ It can be used to detect aircraft, ships, spacecraft, guided missiles, motor vehicles, weather formations, and terrain.
  - ❖ A radar system consists of a **transmitter** producing electromagnetic waves in the radio or microwaves domain, a **transmitting antenna, a receiving antenna** (often the same antenna is used for transmitting and receiving) and a **receiver and processor** to determine properties of the object(s). Radio waves from the transmitter reflect off the object and return to the receiver, giving information about the object's location and speed.
- SONAR (SOUND NAVIGATION AND RANGING)** is a technique that uses sound propagation (usually underwater, as in submarine navigation) to navigate, measure distances (ranging), communicate with or detect objects on or under the surface of the water.
- ❖ Two types of technology share the name "sonar": **passive sonar** is essentially listening for the sound made by vessels; **active sonar** is emitting pulses of sounds and listening for echoes.

## INDIA SET TO COMMISSION ITS SECOND NUCLEAR-MISSILE SUBMARINE 11/8/24 ET

India is now all set to commission its **second nuclear-powered submarine, INS Arighat**, armed with nuclear missiles for strategic deterrence.

### About INS Arighat:

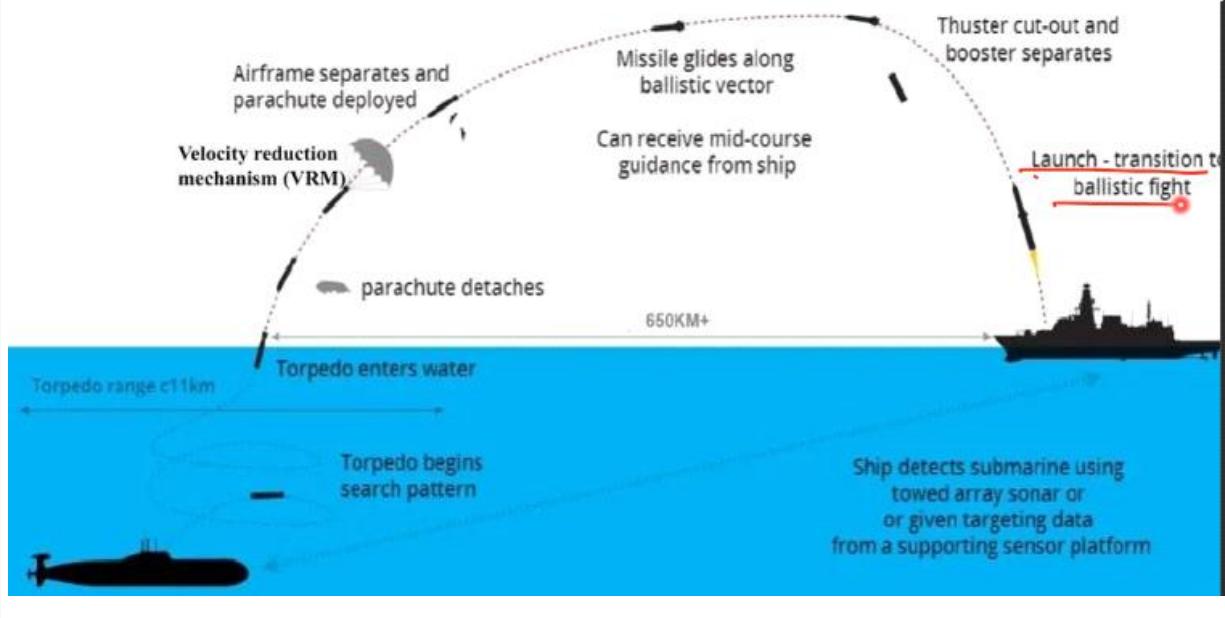
- It is India's second indigenously built nuclear-powered ballistic missile submarine (SSBN), following **India's first nuclear submarine, INS Arihant**, commissioned in 2018.
- It was constructed at the Indian Navy's Ship Building Centre (SBC) in Visakhapatnam.
- It represents a critical component of **India's nuclear triad**, enabling the nation to launch nuclear missiles from land, air, and sea.

### **Features:**

- It measures 111.6 meters in length, has a beam of 11 meters, a draught of 9.5 meters, and a displacement of 6,000 tonnes.
- It will have one seven-blade propeller powered by a pressurised water reactor.
- It can achieve a maximum speed of 12–15 knots (22–28 km/h) when on surface and 24 knots (44 km/h) when submerged.
- It can carry up to four nuclear-capable K-4 SLBMs (Submarine Launched ballistic Missile) with a range of over 3500 kilometers or twelve conventional warhead K-15 SLBMs with a range of about 750 kilometers.
- The K-15 can also carry a strategic nuclear warhead.
- It also carries torpedoes and mines.
- Additional safety measures include two standby auxiliary engines and a retractable thruster for emergency power and mobility.

## **'SMART' torpedo (Anti submarine torpedo)**

- SMART (**S**upersonic **M**issile **A**sisted **R**elease of **T**orpedo)
- Tested in **October 2020** from the APJ Abdul Kalam Island.
- **Anti-submarine** torpedo (under-water missile).
- *SMART is a missile-assisted release of lightweight anti-submarine torpedo system for beyond the range of a torpedo.*
- Indigenously developed by **DRDL** (Defence Research & Development Laboratory), **Research Centre Imarat** (RCI) and other defence organizations.

**GAME CHANGER ANTI SUBMARINE WARFARE****WARSHIPS****Types of war ships**

**Aircraft Carriers:** An aircraft carrier is a warship that serves as a seagoing airbase, equipped with a full-length flight deck and facilities for carrying, arming, deploying, and recovering aircraft. Typically, it is the capital ship of a fleet, as it allows a naval force to project air power worldwide without depending on local bases for staging aircraft operations.



**2. Cruisers:** A cruiser is a type of warship. Modern cruisers are generally the largest ships in a fleet after aircraft carriers and amphibious assault ships, and can usually perform several roles. As of 2021 only two countries operate cruisers: the United States and Russia, and in both cases the vessels are primarily armed with guided missiles.



**3. Destroyers:** A destroyer is a fast, manoeuvrable, long-endurance warship intended to escort larger vessels in a fleet & defend them against powerful short range attackers. Most destroyers are armed with guided missile systems.



**4. Frigates:** A frigate is a fairly small ship owned by the navy that can move at fast speeds. Frigates are often used to protect other ships.

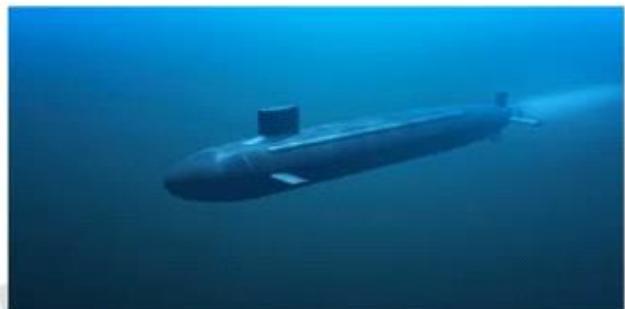


**5. Corvettes:** A corvette is a small warship. It is traditionally the smallest class of vessel considered to be a proper warship. A corvette is typically between 500 tons and 2,000 tons, although recent designs may approach 3,000 tons, which might instead be considered a small frigate.

The modern types of ship below a corvette are coastal patrol craft, missile boats and fast attack craft.



**6. Submarines:** A submarine is a watercraft capable of independent operation underwater. Submarines are referred to as "boats" rather than "ships" irrespective of their size.

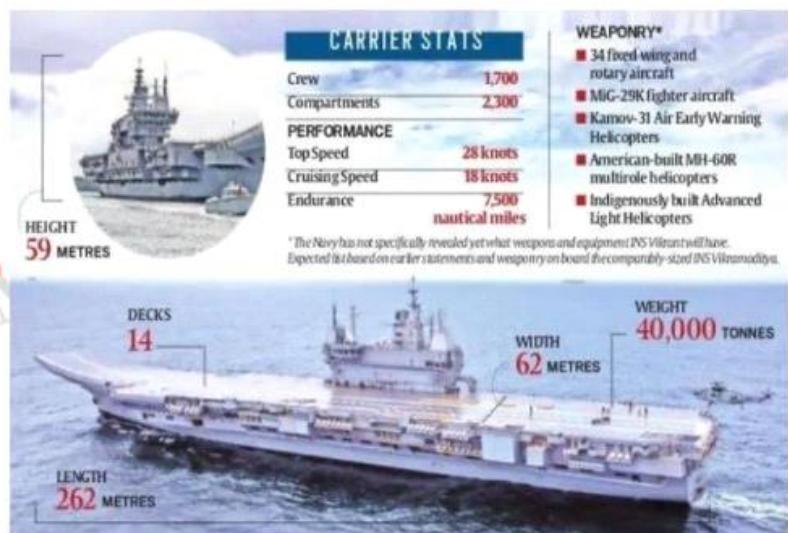


**7. Amphibious assault ships:** An amphibious assault ship is a type of amphibious warfare ship employed to land and support ground forces on enemy territory by an amphibious assault.



- India's first **Indigenous Aircraft Carrier (IAC-1)** - Commissioned on **September 2, 2022**.
- IAC-1 is designed by the Navy's **Warship Design Bureau** and built by the public-sector manufacturer **Cochin Shipyard Limited**.
- At present, India has only one other aircraft carrier, **INS Vikramaditya**, which was commissioned in 2013 and was built on a Russian platform.
- Defence forces were **seeking three carriers in all** — one in spare besides one each for the two main naval fronts, in the Indian Ocean and Bay of Bengal.

## INS Vikrant



Destroyer

## Project 15B (Missile destroyers)

- Project 15B is an ongoing project that involves construction of the Visakhapatnam-class destroyer (A class of stealth guided missile destroyers).
- They are designed by the Indian Navy's Directorate of Naval Design, based on the older **Project 15A** Kolkata-class destroyers (made with Russia's help).
- Visakhapatnam, a P15B stealth guided missile destroyer named after the port city of Andhra Pradesh on the East coast, is commissioned into the Indian Navy by Defence Minister Rajnath Singh at the Naval Dockyard, Mumbai on November 21, 2021.
- Visakhapatnam is packed with sophisticated 'state of the art' weapons and sensors such as Surface to Surface Missile and Surface to Air Missiles (Barak-8 & BrahMos).
- The ship is fitted with a modern Surveillance Radar which provides target data to the gunnery weapon systems of the ship.
- The ship's Anti-Submarine Warfare capabilities are provided by the indigenously developed Rocket Launchers, Torpedo Launchers and Anti Submarine Warfare, ASW helicopters.
- The ship is equipped to fight under Nuclear, Biological and Chemical (NBC) warfare conditions.
- The first vessel of the class, **INS Visakhapatnam** was commissioned on 21 November 2021.

### **Highlights:**

- Project was signed in January 2011.
- The first-of-class, **Visakhapatnam** was launched in April 2015.
- The first of the four, Visakhapatnam was commissioned into the Indian Navy in November 2021.
- The second ship of the type, **Mormugao** (named after a port city in Goa), was launched in September 2016 and commissioned into the Indian Navy on 18<sup>th</sup> December'22.
- In April 2019, India launched the third ship of Project 15B, a guided missile destroyer **Imphal**, at Mazagon Dock Shipbuilders, Mumbai. Planned to be commissioned in 2023.
- The fourth Visakhapatnam-class guided missile-destroyer, **Surat** is expected to enter service in 2024.

Frigates Class

### **Project 17A**

- Project 17A (Nilgiri class frigates) was approved by the Indian Government in **February 2015** to enhance the combat capabilities of the Indian Navy.
- The programme is a follow-on of the Project 17 **Shivalik-class frigates**.
- **Nilgiri-class vessels** were the updated versions of **British Leander class frigates**.
- The project involves the development of **seven advanced guided-missile frigates**, of which four will be built by **Mazagon Dock Shipbuilders** and the remaining three ships by **Garden Reach Shipbuilders & Engineers (GRSE)**.
- The first major class of Indian designed Stealth frigates (smaller warships than destroyers and are known for their maneuverability) are named INS Nilgiri (launched September 2019), INS Udaygiri (launched May 2022), INS Taragiri (launched September 2022), INS Himgiri (launched in Dec 2020 & expected to be commissioned in 2023), INS Dunagiri (Launched in July 2022), INS Vindhyaagiri and INS Mahendragiri after the names of hill ranges in India.
- They will feature improved stealth capabilities and roll stabilisation (To have a stable ship in challenging sea conditions) than its predecessor.
- They have the capability to accommodate two medium-sized **rotorcraft (Helicopters)** such as **HAL Dhruv or Sea King Mk. 42B helicopters**.
- The **Barak-8** missiles can be fired from their vertical launch system that can launch multiple missiles simultaneously.
- They are also equipped with **Brahmos supersonic cruise missiles**.

Missile name	Range	Payload
Prithvi Air Defence Missile	3000 km (Exo-atmosphere at 80 km)	5 kg
Advanced Air Defence Missile	150-200 km (Endo-atmosphere at 30 km)	50 kg
Prithvi Air Defence Vehicle	2,000 to 3,000 km (Exo-atmospheric at more than 120 km altitude)	10 kg

**1. India's Ballistic Missile Defence (BMD)** is announced ready for deployment (at Delhi) in **January 2020**. It consists of a Prithvi Air Defence (PAD) missile to intercept incoming missiles in exo-atmosphere and Advanced Air Defence (AAD) missile in endo-atmosphere.

- 1st : BMD
- 2nd : S400
- 3rd : BARK 8
- 4th : Akash
- 5th : NASAMS (inner most)

### PROPOSED MULTI-LAYERED **MISSILE SHIELD FOR NCT OF DELHI**

#### 1. Outermost BMD layer

- Two-tier indigenous system of AAD (advanced air defence) & PAD (Prithvi air defence) interceptor missiles
- Designed to track & destroy ballistic missiles both inside (endo) and outside (exo) at altitudes from 15-25 km to 80-100 km
- Phase-I (interceptor missiles with 4.5 Mach speed) meant for 2,000-km range enemy missiles. System almost ready
- Phase-II (interceptor missiles with 6-7 Mach speed) will be for 5,000-km class missiles

#### 2. S-400 layer

- Russian Triumf surface-to-air missile (SAM) systems
- \$5.43 billion (Rs 40,000 crore) deal inked in October 2018
- Missiles with interception ranges of 120, 200, 250 & 380 km
- Deliveries of 5 squadrons from Oct 2020 to April 2023

#### 5. NASAMS layer

- Quick reaction, networked system of Stingers, gun systems & AMRAAM missiles
- Deal for almost \$1 billion being finalized with the US
- Geared to track & destroy small incoming targets, shoot around buildings

#### 4. Akash layer

- Indigenous area defence missile system
- Range: 25-km
- IAF inducting 15 squadrons of Akash-1 & 2 systems for Rs 10,900 cr
- Army has inducted 2 regiments for Rs 14,180 cr. Two Akash-2 regiments on the way

#### 3. Barak-8 layer

- Interception range of 70 to 100 km
- Medium & long-range SAM systems jointly developed by Israeli Aerospace Industries & DRDO
- Systems being delivered to Navy (initial cost Rs 2,606 crore), IAF (Rs 10,076 crore) & Army (Rs 16,830 crore)

## 2. S-400

- The **S-400 Triumf** is Russia's air defence missile system.
- In October 2018, India signed a deal of **5.43 billion USD** with Russia for procuring **five squadrons** of S-400s.
- Trump administration had threatened India with **CAATSA sanctions** (The Countering America's Adversaries Through Sanctions Act-2017).
- S-400, a **long-range surface-to-air missile system**, intended to act as a shield over a particular area.
- It is considered one of the most advanced and potent air defence systems in the world, it has the capability to protect against **almost all sorts of aerial attacks**, including drones, missiles, rockets and even fighter jets.
- It comes with a capability of **tracking radars and airborne threats**.
- It can target enemy fighter jets and cruise missiles from **a distance of almost 400 km**.
- S-400 can be **assembled in a very short time** of mere five minutes and **can be fired from any terrain**.
- It is hard to detect and destroy S-400s, as they are very mobile.

**Q. How is S-400 air defence system is technically superior to any other system potentially available in the world? (10M, 150 words) UPSC 2021**

### Comparison with THAAD

- The American THAAD (Terminal High Altitude Area Defense) has a **single layer defence** has the capability to intercept and destroy short, medium and intermediate range ballistic missiles at the range of **200 Km** and altitudes of up to **150 Km**.
- It is a one dimensional missile system as it can fire only one type of missile and cannot intercept a fighter jet.

### • PATRIOT Advanced Capability – 3 (PAC-3)

- On the other hand, USA's **PATRIOT PAC-3** has the ability to intercept aerial targets at a **range of 180 km**. It also has the capability of launching ballistic missiles up to a range of 100 km.
- S-400 can **simultaneously track up to 160 objects** in a 600 km range, and **target 72 objects** in a 400 km range. Same parameters for Patriot are **36** and **125 targets**.
- S-400 can **shoot down targets** moving at a speed of 17 km/hour, while Patriot/PAC-3 could only shoot down a target moving at 8 km/hour.
- S-400 can be **deployed within five minutes**, compared to 25 minutes for Patriot (PAC-3).
- It is **cheaper** too, with an estimated per-battery cost of approximately \$500 million, compared to the **Patriot's \$1 billion** and **THAAD's \$3 billion**.

# L24 Drones, Jets, Reforms in Defence

17 November 2024 11:23 PM

DRONES	<ul style="list-style-type: none"><li>• UAV : Unmanned Aerial Vehicles<ul style="list-style-type: none"><li>• Drones, also known as <b>Unmanned Aerial Vehicles</b>, are often used for military purposes because they don't put a pilot's life at risk in combat zones.</li><li>• They are indispensable in reconnaissance, intelligence gathering, transporting and launching weapons/ammunition with high precision.</li><li>• <u>The first drones were imported into India from Israel</u> for use in active combat. India's DRDO has since then <u>developed numerous indigenous drones</u>.</li></ul></li></ul>
Rules	<ul style="list-style-type: none"><li>• India New Drone Rules 2021<ul style="list-style-type: none"><li>• Indian government in April 2018 launched "The iDEX initiative" (Innovations for Defence Excellence) to achieve self-reliance and foster innovation &amp; technology development in defence and aerospace sectors.</li><li>• In June 2021, to encourage <b>domestic innovation and indigenous development</b> of drone systems, <b>498.8 crore</b> budget was allocated by Ministry of Defence under iDEX.</li><li>• IDEX engages with MSMEs, start-ups, innovators, academics, and R&amp;D institutions to evaluate technologies for scalability and aids the armed forces in technological adoption.</li><li>• <u>In August 2021, India's Ministry of Civil Aviation notified the new liberalized Drone Rules, 2021.</u></li><li>• They came in place of <b>previous rules</b> released in March 2021, which were perceived as <b>restrictive</b> as they involved <b>considerable paperwork, required permissions</b> for every drone flight and <b>very few "free to fly" green zones</b>.</li><li>• These liberalized rules are aimed at making India <b>global drone hub by 2030</b>.</li><li>• These rules marks <b>a new era</b> in the Indian drone ecosystem which as per the Civil Aviation Ministry estimates to achieve a total turnover of Rs. 120-150 billion by 2026, from its current turnover of about Rs. 800 million and can <b>create 5,00,000 professional jobs</b> in the next 5 years.</li><li>• <b>Applications of drones</b> in areas like precision farming, 3D terrain mapping, medical supplies, inspections of irrigation and other construction projects is expected to explode in future.</li></ul></li></ul>

## India's New liberalized Drone Rules-2021

### Drone categories

Category	Weight
<b>Nano</b>	< 250 g
<b>Micro</b>	250 g – 2 kg
<b>Small</b>	2 kg – 25 kg
<b>Medium</b>	25 kg – 150 kg
<b>Large</b>	> 150 kg

### Zones

**GREEN ZONE:** Airspace up to a vertical distance of 400 feet that is not designated as red or yellow zone

**YELLOW ZONE:** Airspace above 400ft in green zone, and air space above 200ft within 8 to 12km from an airport. These are restricted, and need ATC permit

**RED ZONE:** Airspace where UAVs only allowed by Centre are permitted

ATC: Air Traffic Control

An [interactive airspace map](#) is available on Digital Sky.

## Draft Drone Rules, 2021: Highlights

Number of forms reduced from  
**25 to 6**



Digital sky platform shall be developed as a **business-friendly, single-window online system**

**No flight permission required up to 400 feet in green zones, and up to 200 feet in the area between 8 and 12 km from the airport perimeter**

**No pilot licence required for micro drones** (for non-commercial use), nano drones and for R&D organisations.

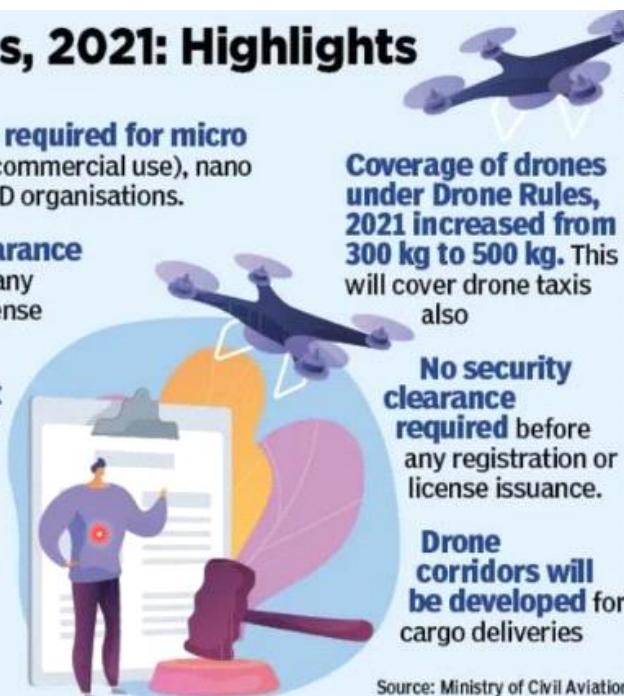
**No security clearance required** before any registration or license issuance.

**No requirement of certificate of airworthiness, unique identification number**, prior permission and remote pilot license for R&D entities.

**Coverage of drones under Drone Rules, 2021 increased from 300 kg to 500 kg.** This will cover drone taxis also

**No security clearance required** before any registration or license issuance.

**Drone corridors will be developed** for cargo deliveries



Source: Ministry of Civil Aviation

**REGISTRATION**

Online registration of operators  
Pilots and UIN issuance (**Unique Identification Number**)

**FLIGHT PLANNING**

App-based permit request  
UAV verifies Permission Artefact

**REPORTING**

Logging of Flight Plans with DGCA  
Incident Reporting

- Import of drones to be regulated by **Director General of Foreign Trade (DGFT)**.
- The **Directorate General of Civil Aviation (DGCA)** shall prescribe drone training requirements, oversee **drone schools** and provide **pilot licenses** online.

Kamikaze Drones

**Kamikaze (suicide) drones**

- Also called '**Switchblade drones**', these are unmanned aircrafts that don't fire missiles, but **they are the missiles**.
- These could be viewed as **flying bombs** that explode on contact.
- About 100 of such drones are being sent by the **US to Ukraine** to assist their fight against Russia.
- They are **Low-cost, light-weight "killer" drones** - can change ground warfare.
- They are equipped with cameras and provide areal view of the battle ground.



NETRA

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**NETRA**

- Netra is an indigenously made, **autonomous UAV** for surveillance and reconnaissance operations.
- It has been jointly developed by the DRDO's Research and Development Establishment (R&DE), and IdeaForge, a Mumbai-based private firm.
- Netra is equipped with a resolution CCD camera with a pan/tilt and zoom to facilitate wider surveillance. It can also be fitted with thermal cameras to carry out night operations.
- operational altitude of the UAV is **200 meters maximum**, having a vertical take-off and landing capacity (VTOL) and is equipped with a **wireless transmitter**.
- In-built fail-safe features allows Netra to return to base on loss of communication or low battery.

**Light Combat aircraft (LCA) Tejas (India's Eagle in the sky)**

- It is designed by **Aeronautical Developmental Agency** (ADA) & manufactured by **Hindustan Aeronautics Ltd. (HAL)**.
- It is being developed in **single-seat fighter** and **twin seat trainer** variants for the Indian Air Force and Indian Navy. Tejas currently has 3 production models Tejas Mark1, Mark 1A and trainer variant.
- The IAF currently placed an order for 40 Tejas Mark 1, 73 Tejas Mark 1A & 10 trainer air crafts.
- So far, IAF has inducted 30 of the 123 Tejas jets ordered previously from HAL.
- Going to be the **backbone of the fighter fleet** of the Indian Air Force (**Self-reliance**)
- It is the smallest **lightweight, multi-role, single-engine** tactical fighter aircraft in the world. (Note: Tactical weapons or forces are those which a military leader can decide for them selves to use in a battle, rather than waiting for a decision by a political leader)
- It has many **advanced features** like: Beyond Visual Range Missile capabilities, Air-to-Air Refuelling and Air-to-Ground weapons.



Characteristics	Tejas Mark 1/1A	Tejas Mark II
Class	Multi role light fighter (MRLF)	Multi role medium weight fighter (MRMWF)
Wing type	Delta	Delta with Canards (fore wings)
Empty weight	6560kg	7850kg
Max take-off weight	13500kg	17500kg
Range	1850km	2500km
Speed	Mach 1.6-1.8	Mach 2
Air-air refueling	Yes	Yes
Expected replacement for	MiG-21	Jaguar, Mirage-2000, MIG-29
Present status	inducted into service	prototype
Generation	4.5 gen	4.5 generation
Series production	Commenced 2015	Expected in 2026

- After the success of LCA, government has approved the project to **Tejas mark-2**, a much more powerful version.
- Flight testing and certification of Tejas Mark-2 would cost 6500 crore in addition to the 2500 crore earlier sanctioned for it.
- Tejas Mark-2 would have a longer combat range and greater capacity to carry the weapons.
- Once **Tejas Mark-2** is completed, it could be followed by a mega project to build **5<sup>th</sup> gen, Advanced Medium Combat Aircraft (AMCA)**.
- CCA (Controller of certifying authorities) clearance of 15000 crore project to build 5<sup>th</sup> gen AMCA will follow within the next few months.

Rafale  
Fighter Jets

## Rafale Fighter Jets

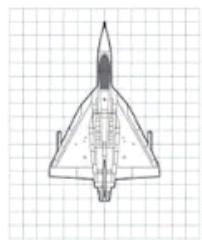
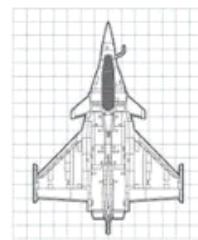
- Rafale is a **French-designed twin-engine**, delta wing, omni role fighter aircraft.
- In 2016, India had signed a deal with the **French government and Dassault Aviation** to acquire 36 Rafale fighter jets for over Euro 7.8 billion.
- Categorised as a **4.5 generation aircraft** for its radar-evading stealth profile, and a **level up over the Dassault Mirage 2000 (A French multi role single engine 4<sup>th</sup> gen fighter jet, Used in Kargil war and Balakot attack)** and the Russian **Su-30 MKI**, (India's most popular fighter jet and serves as back bone of IAF).
- The Rafale can fly at speeds of 1.8 mach (2,222.6km per hour) and can climb to a height of 50,000 feet. It has a range of 3,700km, which can be increased with mid-air refuelling.

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- It can carry 9,500kg of bombs and munitions. This is more than the **Sukhoi 30 MK1**, which can carry loads of up to 8,000kg
- The indigenously developed Light Combat Aircraft (LCA) Tejas can be categorised as 4.5 generation in terms of avionics and technology but it is too small in comparison with Raffale.

DASSAULT  
Rafale

HINDUSTAN AERONAUTICS  
Tejas-Mark 1A



### HOW THEY COMPARE

	Rafale	Tejas-Mark 1A
Crew	1-2	1
Length	15.3 m	13.2 m
Wingspan	10.9 m	8.2 m
Maximum speed (Mach)	1.8	1.8
Maximum takeoff weight	24,500 kg	13,500 kg
Payload	9,500 kg	5,300 kg
Combat radius	1,852 km	300 km
Service ceiling	15,240 m	16,000 m
Range	3,700+ km	3,000 km



### Sukhoi 30 MK 1

It is a twinjet multirole air superiority fighter (designed to seize control of an enemy airspace) developed by Russia's Sukhoi and built under licence by India's Hindustan Aeronautics Limited (HAL) for the Indian Air Force (IAF). A variant of the Sukhoi Su-30, it is a heavy, all-weather, long-range fighter.

#### Apache Helicopter

- Said to be the **most modern attack helicopters** (AH-64E)
- Designed and equipped with the latest communication, navigation, sensors and weapon systems.
- India purchased **22 Apache helicopters** from USA's **Boeing** to replace **Russian-built Mi-25 and Mi-35 helicopters**
- Apache Helicopters were delivered by July 2020.



#### Chinook Helicopters

- Contract signed in 2015 with USA's **Boeing** for **15 helicopters**.
- Payload capability of **10 tonnes** and **high altitude performance**, these helicopters have filled the gap in IAF's **heavy-lift helicopter** capability.
- To replace the **Russia-made Mi-17** medium-lift helicopters & **Mi-26** helicopters
- Advanced multi-mission helicopters, with primary role of **transportation** of troops, artillery, equipment, and fuel.
- Disaster relief, rescue operations etc.
- Have been of great help in the **construction of infrastructure** and border road projects especially in the North East.



ALH MK III

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### Advanced Light Helicopter (ALH) MK III

- Indian coast guard commissioned “**835 squadron (CG)**”, an indigenous **Advanced Light Helicopter (ALH) MK-III squadron** on 28<sup>th</sup> June 2022. It is a tremendous leap towards self reliance in maritime surveillance.
- ALH are developed and manufactured by **Hindustan Aeronautics Limited (HAL)**
- These helicopters consists **modern surveillance radar** and **electro-optical sensors**. (More covert than RADARs. They are either completely passive or emit much narrow beams than RADARs. They are more precise than RADARs)
- Apart from their primary roles of integral Maritime Reconnaissance (MR) and Search and Rescue (SAR), they can also be deployed for **Humanitarian Assistance and Disaster Relief (HADR)** Operations as well as Special Operations with Marine Commandos.
- These helicopters also have **an airborne Medical Intensive Care Unit (MICU)** for use in the Air Ambulance role to facilitate the medical evacuation of critically ill patients.



## Light combat helicopter (LCH) 'Prachand'

An Indian multi role, light attack helicopter, designed and manufactured by Hindustan Aeronautics Limited (HAL) under project LCH. It is customized as per the requirement of Indian armed forces to operate both in desert terrains and high-altitude sectors.



## Reforms in Defense sector in India for self-reliance

- **Defence Procurement Procedure – 2016** (DPP-2016) introduced many **significant policy changes** pertaining to India's defence acquisition, **the most significant reform measure** of being in '**Strategic Partnership**'.
- **This model has four segments** — submarines, single-engine fighter aircraft, helicopters and armoured carriers/main battle tanks — which would be specifically opened up for the private sector.
- **As part of this, one Indian private company** would be selected in each segment which would **tie-up with shortlisted global equipment manufacturers** to manufacture the equipment in India under **technology transfer**.
- '**Innovations For Defence Excellence (iDEX)**' was launched by the government of India in **2018** to **modernize the Defence Industry**.
- iDEX aims at creation of an ecosystem to foster innovation and technology development in **Defence and Aerospace** by **engaging Industries including MSMEs, start-ups, individual innovators, R&D institutes & academia**.
- The **Defence Acquisition Procedure (DAP) 2020** has **increased the indigenous content** requirement in all categories of defence procurement.
- Increase in indigenous availability of high-end military materials, the use of indigenous software in equipment/systems and a boost to innovation by start-ups and Micro, Small and Medium Enterprises (MSMEs).
- In **September 2020**, increased the **Foreign Direct Investment** in the defence sector from 49% to 74% under the automatic route.
- In **September 2021**, new rules are announced to **enhance the delegation of revenue procurement powers** for the Army, Navy and Air Force.
- Under the new rules, critical equipment like air-to-air refuellers for the Air Force, can be hired for short periods as compared to buying them or a long-term lease.

BIOFUELS	<p>Energy markets began to tighten in 2021 because of a variety of factors, including the extraordinarily rapid economic rebound following the <b>pandemic</b>. But the situation escalated dramatically into a full-blown global energy crisis following <b>Russia's invasion of Ukraine in 2022</b>.</p> <p>The <b>International Energy Outlook</b> predicts that from 2003 to 2030, global energy consumption would rise by 71%. This created an increased need to search for alternative sources of energy.</p> <p>Microorganisms can act as a reliable source of alternative fuel to meet the current shortage in various ways:</p> <ul style="list-style-type: none"> <li>• Fermentation : Cellulose -&gt; Bio ethanol</li> <li>• Tran Esterification : Oils -&gt; Bio diesel</li> <li>• Bio Methanation : Organic material -&gt; Bio gas (Methane+ CO2)</li> </ul>
Types	<p>✓ <b>First Generation biofuels:</b> Made from food related sources like Sugar cane, Sorghum, Corn, Wheat, Barley etc. using <b>fermentation process</b> e.g. <b>Bioethanol</b>, and Sunflower, rape seed etc by <b>trans esterification, a process that converts fats and oils into Biodiesel</b>. They impact food security and bio diversity</p> <ul style="list-style-type: none"> <li>• <b>Second generation biofuels:</b> Non-food related sources like waste from food crops, agricultural residue, wood chips, waste cooking oil etc by <b>fermentation or transesterification</b>. No impact on food security and bio diversity <b>E.g., Bio methanation:</b> It is a process by which organic material is microbiologically converted under anaerobic conditions to <b>biogas (Mixture of Methane &amp; Carbon dioxide)</b> by <b>fermenting bacteria, organic acid oxidizing bacteria, and methanogenic archaea</b>. It will help to reduce the use of fossil fuels. While combustion of biogas produces carbon dioxide, a greenhouse gas, it comes from plant matter that fixed this carbon from atmospheric carbon dioxide. Thus, biogas is carbon neutral)</li> <li>• <b>Third generation biofuels:</b> Made from micro algae. No impact on food security and bio diversity. <b>E.g., “Algae fuel” or “oilgae”.</b> It includes use of <b>specially cultivated Microalgae</b>. For example, generation of <b>Butanol</b> using microalgae.</li> <li>• <b>fourth generation biofuels:</b> Made from genetically modified microbes that give high yield of the biofuel. No impact on food security and bio diversity</li> </ul>

**Bioprocessing:** Microorganisms can be used to **upgrade the quality of petroleum** and coal by removing undesirable elements such as sulfur, nitrogen, metals, and ash using Bioprocessing. It can make fuel less expensive.

**Biomass gasification:** A pathway that uses a controlled process involving heat, steam, and oxygen to convert biomass to hydrogen. It is **partial oxidation of biomass with very high temperature** ( $800 - (900^{\circ}\text{C})$ ) to produce Hydrogen.

#### **Advantages of biofuels:**

**Availability of source material:** Biofuels can be produced from a variety of materials, such as crop waste, manure, and other by-products, unlike oil, which is a finite resource.

**Environment Pollution:** Can help in reducing carbon dioxide emission and achieving **Intended Nationally Determined (INDC)** targets to generate **40% of electricity** from non-fossil fuel sources By 2030.

**Management of municipal solid waste** by converting waste into fuel.

- Local production of biofuels reduces the country's reliance on imported energy and help in creating employment in rural areas.
- **Stimulation to the agriculture sector:** Biofuel production will also increase the demand for suitable biofuel crops, providing economic incentives to the sector.

#### **Challenges:**

**Efficiency:** Fossil Fuels produce more energy than some biofuels. E.g., 1 gallon of ethanol produces less energy as compared to 1 gallon of gasoline (a fossil fuel).

**Cost:** land is needed to produce biofuels, which has an impact on both the price of biofuels and the price of food crops.

**Food Vs Fuel debate:** There is a concern that using valuable cropland to grow **fuel crops** could have an impact on the cost of food and could lead to food shortages.

**Water use:** Massive quantities of water are required for proper irrigation of biofuel crops as well as to manufacture the fuel, which could strain local and regional water resources.

Biofuels are a **promising alternative** to fossil fuels and can help achieve India's commitments to decrease the carbon footprint and reduce India's **oil and gas import bill**.

**Microbial fuel cells:** A microbial fuel cell (MFC) is a device that uses microorganisms to transform chemical energy into electrical energy. The MFC consists of anode and cathode chambers, and they are separated by a proton exchange membrane (PEM). At the anode, the fuel/substrate is oxidised using bacteria as catalyst to generate protons, electrons, and CO<sub>2</sub>. While the protons are moved to the cathode chamber through the exchange membrane.

The electrons are transferred from anode chamber to cathode chamber employing an external electrical circuit to generate electrical energy. At the cathode, the protons and electrons combine with oxygen (O<sub>2</sub>), and form into water.

