



# मुख्यमंत्री अभ्युदय योजना



General Studies

## SCIENCE AND TECHNOLOGY

मुख्यमंत्री अभ्युदय योजना प्रकोष्ठ  
उत्तर प्रदेश प्रशासन और प्रबंधन अकादमी  
सेक्टर-D, अलीगंज, लखनऊ - 226024

यह अध्ययन-सामग्री मुख्यमंत्री अभ्युदय योजना प्रकोष्ठ (उत्तर प्रदेश प्रशासन और प्रबंधन अकादमी) द्वारा उत्तर प्रदेश सरकार की मुख्यमंत्री अभ्युदय योजना के अंतर्गत सिविल सेवा परीक्षा की तैयारी कर रहे प्रतियोगियों की सहायता के लिए तैयार कराई गई है।

इस पाठ्य-सामग्री को उत्तर प्रदेश प्रशासन एवं प्रबंधन अकादमी, लखनऊ में 65वें आधारभूत प्रशिक्षण कार्यक्रम के अंतर्गत प्रशिक्षण प्राप्त कर रहे प्रशिक्षु (डिप्टी कलक्टर-UPPCS-2018) द्वारा प्रोजेक्ट कार्य के रूप में तैयार किया गया है।

इस सामग्री की पूर्णतः शैक्षणिक और जन कल्याणकारी-उद्देश्यों के लिए तैयार किया गया है-इसका एक मात्र उद्देश्य प्रदेश के छात्र/छात्राओं का प्रतियोगी परीक्षाओं की तैयारी में मार्गदर्शन व सहयोग करना है।

**वैधानिक सूचना** - इस अध्ययन सामग्री का किसी भी प्रकार से व्यावसायिक उपयोग प्रतिबंधित है।

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# SPACE AND SPACE TECHNOLOGY

## EVOLUTION OF UNIVERSE- BIG BANG THEORY-

- It is believed that universe was born about **13.8 billion years ago** in an event called Big Bang. It is most prevailing cosmological model for birth of the universe.
- **Big Bang Theory**: it states that at some moment all of space was contained in a **single point of very high-density and high-temperature state** from which the universe has been expanding in all directions ever since.
- After the initial expansion, the universe cooled sufficiently to allow the formation of subatomic particles and later simple atoms.
- The majority of atoms produced by the **Big Bang were hydrogen and helium** along with trace amounts of lithium and beryllium.
- Giant clouds of these primordial elements (hydrogen and helium) later coalesced through gravity to **form stars and galaxies**.

## NEUTRINOS-

- Neutrinos are the **second most widely occurring particle** in the universe, only second to photons, the particle which makes up light.
- These were first proposed by Swiss scientist **Wolfgang Pauli** in 1930.

<b>Characteristics:</b>	<ul style="list-style-type: none"><li>• They are elementary <b>weakly interacting subatomic</b> particles.</li><li>• They have little mass or are <b>nearly massless</b>.</li><li>• They are <b>no-charge</b> particles that only interact with weak nuclear force.</li><li>• <b>Least harmful</b> of all elementary particles, as they seldom react with solid bodies.</li></ul>
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	<ul style="list-style-type: none"> <li>• Gave astronomical information like beta decay of star or supernova.</li> </ul>
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## INDIA-BASED NEUTRINO OBSERVATORY (INO):

- INO is a **multi-institutional effort** aimed at building a world-class underground laboratory with a **rock cover** of approximately 1200 m **for Non-accelerator based high energy and nuclear physics research** in India. It is situated at **Theni (Tamil Nadu)**.
- It is a **mega-science project** jointly funded by the **Department of Atomic Energy (DAE)** and the **Department of Science and Technology (DST)**.
- The initial goal of INO is to **study Neutrinos**.

<b>Why TO detects Neutrinos?</b>	<ul style="list-style-type: none"> <li>• Neutrinos hold the key to important and fundamental questions on the origin of the Universe and the energy production in stars.</li> <li>• For Neutrino tomography of the earth, that is a detailed investigation of the structure of the Earth from core onwards. This is possible with neutrinos since they are the only particles which can probe the deep interiors of the Earth.</li> </ul>
<b>The INO project includes:</b>	<ul style="list-style-type: none"> <li>• Construction of an <b>underground laboratory</b> and associated surface facilities at Pottipuram in <b>Bodi hills</b> of Theni District of <b>Tamil Nadu</b>.</li> <li>• Construction of an <b>Iron Calorimeter (ICAL) detector</b> for studying neutrinos.</li> <li>• Setting up of <b>National Centre for High Energy Physics at Madurai</b>, for the operation and maintenance of the underground laboratory.</li> </ul>



## STARS AND THEIR LIFECYCLE-

<b>Formation:</b>	<ul style="list-style-type: none"><li>Stars are formed in clouds of gas and dust, known as nebulae. Nuclear reactions (fusion- hydrogen to helium) at the center (or core) of stars provides enough energy to make them shine brightly for many years.</li></ul>
<b>Lifetime:</b>	<ul style="list-style-type: none"><li>The exact lifetime of a star depends very much on its size. Very large, massive stars burn their fuel much faster than smaller stars and may only last a few hundred thousand years. Smaller stars, however, will last for several billion years, because they burn their fuel much more slowly.</li></ul>
<b>Phases:</b>	<ul style="list-style-type: none"><li>When hydrogen fuel that powers the nuclear reactions within stars will begin to run out, they enter into the final phases of their lifetime. Over time, they will expand, cool and change color to become <b>red giants</b>. The path they follow beyond that depends on the mass of the star.</li></ul>
<b>Small stars:</b>	<ul style="list-style-type: none"><li>Like the Sun, will undergo a relatively peaceful and beautiful death that sees them pass through a <b>planetary nebula</b> phase to become a <b>white dwarf</b>, which eventually cools down over time and stops glowing to become a so-called "<b>black dwarf</b>" which emits no energy.</li></ul>
<b>Massive stars:</b>	<ul style="list-style-type: none"><li>Will experience a most energetic and violent end, which will see their remains scattered about the cosmos in an enormous explosion, called a <b>supernova</b>. Once the dust clears, the only thing remaining will be a very dense star known as a <b>neutron star</b>, these can often be rapidly spinning and are known as <b>pulsars</b>. If the star which explodes is especially large, it can even form a <b>black hole</b>.</li></ul>

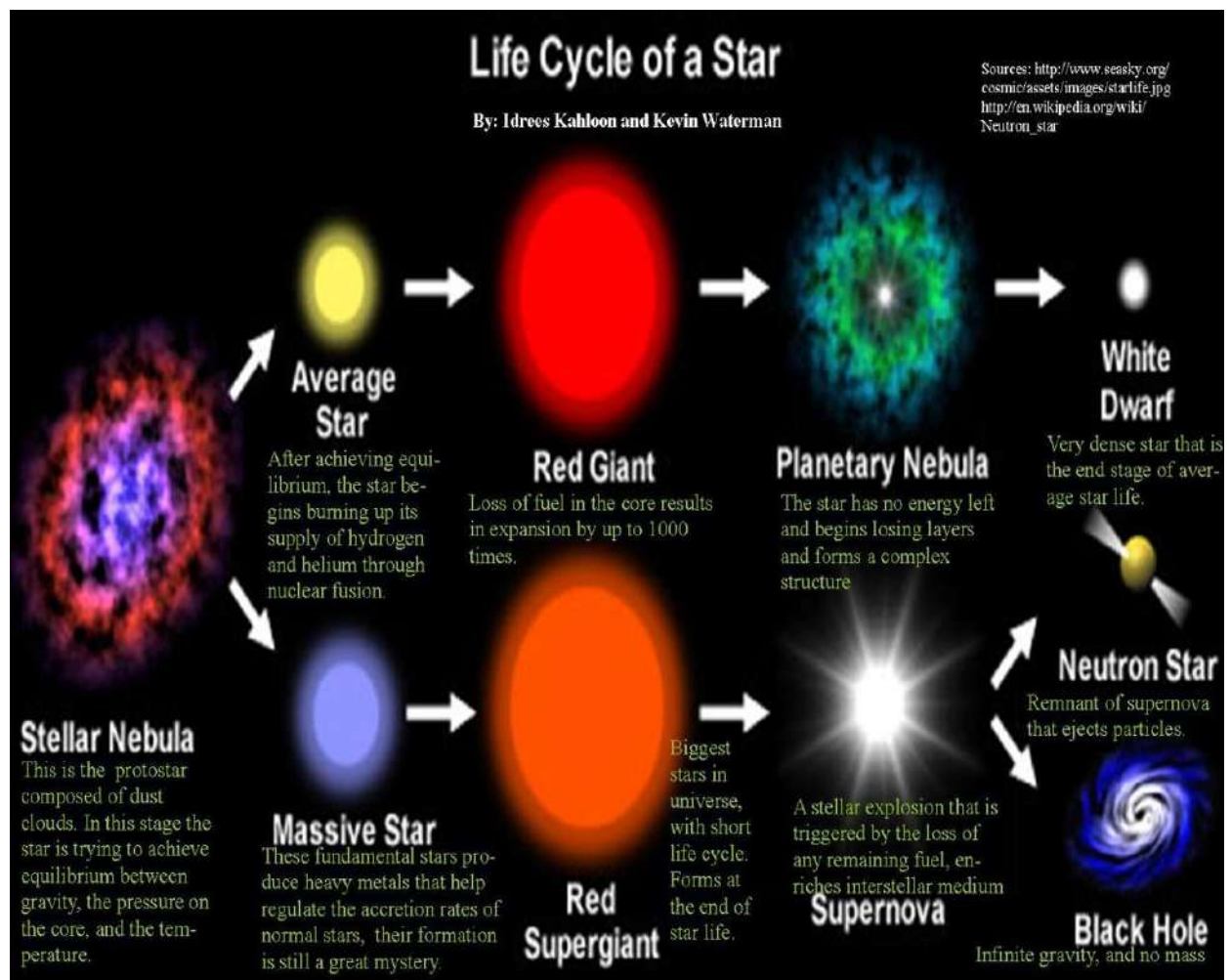
## BLACKHOLE-

A black hole is an object in space that is formed after **the death of a star** (core runs out of fuel) and is so dense and has strong gravity that no matter or light can escape its gravity pull. Because no light can escape, it is **black and invisible**.

<b>Types of Black holes:</b>	<b>Steller-mass black holes:</b> Small black holes, have masses about five to 20 times the mass of the sun.
	<b>Super-massive black holes:</b> which are millions to billions time more massive than the sun. Super-massive black holes are found at the centre of most galaxies. The super-massive black hole in our own galaxy, Milky way is called Sagittarius A*.

<b>Event Horizon Telescope project:</b>	<ul style="list-style-type: none"><li>• EHT is group of 8 radio telescopes used to detect radio waves from space.</li><li>• In 2019, Scientists from EHT project released the first-ever optical image (or shadow image) of a Black hole located in the center of galaxy Messier 87 in the constellation Virgo.</li><li>• <b>Sagittarius A*</b> is the 2nd black hole to get photographed.</li></ul>
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## Life cycle of a star-



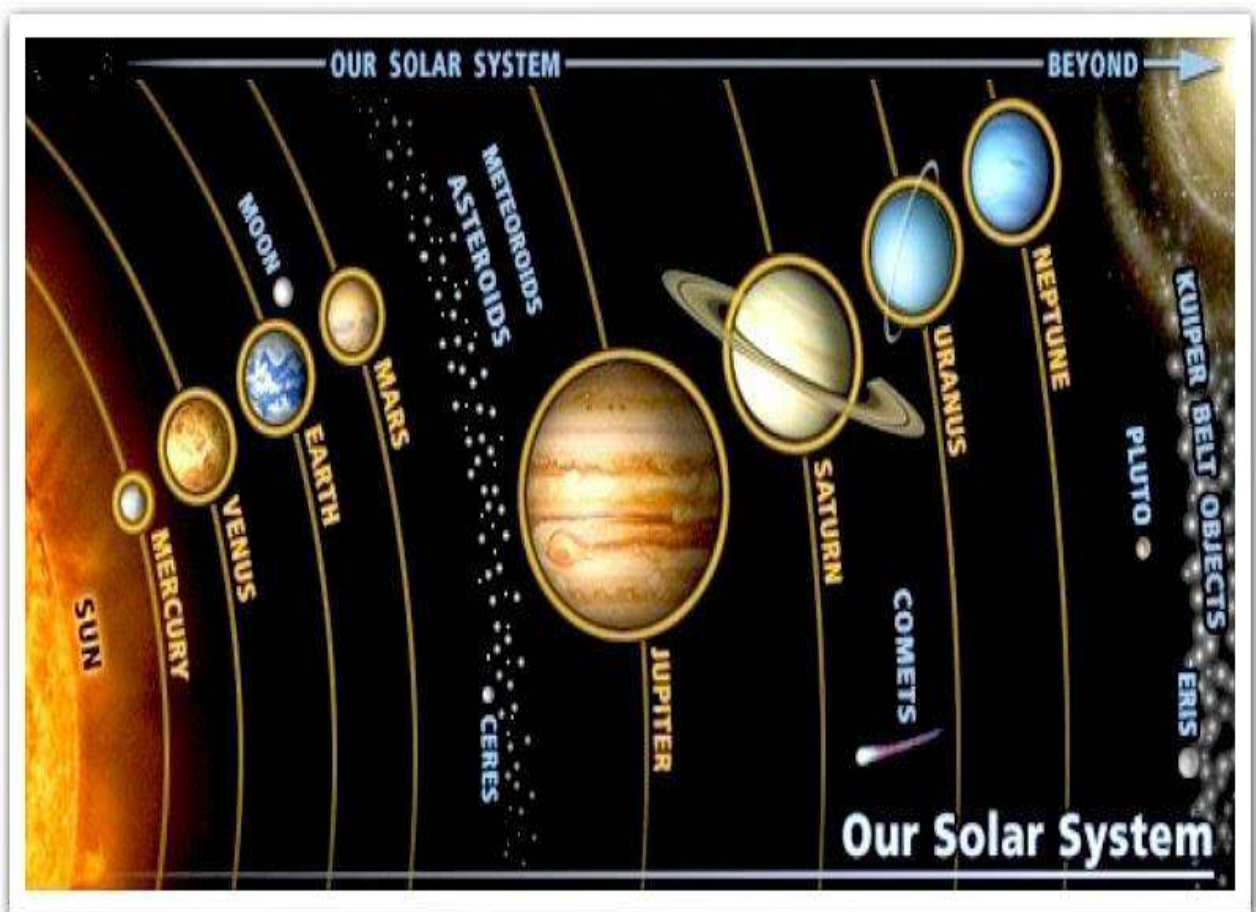
# अभ्युदय



## SOLAR SYSTEM AND ITS PARTS-

- The planets of our solar system are divisible in two groups: **Terrestrial planets and Jovian planets.**
- **Terrestrial planets or inner plants:** - lie between sun and the belt of asteroids, Earth like planets made up of rocks and metals and relatively high densities. E.g., **Mercury, Venus, Earth, Mars.**

**Jovian planets or outer planets:** - gas giants or Jupiter like planets, larger size and less dense materials, have thick atmosphere, mostly of helium and hydrogen. E.g., **Jupiter, Saturn, Uranus, Neptune**



## KUIPER BELT-

The Kuiper Belt is a ring of icy rocks & dust bodies just outside of Neptune's orbit, known as Kuiper belt objects or **trans-neptunians**.

## ASTEROID BELT-

- Asteroids are remnants of planetary formation **mainly composed of refractory rocky and metallic minerals and some ice**, that circle the sun in a zone lying between Mars and Jupiter. The circular chain of asteroids is called **asteroid belt or main asteroid belt**.
- The remnants of planetary formation **failed to coalesce** due to **gravitational interference of Jupiter**.

## ASTEROIDS-

- **Big chunks of rocks** floats through space and orbit the sun, mostly found in main asteroid belt i.e., between **Mars and Jupiter**.
- The biggest one is **Ceres** (940km wide), as twice as big as Grand Canyon.

## METEROIDS-

- Smaller rock pieces that break off from asteroid, it floats through interplanetary space. Can be as small as grain of sand or as large as a meter across.

## METEOR-

- When **meteoroid enters into earth atmosphere**, it begins to burn up and fall to the ground.
- This burning trail is known as **meteor or “falling stars”**.
- Meteors and comets both create bright trails through night, but comets are made up of ice and dust, not rock – like a giant dirty snowball.

## COMETS-

- Comets are frozen leftovers from the formation of the solar system composed of **dust, rock and ices, ranges** from few miles to tens of miles wide.
- Orbits closer to the sun, they heat up and spew gases and dust into a **glowing head** visible in atmosphere.
- Comets have **highly elliptical orbits**, unlike planets which have near-circular orbits.

## INDIAN SPACE RESEARCH ORGANISATION-

- **Nodal space research agency** of Government of India
- Founded on 15<sup>th</sup> August, 1969. Headquarter - Bengaluru, Karnataka
- Managed by Department of Space (DOS), which **reports directly to PM.**

## ISRO COMMERCIAL ARM-

<b>Indian National space, Promotion &amp; Authorization Centre (IN-SPACe):</b>	<ul style="list-style-type: none"><li>● Under Department of space to encourage, promote and hand hold the private sector for their participation in space sector.</li><li>● Private players will also be able to use ISRO infrastructure through IN-SPACe.</li></ul>
<b>New Space India Limited (NSIL):</b>	<ul style="list-style-type: none"><li>● A public sector undertaking (PSU) under the department of Space.</li><li>● It will commercially exploit the research and development work of space agency.</li><li>● Co-produce PSLV and launch satellite through SSLVs.</li></ul>

## TYPES OF ORBITS-

- Satellites are generally characterized by the distance from the earth at which they revolve and on basis of application of the Earth.
- **On basis of height-**
  1. LEO Satellite (Lower Earth Orbit)
  2. MEO Satellite (Middle Earth Orbit)
- **On basis of application-**
  1. Geo- Synchronous Earth Orbit
  2. Geo- Stationary Earth Orbit

<b>Low Earth Orbit (LEO)</b>	<ul style="list-style-type: none"><li>• LEO is commonly used for communication and remote sensing satellite systems, as well as the International Space Station (400km) and Hubble Space Telescope (560km).</li></ul>
<b>Medium Earth Orbit</b>	<ul style="list-style-type: none"><li>• MEO is commonly used for navigation systems, including the U.S. Global Positioning System (GPS).</li></ul>
<b>Geosynchronous Orbit (GSO) &amp; Geostationary Orbit (GEO)</b>	<ul style="list-style-type: none"><li>• Objects in GSO have an orbital speed that matches the Earth's rotation, yielding a consistent position over a single longitude.</li><li>• An orbit is called sun-synchronous when the angle between the line joining the centre of the Earth and the satellite and the Sun is constant throughout the orbit.</li><li>• It enables the on-board camera to take images of the earth under the same sun- illumination conditions during each of the repeated visits</li></ul>
<b>Geosynchronous Transfer Orbit (GTO)</b>	<ul style="list-style-type: none"><li>• To attain geosynchronous (and also geostationary) Earth orbits, a spacecraft is first launched into an elliptical orbit with an apoapsis altitude in the neighbourhood of 37,000 km. This is called a Geosynchronous Transfer Orbit (GTO).</li><li>• The spacecraft then circularizes the orbit by turning parallel to the equator at apoapsis and firing its rocket engine.</li></ul>



<b>Polar Orbit</b>	<ul style="list-style-type: none"> <li>• Polar orbits are 90-degree inclination orbits, useful for spacecraft that carry out mapping or surveillance operations.</li> <li>• Within 30 degrees of the Earth's poles, the polar orbit is used for satellites providing reconnaissance, weather tracking, measuring atmospheric conditions, and long-term Earth observation.</li> </ul>
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## TYPES OF SATELLITES-

A satellite is a moon, planet or machine that orbits a planet or star. Thousands of artificial, or man-made, satellites orbit Earth.

<b>Communications Satellites:</b>	They are used for communicating over large distances. Ex: INSAT series.
<b>Earth Observation Satellites:</b>	These satellites are used for observing the earth's surface and as a result, they are often termed geographical satellites. The data is used for several applications covering agriculture, water resources, urban development, mineral prospecting, environment, forestry, drought and flood forecasting, ocean resources and disaster management. Ex: OCEANSAT
<b>Navigation Satellites:</b>	Used for navigation purposes. Ex: IRNSS (India), GPS (USA)

## LAUNCH VEHICLE TECHNOLOGY-

- Launchers or Launch Vehicles are used to carry spacecraft to space.
- **Historic launchers:** SLV, Augmented Satellite Launch Vehicle (ASLV)
- India has **two operational launchers:** Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV).
- GSLV with indigenous Cryogenic Upper Stage has enabled the launching up to 2 tons class of communicationsatellites.
- The next variant of GSLV is GSLV Mk III, with indigenous high thrust cryogenic engine and stage, having the capability of launching 4



tons class of communication satellites.

- Vikram Sarabhai Space Centre, located in Thiruvananthapuram, is responsible for the design and development of launch vehicles.
- Liquid Propulsion Systems Centre and ISRO Propulsion Complex, located at Valiamala and Mahendragiri respectively, develop the liquid and cryogenic stages for these launch vehicles.
- Satish Dhawan Space Centre, SHAR, is the spaceport of India and is responsible for the integration of launchers. It houses two operational launch pads from where **all** GSLV and PSLV flights take place.

### **SATELLITE LAUNCH VEHICLE-3 (SLV-3)-**

- SLV-3 was India's first experimental satellite launch vehicle.
- Which was an **all solid, four-stage vehicle**
- Capable of placing 40 kg payloads in **Low Earth Orbit (LEO)**.
- First successful launch: Rohini Satellite on 18<sup>th</sup> July 1980 from Sriharikota.
- This made India the **sixth member** of an exclusive club of space-faring nations.



## AUGMENTED SATELLITE LAUNCH VEHICLE(ASLV)-

- Designed to augment the payload capacity to 150 kg, thrice that of SLV-3, for Low Earth Orbits (LEO) in 1987.
- ASLV proved to be a low-cost intermediate vehicle to demonstrate and validate critical technologies.

## POLAR SATELLITE LAUNCH VEHICLE (PSLV)-

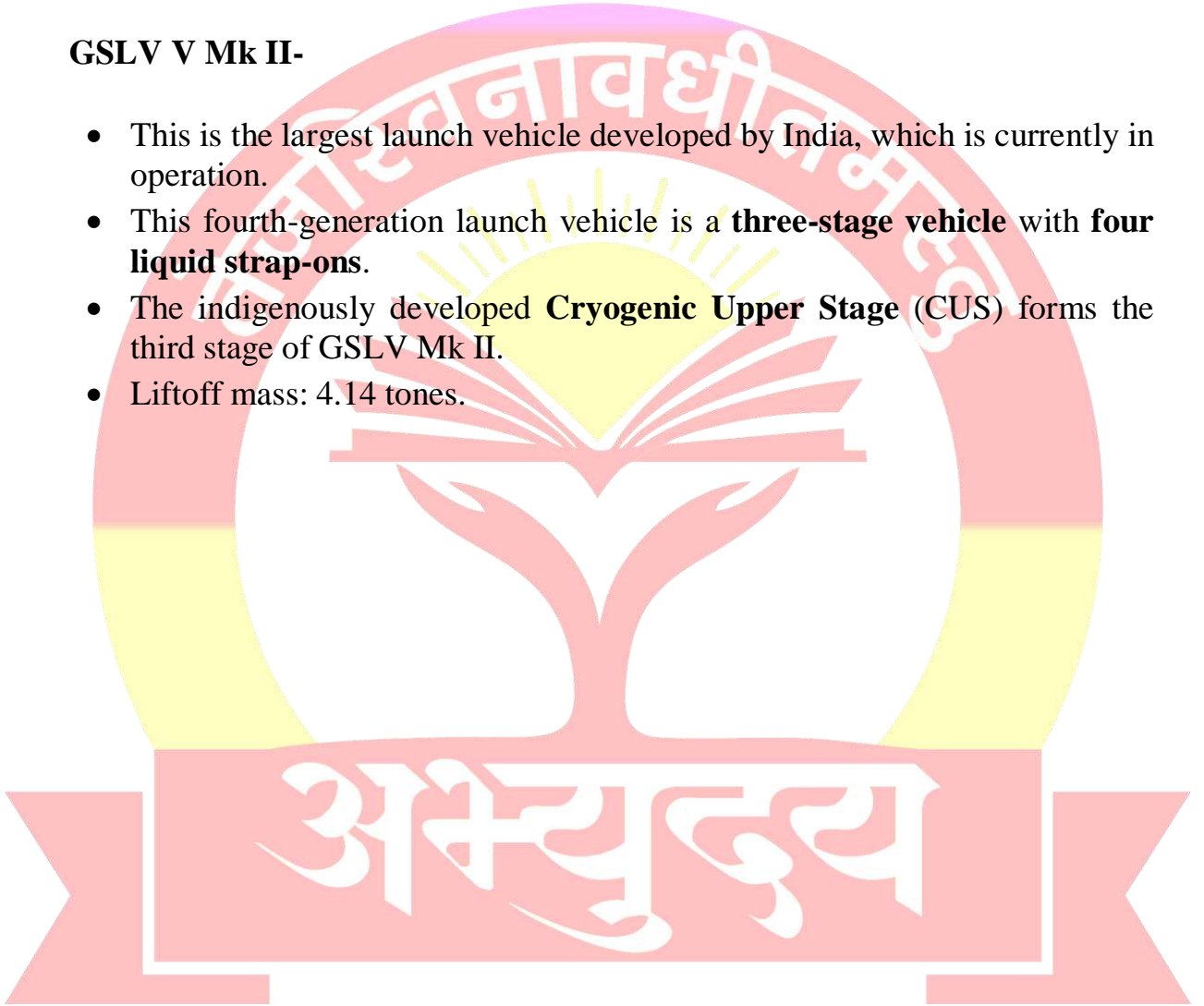
- PSLV is the third generation launch vehicle of India, operationalized in 1994.
- It is the first Indian launch vehicle to be equipped with liquid stages.
- PSLV is a **4-stage launch vehicle** that uses an alternate combination of liquid and solid-fueled rocket stages.
  - 1st & 3rd stages are solid-fueled.
  - 2nd & 4th stages are liquid-fueled.
- PSLV emerged as the reliable and **versatile workhorse launch vehicle** of India with 39 consecutively successful missions by June 2017.
- Primarily used to launch **remote sensing satellite**.
- **PSLV can deliver payloads of up to:**
  1. 3,250kg to LEO (Low Earth Orbit)
  2. 1600 kg to SSO (Sun Synchronous orbit)
  3. 1400 kg to GTO (Geosynchronous Transfer Orbit)
- **Most famous launches by the PSLV:**
  4. Chandrayaan-1 in 2008 and
  5. Mangalyaan/Mars Orbiter Mission in 2013.
  6. PSLV-C37 launched 104 satellites on February 15, 2017, the highest number of satellites launched in a single flight so far
- **Currently, PSLV rockets have 4 variants:**
  1. PSLV-CA (core alone)
  2. PSLV-DL (Dual strap-on motors)
  3. PSLV-QL (4 strap-on motors)
  4. PSLV-XL (6 strap-on motors)

## GEOSYNCRONOUS SATELLITE LAUNCH VEHICLE(GSLV)-

- GSLV is a 3-stage Launch vehicle with solid fuel in the 1st stage, liquid in the 2nd stage and cryogenic in the 3rd stage.
- It was developed **primarily to launch communication satellites** (INSAT Series) of 2.5-tonne class in Geostationary Transfer Orbit and about 4.5 tons class in Low Earth Orbit.

### GSLV V Mk II-

- This is the largest launch vehicle developed by India, which is currently in operation.
- This fourth-generation launch vehicle is a **three-stage vehicle** with **four liquid strap-ons**.
- The indigenously developed **Cryogenic Upper Stage (CUS)** forms the third stage of GSLV Mk II.
- Liftoff mass: 4.14 tones.



## GSLV Mk III

- This is a 3-stage **heavy-lift rocket** with an indigenous cryogenic engine in the 3rd stage.
- GSLV Mk III (ISRO's **Fat boy**) is designed to carry 4-ton class of satellites into Geosynchronous Transfer Orbit (GTO) or about 10 tons to Low Earth Orbit (LEO), which is about twice the capability of the GSLV Mk II.
- Most famous launches: injected Chandrayaan-2, India's second Lunar Mission, into Earth Parking Orbit on July 22, 2019, from Satish Dhawan Space Centre SHAR, Srihari kota.
- Further, India's first human space flight **Gaganyaan** to be launched using **GSLV Mk III** in 2022.

## SOUNDING ROCKETS-

- These are one or two-stage solid propellant rockets used for probing the upper atmospheric regions and for space research.
- They also serve as easily affordable platforms to test or prove prototypes of new components or subsystems intended for use in launch vehicles and satellites.
- The launch of the first sounding rocket from Thumba near Thiruvananthapuram, Kerala on 21 November 1963, marked the beginning of the Indian Space Programme.

## INDIA'S SPACE PROGRAMMES-

### COMMUNICATION SATELLITES-

- The **Indian National Satellite** (INSAT) systems are the set of communication satellites launched in Geo-synchronous orbit at an altitude of about 36,000 km.
- **Applications:** The INSAT system with more than 200 transponders in the **C**, **Extended C** and **Ku-bands** provides services to telecommunications, television broadcasting, satellite newsgathering, societal applications, weather forecasting, disaster warning and Search and Rescue operations.

## REMOTE SENSING (EARTH OBSERVATION) SATELLITES-

- ISRO has launched many operational remote sensing satellites.
- They are mostly polar, sun-synchronous satellites in low- earth orbit (LEO) at about 800 km from the earth surface.
- Currently, 13 operational satellites are in **Sun-synchronous orbit**: RESOURCESAT-1, 2, 2A CARTOSAT-1, 2, 2A, 2B, RISAT-1 and 2, OCEANSAT-2, Megha-Tropiques, SARAL and SCATSAT-1, and 4 in **Geo-stationary orbit**: INSAT-3D, Kalpana & INSAT 3A, INSAT -3DR.
- They are commonly called as remote sensing satellites as they collect information of any object on Earth through the measurement of radiation of the Sun that is reflected and scattered by objects on the surface of the earth.

**Applications** covering agriculture, water resources, urban planning, rural development, mineral prospecting, environment, forestry, ocean resources and disaster management.





## INDIAN REGIONAL NAVIGATION SATELLITE SYSTEM (IRNSS)-

- IRNSS (also known as **NavIC**) is an independent regional navigation satellite system being developed by India.
- It is designed to provide accurate position information service to users in India as well as the region extending up to 1500 km from its boundary.
- IRNSS will provide **two types of services**, namely:
  1. **Standard Positioning Service (SPS)** which is provided to all the users and
  2. **Restricted Service (RS)**, which is an encrypted service provided only to authorized users.
- The IRNSS System is expected to provide a **position accuracy of better than 20m** in the primary service area.



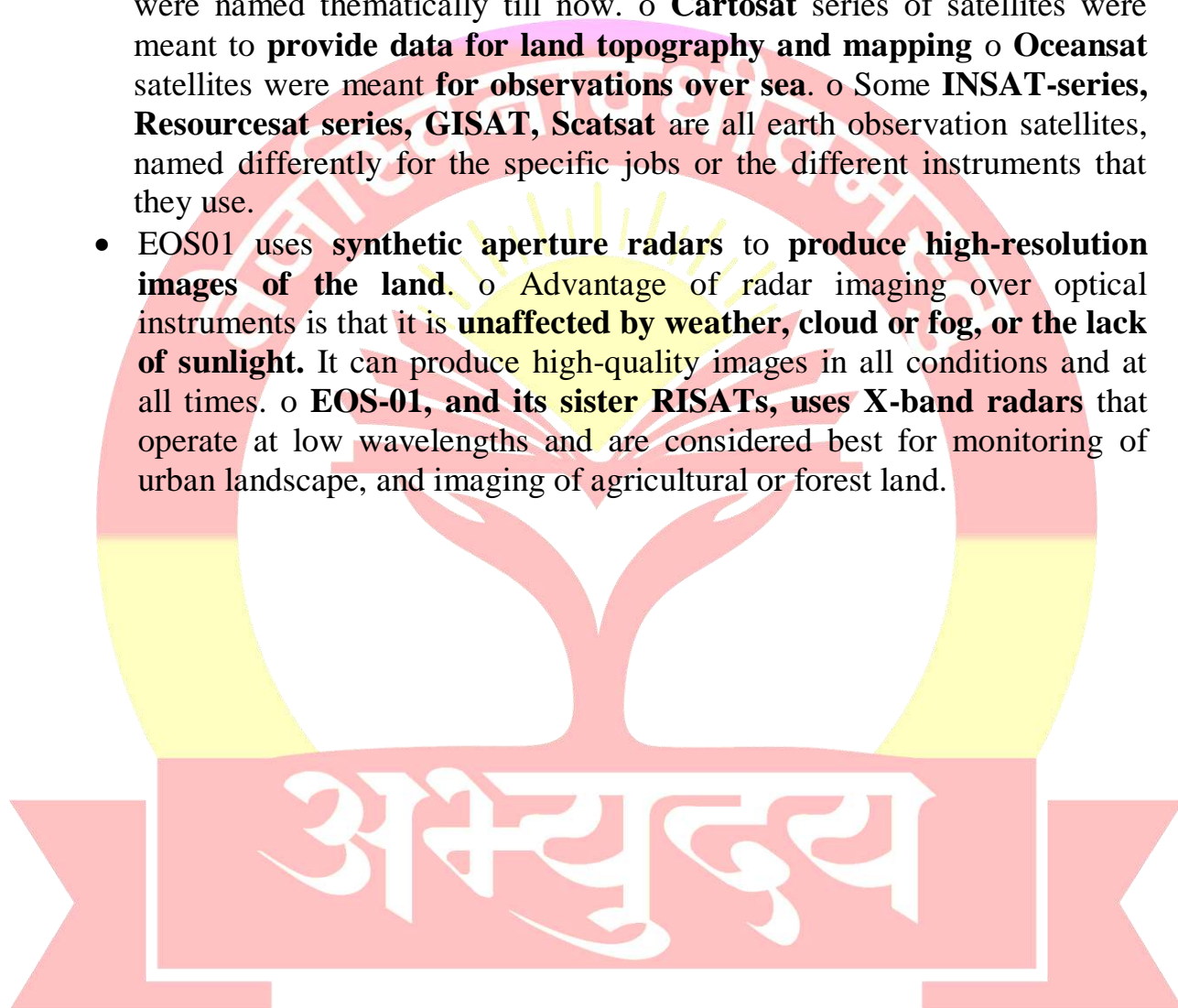
- There are currently seven IRNSS satellites (1A to 1G) in orbit.
  1. 4 satellites: A, B, F, G - are placed in a Geosynchronous Orbit. (1A is replaced by 1I recently)
  2. 3 satellites: C, D, E - are located in Geostationary Orbit

### Earth Observation Satellite-

- Recently, Polar Satellite Launch Vehicle, in its fifty first flight (PSLV-C49), **successfully launched EOS-01 along with nine international customer satellites** from Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota.
- The nine customer satellites are from Lithuania (1), Luxembourg (4) and

#### USA (4). About EOS-01

- It is another **Radar Imaging Satellite (RISAT)** that will work together with RISAT-2B and RISAT-2BR1 launched last year.
- **It will operate in Low-earth orbit.** A low Earth orbit (LEO) is relatively close to Earth's surface. It is normally at an altitude of less than 1000 km but could be as low as 160 km above Earth.
- With EOS-01, **ISRO is moving to a new nomenclature for its earth observation satellites** according to the purpose they are meant for. They were named thematically till now.
  - **Cartosat** series of satellites were meant to **provide data for land topography and mapping**
  - **Oceansat** satellites were meant **for observations over sea.**
  - Some **INSAT-series, Resourcesat series, GISAT, Scatsat** are all earth observation satellites, named differently for the specific jobs or the different instruments that they use.
- EOS01 uses **synthetic aperture radars** to **produce high-resolution images of the land.**
  - Advantage of radar imaging over optical instruments is that it is **unaffected by weather, cloud or fog, or the lack of sunlight.** It can produce high-quality images in all conditions and at all times.
  - **EOS-01, and its sister RISATs, uses X-band radars** that operate at low wavelengths and are considered best for monitoring of urban landscape, and imaging of agricultural or forest land.



## SPACE EXPLORATION MISSIONS-

### CHANDRAYAAN-

<b>CHANDRAYA AN-1</b>	<ul style="list-style-type: none"> <li>India's first mission to Moon.</li> <li>Launched successfully on October 22, 2008 (G. Madhavan Nair was ISRO chairman) from SDSC, Sriharikota, Andhra Pradesh.</li> </ul>
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- The spacecraft orbited around the Moon at an altitude of 100 km & 200 km from the lunar surface for chemical, mineralogical and photo-geologic mapping of the Moon.

<b>CHANDRAYAAN-2</b>	<ul style="list-style-type: none"> <li>The second lunar exploration and 1st lander and rover mission of ISRO   Launcher: GSLV MK III</li> <li>It is the world's 1st lunar mission to the South Pole of the Moon's near side.</li> <li>The South Pole of the lunar surface remains in shadow is much larger than that at the North Pole.</li> <li>Aims at studying not just one area of the Moon but all the areas combining the exosphere, the surface as well as the sub-surface of the moon in a single mission.</li> <li>The Orbiter will observe the lunar surface and relay communication between Earth and Chandrayaan 2's <b>Lander Vikram</b>.</li> <li>The lander was designed to execute India's first soft landing on the lunar surface.</li> <li>The <b>lander-rover integrated module</b> was supposed to soft-land near South Pole (about 600 km) of the moon.</li> <li>The rover was a 6-wheeled, AI-powered vehicle named <b>Pragyan</b>, which translates to 'wisdom' in Sanskrit.</li> <li>However, a last-minute software glitch led to crash-landing of Vikram and Pragyan.</li> </ul> <p><b>PURPOSE:</b></p> <ol style="list-style-type: none"> <li>To find traces of Water and Helium-3</li> <li>On-site chemical analysis of the surface</li> <li>To click pictures of the moon via the orbiter.</li> </ol>
<b>CHANDRAYAAN-3</b>	Recently ISRO has announced Chandrayaan-3, another attempt to soft landing mission, after the failure of Vikram Lander under Chandrayaan-2.



## MANGALYAAN-

- Also called Mars Orbiter Mission, it is India's 1st interplanetary mission
- Launched using **PSLV C-25** on Nov-5, 2013 & reached Mars on 24<sup>th</sup> Sept 2014.
- It costs 450 crores, **weight 1350 kg**, travelled for 300 days covered 65 crore km.
- ISRO has become the **4<sup>th</sup> space agency** to reach Mars, after the Soviet space program, NASA, and the European Space Agency.
- **Objective:** Exploration of Martian surface features, morphology, mineralogy and atmosphere.
- Important payloads:
  1. **Atmospheric studies** (Lyman-alpha Photometer (LAP), Methane Sensor for Mars (MSM))
  2. **Particle environment studies** (Mars Exospheric Neutral Composition Analyzer (MENCA)),
  3. **Surface imaging studies** (Thermal Infrared Imaging Spectrometer (TIS), Mars Colour Camera (MCC))

## GAGANYAAN-

- India's **1st Human spaceflight programme** (announced in 2018) to be launched by 2022.
- It will make India the 4th country to send manned mission after Russia, USA and China.
- Over the years, the ISRO has developed and tested many technologies that are critical to a human space flight.
- These include a Space Capsule Recovery Experiment (SRE-2007), Crew module Atmospheric Reentry Experiment (CARE-2014), GSLV Mk-III (2014), Reusable Launch Vehicle- Technology Demonstrator (RLV- TD), Crew Escape System and Pad Abort Test.
- It will include two unmanned flights to be launched in December 2020 (deferred) and July 2021 and one human space flight to be launched in December 2021.
- GAGANYAAN expected to carry 3 astronauts to a Low Earth Orbit on board GSLV Mark III vehicle, for at least 7 days.

<b>VYOMAMITRA</b>	<ul style="list-style-type: none"> <li>• Vyoma (space) + mitra (friend) □ Vyomamitra</li> <li>• It is a Gynoid (female humanoid robot).</li> <li>• ISRO has planned to send Vyomamitra in the unmanned crew module of Gaganyaan.</li> <li>• <b>Objective:</b> To test the Environmental Control &amp; Life Support System of Gaganyaan to detect environmental changes.</li> <li>• It has been developed by scientists at IISc in collaboration with ISRO.</li> </ul>
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<b>NASA MISSIONS</b>	<b>RELATED INFORMATION</b>
<b>ARTEMIS program</b>	NASA will land the first woman and next man on the Moon by 2024
<b>CURIOSITY</b>	<ul style="list-style-type: none"> <li>• Mars Rover Mission</li> <li>• Launched in 2011</li> <li>• Goal: Determine if Mars was ever able to support microbial life.</li> </ul>
<b>InSights Mission</b>	<ul style="list-style-type: none"> <li>• The first mission to explore Mars' deep interior.</li> <li>• It is part of NASA's Discovery Program.</li> </ul>
<b>Parker Solar Probe</b>	<ul style="list-style-type: none"> <li>• launched in 2018 with the mission of making observations of the outer corona of the Sun.</li> </ul>



## SPACE OBSERVATORIES ON SURFACE IN SPACE- IMPORTANT TELESCOPES

<b>HUBBLE SPACE TELESCOPE (HST)</b>	<ul style="list-style-type: none"> <li>• One of the largest multi-wavelength space telescopes.</li> <li>• It's a Joint project of NASA and ESA</li> <li>• 600 km above the surface of the earth.</li> <li>• Can observe objects in visible, near-ultraviolet, and near-infrared light.</li> </ul>
<b>JAMES WEBB TELESCOPE</b>	<ul style="list-style-type: none"> <li>• The successor of Hubble Space Telescope to be launched in 2021.</li> <li>• Times bigger than HST and 6 times more powerful.</li> <li>• JWST will orbit the Sun. (not earth like HST)</li> </ul>
<b>THIRTY METER TELESCOPE (TMT)</b>	<ul style="list-style-type: none"> <li>• TMT project is an international partnership between the USA, Canada, Japan, China, and India.</li> <li>• It will allow deeper exploration into space and observe cosmic objects with unprecedented sensitivity.</li> <li>• Installation site: <b>Mauna Kea</b> in Hawaii.</li> <li>• TMT has been developed by close collaboration between the 2020 Physics Nobel Laureate Prof. Andrea Ghez and Indian astronomers.</li> </ul>
<b>THE GIANT METERWAVE RADIOTELESCOPE</b>	<ul style="list-style-type: none"> <li>• An array of 30 fully steerable parabolic radio telescopes of 45-metre diameter.</li> <li>• Located near Pune, India.</li> <li>• Can scale deep space objects such as a galaxy, neutron star, pulsar, etc.</li> </ul>

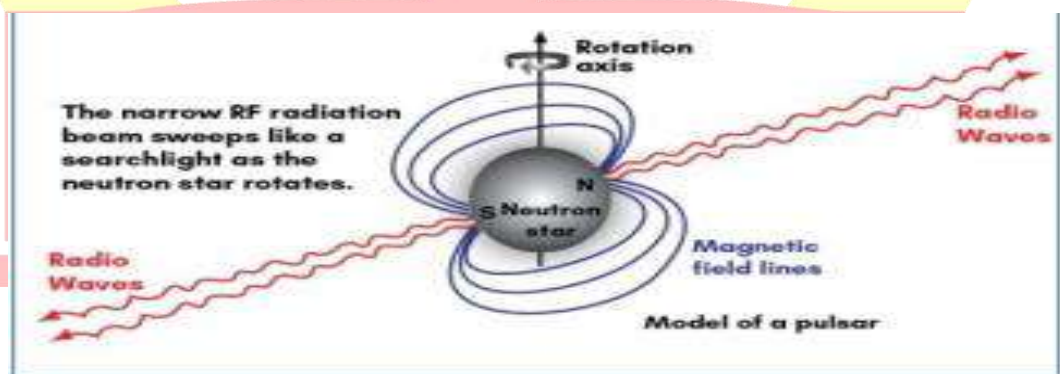
## RELATED RECENT ADVANCEMENTS-

### PULSARS-

- **Recently, The Royal Society unveiled a new portrait of** astrophysicist Dame Jocelyn Bell Burnell, who is credited with discovering pulsars in 1967.
- **Discovery was recognised by a Nobel Prize in physics in 1974 that was shared by two professors, Antony Hewish (Burnell's supervisor) and Martin Ryle.**

#### What are Pulsars?

- **Pulsars are rapidly rotating neutron stars that emit radio-frequency pulses.**
- **Pulsars are highly magnetic. Pulsars have magnetic fields that range from 100 million times to 1 quadrillion (a million billion) times stronger than Earth's.**
- **Pulsars can radiate light in multiple wavelengths, from radio waves all the way up to gamma-rays, the most energetic form of light in the universe.**
- **Also, the beam of radio waves emitted by a pulsar may not pass through the field of view of an Earth-based telescope, preventing astronomers from seeing it.**
- **Scientists use pulsars to study extreme states of matter, gravitational waves, search for planets beyond Earth's solar system and measure cosmic distances.**



# BIOTECHNOLOGY

Biotechnology is the use of biological systems found in organisms or the use of the living organisms themselves to make technological advances and adapt those technologies to various fields.

## GENOME:

- Genome is the complete set of genes or genetic material present in a cell or organisms.
- The human genome is a complex set of instructions, like a recipe book, directing organism growth & development.

## GENOMIC ORGANIZATION:

- This refers to the linear order of DNA elements and their division into chromosomes.
- Can also refer to the 3D structure of chromosomes & the positioning of DNA sequences within the nucleus.

## CHROMOSOME:

- These are thread-like structures located inside the nucleus of animal & plant cells.
- Each chromosome is made of protein and a single molecule of Deoxyribose-Nucleic Acid (DNA).
- Chromosomes are a key part of the process that ensures DNA is accurately copied and distributed in the vast majority of cell divisions.
- Changes in the number or structure of chromosomes in new cells may lead to serious problems like: Down Syndrome, Turner Syndrome etc.

## DEOXYRIBONUCLEIC ACID (DNA):

- DNA is an organic chemical that contains genetic information and instructions for protein synthesis.
- DNA is a key part of reproduction in which genetic heredity is passed down through DNA from parents to offspring.

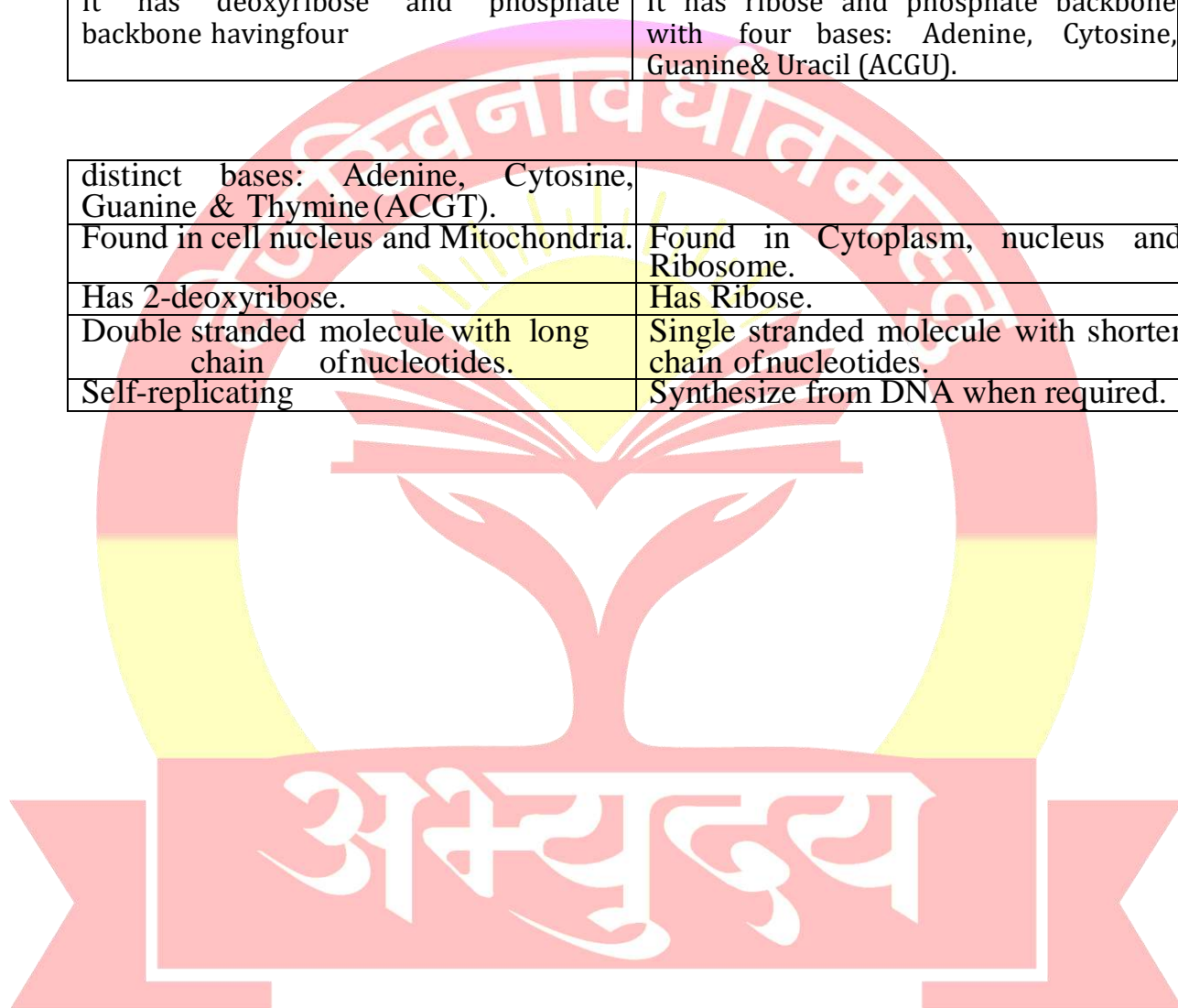
## RIBONUCLEIC ACID (RNA):

- RNA is a nucleic acid principally involved in the **synthesis of proteins**, carrying the messenger (ex: mRNA) **instructions from DNA**, which itself contain the **genetic instructions**.

### DIFFERENCES BETWEEN DNA AND RNA:

DNA	RNA
It has deoxyribose and phosphate backbone having four	It has ribose and phosphate backbone with four bases: Adenine, Cytosine, Guanine & Uracil (ACGU).

distinct bases: Adenine, Cytosine, Guanine & Thymine (ACGT).	
Found in cell nucleus and Mitochondria.	Found in Cytoplasm, nucleus and Ribosome.
Has 2-deoxyribose.	Has Ribose.
Double stranded molecule with long chain of nucleotides.	Single stranded molecule with shorter chain of nucleotides.
Self-replicating	Synthesize from DNA when required.





## CELL

- A Cell is defined as **smallest, basic unit of life** responsible for all life's processes.
- **Robert Hooke** coined the term **Cell** in 1665.
- Cells provide structure and support to the body of an organism.
- **Cells are of 2 types** namely, Prokaryotes & Eukaryotes.

Prokaryotes	Eukaryotes
Size of cell is generally small	Size of cell is generally large.
Nucleus absent.	Nucleus present.
It contains single chromosome	It contains more than one chromosome
Membrane bound cell organelles are absent.	Cell organelles are present.
Cell division takes place by fission or budding.	Cell division takes place by mitosis and meiosis.

### Structure of a cell-

<b>The Cell membrane</b>	<ul style="list-style-type: none"><li>• Every cell in the body is enclosed by a cell (Plasma) membrane.</li><li>• It maintains the integrity of a cell and controls passage of materials into and out of the cell.</li><li>• All materials within a cell must have access to the cell membrane for the needed exchange.</li></ul>
<b>The Nucleus</b>	<ul style="list-style-type: none"><li>• The nucleus determines how the cell will function, as well as the basic structure of that cell.</li><li>• Threads of chromatin in the nucleus contain Deoxyribonucleic Acid (DNA), the genetic material of the cell.</li><li>• The nucleolus is a dense region of ribonucleic acid (RNA) in the nucleus and is the site of ribosome formation.</li></ul>
<b>The cytoplasm</b>	<ul style="list-style-type: none"><li>• Cytoplasm is a thick solution that fills each cell and is enclosed by the cell membrane.</li><li>• Within the cytoplasm lie intricate arrangements of fine fibres and hundreds or even thousands of miniscule but distinct structures called org</li></ul>

Each type of organelle has a definite structure and a specific role in the function of the cell.



## ORGANELLE AND ITS FUNCTION

Organelle	Function
Nucleus	DNA Storage
Mitochondrion (Power house)	Energy production
Smooth Endoplasmic Reticulum (SER)	Lipid Production; Detoxification
Rough Endoplasmic Reticulum (RER)	Protein production.
Golgi apparatus (Cell's Post office)	Made of tubes, vesicles & vacuoles. Protein Modification and material transfer, also involved in the synthesis of Cell wall, Plasma membrane & Lysosomes
Peroxisome	Lipid Destruction; contains oxidative enzymes
Lysosome (cell's suicide bags)	Protein Destruction
Chromosomes	Determine the sex of an individual
Ribosome	Protein synthesis
Chloroplast (Kitchen of the plant cell)	It contains the pigment Chlorophyll—take part in Photosynthesis
Vacuole	It helps in Osmoregulation. It stores toxic metabolic waste.

**NOTE:** Some Organelles are found **only in plant cells**.

### **PLASTID:**

- Plastid is a **double membrane-bound organelle** involved in the **synthesis and storage of food**.
- Commonly found within the **cells of photosynthetic plants**.

**It is of 3 types:**

Chloroplasts, Chromoplast & Leucoplast.

### **Chloroplasts:**

These are green pigments found in green plant involve in photosynthesis.

**Chromoplast** provides various colors to the plant like flower, fruit etc. For example, Carotene provide orange color for Carrot & Lycopene in tomato provide red color.

**Leucoplast is colorless.** It stores the food in the form of starch, fat & protein.

**NOTE:** Plastids were discovered and named by **Ernst Haeckel**, but A. F. W. Schimper was the first to provide a clear definition.

## CELL WALL:

- A cell wall is an outer layer surrounding certain cells that is outside of the cell membrane.
- All cells have cell membranes, **but** generally **only** plants, fungi, algae, most bacteria, and archaea **have cells with cell walls**.
- The cell wall provides strength and structural support to the cell.

**NOTE:** **Chitin** a polysaccharide that is a main component of **fungal cell walls** and also of the exoskeletons of certain animals like insects.

## DIFFERENCE BETWEEN PLANT AND ANIMAL CELL:

Plant Cell	Animal Cell
Cells are larger in size	Generally smaller
Cell wall– Present. Made up of Cellulose & Chitin	Cell wall- Absent
Plastid present	Plastid absent
Centrosome absent	Centrosome present
Vacuole are larger in size	Vacuole are smaller in size

## STEM CELLS

- The smallest functional unit of life is called the Cell.
- These cells develop to form tissues which in turn develop to form organs.
- Stem cells are basically undifferentiated, primitive cells which have the potential to develop into many different types of cells like those in muscles, kidney, liver etc.

Stem cell therapy has shown potential to cure many severe ailments. It is touted as future of medical treatments. They have proved effective in the treatment of blood disorders, immune disorders, metabolic problems, & other organ degenerated diseases.

## DNA PROFILING

- DNA profiling is the **process where a specific DNA pattern**, called a **profile**, is obtained from a person or sample of bodily tissue.
- It is a **forensic technique** in criminal investigations, comparing criminal suspects profiles to **DNA** evidence so as to assess the likelihood of their involvement in the crime.
- It is **also used in parentage testing**, to establish immigration eligibility, and in genealogical and medical research.

### Short Tandem Repeats (STRs):

- One of the current techniques for DNA profiling uses polymorphisms called STRs.
- These are regions of non-coding DNA that contain repeats of the same nucleotide sequence. Ex: GATAGATA

## GENETIC DISORDERS

- A genetic disorder **is a disease that is caused by** a change, or mutation, in an individual's DNA sequence.
- These mutations can be due to **an error in DNA replication** or due to **environmental factors**, such as cigarette smoke & exposure to radiation, which cause changes in the DNA sequence.

- **The three main categories are:**

<b>Single Gene Disorders:</b>	Disorders caused by defects in one particular gene, often with simple and predictable inheritance patterns. Ex: Huntington's disease, Cystic fibrosis.
<b>Chromosome Disorders:</b>	Disorders resulting from changes in the number or structure of the chromosomes. <b>Ex:</b> Down's syndrome, which results from an extra chromosome 21.
<b>Multifactorial Disorders (Complex Diseases):</b>	Disorders caused by <b>changes in multiple genes</b> , often in a complex interaction with environmental & lifestyle factors such as diet or cigarette smoke. <b>Ex:</b> Cancer.

## GENE THERAPY:

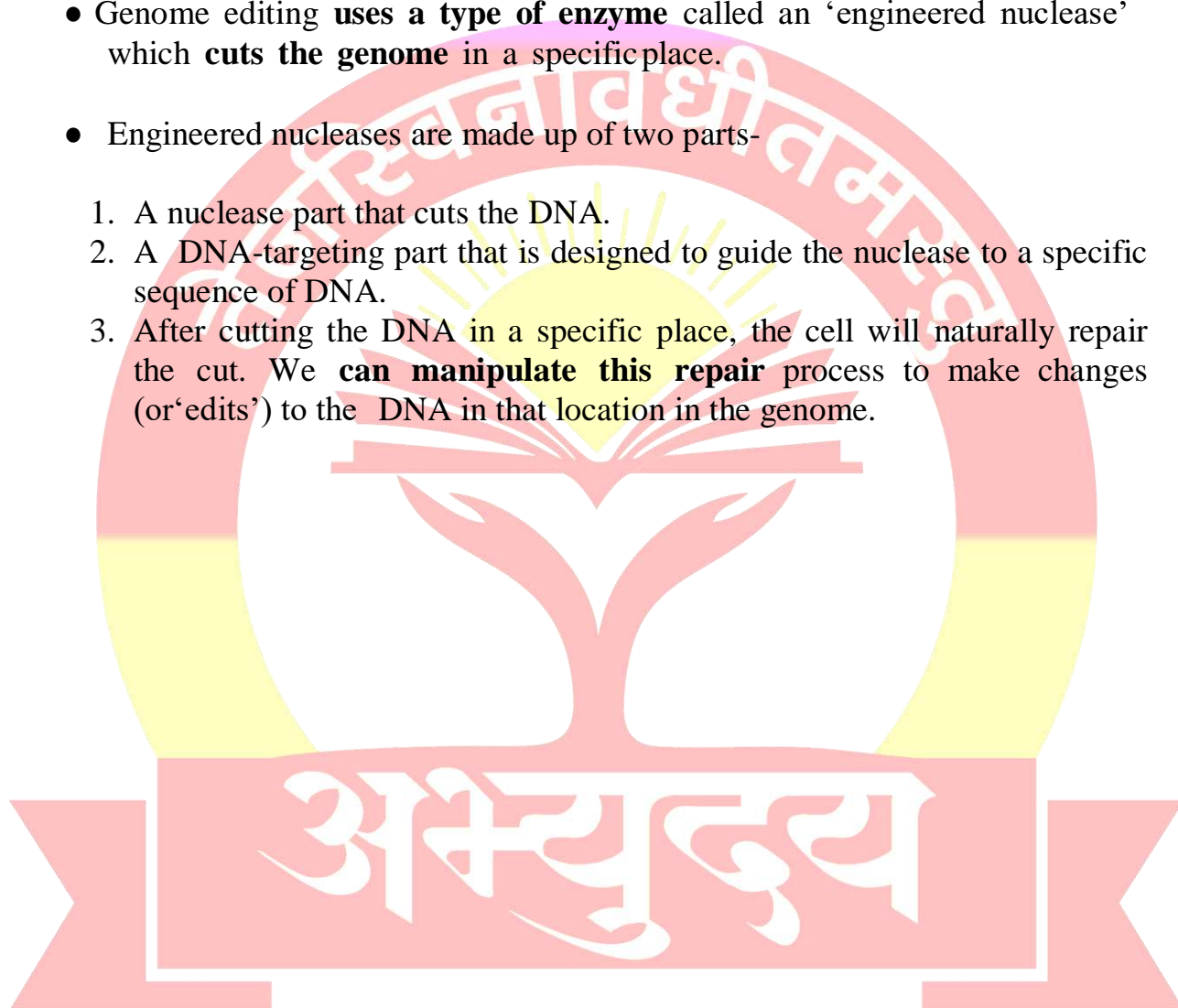
- Technique to **replace defective genes with healthy genes** to treat genetic disorders.
- Artificial method that introduces DNA into the cells of human body. First developed in 1972, but has limited success.
- Two types of gene therapy: **Somatic gene therapy**, **Germline gene therapy**.

### GENE EDITING:

- Gene editing is a technique of **making specific changes to the DNA** at a specific sequence.
- For this DNA is inserted, deleted, modified or replaced in the genome.
- For this **CRISPR CAS9 Scissor** is used. It involves making cuts at specific DNA sequences with enzymes called '**engineered nucleases**'.

### How does genome edit work?

- Genome editing **uses a type of enzyme** called an 'engineered nuclease' which **cuts the genome** in a specific place.
- Engineered nucleases are made up of two parts-
  1. A nuclease part that cuts the DNA.
  2. A DNA-targeting part that is designed to guide the nuclease to a specific sequence of DNA.
  3. After cutting the DNA in a specific place, the cell will naturally repair the cut. We **can manipulate this repair** process to make changes (or 'edits') to the DNA in that location in the genome.





<b>Gene Silencing</b>	<ul style="list-style-type: none"> <li>• Gene silencing is the <b>regulation of gene expression in a cell to prevent the expression of a certain gene.</b></li> <li>• When genes are silenced, <b>their expression is reduced.</b> Ex: the researchers designed two small RNA molecules that silence the fungal genes which produce aflatoxin in Groundnut.</li> <li>• When genes are knocked out, they are completely erased from the organism's genome and thus, have no expression.</li> </ul>
<b>Applications:</b>	<ul style="list-style-type: none"> <li>• Specific gene silencing using RNAi in cell</li> <li>• Cancer treatments RNA interference has been used for applications in biotechnology.</li> <li>• Useful in epigenomic analysis and clinical application of molecular diagnosis.</li> <li>• Neuro-degenerative disorders treatment.</li> </ul>

## MRNA VACCINE-

- Unlike a normal vaccine, RNA vaccines **work by introducing an mRNA sequence which is coded for a disease specific antigen.** Once produced within the body, the antigen is recognised by the immune system, preparing it to fight the real thing.
- **mRNA vaccines teach our cells how to make a protein** that triggers an immune response inside our bodies. That immune response, which produces antibodies, is what protects us from getting infected if the real virus enters our bodies.
- **mRNA vaccines can be delivered using a number of methods,** via needle-syringe injections or needle-free into the skin, injection into the blood, muscle, lymph node or directly into organs; or via a nasal spray.
- There are **different types of mRNA vaccine** like Non-replicating mRNA, In vivo self-replicating mRNA, In vitro dendritic cell non-replicating mRNA vaccine etc

Conventional Vaccines	Gene based Vaccines
<ul style="list-style-type: none"> <li>• Includes live attenuated vaccines, inactivated pathogens (also known as "killed vaccines"), viral-vectored vaccines, and other types known as subunit, toxoid and conjugate vaccines.</li> <li>• It exposes the body to proteins made by a virus or bacteria, are often made by using weakened or inactive versions of that virus or bacteria.</li> <li>• Traditional vaccines require refrigeration.</li> </ul>	<ul style="list-style-type: none"> <li>• They contain two types of Vaccine: DNA and RNA vaccines.</li> <li>• Instead of injecting a weakened form of a virus or bacteria into the body, DNA and RNA vaccines use <b>part of the virus' own genes to stimulate an immune response.</b> In other words, they carry the genetic instructions for the host's cells to make antigens</li> <li>• Both DNA and RNA vaccines deliver the message to the cell to create the desired protein so the immune system creates a response against this protein.</li> <li>• They can be stored at room temperature and are more stable than conventional vaccines in warm climates "If kept dry and/or sterile at pH8".</li> </ul>

## GM Crops-

A GM crop has a **gene artificially inserted into it from another species to give it some desired properties** like – pest resistance, herbicide-tolerance, drought resistance etc.

- **Currently, only GM crop permitted for cultivation in India is Bt Cotton.**
- There is a well-established **regulatory framework** for approval of GM Crops as per “Rules for the Manufacture/Use/Import/Export and Storage of Hazardous Microorganisms, Genetically Engineered Organisms or Cells, 1989” under the **Environment (Protection) Act, 1986.**
- **There are certain concerns regarding GM crops for Human health** (like allergic reaction, gene transfer etc.), **Environment** (like introduction of engineered genes into wild populations, loss of biodiversity etc).

### About Genetic Engineering Appraisal Committee (GEAC)

- GEAC established under Ministry of Environment, Forest and Climate Change is the apex body for **approval of activities involving large scale use of hazardous microorganisms and recombinants in research and industrial production** from the environmental angle.
- The GEAC is also responsible for **approval of proposals relating to release of genetically engineered organisms** and products into the environment including experimental field trials

# HEALTH

## CARBOHYDRATES-

- Any of a large group of organic compounds occurring in foods and living tissues and including sugars, starch and cellulose.
- They contain hydrogen and oxygen in the same ratio as water (2:1) and typically can be broken down to release energy in the animal body.

## TYPES OF CARBOHYDRATES-

<b>Monosaccharides</b> :	<ul style="list-style-type: none"><li>• It cannot be hydrolysed further into a simpler unit of polyhydroxy aldehyde or ketone. E.g.: Glucose, Fructose, Ribose, Galactose, etc.</li></ul>
<b>Oligosaccharides</b> :	<ul style="list-style-type: none"><li>• On hydrolysis, it yields two to ten monosaccharides units, e.g., disaccharides, trisaccharide, etc.</li><li>• Sucrose == Glucose + Fructose</li><li>• Maltose == Glucose + Glucose</li><li>• Lactose == Glucose + Galactose</li></ul>
<b>Polysaccharides:</b>	<ul style="list-style-type: none"><li>• On hydrolysis, it yields a large number of monosaccharides unit. E.g.: Starch, Cellulose, Glycogen, Gums.</li><li>• Polysaccharides are long chains of sugars, not sweet, hence called non-sugars.</li><li>• Insulin is a polymer of fructose.</li></ul>

## VITAMINS

- Organic compounds required in small amount in our bodies to develop and function normally.
- Most of the vitamins **cannot be synthesized in our body** but plants can synthesize almost all of them.
- Vitamins can be classified on basis of solubility:
- **Fat-Soluble vitamins:** Soluble in fats and oil but insoluble in water. They are stored in liver and adipose tissues. E.g., vitamin A, D, E, K

(KEDA).

- **Water-Soluble vitamins:** needs regular supply in the diet, excreted in urine and cannot be stored in our body. E.g., vitamin B and C groups (except B12).
- Deficiency of vitamins can cause several diseases.

Vitamins/Minerals	Deficiency disease	Sources	Functions
<b>A (Retinol) – Fat soluble</b>	Night blindness	Green leafy vegetables, broccoli, tomatoes, carrots, milk, liver, watermelon etc.	Necessary for wound healing, growth and normal immune functions, formation of rhodopsin for vision in dim light
<b>B1 (Thiamine) – Water soluble (Anti stress vitamin)</b>	Beriberi	Fresh fruits, corn, cashew nuts, peas, wheat, milk, dates, black beans etc.	Part of an Enzyme, needed for energy metabolism and nerve functions.
<b>B2 (Riboflavin) - Water soluble</b>	Ariboflavino is, Photophobia, poor growth	Bananas, grapes, pumpkin, yoghurt, mushroom, popcorn, liver etc.	Essentials for growth enzymatic role in tissue respiration and acts as transporter of hydrogen ions.
<b>B3 (Niacin) - Water soluble</b>	Pellagra, dermatitis, dementia	Meat, eggs, fish, milk, guava, peanuts, cereals, green peas etc.	Helps in oxidation and energy releases, synthesis of glycogen and breakdown of fatty acids



<b>B5 (Pantothenic Acid) - Water soluble</b>	Fatigue, loss of antibody production, sleep disturbances	Meat, kidney, egg yolk, fish, chicken, legumes, avocado etc.	Synthesis of vital body compounds, essential in intermediary metabolism of carbohydrates, fats and protein.
<b>B6 (Pyridoxine) - Water soluble</b>	Microcytic Anaemia, irritability	Pork, chicken, bread, wholegrain, soya beans, cereals etc.	Essential for normal growth, Synthesis and breakdown of amino acids fatty acids
<b>B7 (Biotin) - Water soluble</b>	Dermatitis, enteritis, insomnia	Walnuts, peanuts, milk, egg yolks, salmon, mushroom, cauliflower, banana, raspberries etc.	Essential components of enzymes, carrier of carbon dioxide, metabolism of fatty acids and amino acids
<b>B9 (Folic Acid) - Water soluble</b>	Megaloblastic anaemia (poor growth)	Citrus fruits, green leafy vegetables, beets, legumes etc.	Essential in biosynthesis blood cell maturation
<b>B12 (Cobalamin)</b>	Pernicious anaemia, neurological deterioration	Fish, meats, poultry, eggs, Breast milk etc.	Essential in biosynthesis of nucleic acids, red blood cell maturation; involved in central nervous system metabolism

<b>C (Ascorbic Acid) - Water soluble</b>	Scurvy(bleeding gums)	Fresh citrus such	Essential in synthesis of collagen, iron absorption and transportation, water soluble antioxidants;
<b>D (Calciferol) Fat soluble</b>	Rickets (soft bones)	Fish, beef, cod liver oil, egg yolk, liver, cereals etc.	Necessary for normal bone formation, helps absorption of calcium and phosphorus in Intestines
<b>E (Tocopherol) -Fat soluble</b>	Muscles damages, less fertility	Potatoes, pumpkin, guava, mango, Breast milk, nuts and seeds.	Antioxidants, role
<b>K (Phytonadione) - Fat soluble</b>	Non-clotting of blood	Tomatoes, broccoli, mangoes, grapes, chestnuts, lamb etc.	Required in other blood clotting factors, synthesis by intestinal bacteria
<b>Calcium</b>	Rickets-abnormal development of bones	Breast milk, yogurt, cheese, fortified grains, kale, mustards, salmon.	Builds and maintains bones and teeth, essential in blood clotting
<b>Iodine</b>	Endemic goitre, depressed thyroid function	Breast milk, seafood, iodized salt	Helps regulate thyroid hormones, regulation of cellular oxidation and growth

<b>Iron</b>	Hypochromic anaemia, lethargy	Breast milk, meat, liver, legumes, cereals, green leafy vegetables	Formation of haemoglobin and oxygen transport, increase resistant to infections.
<b>Zinc</b>	Mild anaemia, hair loss, growth failure	Breast milk, egg yolk, seafood, liver, oysters, whole-grain breads, cereals	Components of many enzyme system and insulin
<b>Phosphorus</b>	Muscles weakness, cardiac arrhythmias.	Orange juice, bananas, yogurt, potatoes, soy products	Builds and maintains bones and teeth, functions in energy metabolism.

## CHOLESTROL

- It is an organic compound, **fat-like insoluble waxy substance**, found in all cells of our body and is **circulated through the blood cells** with the help of Lipoproteins.
- Cholesterol plays an important role in creating cells, hormones, vitamin D production and bile acids.

## FATS

- Fat is a major source of energy and helps **our body absorb vitamins**.

## TYPES OF FATS ON THE BASIS OF SATURATION

<b>SATURATED FAT:</b>	<ul style="list-style-type: none"><li>• Fats in which the fatty acids all have single bonds.</li><li>• Saturated fat has the maximum number of hydrogens bonded to the carbons.</li><li>• Not healthy, less vulnerable to rancidity, solid at room temperature.</li></ul>
<b>UNSATURATED FAT:</b>	<ul style="list-style-type: none"><li>• In which there is at least one double bond within the fatty acid.</li><li>• Hydrogen is eliminated by double bonds.</li><li>• The greater the unsaturation means more vulnerable to rancidity.</li></ul>

## MALNUTRITION

Malnutrition occurs when the body doesn't get enough nutrients. Causes include a poor diet, digestive conditions or another disease. The nutrients involved are **calories, carbohydrates, vitamins, proteins or minerals**.

### MALNUTRITION TYPES-

<b>Undernutrition:</b>	This covers stunting (low height for age), wasting (low weight for height), underweight (low weight for age) and micronutrient deficiencies (lack of important minerals).
<b>Acute Malnutrition or wasting:</b>	<ul style="list-style-type: none"><li>• Marasmus- due to lack of nutrients, body fats and tissues starts degenerating at an alarming rate, affects the immune system of the body.</li><li>• Kwashiorkor- happens due to retention of fluid in legs, an under-nourished child looks very plump.</li></ul>
	<ul style="list-style-type: none"><li>• Marasmic - Kwashiorkor – happens due to oedema and severe wasting.</li></ul>



<b>Obesity:</b>	<ul style="list-style-type: none"> <li>• Overweight and obesity are defined as abnormal or excessive fat accumulation that presents a risk to health such as heart diseases, stroke, diabetes etc.</li> <li>• A body mass index (BMI) over 25 is considered overweight, and over 30 is obese.</li> <li>• Body Mass Index (BMI)= Weight/Height.</li> <li>• Normal BMI is in the range of 18-25.</li> </ul>
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### Related Information:

- **Global Nutrition Report 2020-** India is among 88 countries that are likely to miss the global nutrition's target by 2025.
- **FAO-** 14.5% of India's population is undernourished.
- **Global Hunger Index 2019 report-** India ranked 102<sup>nd</sup> out of 117 countries.
- **UNICEF report-** 38% of children younger than 5 years of age in India are stunted.
- Rajasthan, Madhya Pradesh, Uttar Pradesh has the highest percentages of underweight childbirths in India.

<b>Initiatives</b>	<ul style="list-style-type: none"> <li>• <b>World Food Day-</b> October 16, to address the problem of global Hunger.</li> <li>• <b>POSHAN Abhiyan-</b> to ensure a "Malnutrition Free India" by 2022.</li> <li>• <b>Mid-day Meal scheme-</b> to improve nutritional levels in school children.</li> <li>• <b>National Food Security Act (NFSA), 2013-</b> to ensure food and nutrition security to most vulnerable, making access to food a legal right.</li> <li>• <b>Integrated Child Development Services (ICDS) scheme-</b> aims at providing food, preschool education, primary healthcare to children under 6 years of age and their Mothers.</li> </ul>
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## DISEASES

Diseases are **abnormal conditions** that have a **specific set of signs and symptoms**.

### COMMUNICABLE DISEASE CAUSED BY BACTERIA-

#### TUBERCULOSIS (TB)-

- According to WHO, TB is one of the top 10 causes of death worldwide and the leading cause of death from a single infectious agent (ranking above HIV/AIDS).
- TB is caused by the bacillus *Mycobacterium tuberculosis*.
- The disease typically affects the lungs (pulmonary TB) but can also affect other sites (extra pulmonary TB).
- TB is a disease of poverty, and economic distress, vulnerability, marginalization, stigma and discrimination are often faced by people affected by TB (WHO).

<b>Tuberculosis Signs and Symptoms</b>	<ul style="list-style-type: none"><li>• Latent TB doesn't have symptoms. A skin or blood test can tell if you have it.</li><li>• Signs of active TB disease include: A cough that lasts more than 3 weeks, Chestpain, Coughing up blood, Feeling tired all the time, Night sweats, Chills, Fever, Loss of appetite, Weight loss.</li></ul>
<b>Tuberculosis Treatment</b>	<ul style="list-style-type: none"><li>• TB is curable and preventable.</li><li>• About 85% of people who develop TB disease can be successfully treated with a 6-month drug regimen.</li><li>• Vaccine/drug: BCG living attenuated bacteria, Antibiotics e.g. streptomycin.</li></ul>
<b>Drug-Resistant TB:</b>	<ul style="list-style-type: none"><li>• <b>Multidrug Resistance TB (MDR):</b> It is TB that does not respond to at least isoniazid and rifampicin (2 of the most powerful first-line drugs).</li></ul>

	<ul style="list-style-type: none"><li>• <b>Extensively Drug-Resistant Tuberculosis(XDR-TB):</b> It is resistant to at least four of the core anti-TB drugs. It involves multidrug-resistance (MDR- TB), in addition to resistance to any of the fluoroquinolones (such as levofloxacin or moxifloxacin) and at least</li></ul>
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	<p>one of the three injectable second- line drugs (amikacin, capreomycin or kanamycin).</p> <ul style="list-style-type: none"> <li>• <b>Totally Drug-Resistant Tuberculosis(TDR-TB):</b> TB which is resistant to all the first- and second-line TB drugs.</li> </ul>
<b>WHO- End TB Strategy:</b>	<ul style="list-style-type: none"> <li>• Vision: A world free of TB with zero deaths, disease and suffering due to TB. o It has three high-level, overarching indicators and related targets for 2035: <ul style="list-style-type: none"> <li>➤ 95% reduction in the number of TB deaths compared with 2015.</li> <li>➤ 90% reduction in TB incidence rate compared with 2015.</li> <li>➤ Zero the level of catastrophic costs for TB-affected families.</li> </ul> </li> <li>• <b>TrueNat:</b> is a new molecular test that can diagnose TB in one hour as well as testing for resistance to the drug rifampicin. Developed by an Indian firm MolBio Diagnostics Pvt Ltd &amp; endorsed by the WHO.</li> </ul>
<b>Government interventions to eliminate TB:</b>	<ul style="list-style-type: none"> <li>• TB Vaccination has been covered under the ‘<b>Universal Immunization Programme</b>’.</li> <li>• Revised National TB Control Programme (RNTCP) released ‘<b>National Strategic Plan to end TB</b>’ framework in 2017 for the control and elimination of TB in India by 2025. The RNTCP is being implemented under the umbrella of the National Health Mission.</li> <li>• ‘<b>TB Harega Desh Jeetega Campaign</b>’ by the Ministry of Health to improve the reach of TB care services across the country, by 2022</li> </ul>

## National Strategic Plan to end TB in India by 2025

- It provides goals and strategies for the country's response to the disease during the period 2017-2025.
- It targets to eliminate TB five years ahead of the global End TB (by 2030) targets under SDGs to attain the vision of a TB-free India
- TB elimination has been integrated into the four strategic pillars of “**Detect – Treat – Prevent – Build**” (DTPB).

### DIARRHOEA-

- Loose, watery stools that occur more frequently than usual.
- It is primarily caused when there is a reduction in the absorption of fluid by intestines or an increase in the secretion of fluid or speedy passage of stool through intestines.
- Diarrhoea is classified into two types, namely:
  1. **Acute diarrhoea:** may last for 2 or 3 days, but not more than a week. It is not a life-threatening condition and can be cured by taking relevant medications.
  2. **Chronic diarrhoea:** may last for 1 or 2 weeks, but it can last much longer. This is usually due to other underlying gastrointestinal diseases.
- **Symptoms:** Loose stools, Vomiting, Nausea, Cramps, The feeling of a bowel movement, Abdominal pain, Fever, Bloody stools (rare cases)
- **Treatment:** Generally, acute diarrhoea will recede on its own, within 2 to 3 days without any treatment. But it is advised to consult the physician regardless.

### ANTHRAX-

- Anthrax is a serious infectious disease **caused by** gram-positive, rod-shaped bacteria known as **Bacillus anthracis**.
- Anthrax can be found naturally in soil and commonly affects domestic and wild animals around the world.
- **Affects animals** such as cattle, sheep, and goats more often than people. **People** can get anthrax from contact with infected animals, wool, meat, or hides.



- **Spread:** It does not spread directly from one infected animal or person to another; it is **spread by spores**. These spores can be transported by clothing or shoes.
- **Symptoms:** People may experience pain in the chest or muscles, Skin blister, dark scab, Ulcers, fever or malaise, respiratory distress or shortness of breath, coughing, headache, itching, nausea, sore throat, or swollen lymph nodes.
- **Treatment:** The standard treatment for anthrax is a 60-day course of an antibiotic. Examples include ciprofloxacin (Cipro) or doxycycline (Doryx, Monodox).
- The **anti-anthrax vaccines** available in the market generate an immune response against a **Bacillus protein- protective antigen-** a protein that helps in the transport of bacillus toxins inside the cells.

### LEPROSY

- Leprosy is a chronic, curable infectious disease mainly causing skin lesions and nerve damage.
- **Caused by:** bacterium **Mycobacterium leprae**. It mainly affects the skin, eyes, nose and peripheral nerves.
- **Symptoms** include light-colored or red skin patches with reduced sensation, numbness and weakness in hands and feet.
- **Mode of Transmission:** Mainly by breathing airborne droplets from the affected individuals. It can be contacted at any age.
- **Treatment:** Leprosy can be cured with 6-12 months of **Multi-Drug Therapy (MDT)**. Early treatment avoids disability.
- Rifampicin and clofazimine are now combined with dapsone to treat multi-bacillary leprosy.

<b>Related Information</b>	<ul style="list-style-type: none"> <li>• Leprosy is one of the oldest diseases in recorded history, afflicting humanity since time immemorial. A written account of Leprosy date as far back as 600 B.C.</li> <li>• Leprosy is also known as <b>Hansen's Disease</b>.</li> <li>• World Leprosy Day is observed on the last Sunday in January every year. Theme (2020): 'Leprosy isn't what you think'.</li> <li>• The day was chosen by French humanitarian Raoul Follereau in 1953 to coincide with the anniversary of Mahatma Gandhi's death on 30th January 1948.</li> </ul>
<b>Global Leprosy Strategy 2016–2020: Accelerating towards a leprosy-free world</b>	<ul style="list-style-type: none"> <li>• Launched the WHO in 2016</li> <li>• <b>Aims</b> to reinvigorate efforts to control leprosy and avert disabilities, especially among children still affected by the disease in endemic countries.</li> <li>• The <b>strategy emphasizes</b> the need to sustain expertise and increase the number of skilled leprosy staff, improve the participation of affected persons in leprosy services and reduce visible deformities as well as stigmatization associated with the disease.</li> </ul>

## COMMUNICABLE DISEASES

### CAUSED BY VIRUS

#### 1. ACQUIRED IMMUNODEFICIENCY SYNDROME (AIDS) -

- Caused by the **Human Immunodeficiency Virus (HIV)**.
- HIV is a **lentivirus**, which is a sub-classification of the retrovirus. It causes the HIV infection which over time leads to AIDS.
- HIV demolishes a particular type of **WBC** (White Blood Cells) and the **T-helper (CD4) cells**.

<b>ELISA</b> (Enzyme-Linked Immunosorbent Assay) TEST:	<ul style="list-style-type: none"><li>• ELISA is a test that <b>detects &amp; measures antibodies in the blood</b>.</li><li>• This test can be used to determine antibodies related to certain infectious conditions.</li><li>• Antibodies are proteins that your body produces in response to harmful substances called antigens.</li><li>• An ELISA test may be used to diagnose: HIV, which causes AIDS, Lyme disease, Pernicious anaemia, Rotavirus, Varicella-zoster virus (which causes chickenpox) and shingles Zika virus.</li><li>• ELISA is often used as a screening tool before more in-depth tests are ordered.</li><li>• <b>NOTE:</b> For the 1<sup>st</sup> time India has developed (by National Institute of Virology, Pune) an indigenous ELISA test for coronavirus.</li></ul>
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<b>Highly Active Antiretroviral Therapy (HAART)</b>	<ul style="list-style-type: none"> <li>• HAART is a treatment regimen typically comprised of a combination of three or more antiretroviral drugs.</li> <li>• HAART may also be called <b>Anti-Retroviral Therapy</b> (ART) or combination antiretroviral therapy (cART).</li> <li>• This combination therapy is primarily indicated <b>to treat</b> Human Immunodeficiency Virus Type 1 (<b>HIV-1</b>) infected patients.</li> <li>• A key feature of HAART is the <b>co-administration of different drugs</b> that inhibit viral replication by several mechanisms so that propagation of a virus with resistance to a single agent becomes inhibited by the action of the other two agents.</li> <li>• <b>NOTE:</b> Though HAART's primary goal is to reduce the transmission of HIV-1, HAART is also utilized in the treatment of HIV Type-2. But currently, there is <b>no specific guideline</b> of recommendations for HIV-2 treatment. Instead, HIV-2 management is under HIV-1 guidelines with some modifications.</li> </ul>
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## 2. POLIO

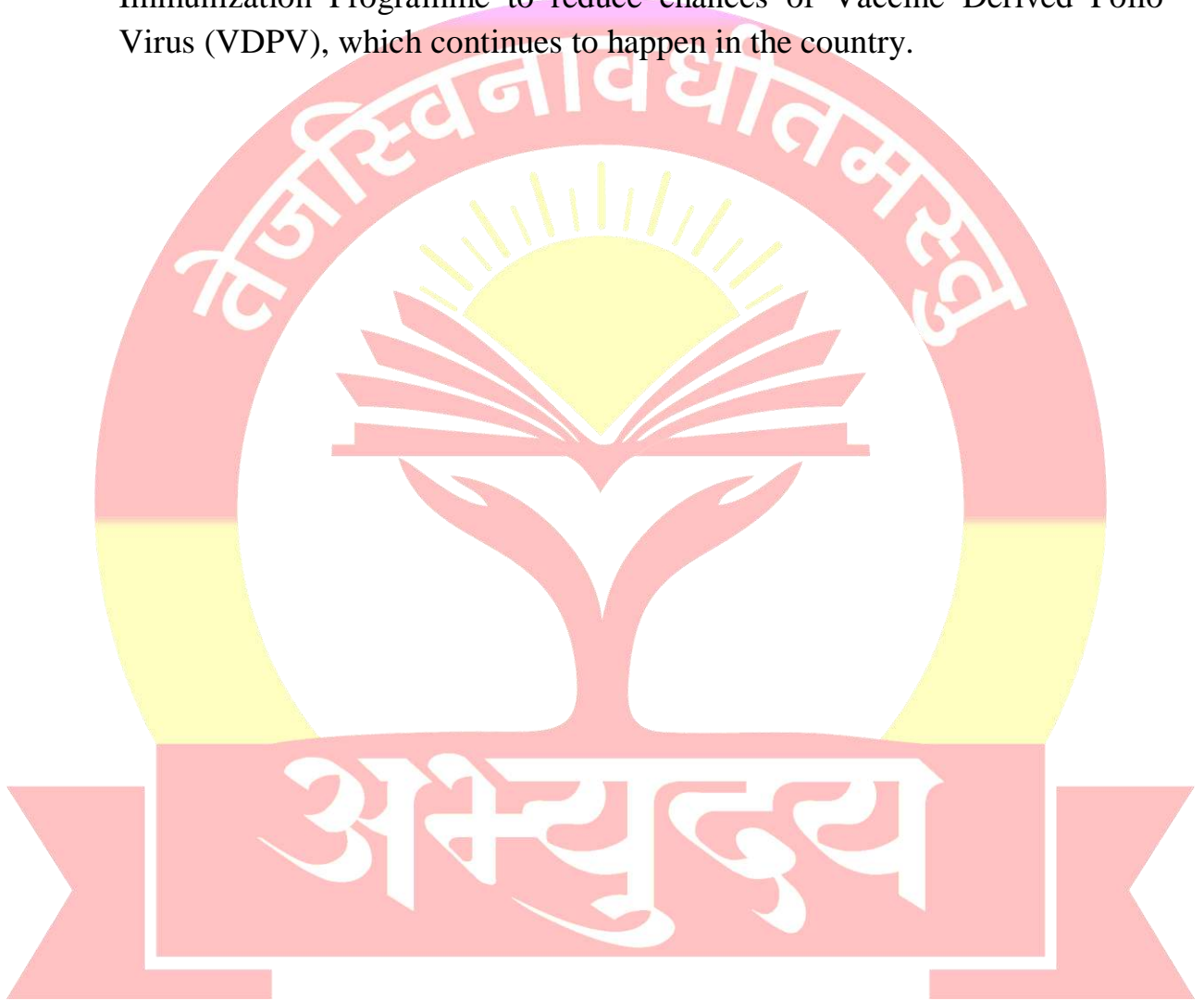
- It is a highly infectious viral disease which **invades the nervous system** and can cause irreversible paralysis within hours.
- There are three individual and immunologically distinct wild poliovirus strains: Wild Poliovirus Type1 (WPV1), Wild Poliovirus Type 2 (WPV2) and Wild Poliovirus Type 3 (WPV3).

<b>Oral polio vaccine:</b>	<ul style="list-style-type: none"> <li>• It consists of a mixture of live attenuated strains of polioviruses of three (now only two OPV 1 and OPV 3) different types of serotypes.</li> </ul>
<b>Inactivated Poliovirus Vaccine (IPV):</b>	<ul style="list-style-type: none"> <li>• This protects people against all three types of poliovirus.</li> <li>• IPV <b>does not contain a live virus</b>, so people who receive this vaccine do not shed the virus and cannot infect others and the vaccine cannot cause disease.</li> </ul>



### Polio Status in India:

- India launched the **Pulse Polio Immunization Programme** in 1995 brought down polio cases from 50,000- 100,000 each year in the 80s to zero in 2012.
- In **January 2014**, **India** was declared **polio-free** after three years on zero cases.
- India introduced the **injectable polio vaccine** in the Universal Immunization Programme to reduce chances of Vaccine Derived Polio Virus (VDPV), which continues to happen in the country.



## 2. DENGUE-

- Dengue is a viral disease transmitted mainly through **female mosquitoes** of the species **Aedes Aegypti**, which thrives in tropical climates.
- **Symptoms** include high fever, headache, rash and muscle and joint pain.
- The disease may develop into the life-threatening dengue hemorrhagic fever, resulting in bleeding, low levels of blood platelets and blood plasma leakage.
- Recently, Spanish health authorities confirmed the world's first case of dengue being **transmitted through sex**.
- **Treatment** includes fluids and pain relievers. Severe cases require hospital care. Medication example, Analgesic.

## 3. FLU/ INFLUENZA-

- A common viral infection that can be deadly, especially in high-risk groups.
- The **flu attacks** the lungs, nose and throat. Young children, older adults, pregnant women and people with chronic disease or weak immune systems are at high risk.
- **Symptoms** include fever, chills, muscle aches, cough, congestion, runny nose, headaches and fatigue.
- **Treatment:** Flu is primarily treated with rest and fluid intake to allow the body to fight the infection on its own.
- There are four species of Influenza Virus viz. Influenza-A, Influenza-B, Influenza-C, and Influenza-D.
- Human influenza A and B viruses cause seasonal epidemics of disease (known as the flu season).
- **Influenza type C** infections generally cause mild illness and are not thought to cause human flu epidemics.
- **Influenza D** viruses primarily affect cattle and are not known to infect or cause illness in people.
- The common Influenza outbreaks caused by Influenza-A strains include
  1. H1N1 (Swine Flu)
  2. H5N1, H5N8, H2N9 (Bird Flu)

#### 4. CORONA-

- **Coronaviruses** are a large family of viruses that circulate among a range of animals, such as bats, cats, and birds.
- The virus causes **respiratory and gastrointestinal symptoms** in humans with infectious diseases ranging from the common cold to more severe diseases such as **Severe Acute Respiratory Syndrome (SARS)**, **Middle East Respiratory Syndrome (MERS)** and **CoVID-19**.

#### Coronavirus Disease 2019 (COVID-19)

- COVID-19 is an infectious disease caused by a **newly discovered coronavirus**. COVID-19 is a Zoonotic disease.
- **Symptoms:** mild to moderate respiratory illness and recover without requiring special treatment. Older people and those with underlying medical problems like cardiovascular disease, diabetes, chronic respiratory disease, and cancer are more likely to develop serious illness. (WHO)
- **Vaccine:** Currently under development. Few approved drugs include Pfizer (USA), Covaxin, Covishield (India).

#### HEPATITIS-

- Hepatitis refers to an **inflammatory condition of the liver**.
- It's commonly caused by a viral infection, but there are other possible causes of hepatitis. These include autoimmune hepatitis and hepatitis that occurs as a secondary result of medications, drugs, toxins, and alcohol.

Hepatitis	A	B	C	D	E
Transmission	-Fecal-Oral -Contaminated Food/Water	-Blood to blood -Sex	-Blood to blood -Sex (less common)	-Blood to blood -Sex -Only occurs when HBV is present	-Fecal-Oral -Contaminated Food/Water
Chronic Infection	No	Yes	Yes	Yes	Genotype 3 only
Prevention	-Pre-exposure vaccine	-Pre-exposure vaccine	-Screening donor blood -Harm reduction	-Pre-exposure vaccine	-Ensure safe drinking water, -Avoid undercooked pork & shellfish
Treatment	-Management of symptoms	-Treatment for management of chronic infection	-Treatment/cure for chronic infection	-No approved treatments	-Management of symptoms

- **Hepatitis B and C** can cause **chronic hepatitis** and are responsible for 96% of overall hepatitis mortality.
- **Hepatitis A and E** usually cause **acute hepatitis**.
- **Note:** Hepatitis D infections occur **only in** those who are infected with Hepatitis B Virus.
- There are **vaccines** to prevent Hepatitis **A, B and E**. However, there is **no vaccine** for Hepatitis C.
- **Nobel Prize for Medicine or Physiology, 2020** for the discovery of the **Hepatitis C virus**.



## COMMUNICABLE DISEASES CAUSED BY PARASITES-

### MALARIA-

- Malaria is a disease caused by a **plasmodium parasite**, transmitted by the bite of infected **female Anopheles** mosquitoes.
- **Symptoms** are chills, fever and sweating, usually occurring a few weeks after being bitten.
- **Treatment** includes antimalarial drugs.

### RELATED INFORMATION

- World's first vaccine against a parasitic disease: Mosquirix
- Recently, Algeria and Argentina have been officially recognized by the WHO as malaria-free.
- **WHO's E-2020 initiative:** It is part of the **Global Technical Strategy for Malaria 2016-2030** endorsed by WHO which **aimed to** dramatically lower (or eliminate) the global malaria burden over these 15 years.

### KALA AZAR/ BLACK FEVER-

- It is a **neglected tropical disease** affecting almost 100 countries including India, caused by infection with **Leishmania parasites**.
- Also known as **Dumdum fever**. It **spread** through **sandfly bites**.
- **Symptoms:** some people have no symptoms. For others, symptoms may include fever, weight loss and swelling of the spleen or liver.
- There are **three types of leishmaniasis**:
  1. **Visceral leishmaniasis**, which affects multiple organs and is the most serious form of the disease.
  2. **Cutaneous leishmaniasis**, which causes skin sores and is the most common form.
  3. **Mucocutaneous leishmaniasis**, which causes skin and mucosal lesions.
- Visceral leishmaniasis which is commonly known as **Kala-azar in India** is fatal in over 95% of the cases if left untreated. This type of

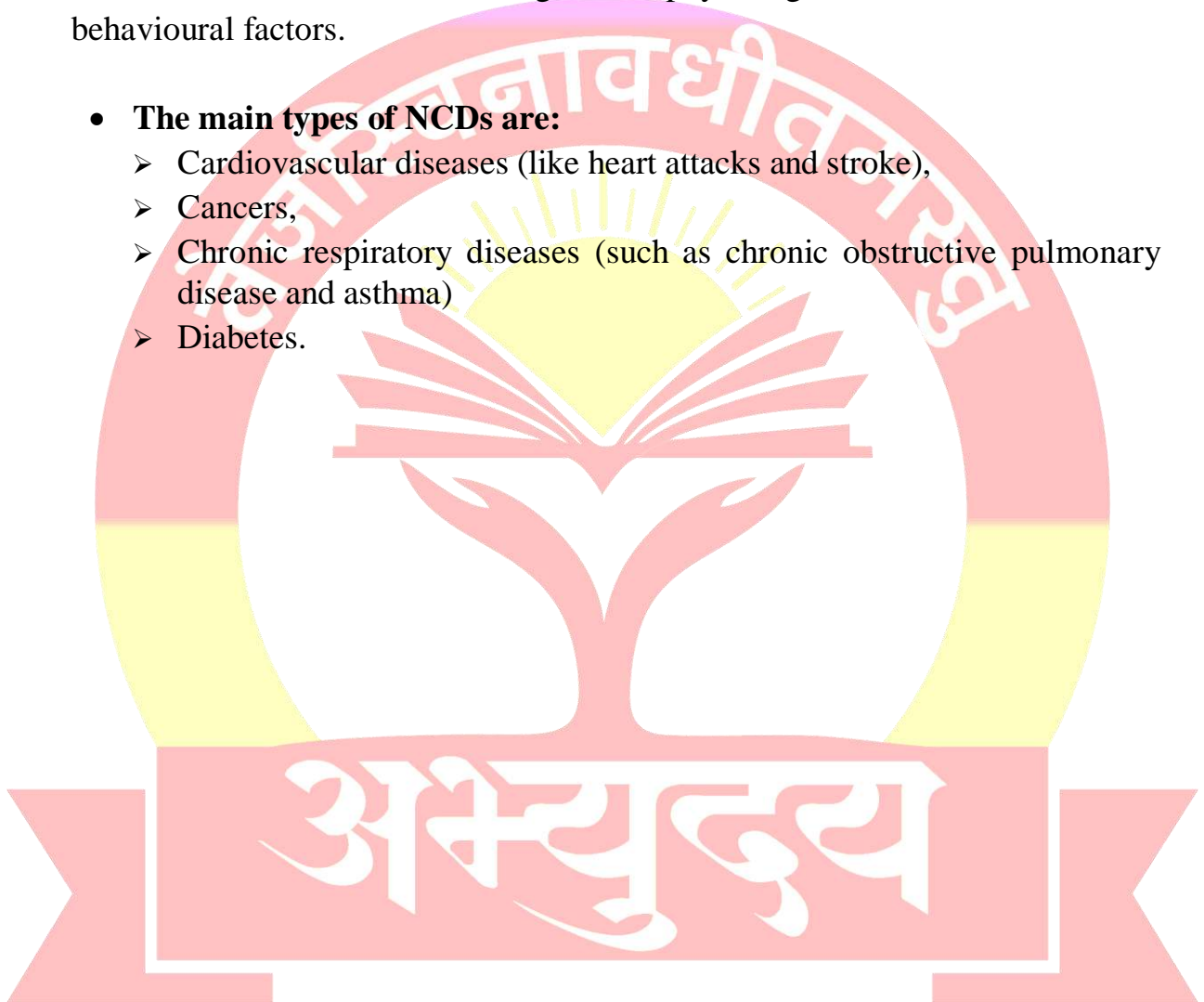
leishmaniasis **affects** the internal organs, usually the spleen, liver and bone marrow.

- **Medication** exists to kill the parasites. If left untreated, severe cases are typically fatal.

## **NON COMMUNICABLE DISEASES (NCDs)-**

Also known as chronic diseases that tend to be of long duration and are a result of a combination of genetic, physiological, environmental and behavioural factors.

- **The main types of NCDs are:**
  - Cardiovascular diseases (like heart attacks and stroke),
  - Cancers,
  - Chronic respiratory diseases (such as chronic obstructive pulmonary disease and asthma)
  - Diabetes.



## HEALTH MISSIONS-

<b>Universal Immunization Programme (UIP):</b>	<ul style="list-style-type: none"> <li>• One of the largest public health programs in the world started in 1985 in a phased manner.</li> <li>• India's Universal Immunization Programme (UIP) provide free vaccines against 12 life-threatening diseases, to 26 million children annually.</li> <li>• The UIP provides life-saving vaccines to all children across the country free of cost to protect them against- Tuberculosis, Diphtheria, Pertussis, Tetanus, Polio, Hepatitis B, Pneumonia and Meningitis due to Haemophiles Influenzae type b(Hib), Measles, Rubella, Japanese Encephalitis (JE) and Rotavirus diarrhea.</li> </ul>
<b>Mission Indradhanush:</b>	<ul style="list-style-type: none"> <li>• Launched by Ministry of Health and Family Welfare, GOI on Dec 25, 2014.</li> <li>• <b>Aims</b> to fully immunize more than 89 lakh children who are either unvaccinated or partially vaccinated under UIP by 2020.</li> <li>• It targets children under 2 years of age and pregnant women for immunization.</li> <li>• It provides Vaccination against 12 Vaccine-preventable diseases (VPD).</li> <li>• Earlier the increase in full immunization coverage was 1% per year which has increased to 6.7% per year.</li> <li>• <b>Intensified Mission Indradhanush (IMI)</b> was launched on Oct 8, 2017, to improve immunization coverage and to ensure full immunization to more than 90% by Dec 2018.</li> </ul>
<b>Ayushman Bharat:</b>	<p>Flagship initiative for comprehensive need-based health care service.</p>
	<p>Two-pronged approach: - Creation of health and wellness centers, Pradhan mantra Jan Arogya Yojana (PMJAY).</p> <ol style="list-style-type: none"> <li>1. Wellness centers will provide comprehensive primary health care, covering both maternal and child health services and non-communicable diseases, including free essential drugs and diagnostic services.</li> <li>2. PMJAY: provides insurance of 5 lakh per family for secondary and tertiary care to beneficiaries identified by the latest Socio-Economic Caste Census, 2011 (SECC)</li> </ol>

	<p>2011) data.</p> <p>The insurance cost is shared by the centre and states in the ratio of 60:40.</p> <p>National Health Agency has been constituted as an Autonomous entity for effective implementation of PMJAY.</p>
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### Recent developments-

**Trans Fats-** World Health Organization (WHO) released progress report on trans-fat elimination titled “Countdown to for the global elimination of industrially produced trans-fatty acids (TFA) by 2023.

- In May 2019, WHO released REPLACE action framework which is a roadmap for countries to implement the prompt, complete and sustained elimination of industrially produced TFA from the food supply.

- **Under REPLACE framework, the six areas of action include:**





## Miscellaneous-

Glucose-6-Phosphate Dehydrogenase (G6PD) Deficiency	<ul style="list-style-type: none"> <li>It is a genetic abnormality (more prevalent in males) that results in an inadequate amount of G6PD in the blood. <ul style="list-style-type: none"> <li>This is a very important enzyme (or protein) that regulates various biochemical reactions in the body.</li> <li>G6PD is also responsible for keeping red blood cells healthy.</li> </ul> </li> <li>Recently, Surat Municipal Corporation raised a specific COVID-19 alert for Vataliya Prajapati community whose 25% population suffers from G6PD deficiency.</li> </ul>
Lead Poisoning in Children	<ul style="list-style-type: none"> <li>According to a new report launched by UNICEF and Pure Earth (Non-Profit Organization), around one third i.e. 800 million children globally, are affected by lead poisoning.</li> <li>Lead is a cumulative toxicant (increasing in quantity in the body over many years) that affects multiple body systems.</li> <li>Bureau of Indian Standard (BIS) Drinking Water Specifications prescribed lead content in water not to exceed 50 parts per billion (ppb). <ul style="list-style-type: none"> <li>World Health Organisation (WHO) limit for lead in drinking water is 5 ppb.</li> </ul> </li> </ul>
Kala-azar or Visceral Leishmaniasis (VL)	<ul style="list-style-type: none"> <li>It is a tropical disease characterised by irregular fever, weight loss, anaemia and swelling of the spleen and liver.</li> <li>It is caused by a protozoan Leishmania parasite and is transmitted to humans by the bite of infected female sandflies.</li> <li>According to WHO, globally, about 7 to 10 lakh new cases occur annually. <ul style="list-style-type: none"> <li>India accounts for about two-thirds of the total global cases, and the disease is endemic to Bihar, Jharkhand, Uttar Pradesh and West Bengal.</li> </ul> </li> <li>An initiative was launched by WHO to eliminate VL as a public health problem from the South East Asia region by 2020. The deadline has now been extended to 2023.</li> </ul>
Neglected tropical diseases (NTDs)	<ul style="list-style-type: none"> <li>Recently, UP and West Bengal have achieved their elimination target of the deadly Kalaazar a NTDs while only four blocks in Bihar and 12 in Jharkhand have reported more than one case per 10,000 population.</li> <li>NTDs such as dengue, rabies, leprosy, lymphatic filariasis, trachoma, and leishmaniasis, are called "neglected," because they generally afflict the world's poor and historically have not received as much attention as other diseases.</li> </ul>



# DEFENCE

Organization	Important Information
DEFENCE RESEARCH AND DEVELOPMENT ORGANISATION (DRDO)	<ul style="list-style-type: none"> <li>• DRDO is the R&amp;D wing of Ministry of Defence, Government of India.</li> <li>• Established in 1958.</li> </ul>

- India conducted its first nuclear test in 1974 and the second nuclear test in 1998.
- **India declared herself a nuclear weapon state in 1998 and came forward with Nuclear Doctrine in 2003.**
- India's Nuclear Doctrine consist of the following major points:
  - Credible Minimum Deterrence.
  - No First Use policy i.e., India will use the weapon only in retaliation to a nuclear attack on Indian territory or against Indian forces anywhere.
  - Nuclear Command Authority-Retaliatory attacks will be authorized only by the civilian political leadership
  - Nuclear weapons will not be used against non-nuclear weapon states.
  - Massive Retaliation.

## NUCLEAR TRIAD

- A three-sided military-force structure consisting of land-launched nuclear missiles, nuclear-missile-armed submarines, and strategic aircraft with nuclear bombs and missiles.

Land Based	Agni; Agni-I; Agni-II; Agni III; Agni-IV; ICBM - Agni-V; SLBM - Sagarika (K-15); Cruise – Brahmos Supersonic etc.
Sea Based	Arihant class submarine
Air Based	Mig-27 ETC

## MISSILES

A missile is an intelligent unmanned rocket designed to carry the payload to a designated point with an aim of destroying the object/target.

### PROPULSION SYSTEMS

Type of Propulsion	Features
<b>Solid propulsion</b>	<ul style="list-style-type: none"><li>• Solid fuel used, mostly aluminium powder.</li><li>• Can be easily stored.</li><li>• Reach high speed quickly.</li></ul>
<b>Liquid Propulsion</b>	<ul style="list-style-type: none"><li>• Liquid fuel used, i.e., hydrocarbons.</li><li>• Storage difficult and complex.</li><li>• Can be controlled easily.</li></ul>
<b>Cryogenic</b>	<ul style="list-style-type: none"><li>• Liquified gases at very low temp. e.g. Liquid hydrogen.</li><li>• Need insulated containers and vents.</li><li>• No air intake is required.</li><li>• India is sixth country apart from USA, Russia, France, Japan, China to have this technology.</li></ul>

## INDIAN MISSILE SYSTEM

### Integrated Guided Missile Development Programme (IGMDP):

- It was conceived by Dr. A P J Abdul Kalam to enable India attain self-sufficiency in missile technology, in response to the Missile Technology Control Regime.
- IGMDP was started in 1983 and completed in March 2012.
- It developed 5 types of missiles under it.

MISSILE	DETAILS
<b>AGNI</b>	<ul style="list-style-type: none"><li>• It is an <b>intercontinental surface-to-surface</b>, nuclear capable ballistic missile developed by DRDO.</li><li>• At present, US, China, Russia, UK, France and Israel are known to have ICBMs.</li><li>• It has been equipped with very high accuracy.</li><li>• Ring Laser Gyro based Inertial Navigation System (RINS) and Micro Navigation System (MINS).</li></ul>

<b>PRITHVI</b>	<ul style="list-style-type: none"> <li>• Tactical surface-to-surface short range ballistic missile.</li> <li>• First missile developed under IGMDP in 1983.</li> <li>• Uses either liquid or both liquid and solid fuels and are capable of carrying conventional as well as nuclear warhead.</li> <li>• Prithvi I- Army version-150 km range</li> <li>• Prithvi II- Air force version-350 km range</li> <li>• Prithvi III- Naval version-600 km range</li> </ul>
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<b>TRISHUL</b>	<ul style="list-style-type: none"> <li>• Short range surface-to-air missile for Indian Navy used for Immediate combat action.</li> <li>• Range - 9km.</li> <li>• Currently not in service.</li> </ul>
<b>NAG</b>	<ul style="list-style-type: none"> <li>• Anti-tank missile.</li> <li>• Range - 4km.</li> <li>• 3rd generation 'fire and forget' guided missile where the target is identified and designated before the weapon is launched.</li> <li>• It is an all-weather condition with day and night capabilities.</li> <li>• Launched from land and air-based platforms.</li> </ul>
<b>AKASH</b>	<ul style="list-style-type: none"> <li>• Group of 4 medium range surface-to-air missile with a radar called Rajendra.</li> <li>• Multi-target engagement capacity. Radar detects incoming objects and missiles are fired.</li> <li>• Range – 30 km. Altitudes up to 18000m.</li> <li>• Already in use.</li> </ul>

### OTHER MISSILES

<b>ASTRA</b>	<ul style="list-style-type: none"> <li>• Astra is an all-weather beyond-visual-range air-to-air missile (BVRAAM)</li> <li>• Range - 80km.</li> <li>• Payload capacity: 15 kg.</li> <li>• First indigenously developed missile of India</li> <li>• Uses solid fuel ducted Ramjet and has BVRAAM (beyond visual range air-to-air missile) technology.</li> <li>• Can destroy enemy aircrafts at supersonic speed.</li> </ul>
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<b>NIRBHAY</b>	<ul style="list-style-type: none"> <li>• NIRBHAY is India's first indigenous Long Range, all-weather, Sub-Sonic Cruise Missile,</li> <li>• It can carry a warhead of 200 kg to 300 kg at a speed of 0.6 to 0.7 Mach with a launch weight of about 1500 kg.</li> <li>• It can avoid detection as it has ability to cruise at heights as low as 100 m.</li> <li>• Can be launched from multiple platforms and is capable of carrying conventional and nuclear warheads.</li> <li>• Two-stage missile powered by Solid rocket motor booster.</li> <li>• Range of 1000km.</li> </ul>
<b>DHANUSH</b>	<ul style="list-style-type: none"> <li>• Sea-to-sea/surface short range ballistic missile.</li> <li>• Range - 350km.</li> <li>• Capable of carrying nuclear warheads.</li> </ul>
<b>BRAHMO MISSILE SYSTEM</b>	<ul style="list-style-type: none"> <li>• BRAHMOS is a joint venture between the Defence Research and Development Organisation of India (DRDO) and the NPOM of Russia.</li> <li>• Named after the rivers Brahmaputra (India) and Moskva (Russia).</li> <li>• Two-stage (solid propellant engine in the first stage and liquid ramjet in second) air-to-surface missile.</li> <li>• Range - around 300 km.</li> <li>• Speed - Mach 2.8</li> <li>• India's entry into the Missile Technology Control Regime (MTCR) has extended the range of the BRAHMOS missile to reach 450 km-600km.</li> <li>• Can be launched from land, air, and sea and multi capability missile with pinpoint accuracy that works in both day and night irrespective of the weather conditions.</li> <li>• Operates on the "Fire and Forgets" principle.</li> </ul>
	<ul style="list-style-type: none"> <li>• One of the fastest cruise missiles currently operationally deployed.</li> <li>• Lower target dispersion and quicker engagement.</li> <li>• Low radar signature.</li> </ul>
<b>PINAKA MISSILE SYSTEM</b>	<ul style="list-style-type: none"> <li>• Indigenous multi-barrel rocket launch system, for the Indian Army by DRDO</li> <li>• The navigation system - aided by the Indian Regional Navigation Satellite System (IRNSS).</li> <li>• Range more than 70 km.</li> </ul>
<b>Rudra M-I</b>	<ul style="list-style-type: none"> <li>• It is the first indigenous anti-radiation missile of the country.</li> <li>• Range of up to 200 km depending upon the launch conditions.</li> <li>• Can be launched from altitudes of 500 m to 15 km and speeds of 0.6 to 2 mach.</li> <li>• Can locate and target any radiation-emitting source like enemy radars, communication sites and other Radio Frequency (RF) emitting targets.</li> </ul>

<b>Anti-Satellite Weapons (ASAT) MISSION SHAKTI</b>	<ul style="list-style-type: none"> <li>• To develop highly potent Anti-satellite weapons (ASAT).</li> <li>• It is a joint programme of DRDO and the Indian Space Research Organisation (ISRO).</li> <li>• Anti-satellite (ASAT) System is missile-based system to attack moving satellites.</li> <li>• ASAT propels India to the coveted space-superpower league.</li> <li>• India will now have the power to decimate satellites for pure military and strategic purpose.</li> <li>• India will have the capability to interfere with satellites or engage in direct attacks.</li> <li>• ASAT missile can be air, sea or land based.</li> <li>• Can also help in creating nuclear missile deterrence.</li> <li>• In March 2019, India successfully tested its ASAT missile.</li> <li>• joining a select group of nations – USA, Russia and China with a similar technology.</li> <li>• India used the Kinetic Kill space technology.</li> <li>• The ASAT missile destroyed a live satellite in Low Earth orbit (283-kilometre).</li> <li>• As per DRDO, the missile is capable of shooting down targets moving at a speed of 10 km per second at an altitude as high as 1200 km.</li> </ul>
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## AIR DEFENCE SYSTEMS

### INDIAN BALLISTIC MISSILE DEFENCE PROGRAMME:

- India's BMD development began in 1999, after the Kargil war.
- It is a two-tiered defence system and will be able to intercept any incoming missile launched 5,000 km away.
  - a) **Prithvi Air Defence (PAD):** It's designed for High altitude interception (exo-atmospheric interception).
  - b) **Advanced Air Defence (AAD):** It's endo-atmospheric interception system (for low altitude interception).

## SUBMARINES

<b>Submersible</b>	<ul style="list-style-type: none"> <li>• Provide excellent second-striking capability</li> <li>• <b>SSN:</b> submersible ship nuclear-powered-specifically designed for attacking and sinking other submarines/ships. Generally, do not carry long range missiles.</li> <li>• <b>SSBN:</b> submersible ship Ballistic Nuclear-Powered-have the capability to deploy submarine launched ballistic missiles with nuclear warheads.</li> </ul>
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<b>Diesel-powered</b>	<ul style="list-style-type: none"> <li>• Come on waterbody surface after regular intervals because burning of diesel needs oxygen</li> <li>• Easy for enemy to detect</li> <li>• Can't float near territorial waters of enemy nation</li> <li>• Don't possess that advantage</li> </ul>
<b>Nuclear-powered</b>	<ul style="list-style-type: none"> <li>• Gets energy from nuclear reactor so can stay submerged in water for months.</li> <li>• Difficult for enemy to detect.</li> <li>• Can float near territorial waters of enemy nation.</li> </ul>
<b>Attack Submarines</b>	<ul style="list-style-type: none"> <li>• Generally small submarines designed for specific tasks, which include attack on enemy in combat.</li> <li>• It uses torpedoes and other small range missiles.</li> <li>• These submarines have limited range and need to come out of the water after sometime.</li> </ul>
<b>Ballistic Missile Submarines</b>	<ul style="list-style-type: none"> <li>• Bigger in size and are more destructive for the enemy.</li> <li>• It is used as a launch platform for ballistic or long-range missiles.</li> <li>• These can carry nuclear warheads.</li> <li>• These submarines are nuclear powered submarines. As a result, have almost unlimited range because of availability of unlimited power supply.</li> <li>• These can remain under water for months and can travel up to thousand miles.</li> </ul>

## DEFENCE INDIGENISATION-

- Raising the sectoral cap of foreign direct investment (FDI) (automatic approval) from the existing 49% to **74%.**
- A negative list for the import of defence equipment in India- means that the Armed Force will only procure all of these 101 items from domestic manufacturers.
- Corporatization of the **Ordnance Factory Board (OFB)** and Defence industrial corridors in Tamil Nadu and UP.
- **SRIJAN portal for domestic vendors**- one stop shop online portal that will give information on items that can be taken up for indigenization by the private sector.
- Naval Innovation and Indigenization Organisation (NIIO) has been launched by the Defence Minister of India.
- **Objective**- To foster innovation and indigenization for self-reliance in defence in keeping with the vision of AtmaNirbhar Bharat.
- **Mission Raksha Gyan Shakti** -to promote a culture of innovation and technology development and for promoting the creation of Intellectual Property in the sector and its commercial utilisation.

## NEW DEFENCE ACQUISITION PROCEDURE 2020 (DAP 2020)

- DAP 2020 will govern the procurement of defence equipment from the capital budget.
- It superseded the Defence Procurement Procedure of 2016.
- **Reservation in Categories for Indian Vendors**- Some categories like Buy (Indian Indigenously Designed Developed and Manufactured - IDDM), Production Agency in Design & Development etc. will be exclusively reserved for Indian Vendors.
- **Measuring indigenous content**- Indigenous content will now be calculated on **‘Base Contract Price’-Total Contract Price, less taxes and duties.**
- **Offset liability**- The government has decided not to have an offset clause in procurement of defence equipment if the deal is done through inter-government agreement (IGA), government-to-government, single vendor.
- **Leasing** introduced as a new category for acquisition in addition to the existing **‘Buy’ and ‘Make’ categories**



so that periodical rental payments are made instead of huge capital investment.

### UNMANNED AERIAL VEHICLE

- Unmanned aerial vehicles (UAV)/Drones are a class of aircrafts that can fly without the onboard presence of pilots.
- Registration is required for all but the Nano category.

#### 1. Drone Categories in India:

2. **Nano:** Less than or equal to 250 grams
3. **Micro:** From 250 grams to 2 kg
4. **Small:** From 2 kg to 25 kg
5. **Medium:** From 25 kg to 150 kg
6. **Large:** Greater than 150 kg

### CHEMICAL WEAPONS

	<ul style="list-style-type: none"> <li>• Three states have neither signed nor ratified the convention are Egypt, North Korea and South Sudan.</li> </ul>
<b>Organization for the Prohibition of Chemical Weapons (OPCW)</b>	<ul style="list-style-type: none"> <li>• Headquarter-Hague, Netherlands.</li> <li>• OPCW was established by the Chemical Weapons Convention, 1997 to implement and enforce the terms of the non-proliferation treaty.</li> <li>• It is authorized to perform inspections, perform testing of sites and victims of suspected chemical weapons attacks to verify that signatory states are complying with the convention.</li> <li>• OPCW won the 2013 Nobel peace prize.</li> </ul>
<b>Chemical weapons and India</b>	<ul style="list-style-type: none"> <li>• India ratified the CWC in 1996.</li> <li>• As a state party to the CWC India enacted Chemical Weapons Convention Act in 2000.</li> <li>• National Authority Chemical Weapons Convention (NACWC) has been established under the Chemical Weapons Convention Act, 2000 for implementing the provisions of the Convention</li> </ul>

<b>Chemical agents in news</b>	<ul style="list-style-type: none"> <li>• <b>Chlorine gas</b> - Choking agent</li> <li>• <b>Sarin gas</b> - Nerve agent.</li> <li>• <b>Novichok</b> -Nerve Agent- 5-8 times more lethal than VX nerve agent.</li> <li>• <b>Cyanide</b>- Blood Agent</li> <li>• <b>Phosgene, Sulphur Mustard</b>- Blister agents</li> <li>• <b>VX</b>- very persistent once in the atmosphere, it is slow to evaporate, and thus tends to cause prolonged exposure.</li> </ul>
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## BIOLOGICAL WEAPONS

Biological weapons are microorganisms like **virus, bacteria, fungi, or other toxins** that are produced and **released deliberately** to cause disease and death in humans, animals or plants. Examples- **anthrax, botulinum toxin, Plague, Ricin etc.**

## BIOLOGICAL WEAPON CONVENTION (BWC)

- **It is the first multilateral disarmament treaty** banning the development, production and stockpiling of an entire category of weapons of mass destruction. **BWC entered into force on 26 March 1975.**
- **India signed the convention in 1973.**
- **The BWC bans:**
  - The development, stockpiling, acquisition, retention, and production of:
  - Biological agents and toxins “of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes;”
  - Weapons, equipment, and delivery vehicles “designed to use such agents or toxins for hostile purposes or in armed conflict.”
  - The transfer of or assistance with acquiring the agents, toxins, weapons, equipment, and delivery vehicles described above.

# NANOSCIENCE AND NANO TECHNOLOGY

## NANO SCIENCE-

- It is the study of structures and materials on an ultra-small scale (in range of 1-100 Nanometers).
- and the unique and interesting properties these materials demonstrate.

## NANOTECHONOLGY –

<b>Difference:</b>	<ul style="list-style-type: none"><li>• Nanoscience is studying nanomaterials and their properties.</li><li>• Nanotechnology is using those materials and properties to create something new or different.</li></ul>
<b>Origination:</b>	<ul style="list-style-type: none"><li>• The development of nanoscience can be traced back to <b>5th Century B.C.</b></li><li>• Nobel laureate Richard Feynman introduces the concept of Nanotechnology in 1959 during a lecture entitled “<b>There’s Plenty of Room at the Bottom</b>”.</li></ul>

## CARBON BASED NANO MATERIAL-

<b>FULLERENE:</b>	<ul style="list-style-type: none"> <li>Carbon atoms connected to three others carbon atoms by covalent bonds in pentagons and hexagons pattern giving spherical shape.</li> <li>Bucky balls used in Composites to strengthen materials.</li> <li>Being a good electron acceptors, used in increasing efficiency of solar cells in transforming sunlight into electricity.</li> </ul>
<b>CARBON NANOTUBES (CNT):</b>	<ul style="list-style-type: none"> <li>CNTs are rolled graphene sheets in a cylindrical shape.</li> <li><b>Strongest and stiffest materials</b> on earth in terms of tensile strength.</li> <li>Forms in either a <b>seamless cylinder, known as Single-Walled CNTs</b> or many cylinders stacked one inside the other, known as <b>Multi-Walled CNTs</b>.</li> </ul>

## APPLICATIONS OF NANOTECHNOLOGY:

<b>Health &amp; Medicine:</b>	<ul style="list-style-type: none"> <li>Targeted drug delivery in destroying the cancer cells without harming healthy cells,</li> <li>Nano sponges (polymer) for absorbing toxins and removing them from bloodstreams.</li> <li>Gold nano cells for location and elimination of cancer cells.</li> <li>Antiviral Nano coating on Face mask and PPE kits.</li> <li>Nano robotics can acts as miniature surgeons.</li> </ul>
<b>Environment:</b>	<ul style="list-style-type: none"> <li>CNTs membrane used for water desalination, nanoscale sensors for identifying water contaminations.</li> <li>Nano fabric “Paper-towel” used in oil for clean-up applications.</li> <li>Iron nanoparticles for remediation of contaminated ground water.</li> </ul>
<b>Food and Agriculture:</b>	<ul style="list-style-type: none"> <li>Titanium dioxide nanoparticles as antimicrobial agents.</li> <li>Bio indicators to detect the bio magnification of pesticide and fertilizers.</li> </ul>



## IMPLICATIONS OF NANOTECHNOLOGY-

<b>Risks to Human Health:</b>	Nano particles being slowly degradable, may accumulate into human body and affect regulatory mechanisms, compromise immune system response.
<b>Environmental Issues:</b>	Nano pollution created by toxic wastes from nano material manufacturing. Greater bioavailability and greater bioactivity may introduce new toxicity risk.

## NANOTECH FIBRE-

- It is a new carbon nanotube (CNT) based fiber that looks and acts like textile thread but is able to conduct heat and electricity.
- Behaves like both metal wires and strong carbon fibers.
- Used in field of aerospace, automotive, medical and smart-clothing markets.

## SMART MATTER/SMART DUST-

- Is the use of tiny wireless sensors and transponders to communicate the information they sense.
- Made by Hitachi, have GPS capabilities, they can be sprayed on us and absorbed or taken in foods, drinks and even injected to monitor health and activities.

## SEMICONDUCTORS-

- These are materials which have a conductivity between conductors (generally metals) and non-conductors or insulators (such as ceramics).
- Its resistance falls with rise in temperature, opposite to metals.
- Semiconductors acts like an insulator at Zero Kelvin.

E.g.: pure metals such as **silicon or germanium** or compounds such as **gallium arsenide or cadmium selenide**.

### Types of Semiconductors

<b>Intrinsic material:</b>	Material made to be very pure chemically. It possesses a very low conductivity level having very few number of charge carriers, namely electrons and holes(in equal quantities). E.g.: germanium, silicon.
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**Extrinsic material:**

**Extrinsic material** - Electrical conductivity is higher than Intrinsic material. In this a small amount of impurity has been added to the basic intrinsic material. This creates either an excess or shortage of electrons. In this way, two types of semiconductors are available:

- **N-type:** has excess of electrons. Free electrons are available within the lattices and their overall movement in one direction under the influences of potential differences result in an electric current flows.
- **P-type:** has shortages of electrons, i.e. there are 'holes' in crystal lattice.



# NUCLEAR SCIENCE

## NUCLEAR FUEL-

- Nuclear fuel is the fuel that is used in a nuclear reactor **to sustain a nuclear chain reaction**.
- U-233, U-235 & Pu-239 are **fissile in nature** i.e., they **exhibit nuclear fission** when targeted with a neutron.
- U-238 & Th-232 are **fertile in nature** i.e., when targeted with neutrons instead of breaking down, they **change into new element**. (U238  $\rightarrow$  Pu239, Th232  $\rightarrow$  U233).

	<b>Nuclear Fission</b>	<b>Nuclear Fusion</b>
<b>Definition</b>	Fission is the splitting of a large atom into two or more smaller ones.	Fusion is the fusing of two or more lighter atoms into a larger one.
<b>Natural occurrence</b>	Does not normally occur in nature.	Yes. occurs in stars, such as the sun.
<b>By-products</b>	Produces many highly radioactive particles	Few radioactive particles are produced
<b>Energy Requirement</b>	Takes little energy to split atoms	Extremely high energy is required to bring two or more protons close enough that nuclear forces overcome their electrostatic repulsion.
<b>Energy Released</b>	Lower than Fusion reaction but higher than other chemical reactions	Higher than Fission reaction
<b>Usage</b>	In nuclear power generation, Atom bombs	In experimental stage for future power generation.

## URANIUM ENRICHMENT-

- The Natural Composition of Uranium extracted from earth is that 99.3% is U-238, which is fertile and remaining is U-235, which is fissile.
- **On the basis of enrichment, two types of Uranium:** 1) Low Enriched uranium (LEU), 2) High enriched Uranium (HEU).
  - LEU is used for peaceful purposes like fuel in nuclear reactors (Kudankulam (1.5%) & Jaitapur (5%)) required enriched Uranium.
  - HEU is weapon grade uranium used for conducting nuclear test and nuclear weapons.

## FISSILE MATERIAL CUT-OFF TREATY (FMCT)-

- Proposed International agreement that would prohibit the production of two main components of nuclear weapons: **highly enriched uranium (HEU) and Plutonium.**
- **FMCT** would provide **new restrictions** for the five recognized nuclear weapon states (US, Russia, UK, France, China) and the four states that are not NPT members (Israel, India, Pakistan, & North Korea).

## MODERATORS-

- Moderators are generally atoms with lighter nuclei and **does not absorb neutron.**
- Hence, these are **used in nuclear reactors** to slow down the neutron in a controlled chain reaction.
- Generally **Ordinary Water, Heavy Water and Graphite rods** are used as moderators.

## CONTROL RODS-

- There are used in nuclear reactors **to control the fission rate** of uranium or plutonium.
- Control rods are made of **neutron poisons** & therefore **absorb neutrons.** This action results in **fewer neutrons available to cause fission** & reduces the reactor's power output.
- Control rods absorb neutrons but do not release energy in the process.
- Their compositions include chemical elements such as **Boron, Cadmium, Silver, or Indium,** that are capable of absorbing many



neutrons without themselves fissioning.

### NUCLEAR REACTORS AND ITS TYPES-

Reactor Type	Coolant	Moderator	Fuel	Comment
Light Water-Graphite Reactor	Light Water	Graphite	Enriched Uranium	
Boiling Water Reactor	Light Water	Light Water	Enriched Uranium	Steam from boiling water fed to turbine. (BWRs don't have any steam generator)
Pressurized Water Reactor	Light Water	Light Water	Enriched Uranium	Steam generated in secondary loop
Pressurized Heavy Water (CANDU) Reactor	Heavy Water (D <sub>2</sub> O)	Heavy Water	Natural Uranium	D <sub>2</sub> O helps in better moderation & sustain chain reaction
Fast Breeder Reactors	liquid sodium	No moderator used	U-238	produce more fuel than they consume (Breed)

- The commercial power plants have several types of design. They vary depending on the type of heat transfer fluid that is used and other design elements.
- **Fusion reactors:** increasingly seen as the **future of energy security** due to following factors:
  1. Abundance of fuel (Hydrogen)
  2. Clean source of energy as it involves no release of CO<sub>2</sub>
  3. Elimination of risk from nuclear waste.
- But these Fusion reactors are still in experimental stage due to their complexity in its operational handling.
- Different types of **fission reactors** are as listed in the table below.

### **Why India Prefers Fast Breeder Reactors (FBR)?**

- FBRs are designed to produce more fissile material (plutonium) than they

consume (Thorium Th-232).

- Enrichment and Re-processing technology (ENR) are not easy and costly, and FBRs Effectively utilizes the natural uranium (nearly 80%).
- Consumes the depleted fuel discharged from thermal reactors, FBRs is important from Waste management and environmental considerations.
- FBR technology can use Thorium (as fertile material) which gets converted to U-233, a fissile isotope. This holds great promise as India has one of the world's largest deposit of Thorium (450,000 tons) in form of sand dunes in Kerala and Chhatarpur coast of Orissa.

### **INDIA'S THREE STAGE NUCLEAR PROGRAM-**

- India has consciously proceeded to explore the possibility of tapping nuclear energy for the **purpose of power generation** and the Atomic Energy Act was framed and implemented with the **set objectives** of using two naturally occurring elements **Uranium & Thorium** having good potential to be utilized as nuclear fuel in Indian Nuclear Power Reactors.
- The **3-stage nuclear programme** is developed with the **aim of utilizing the vast Thorium** reserves in India (about 25% of the world) as India is a Uranium scarce country.

<b>Stage-1: Pressurized Heavy Water Reactor</b>	PHWRs using: <ul style="list-style-type: none"><li>• Natural UO<sub>2</sub> as fuel matrix (contains 99.3% U-238 and 0.7% U-235)</li><li>• Heavy water as moderator and coolant.</li></ul>
<b>Stage-2: Fast Breeder Reactor</b>	<ul style="list-style-type: none"><li>• Primarily based on <b>Plutonium</b> which was obtained from the first stage reactor operation, <b>as the fuel</b> core.</li></ul>
	<ul style="list-style-type: none"><li>• A blanket of <b>U-238</b> surrounding the fuel core will undergo nuclear transmutation to produce fresh Pu-239 as more and more Pu-239 is consumed during the operation.</li><li>• Besides a blanket of Th-232 around the FBR core also undergoes neutron capture reactions leading to the formation of U-233.</li><li>• <b>U-233</b> is the nuclear reactor <b>fuel for the third stage</b>.</li></ul>

<b>Stage-3: Breeder Reactor</b>	<ul style="list-style-type: none"> <li>• <b>Fuel: U-233</b> is obtained from the nuclear transmutation of Th-232 in stage-2 programme.</li> <li>• Since India has abundant <b>Thorium</b> reserves in the form of monazite sand, the <b>3rd stage is critical for India's nuclear energy basket.</b></li> </ul>
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Nuclear power in India accounts for 1.8% of the total energy basket. India's nuclear energy target set at 63000 MW by 2032.

### **Nuclear Technology Regulation in India- DEPARTMENT OF ATOMIC ENERGY (DoAE):**

- It is **apex body** under the direct charge of **Prime Minister** working toward development & regulation of nuclear technology in India.
- **Atomic Energy Commission** is the governing body of **DoAE**.

### **ATOMIC ENERGY REGULATORY BOARD (AERB):**

- The Board was constituted on 15 November 1983.
- AERB is the **regulatory authority** responsible for safe operations of **nuclear reactors** as well as regulation at all other nuclear facilities in India.
- It derives its powers from **Atomic Energy Act, 1962** & the **Environmental (Protection) Act, 1986**.

Atomic Minerals Directorate  
for Exploration and  
Research:

- Its prime mandate is to identify and evaluate Uranium resources required for the successful implementation of Atomic Energy Programme of the country.

## IMPORTANT NUCLEAR NON –PROLIFERATION TREATIES

### **PARTIAL TEST BAN TREATY-**

- PTBT is the abbreviated name of the **1963 Treaty Banning Nuclear Weapon Tests** in the Atmosphere, in Outer Space and Under Water, which **prohibited all test** detonations of nuclear weapons **except** for those conducted underground.
- The PTBT was **signed by** the governments of the **Soviet Union**, the **United Kingdom**, & the **United States in Moscow** on 5 August 1963.
- Since then, 123 other states have become party to the treaty. Ten states have signed but not ratified the treaty.



## NON PROLIFERATION OF NUCLEAR WEAPONS TREATY, 1968-

- NPT is an **international treaty** whose objective is to **prevent** the spread of nuclear weapons & weapons technology, **to promote** cooperation in the **peaceful uses** of nuclear energy, and to further the goal of achieving **nuclear disarmament**.
- Signed by 191 countries, the treaty **restricts** nuclear non-weapon states (countries which had no nuclear weapon till 1968) from developing or acquiring nuclear weapons.
- 5 states recognized as **nuclear-weapon states** include the United States, Russia, the United Kingdom, France, and China.
- **Four UN member** states that have **never joined** the NPT are: India, Israel, Pakistan & South Sudan.
- **North Korea** had signed the NPT in 1985 later in 1993 it unilaterally withdrew from NPT.

## COMPEHENSIVE TEST BAN TREATY-

- CTBT was negotiated at the **Conference on Disarmament in Geneva** and **adopted** by the United Nations General Assembly in **1996**.
- The Treaty intends to **ban all nuclear explosions-** everywhere, by everyone.
- So far it has been signed by 184 states, of which 168 have ratified the treaty. However, the **treaty has not come into force yet**.

## EXPORT CONTROL REGIMES-

### THE NUCLEAR SUPPLIERS GROUP

- NSG is a **multilateral export control regime** & a **group of nuclear supplier countries** that seek to prevent **nuclear proliferation** by controlling the export of materials, equipment & technology that can be used to manufacture nuclear weapons.
- The NSG was founded in response to the **Indian nuclear test** in May 1974.
- It is a **48-member** export-control regime that regulates **export of nuclear technology and fuel**.
- Nuclear non-weapon states who have signed NPT can have access to

items listed in NPT.

### AUSTRALIA GROUP

- Was established in response to Chemical Weapon use in Iran-Iraq war in 1984.
- There are around 43 members at present including **India, USA.**
- **Objective:** is to **control exports of biological & chemical agents** used as weapons.

### MISSILE TECHNOLOGY CONTROL

- The MTCR is a **multilateral export control regime**. Established in **1987** by the **G-7** industrialized countries.
- It is an **informal political understanding among 35 member** states that seek to **limit the proliferation** of missiles & missile technology.
- Accordingly, **weapons delivery system** carrying more than 500 kg payload for over 300 km **is restricted** under MTCR.
- In **2018 India joined MTCR**, which enabled India to:
  1. **Increase the range of Brahmos** from 290KM to 450KM.

2. Get access to predator drones from different countries

## NATIONAL AND INTERNATIONAL DEVELOPMENTS

<p><b>INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR(ITER):</b></p>	<ul style="list-style-type: none"> <li>• ITER is an international nuclear fusion research &amp; engineering megaproject, which will be the world's largest magnetic confinement plasma physics experiment.</li> <li>• Headquarters:-Saint-Paul-lez-Durance, France.</li> <li>• ITER was launched in 1985 &amp; is expected to be completed by 2025.</li> <li>• It is a joint collaboration of 35 countries with the following members China, the EU, India, Japan, South Korea, Russia &amp; the US.</li> </ul>
<p><b>Nuclear Medicine</b></p>	<ul style="list-style-type: none"> <li>• It is a <b>branch of non-invasive medical imaging</b> that uses small amounts of radioactive materials to diagnose &amp; determine the severity of diseases or treat a variety of diseases including cancers, heart disease, gastrointestinal, endocrine, neurological disorders etc</li> <li>• For example, Radio-isotopes such as Cobalt-60, Arsenic-74 are used in treating Thyroid disorders &amp; various types of Cancer.</li> </ul>

# RECENT ADVANCEMENTS

## DIGITAL OCEAN-

Recently, web-based application **Digital Ocean** was launched.

### About Digital Ocean

- Digital Ocean is a state of the art data platform to provide ocean data related services at one place. It includes a set of applications developed to organize and present heterogeneous oceanographic data by adopting rapid advancements in geospatial technology.
- It has been developed by Indian National Centre for Ocean Information Services (INCOIS) of the Ministry of Earth Sciences.
- **INCOIS provides ocean information and advisory services to various stakeholders**, including Potential Fishing Zone advisories, Ocean State Forecast, high wave alerts, tsunami early warnings, etc. It is a unit of the Earth System Science Organization (ESSO), an executive arm of the Ministry of Earth Science to develop and improve capability to forecast, weather, climate and hazard related phenomena.
- **Significance of the 'Digital Ocean'**-
- It will serve as a one stop-solution for all the data related needs of a wide range of users. Data from various projects like Deep Ocean Mission, 'Samudrayaan' project, research on alternative sources of energy, etc would be included.
- It will help to assess the evolution of oceanographic features through 3D and 4D data visualization.

## BIO- TERRORISM-

Recently Parliamentary panel has **highlighted the need for the government to have laws to counter bio-terrorism** in its report 'The Outbreak of Pandemic COVID-19 and its Management'.



## About bio-terrorism

- **Bioterrorism is a planned and deliberate use of pathogenic strains of microorganisms** such as bacteria, viruses, or their toxins to spread life-threatening diseases on a mass scale in order to devastate the population of an area.
- **Bioterrorism agents are classified as categories A, B, and C.**
- **Category A:** High-priority agents that pose a risk to national security because they can be easily disseminated or transmitted from person to person, result in high mortality rates. Eg. Anthrax by *Bacillus anthracis*, botulism by *Clostridium botulinum* toxin, plague by *Yersinia pestis* etc.
- **Category B:** The second highest priority agents include brucellosis (*Brucella* species), glanders (*Burkholderia mallei*), melioidosis (*Burkholderia pseudomallei*), psittacosis (*Chlamydia psittaci*) etc.
- **Category C:** This includes emerging pathogens that could be engineered for mass dissemination in the future. Eg. Emerging infectious diseases such as Nipah virus and Hanta virus etc.
- These agents are **delivered by Scud missiles, motor vehicles with spray, hand pump sprayers, book or letter, guns, remote control, robots** etc.

## International Thermonuclear Reactor (ITER)-

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

### About ITER Project-

- Launched in 1985, ITER is an experimental fusion reactor facility currently under construction in Cadarache, South of France.
- It aims to provide the feasibility of nuclear fusion as a future source of energy and build the world's largest tokamak through an international collaboration. Once complete, ITER will be the first fusion device to produce net energy.
- **ITER Members:** Signatories to the ITER Agreement include China, the European Union, India, Japan, Korea, Russia and the United States (35 nations).  
These countries share the cost of project construction, operation and decommissioning, and will also share in the experimental results and any intellectual property generated by the project. European Union being the host party contributes 45% while the rest of the parties contribute 9% each.

Most of these contributions (around nine-tenths) are through ‘inkind’ procurement of ITER components. Each Member has created a Domestic Agency to fulfill its procurement responsibilities to ITER.

- **India’s contribution:** India which formally joined the ITER project in 2005, is responsible for delivery of cryostat, in-wall shielding, cooling water system, cryogenic system, heating systems, Diagnostic Neutral Beam System, power supplies and some diagnostics.
- India is contributing resources worth about \$2.2 billion to this effort.
- ITER-India is the Indian domestic agency, a specially empowered project of the Institute for Plasma Research (IPR), an aided organization under Dept. of Atomic Energy.
- Larsen & Toubro Ltd (L&T) has worked and supplied all the parts for Cryostat.



# NOBEL PRIZES

## NOBEL PRIZE IN MEDICINE-

It was awarded to Harvey Alter, Charles Rice, and Michael Houghton for **discovering the Hepatitis C virus (HCV).**

### About the discovery

- **Clue of the existence of HCV-** In the 1970s, Dr. Harvey Alter led a team of scientists in discovering that most cases of post transfusion hepatitis could not be linked to Type A or B viruses. This discovery provided a hint to the existence of a pathogen that had not yet been described.
- **Identification and Naming of the HCV:** In the 1980s, Dr. Houghton and his colleagues became the first to identify and formally name the hepatitis C virus as the infectious culprit. Their work led to the development of a diagnostic test to identify the virus in blood, enabling doctors and researchers for the first time to screen patients and donors.
- **Confirmation of HCV being the sole cause for “non-A, non-B” cases of hepatitis:** Dr. Rice showed that HCV could be isolated in the lab and cause disease in an animal host, the chimpanzee. These studies confirmed the HCV as the sole infectious agent responsible for the mysterious “non-A, non-B” cases of hepatitis and set up a crucial animal model for future studies.

### About Hepatitis C virus (HCV)

- It is a **blood-borne virus and causes Hepatitis C disease** which affects the liver.
- It happens through **transfusions of HCV-contaminated blood and blood products**, contaminated injections during medical procedures, and through injection drug use.
- **Sexual transmission is also possible**, but is much less common.
- According to WHO, there about 71 million people (6-11 million of them in India) who are suffering from chronic infection caused by HCV.
- It is also a **major cause of liver cancer.**
- **No vaccine is available for HCV yet.**

OTHER TYPES OF HEPATITIS	MODE OF TRANSMISSION	AVAILABILITY OF VACCINE
Hepatitis A virus (HAV)	<ul style="list-style-type: none"> <li>Present in the faeces of infected persons and is most often transmitted through <b>consumption of contaminated water or food.</b></li> <li>Certain <b>sex practices</b> can also spread HAV.</li> </ul>	Yes
Hepatitis B virus (HBV) (Baruch Blumberg won the <b>Nobel Prize in Physiology or Medicine in 1976</b> for HBV discovery)	<ul style="list-style-type: none"> <li>Through exposure to <b>infective blood, semen, and other body fluids.</b></li> <li>Can be transmitted from <b>infected mothers to infants</b> at the time of birth or from family member to infant in early childhood.</li> <li>Through <b>transfusions of HBV-contaminated blood and blood products</b>, contaminated injections during medical procedures, and through injection drug use.</li> </ul>	Yes
Hepatitis D virus (HDV)	<ul style="list-style-type: none"> <li>Infections occur only in <b>those who are infected with HBV.</b></li> </ul>	Hepatitis B vaccines provide <b>protection</b> from HDV infection.
Hepatitis E virus (HEV)	<ul style="list-style-type: none"> <li>Through consumption of <b>contaminated water or food.</b></li> </ul>	Yes

## NOBEL PRIZE IN PHYSICS-

It was awarded to Roger Penrose, Reinhard Genzel and Andrea Ghez for **furthering the understanding of black holes**, the most “enigmatic” objects in the universe.

### More about their discovery

- **Black hole formation is a robust prediction of the general theory of relativity:** In January 1965, Roger Penrose proved that black holes really can form and described them in detail, black holes hide a singularity in which all the known laws of nature cease.
- Penrose used ingenious mathematical methods in his proof that black holes are a direct consequence of Albert Einstein’s general theory of relativity.
- **Discovery of a supermassive black hole (Sagittarius A\*) at the centre of our galaxy:** All the stars in the Milky Way orbit the centre Sagittarius A\* (the Sun orbits Sagittarius A\* in more than 200 million years).
- For nearly three decades, the team led by Genzel and Ghez observed some thirty stars.
- They found that the stars move in perfect elliptical orbits, just as if the



object about which they were orbiting (Sagittarius A\*) is a concentrated mass and not diffused or scattered.

- Given its calculated mass of about four million solar masses, and its invisibility, **this could only be a super massive black hole, they deduced.**

### What are black holes?

- A black hole is a place in **space where gravity pulls so much that even light cannot get out.** The gravity is so strong because matter has been squeezed into a tiny space. This can happen **when a big star is dying** (our sun will never turn into a black hole as it is not big enough to make a black hole).
- Because no light can get out **they are invisible.**
- **In the center of a black hole is a gravitational singularity.**
- **In 2019 scientists got the first optical image of a black hole through Event Horizon Telescope.** It has captured the just outside region of a black hole, located 55 million light-years from Earth, at the centre of a galaxy named **Messier 87.** The image shows a photon (light quantum) can orbit the black hole without falling in. This is called the 'last photon ring'.
- **Sagittarius A\*** is the second black hole whose photographs have been captured by the Event Horizon Telescope project.

#### Basic parts of black hole:

- **Singularity:** It is the one-dimensional point in the centre of a black hole which contains a huge mass in an infinitely small space, where density and gravity become infinite and space-time curves infinitely. It is a tiny volume with very big density.
- **The event horizon:** It is the "point of no return" around the black hole. It is not a physical surface, but a sphere surrounding the black hole that marks where the escape velocity is equal to the speed of light.
- **The Schwarzschild Radius:** This is the event horizon's radius. It is the radius at which the escape velocity is equal to the speed of light.
- **The Ergosphere:** If the black hole is rotating, then as it spins, its mass causes the space time around the black hole to rotate as well. This region is called the ergosphere.
- **The Accretion Disk:** This is a disk composed of stellar material that is spiraling towards that black hole.