CIVILS - 2023-24

PRELIMS SPECIAL EDITION-3

SCIENCE AND TECHNOLOGY

PREPARED BY - SR TEAM

(THE MENTORS FAMILY)

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SCIENCE & TECH 100 + TOPICS FOR 2023-24 IMPORTANT FOR CSE PRELIMS 2023-24

SCIENCE AND TECHNOLOGY

SPACE SECTOR

ARTEMIS PROGRAM

- As NASA makes strides to return humans to the lunar surface under Artemis Mission, the agency announced plans to create opportunities for commercial companies other than Space X to develop an astronaut Moon lander.

NASA published the outline for its Artemis program, which plans to send the next man and first woman to the lunar surface by the year 2024. The last time NASA sent humans to the Moon was in 1972, during the Apollo lunar mission

CONCEPT:

A. With the Artemis program, **NASA wishes to demonstrate new technologies, capabilities and business approaches** that will ultimately be needed for the future exploration of Mars.
B. The program is divided into three parts,
C. Artemis I is most likely to be launched next year and involves an **uncrewed flight to test the SLS and Orion spacecraft**.
D. Artemis II will be the **first crewed flight test** and is targetted for 2023.
E. Artemis III will **land astronauts on the Moon's South Pole** in 2024.
F. For NASA, going to the moon involves various elements – such as the **exploration ground systems** (the structures on the ground that are required to support the launch), **the Space Launch System** (SLS), **Orion** (the spacecraft for lunar missions), **Gateway (the lunar outpost around the Moon), lunar landers** (modern human landing systems) and the Artemis generation spacesuits.
G. NASA's new rocket called SLS will send astronauts aboard the Orion spacecraft a quarter of a million miles away from Earth to the lunar orbit.
H. Once the **astronauts dock Orion at the Gateway** which is a **small spaceship in orbit** around the moon they will be **able to live and work around the Moon**, and from the spaceship, will take expeditions to the surface of the Moon.

ARTEMIS PROGRAM

- The Artemis program that **began in 2017** is a United States-led international human spaceflight program.
- Its primary goal is to **take humans to the Moon, specifically the lunar south pole, by 2025.**

Details

A. For the Artemis program, NASA's **new rocket called the Space Launch System (SLS)** will send astronauts aboard the **Orion spacecraft** away from Earth to the lunar orbit.
B. Once astronauts dock Orion at the Gateway — which is a small spaceship in orbit around the moon — the astronauts will be able to live and work around the Moon, and from the spaceship, astronauts will take expeditions to the surface of the Moon.
C. The astronauts going for the Artemis program will wear newly designed spacesuits, called Exploration **Extravehicular Mobility Unit, or xEMU**. These spacesuits feature advanced mobility and communications and interchangeable parts that can be configured for spacewalks in microgravity or on a planetary surface.

ORGANIZATIONS INVOLVED

A. The Artemis program is carried out predominantly by NASA and U.S. commercial spaceflight contractors, in partnership with the European Space Agency and the space agencies of several other nations.
B. Other countries have been invited to join the program through signing the governing Artemis Accords, which remain open for signature since October 2020.

ARTEMIS ACCORDS

1. This accord ensures that space exploration is conducted in a safe, sustainable and transparent manner and in full compliance with international law.
2. As more countries establish a presence in outer space, via research stations, satellites, or even rocket launches, these accords provide a set of principles to create a safe and transparent environment that inspires exploration, science, and commercial activities.

The other signatories to the accords are the U.S., Australia, Britain, Canada, Italy, Japan, Luxembourg, South Korea, the United Arab Emirates, and Ukraine. Brazil also said it plans to sign.

FINAL THOUGHT

A. If successful, the Artemis program will include the first crewed lunar landing mission since Apollo 17 in 1972, the last lunar flight of the Apollo program.
B. The program will lay the foundations for the extraction of lunar resources, and eventually, make crewed missions to Mars and beyond feasible.

JAMES WEBB TELESCOPE

Much of the universe remains unknown. The James Webb telescope will hopefully provide a powerful window to help resolve some of the cosmos's many mysteries.

A. It is a space telescope being jointly developed by NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA).
B. It has taken 30 years and $10bn to develop, and is being described as one of the grand scientific endeavors of the 21st Century.

The James Webb Space Telescope will not be in orbit around the Earth, like the Hubble Space Telescope is – it will actually orbit the Sun, 1.5 million kilometres (1 million miles) away from the Earth at what is called the second Lagrange point or L2.

MISSION

- It will be "a giant leap forward in quest to understand the Universe and our origins", as it will examine every phase of cosmic history: from the Big Bang to the formation of galaxies, stars, and planets to the evolution of our own Solar System.

SPECIAL FEATURES OF JWST

1. **Time machine in space:** Powerful space telescopes, like JWST or the Hubble Telescope, are often called time machines because of their ability to view very faraway objects. The light coming from those objects, stars or galaxies, which is captured by these telescopes, began its journey millions of years earlier. Essentially, what these telescopes see are images of these stars or galaxies as they were millions of years ago. The more distant the planet or star, the farther back in time are the telescopes able to see.

2. **Farthest from Earth:** James Webb telescope will also be positioned much deeper into space, about a million miles from Earth, at a spot known as L2. It is one of the five points, known as Lagrange's points, in any revolving two-body system like Earth and Sun, where the gravitational forces of the two large bodies cancel each other out.
3. **Engineering marvel:** JWST has one large mirror, with a diameter of 21 feet (the height of a typical two-storey building), that will capture the infra-red light coming in from the deep universe while facing away from the Sun.

GOAL OF THIS TELESCOPE

1. The telescope will be able to see just about anything in the sky.
2. However, it has one overriding objective – to see the light coming from the very first stars to shine in the Universe.
3. These pioneer stars are thought to have switched on about 100-200 million years after the Big Bang, or a little over 13.5 billion years ago.
4. James Webb telescope will be picking out groupings of these stars.

Its significance

1. It is widely expected to unveil many secrets of the universe, particularly those related to the Formation of stars and galaxies in the early period the first few hundred million years after the Big Bang.
2. Some have called James Webb telescope the "telescope that ate astronomy".
3. It is said to look back in time to the Dark Ages of the universe.

CONCLUSION

- ❖ The universe is vast and most of it is unknown. We hope that the James Webb telescope, over its lifetime would provide us with a powerful window to help resolve some of the many mysteries of the cosmos and make it a little bit more comprehensible.

DOUBLE ASTEROID REDIRECTION TEST (DART)

NASA's Double Asteroid Redirection Test (DART) successfully crashed into Dimorphous.

Humanity's first planetary defence test:

- ✓ With the collision, the test has been completed successfully in a mission that went exactly as planned without any hitches.

Reason for test:

1) The impact should have **nudged the asteroid slightly and subtly changed its orbit** around Didymos, the larger asteroid.
2) Telescopes on Earth and in space are going to take measurements of this change to see how the change measures up to computer-generated simulations.

Dimorphos

1. Didymos is a perfect system for the test mission because it is an eclipsing binary which means it has a moonlet that regularly orbits the asteroid and it can be seen when it passes in front of the main asteroid.

2. The Didymos system is not an Earth-crossing asteroid, and there is no possibility that the deflection experiment could create an impact hazard.
3. Earth-based telescopes can study this variation in brightness to understand how long it takes Dimorphos to orbit Didymos.

ASTEROIDS

- Asteroids, sometimes called minor planets, are rocky, airless remnants left over from the early formation of the solar system about 4.6 billion years ago.
- Most of this ancient space rubble can be found orbiting the Sun between Mars and Jupiter within the main asteroid belt.

1. Some asteroids go in front of and behind Jupiter, which are called Trojans.
2. Asteroids that come close to Earth are called Near-Earth Objects (NEOs) for short. NASA keeps close watch on these asteroids.

- Asteroids range in size from Vesta (the largest at about 329 miles in diameter) to bodies that are less than 33 feet across. The total mass of all the asteroids combined is less than that of Earth's Moon.
- Asteroids are not all round like planets. They have jagged and irregular shapes.

STRUCTURE:

Most asteroids are made of different kinds of rocks, but some have clays or metals, such as nickel and iron.

DETECTING ASTEROIDS MISSION

Asteroid Impact and Deflection Assessment (AIDA): This includes NASA's Double Asteroid Redirection Test (DART) mission and Hera Mission.

- **Hera Mission:** It is the asteroid deflection mission of European Space Agency (ESA) that is scheduled to be launched in 2024 to measure the impact crater produced by the DART collision and study the change in the asteroid's orbital trajectory. It will arrive at the Didymos system in 2027.

DART MISSION

It is a planetary defence-driven test of technologies for preventing an impact on Earth by a hazardous asteroid.

OBJECTIVES:

1. DART is the first technology demonstration of the kinetic impactor technique that could be used to mitigate the threat of an asteroid hitting Earth.
2. The kinetic impactor mitigation technique is the impulsive deflection of the asteroid through the sudden addition of momentum. In simpler terms, DART is being sent to collide with an asteroid to change its orbital period.

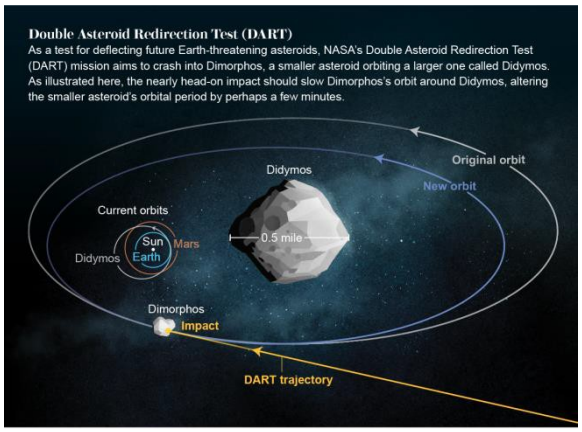


Image Courtesy: Scientificamerican

Follow-up mission: Hera

- The European Space Agency is developing Hera, a spacecraft that will be launched to Didymos in 2024 and arrive in 2027 (5 years after DART's impact), to do a detailed reconnaissance and assessment.

CHINA'S TIANGONG SPACE STATION

- **China's strategically significant space station project** entered the final phase as **three astronauts** entered the orbiting module of the Tiangong Space Station.

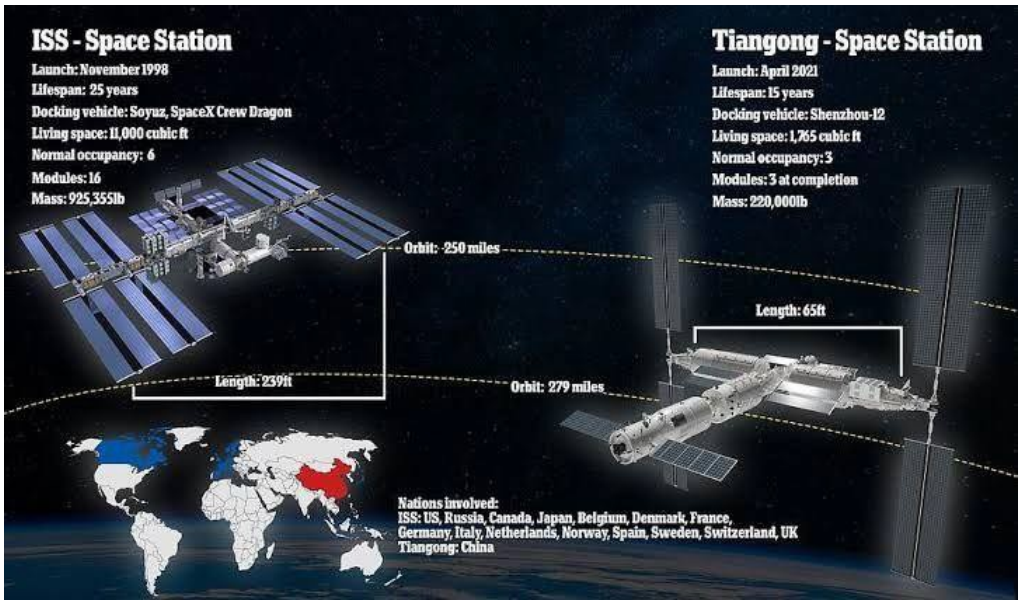
They were launched into the designated orbit by the **Shenzhou-14 spacecraft.**

1. **Shenzhou-1 to 4** space flights were unmanned spaceflight missions.
2. **Shenzhou-5 to 14** spaceflights are manned spaceflight missions.

- A **space station** is a **spacecraft capable** of supporting **crew members**, designed to remain in space for an extended period of time and for other **spacecraft to dock.**

TIANGONG SPACE STATION

A. **The Tiangong space station** is a Chinese space station being built in LEO between **340 and 450 kilometers above the earth.**
B. It is part of **China Manned Space Program** and is the country's **first long-term space station.**
C. China is going to operationalize its new **Tiangong multi-module space station** for at least ten years.
D. **China launched an unmanned module named – TIANHE / HARMONY OF THE HEAVENs** named for its permanent space station in 2021 that it plans to complete by the end of 2022.
E. **Tianhe core module** is the **first module** to launch the **Tiangong space station module.**



CHINA MANNED SPACE PROGRAMME

- The Chinese government decided to launch a human space programme using a "three-step" method in 1992 which is known as the China Manned Space Program.

1. **The 1st step:** To launch manned spaceships to master basic human space technologies.
2. **The 2nd step:** To launch Space Labs to make technological breakthrough in R&D, and accommodation of long-term man-tended utilization on a modest scale
3. **The 3rd step:** To construct China's Space Station to accommodate long-term man-tended utilization on a large scale

It is managed by the China Manned Space Agency.

IMPORTANCE OF THIS LAUNCH FOR CHINA

A. China is **only the third country** in history to have put both astronauts into space and to build a space station, after the Russia and the US.
B. The **China Space Station (CSS)** is also expected to be a competitor to the **International Space Stations.**
C. The ISS Is a collaborative project of several countries.
D. The ISS is the most complex international scientific and engineering project in history and the largest structure humans have ever put into space.

INDIA'S SPACE STATION PROGRAMMES

1. India is planning to **launch its own space station by 2030**, joining the league of US, Russia, and China to an elite space club.
2. The Indian space station will be much smaller **(mass of 20 tonnes)** than the International Space Station and will be used for carrying out microgravity experiments (not for space tourism).
3. Preliminary plan for the space station is to accommodate astronauts for up to **20 days** in space, and the project will be an **extension of the Gaganyaan mission.**
4. It will orbit Earth at an **altitude of around 400 km.**
5. **ISRO (Indian Space Research Organization)** is working on a space docking experiment (Spandex), a technology that is crucial for making the space station functional.

6. Space docking is a technology that allows transferring humans from one spacecraft to another.

SIGNIFICANCE:

1. Space stations are **essential for collecting meaningful scientific data,** especially for biological experiments.
2. Provide platforms for greater number and length of scientific studies than available on other space vehicles. (as GAGANYAAN will take humans and experiments in microgravity for a few days only).
3. Space stations are used to study the effects of long-term space flight on the human body.

HAKUTO-R MOON MISSION: JAPAN

1. Recently, a **Japanese space startup ispace Inc** has launched its own private **lander M1** to the Moon under its **HAKUTO-R mission**, from the SPACE-X Falcon 9 rocket.
2. It is Japan's **first-ever lunar mission** and the first of its kind by a private company.

KEY POINTS OF THE MISSION

A. The name HAKUTO-R refers to the white rabbit that Japanese folklore suggests lives on the Moon.
B. The M1 lander will deploy two robotic rovers, two-wheeled, orange-sized devices from Japan's JAXA space agency and a four-wheeled Rover made by the UAE known as the Explorer Rashid, after the Dubai royal family patriarch.
C. If the rover Rashid lands successfully, it will be the Arab world's first Moon mission.
D. So far only the Us, Russia and China have managed to put a robot on the lunar surface.
E. It will also be carrying an experimental solid-state battery made by NGK Spark Plug Co, a Japanese-based spark plug company

FEATURES:

A. It is designed in such a way that it will use **minimal fuel to save money and leave more room** for cargo.
B. It is taking a **slow, low-energy path to the Moon,** flying 1.6 million km (one million miles) from Earth before looping back and making a planned landing by the end of April.

OBJECTIVE:

1. It is aimed to search for **water deposits before touching down in the Atlas Crater,** which lies in the northeastern section of the Moon's near side and measures more than 87km (54 miles) across and just over 2km (1.2 miles) deep.
2. Mission success would also represent a milestone in space cooperation between **Japan and the US at a time when China is becoming increasingly competitive** and rides on Russian rockets are no longer available in the wake OF –RUSSIAs INVASION OF UKRAINE

3. Japan has a contract with NASA to ferry payloads to the Moon from 2025 and is aiming to build **a permanently staffed lunar colony by 2040**.

RASHID

A. Rashid is UAE's first moon rover and the Arab world's first lunar mission. It will be landed on the moon through the HAKUTO-R mission.
B. The rover will study the properties of the lunar soil, the petrography and geology of the Moon, dust movement, surface plasma conditions, and the Moon's photoelectron sheath.

PSLV-C54 SUCCESSFULLY PLACES NINE SATELLITES IN MULTIPLE ORBITS

- Recently, **ISRO's PSLV-C54** successfully placed nine satellites which includes an **Earth Observation Satellite (EOS-06)** in multiple orbits.
- This is the **56th flight** of the Polar Satellite Launch Vehicle (PSLV) and the 24th flight of the PSLV-XL version.

THE EIGHT NANO SATELLITES INCLUDES:

1. ISRO Nano Satellite-2 for Bhutan (INS-2B)
2. Anand
3. Astrocast (four satellites)
4. Two Thybolt satellites.

EOS-6 is the Oceansat series' third-generation satellite.

- EOS-06 is envisaged to observe ocean colour data, sea surface temperature and wind vector data to use in oceanography, climatic and meteorological applications.

UPCOMING MISSIONS

A. **Aditya-L1**: A coronagraphy spacecraft to **study the solar atmosphere** with a PSLV rocket.
B. **NavIC**: ISRO will also launch a navigation satellite for the country's NavIC constellation.

Polar Satellite Launch Vehicle

1) It is the third generation launch vehicle of India.
2) It is the first Indian launch vehicle to be equipped with liquid stages.
3) After its first successful launch in October 1994, PSLV emerged as the reliable and versatile workhorse launch vehicle of India.
4) Difference: PSLV was developed to launch low-Earth Orbit satellites into polar and sun synchronous orbits whereas GSLV was developed to launch the heavier INSAT class of geosynchronous satellites into orbit.

TYPES OF ORBITS

GEOSTATIONARY ORBIT (GEO):

A. Satellites in geostationary orbit (GEO) circle Earth above the equator from west to east following Earth's rotation.
B. This makes satellites in GEO appear to be 'stationary' over a fixed position.

C. GEO is used by satellites that need to stay constantly above one particular place over Earth, such as telecommunication satellites.

LOW EARTH ORBIT (LEO):

A. A low Earth orbit (LEO) is an orbit that is relatively close to Earth's surface.
B. It is normally at an altitude of less than 1000 km but could be as low as 160 km above Earth.
C. Unlike satellites in GEO that must always orbit along Earth's equator, LEO satellites do not always have to follow a particular path around Earth in the same way their plane can be tilted.

POLAR ORBIT AND SUN-SYNCHRONOUS ORBIT (SSO):

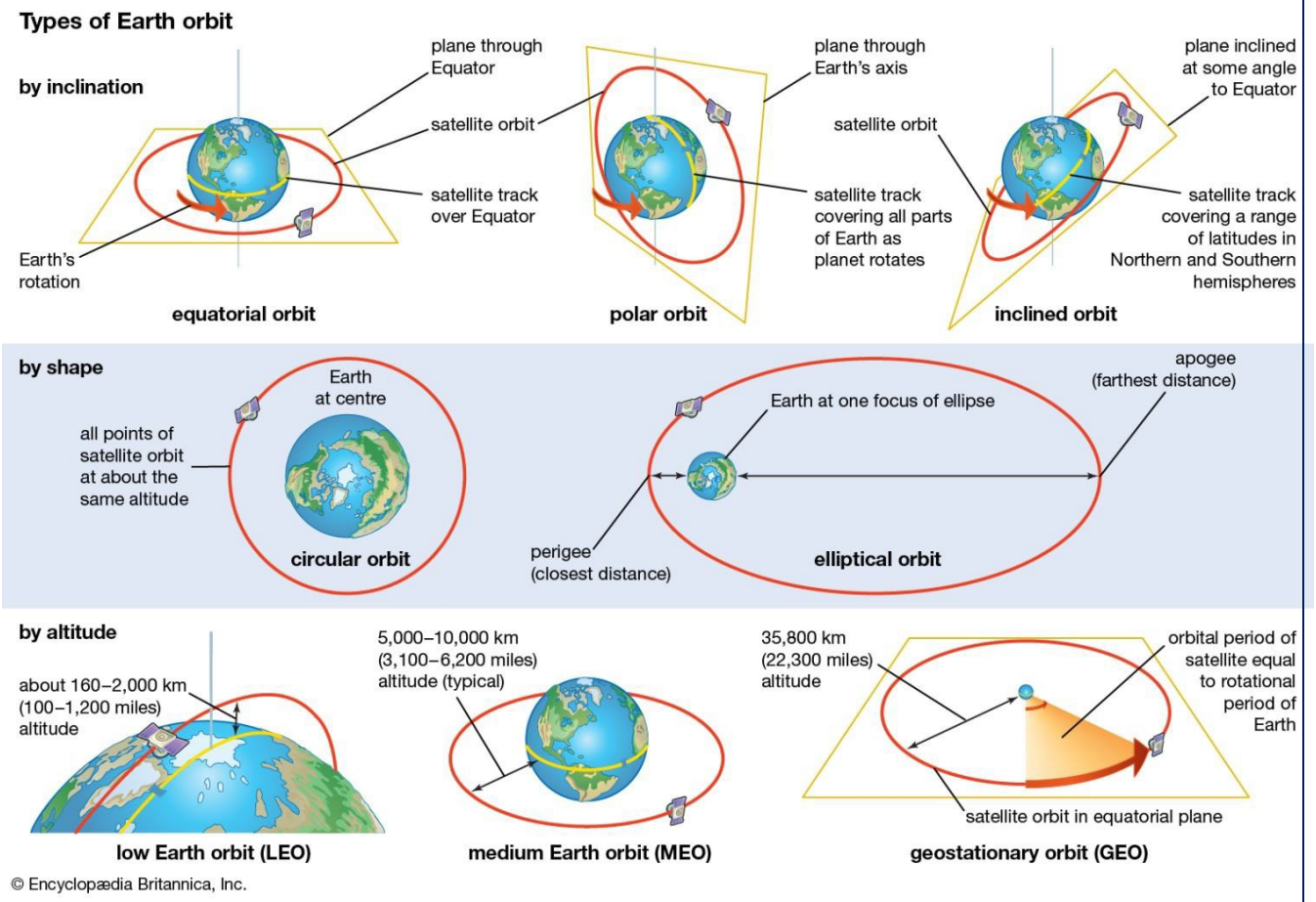
A. Sun-synchronous orbit (SSO) is a particular kind of polar orbit.
B. Satellites in SSO, traveling over the Polar Regions, are synchronous with the Sun.
C. This means they are synchronized to always be in the same 'fixed' position relative to the Sun.
D. This means that the satellite will always observe a point on the Earth as if constantly at the same time of the day.

CIRCULAR ORBIT

1. Though no orbit is perfectly circular, the general name for any orbit that is not highly elliptical is circular
2. Circular orbits have an eccentricity of 0
3. The orbital path of satellites in these circular orbits is also affected by the satellite's altitude – its height above the Earth
4. Satellites in geostationary orbit are always in a high orbit.
5. If the satellite is in a polar, sun-synchronous, or equatorial orbit, its orbital altitude may be medium or it may be low

EQUATORIAL ORBIT

A. Moves along the line of the Earth's equator
B. To get into equatorial orbit, a satellite must be launched from a place on Earth close to the equator
C. Equatorial orbits can be useful for satellites observing tropical weather patterns, as they can monitor cloud conditions around the globe.



GEOSYNCHRONOUS ORBIT

A. Has a period of revolution is equal to period of rotation of earth, but its orbit is not equatorial with anorbital period of one sidereal day, matching the Earth's sidereal rotation period
B. synchronized with the Earth's rotation, but the orbit is tilted with respect to the plane of the equator
C. synchronization of rotation and orbital period means that, for an observer on the surface of the Earth, an object in geosynchronous orbit returns to exactly the same position in the sky after a period of one sidereal day

KEY FEATURES

A. Not in equatorial plane i.e. directly above the equator, it's in inclined orbit
B. Angular velocity of the satellite is equal to angular velocity of earth
C. Period of revolution is equal to period of rotation of earth.
D. Nearly at an altitude of 36000 Km from earth surface
E. There are many geosynchronous orbits used for communication, weather monitoring & surveillance

GEOSTATIONARY ORBIT / GEOSYNCHRONOUS EQUATORIAL ORBIT

A. A circular orbit above the Earth's equator, following the direction of the Earth's rotation; has an orbital period equal to the Earth's rotational period (one sidereal day), and thus appears motionless, at a fixed position in the sky, to ground observers.

B. Speed at which a satellite orbits the Earth coincides with the speed that the Earth turns and at the same latitude, however, this does not mean that the satellite and the Earth are traveling at the same speed, but rather that the satellite is traveling fast enough so that its orbit matches the Earth's rotation.
C. When a satellite is in geostationary orbit, its instruments are looking at a certain part of the Earth. That part of the Earth is called a footprint for ex. India
D. Suitable for communication satellites, or meteorological (weather) satellites

KEY FEATURES

A. Circular orbit **+** in equatorial plane i.e. directly above the equator and thus inclination is zero
B. Geostationary orbit, therefore, is really just a special type of equatorial orbit
C. Angular velocity of the satellite is equal to angular velocity of earth
D. Period of revolution is equal to period of rotation of earth
E. Nearly at an altitude of 36000 Km from earth surface
F. A subset of geosynchronous orbit
G. There is ONLY one geostationary orbit

POLAR ORBIT

1. A polar orbit usually has an inclination of 90 degrees to the equator
2. On every pass around the Earth, it passes over both the north and south poles
3. This allows the satellite to see virtually every part of the Earth as the Earth rotates underneath it
4. Suitable for mapping or surveillance operations

SUN SYNCHRONOUS ORBIT

1. This orbit is a special case of the polar orbit.
2. Like a polar orbit, the satellite travels from the north to the south poles
3. Since there are 365 days in a year and 360 degrees in a circle, it means that the satellite has to shift its orbit by approximately one degree per day.
4. Hence, orbit changes slowly in time with the planet moving around the Sun, and in time with the planet's rotation so that the spacecraft is always at the same angle to the Sun
5. These orbits allow a satellite to pass over a section of the Earth at the same time every day

ELLIPTICAL ORBIT

1. An elliptical orbit, also called an eccentric orbit, is in the shape of an ellipse
2. Elliptical orbits are varying in speed & have eccentricity between zero to one
3. Satellite's velocity changes & depends on where it is in its orbital path
4. When the satellite is in the part of its orbit closest to the Earth, it moves faster because the Earth's gravitational pull is stronger.

❖ The satellite is moving the fastest at the low point of an elliptical orbit viz. perigee
❖ The high point of the orbit, when the satellite is moving the slowest, is apogee

VIKRAM S ROCKET:

pace technology startup Skyroot Aerospace is set to **make history by sending India's first privately developed rocket Vikram-S** into space between 12th and 16th November, 2022 under the **'Prarambh' Mission.**

Skyroot Aerospace is an Indian startup in the aerospace business.

On November 18, 2022, Hyderabad-based **Skyroot Aerospace** scripted history by becoming the **first private Indian organisation** to launch a rocket from Indian Space Research Organisation (ISRO)'s launchpad in Sriharikota.

VIKRAM S ROCKET:

1. It is a part of **Mission Prarambh**, which means the beginning.
2. It is a **sub-orbital rocket**, which reached outer space and then splashed into the sea.
3. Has payload capacity of up to **300 kilograms.**
4. Vikram-S used **solid fuel-ammonium perchlorate**, which is not completely green fuel.
5. With Vikram-2, it is planned to use liquefied natural gas (LNG), which is greener compared with traditional kerosene fuel.

SKYROOT AEROSPACE

The Hyderabad-based Skyroot is the first start-up to sign a Memorandum of Understanding (MoU) with ISRO to launch its rockets into space.

1. Set up in 2018, Skyroot has successfully built and tested India's first privately developed cryogenic, hypergolic-liquid and solid fuel-based rocket engines using advanced composite and 3-D printing technologies.
2. The aim of opening the space sector for private companies in India is to provide a conducive environment for cost-efficient satellite launch services by disrupting the entry barriers. This will help the companies in advancing their mission and make spaceflights affordable, reliable and regular.

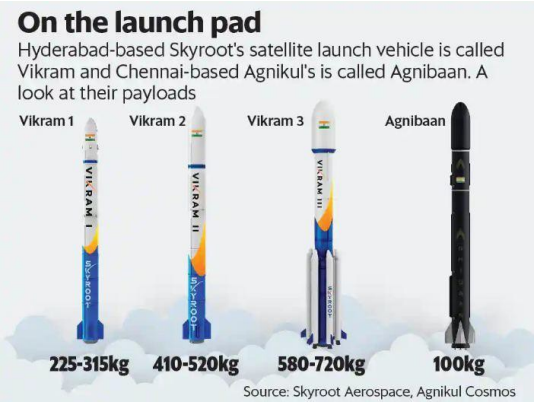
VIKRAM SERIES

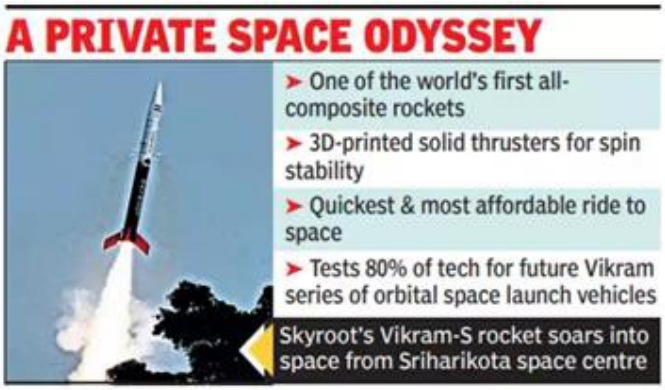
Skyroot has been developing three variants of the Vikram rocket.

1. Vikram I, which has a payload or carrying capacity of 480 kg to 500 km low inclination orbit (LIO).
2. Vikram II, which has a payload or carrying capacity of 595 kg to 500 km LIO, 400 kg to 500 km SSPO (sun-synchronous polar orbits), and
3. Vikram III, which has a payload or carrying capacity of 815 kg to 500 km LIO, 560 kg to 500 km SSPO (sun-synchronous polar orbits).

Mechanisms of Vikram S:

1. There are **four spin thrusters**, which will generate the rocket's spin and **stability** so that it doesn't deviate from the trajectory.
2. **Max-Q** is the maximum stress on the rocket and is experienced during the lift-off.
3. At around 23 seconds, the rocket achieves five times the speed of sound or **Mach 5**.
4. **'Apogee' is the maximum point** after which it descends, falls back and splashes down into the sea.
5. It takes around **two and a half minutes** to reach the Apogee and another two and a half minutes to splash down.





Technologies used:

1. **carbon composites**: porous structure made of carbon and carbon fibre and four times lighter and has higher strength than steel.
2. The lighter the rocket, the more payload we can use.
3. **3D printing:** reduces the cycle time by 90 per cent compared with traditional methods and allows to build complex shapes.
4. **Cycle time** is the time required to manufacture a component.

Cost-effectiveness

1. Efficient technology
2. Utilising existing govt infrastructure
3. Operating out of India

Skyroot Aerospace:

1. It is an Indian private aerospace manufacturer and commercial launch service provider headquartered in Hyderabad.
2. Mandates: cutting-edge innovation and cost-effectiveness
3. Next launch will be **Vikram-1**, an orbital vehicle that puts satellites into orbit.
4. Vikram-2 will have a higher capacity than Vikram-1.
5. Skyroot Aerospace focuses on **reusability** of rockets.

PRARAMBH MISSION :-

- The Prarambh mission is **aimed at carrying three payloads into space,** including a 2.5-kilogram payload that has been developed by students from several countries.
- The Prarambh mission and the Vikram-S rocket were developed by the Hyderabad-based startup with extensive support From ISRO & IN-SPACE.

ISRO'S RISAT-2 SATELLITE

- ISRO's RISAT-2 satellite has made an **uncontrolled re-entry** into the Earth's atmosphere in the **Indian Ocean near Jakarta.**

RISAT-2 is India's first **"eye in the sky"** which keep surveillance on the country's borders as **part of anti-infiltration and anti-terrorist operations**.

A. RISAT-2 was built at an accelerated pace in response to the 2008 Mumbai attacks.
B. It is India's first dedicated reconnaissance satellite.
C. It is the first of the RISAT series to reach orbit.
D. The images RISAT 2 satellites were used to plan the surgical strike in 2016 and the air strike on a Jaish camp in Pakistan's Balakot in 2019.

RISAT

- **RISAT (Radar Imaging Satellite)** is a series of Indian radar imaging reconnaissance satellites built by ISRO.
- It provides all-weather surveillance using synthetic aperture radars (SAR).
- The RISAT series are the first all-weather Earth observation satellites from ISRO.

ISRO's RISAT-2 satellite

1. RISAT-2 was launched by the PSLV-C12 launch vehicle in 2009.
2. The initial designed life of the satellite was four years.

FUNCTIONS

1. It was a radar-imaging satellite that was India's first "eye in the sky" to keep surveillance on the country's borders as part of anti-infiltration and anti-terrorist operations.
2. It possessed day-night as well as all weather monitoring capability.

NEED

- Risat-2 was built at an accelerated pace following the **2008 Mumbai terror attacks** due to delay with the indigenously developed C-band for Risat-1 satellite.

ISRO HAS INFORMED ON RISAT 2

1. According to ISRO's statement, the RISAT-2 satellite, which only weighed around 300 kg, had undergone an uncontrolled re-entry into Earth's atmosphere at the anticipated impact point in the Indian Ocean near Jakarta on October 30, 2022, at 00:06 UTC.
2. ISRO informed that though the initially designed life of the satellite was 4 years, due to proper maintenance of satellite orbit and mission planning by the spacecraft operations team in ISRO and by economical usage of fuel, RISAT-2 provided very useful payload data for the last 13 years.
3. Since there was no fuel in the satellite at re-entry, no contamination or fuel-related explosion had occurred upon re-entry.
4. Studies on the RE-Entry of RISAT 2, proved that no fragments have impacted on Earth because the components created by aero-thermal fragmentation would not have survived re-entry heating.
5. For one month, the re-entry has been under observation by the Indian System for Safe and Sustainable Space Operations Management (IS4OM) facility in ISTRAC, Bengaluru, with analysis by VSSC and ISTRAC teams using Multi-Object Tracking Radar (MOTR) at SDSC, Sriharikota.
6. According to ISRO, MOTR regularly tracked RISAT-2, and the results were used for additional analysis and orbit determination.

RISAT 2 satellite

A. RISAT-2, or Radar Imaging Satellite-2 was India's radar imaging reconnaissance satellite which was part of India's RISAT programme.

B. It was built by Indian Space Research Organisation (ISRO) and successfully launched aboard a PSLV-CA launch vehicle in April 2009 from the Satish Dhawan Space Centre.
C. It is designed to monitor India's borders and as part of anti-infiltration and anti-terrorist operations.
D. The satellite has a mass of 300 kg.
E. The principal sensor of RISAT-2 was an X-band synthetic-aperture radar (SAR) from Israel Aerospace Industries (IAI).

SATELLITES OF RISAT SERIES

RISAT 2	**RISAT 1**	**RISAT 2B**	**RISAT 2BR1**
1. It was launched successfully on April 20, 2009 by a PSLV rocket. The 300-kg satellite was built by ISRO using a X-band SAR manufactured by IAI. 2. This satellite was fast tracked in the aftermath of the 2008 Mumbai attacks. 3. The satellite will be used for border surveillance, to deter insurgent infiltration and for anti-terrorist operations.	1. It was an indigenously developed radar imaging satellite successfully launched by a PSLV-XL rocket on April 26, 2012 . 2. Characteristic of RISAT-1 include: 3. 160 x 4 Mbit/s data handling system 4. 50 NmS reaction wheels 5. SAR antenna deployment mechanism 6. Phased array antenna with dual polarization	1. It is an indigenously developed Synthetic Aperture Radar (SAR) imaging satellite operating in X Band with 3.6 m radial rib antenna. 2. It was launched by PSLV C46 (Core Alone) in May 2019. 3. The satellite has the capability to operate in different modes including Very High Resolution RADAR imaging modes of 1m × 0.5m resolution and 0.5m × 0.3m resolution. 4. it can image during day / night / all weather conditions.	1. It is the fourth satellite in the RISAT series and built by ISRO. 2. It was launched in December 2019 on board a PSLV rocket. 3. The satellite has resolution of 0.35 meters by which two objects separated by distance of 0.35 meters can be distinctly identified. 4. The mission life is planned to be 5 years. 5. It is the 50th launch of PSLV and 75th launch from Satish Dhawan Space Centre.

SIGNIFICANCE:

- Risat-2 provided beneficial payload data for over 13 years.
- Since its injection, Risat-2's radar payload services were provided for various space applications.
- Risat-2 is a clear example of ISRO's capability to carry out spacecraft orbital operations in an efficient and optimal way.
- As Risat-2 re-entered within 13.5 years, it complied with all necessary international mitigation guidelines for SPACE DEBRIS, showing the space agency's commitment towards the long-term sustainability of outer space.

LAUNCH VEHICLE MARK 3

- Recently, the ISRO heaviest rocket **Launch Vehicle Mark 3 (LVM3 or GSLV Mark 3)** has successfully orbited 36 satellites of **U.K.-based OneWeb**.
- OneWeb is a global communications network powered by a constellation of 648 Low Earth Orbit (LEO) satellites.

LMV 3

- The LVM3-M2 mission is a dedicated commercial mission for a foreign customer OneWeb, through **NewSpace India Limited (NSIL)**, a Central Public Sector Enterprise (CPSE).
- It is the first multi-satellite mission with 36 OneWeb Satellites to the LEO as the heaviest Payload mass of 5,796 kg. of LVM3 till date.
- This newest rocket is capable of **launching 4,000-kilogram class of satellites into GTO (Geosynchronous Transfer Orbit)** and 8,000 kgs of payloads into LEO.
- It is a **three-stage launch vehicle consisting of two solid propellant S200 strap-ons** on its sides and core stage comprising L110 liquid stage and C25 cryogenic stage.

Features:

1) First Commercial Mission of LVM3
2) First launch of LVM3 to LEO
3) First Indian rocket with six-ton payload
4) First NSIL Mission with LVM3
5) First OneWeb Mission with NSIL/Department of Space.

Technical Achievements:

1) Handling of multiple satellite separation events
2) Increased nominal mission duration
3) Ensuring safe separation distance through C25 (cryo) stage re-orientation & velocity addition
4) Ensuring data availability for entire mission duration
5) Realisation of new payload adaptor and interface ring for the satellites dispenser

OneWeb Constellation

OneWeb:

1. OneWeb is a joint venture between **India's Bharti Enterprises** and the **U.K**. government.
2. This is OneWeb's **14th launch**, bringing the constellation to 462 satellites.
3. This launch represents more than **70%** of its planned 648 Low Earth Orbit (**LEO**) satellite fleet that will deliver **high-speed, low-latency** connectivity worldwide.
4. With only four more launches to go, OneWeb remains on track to activate **global coverage in 2023.**

- OneWeb Constellation operates in a LEO Polar Orbit Satellites are arranged in **12 rings (Orbital planes) with 49 satellites in each plane**.
- The orbital planes are inclined to be near polar (87.9 Deg.)
- The orbital planes are 1200 km above the Earth. Each satellite completes a full trip around the earth every 109 minutes.
- The earth is rotating underneath satellites, so they will always be flying over new locations on the ground.

LAUNCH VEHICLES DEVELOPED BY ISRO

A. **Satellite Launch Vehicle (SLV):** The first rocket developed by ISRO was simply called SLV, or Satellite Launch Vehicle.
B. It was followed by the Augmented Satellite Launch Vehicle or ASLV.
C. **Augmented Satellite Launch Vehicle (ASLV):** SLV and ASLV both could carry small satellites, weighing up to 150 kg, to lower earth orbits.
D. ASLV operated till the early 1990s before PSLV came on the scene.

PSLV : PSLV's first launch was in 1994, and it has been ISRO's main rocket ever since. Today's PSLV, however, is vastly improved and several times more powerful than the ones used in the 1990s.

1. It is the first Indian launch vehicle to be equipped with liquid stages.
2. PSLV is the most reliable rocket used by ISRO to date, with 52 of its 54 flights being successful.
3. It successfully launched two spacecraft – CHANDRAYAAN-1 **in 2008 and MARS ORBIT SPACECRAFT in 2013** – that later travelled to Moon and Mars respectively.

Geosynchronous Satellite Launch Vehicle (GSLV): GSLV is a much more powerful rocket, meant to carry heavier satellites much deeper into space. To date, GSLV rockets have carried out 18 missions, of which four ended in failure.

A. It can take 10,000 kg of satellites to lower the earth's orbits.
B. The indigenously developed Cryogenic Upper Stage (CUS), forms the third stage of GSLV Mk II.
C. Mk-III versions have made ISRO entirely self-sufficient in launching its satellites.
D. Before this, it used to depend on the European Arianne launch vehicle to take its heavier satellites into space.
E. GSLV Mark-III was used to launch the CHANDRAYAAN -2 MISSION to the moon in 2019, which was the first operational flight of the rocket.

ISRO has renamed the GSLV Mark-III as Launch Vehicle Mark-III.

- A GSLV – for the Geostationary Orbit (GEO) – will continue to be called so. The LVM3 will go everywhere —GEO, Medium Earth orbit (MEO), LEO, and missions to the moon, sun.

NavIC

- ❖ It is an Indian Regional Navigation Satellite System or IRNSS.
- ❖ It was developed in India by Indian Space Research Organisation (ISRO) and its commercial wing ANTRIX.
- ❖ It consists of 8 satellites located at a distance of approximately 36,000 Km. Currently, 7 satellites are active.

1. 3 satellites are in Geostationary Orbit (GEO)
2. 5 satellites are in inclined Geosynchronous Orbit (GSO)

- ➢ The objective of the NavIC is to provide navigation, timing, and reliable positioning services in and around India.
- ➢ Working of the NavIC is very similar to the Global Positioning System(GPS) implemented by the United States.
- ➢ The NavIC is certified by 3GPP (3rd Generation Partnership Project) which is responsible for coordinating mobile telephony standards globally.

INDIAN REGIONAL NAVIGATION SATELLITE SYSTEM (IRNSS)

It is an independent regional navigational satellite system developed by India.

Objective:

- ➢ It is being designed to give precise position data service to users located in India and also to users in the area out-spreading up to 1500 Km from India's boundary.

The two kinds of services provided by IRNSS will be:

A. Standard Positioning Service (SPS) and
B. Restricted Service (RS).

The system can offer a position accuracy of more than 20 m within India which is the primary area of service.

- ❖ The IRNSS is being constructed by the Indian Space Research Organisation (ISRO) and is wholly under the Indian government's control. The need for such a system of navigation is that the availability of global satellite navigation systems like the GPS is not assured in hostile conditions.

Commercialization of NavIC

- ➢ Antrix, the commercial arm of ISRO has floated two separate tenders to identify industries that can develop dedicated NavIC-based hardware and systems.
- ➢ Suitable device manufacturers are being identified along with integrators of NavIC-based systems.
- ➢ NAVIC is being commercialized for the following reasons :

1. Navigation (Aerial, marines and terrestrial)
2. Maps (Charting, Plotting and Geodetic data capture)
3. Disaster Management
4. Fleet Management and Vehicle Tracking (important during mining and transport operations)
5. Mobile phone integration
6. Precise timing (useful for power grids and ATMs)

- ❖ The Ministry of Road Transport and Highways has mandated that all national-permit vehicles must have such tracking devices. As a pilot, many fishing boats have been fitted with these devices that have a unique texting facility.
- ❖ The 3GPP certification will allow multiple possibilities of further commercialization of NavIC.

NAVIC (NAVIGATION WITH INDIAN CONSTELLATION) 2019

There are a few recent developments in the NAVIC (Navigation with Indian Constellation) according to ISRO:

- The leading semiconductor manufacturer *Qualcomm Technologies Inc.* developed and tested NavIC-friendly chipsets.
- This will help NAVIC support upcoming Automotive, Mobile and IoT applications and platforms.
- The collaboration will enable superior location-based services to India's industries and technology ecosystem.

NAVIC vs GPS

Parameter	NavIC	GPS
Accuracy	Up to 5 meters	Up to 20-30 meters
Frequency	S-band and L-Band	L- Band

The use of dual-frequency, both S and L Frequency Bands makes NavIC independent of using any delay-causing frequency models to detect frequency error.

COUNTRIES WITH THEIR OWN NAVIGATION SATELLITE SYSTEM

- Some of the countries provide navigation systems on a global scale, some of them provide navigation on a regional scale. The following countries have their own navigation satellite system.

1. The United States Global Positioning System (GPS) – World's most used GPS system, operational from 1978. Constellation of 32 satellites.
2. Russian GLONASS – It provides global coverage. It has a total of 26 satellites.
3. European Union Galileo – Became operational in 2016, with a constellation of 30 satellites.
4. Chinese BeiDou – Currently it provides regional coverage of the Asia- Pacific region, plans to provide global coverage by 2020. It has a total of 35 satellites.
5. Japanese Quasi-Zenith Satellite System (QZSS) – It is a regional satellite system covering Japan and the Asia-Oceania region. It has a total of 4 satellites, 7 are planned.
6. India (IRNSS-NAVIC) – Constellation of 8 Satellites.

CHANDRAYAAN- 3

A. **Chandrayaan 3** spacecraft is the 3rd lunar exploration expedition, outlined by the ISRO. ISRO planned this spacecraft to exhibit India's soft landing proficiency on a stellar body. It will only consist of a rover and lander and will communicate to the earth via an orbiter from Chandrayaan 2.
B. This ambitious mission encompasses several configurations, integration and cognisance. Additionally, there are several other detailed testing remaining to evaluate the spacecraft.

BACKGROUND OF CHANDRAYAAN 3 MISSION

1. ISRO designed the Chandrayaan 2 mission to send the Chandrayaan 2 spacecraft with an orbiter, rover and lander. They launched this spacecraft on-board the GSLV MK-3, one of the mightiest geosynchronous vehicles.
2. The lander Vikram's failure on a soft landing resulted in hindering the attempt of rover Pragyaan to travel on the Moon. This led to endeavouring another mission to showcase India's landing capabilities required for the Lunar Polar Exploration Mission.
3. This Mission to Moon's south pole is going to be in collaboration with Japan in 2024. While India is going to provide a lander, Japan will yield a rover and launcher.

FEATURES OF CHANDRAYAAN 3 SPACECRAFT

1. **Chandrayaan 3** will take its flight into outer space with a rover and lander. It will not include any orbiter like Chandrayaan 2.
2. India aims to examine the Moon's surface, especially areas that have not been receiving sunlight in some billion years. Scientists and astronomers are suspecting the presence of ice and abundant mineral stocks in these darker parts of the lunar surface.
3. In addition, this exploration will not limit to the surface but aim to study the sub-surface and exosphere.
4. The rover of this spacecraft will communicate to earth via an orbiter taken from Chandrayaan 2.
5. It will study the surface by taking images at a distance of 100km from the lunar orbit.

DESIGN OF CHANDRAYAAN 3 SPACECRAFT

The lander of **ISRO's Chandrayaan 3** will be powered by 4 throttle-able engines. In addition, it will be endowed with a Laser Doppler Velocimeter (LDV).

IMPORTANCE OF EXPLORING THE MOON FOR SCIENTISTS

A. The Moon is the closest heavenly body to our planet to test space technologies for extensive space missions.
B. It also acts as a promising cosmic body to explore and achieve a better understanding of extra-terrestrial territories.
C. This encourages the advancement of technologies, inspire future scientists and promote international alliances.
D. Moreover, it provides a connection to the history of the solar system and primitive earth.

REASON TO TARGET MOON'S SOUTH POLE WITH CHANDRAYAAN 3 SPACE MISSION

- One key reason to target the Moon's southern pole with **Chandrayaan 3** is that it contains larger shadowed areas than the northern pole. Scientists believe that these areas on the lunar surface possibly have a permanent source of water.
- In addition, scientists also have a keen interest in the craters present in the southern pole. They believe these cold traps may contain mysterious fossil records of the early planetary system.

GAGANYAAN(HUMAN SPACEFLIGHT MISSION):

- Gaganyaan, announced by the Prime Minister in August 2018, is the ₹10,000-crore Indian human space flight scheduled for 2022. It is designed to have 3-7 crew members spend 3-7 days in space in a 400-km orbit.

- The first of the two pre-Gaganyaan flights with a humanoid will be launched this year-end along with some of the six shortlisted microgravity experiments.

ISRO'S NEW LAUNCH PAD IN TAMIL NADU:

1. The Tamil Nadu government has started acquiring 2,300 acres of land in Thoothukudi district for ISRO's second launch port.
2. Thoothukudi offers a locational advantage to launch towards India's South. When ready, the new port will handle mainly the small satellite launch vehicle (SSLV) that is under development. SSLVs are meant to put a payload of up to 500 kg in space.

Benefits:

- **Boost in speed-** The Earth's rotation provides a speed boost to rockets launched in the eastward direction and headed for an equatorial orbit around the planet.
- **Less impact on land-** In case of failure during the launch, then the debris from an explosion would fall directly into the Bay of Bengal instead of land.
- **Ideal for SSLV –** This location is ideal for launching small satellites of less than 500kg in the sun-synchronous orbit.
- **Less Cost-** Mission launched would cost less compared to the Sriharikota launch station.

ADITYA L1 MISSION

- The Aditya-1 mission was conceived as a **400kg class satellite**carrying one payload, the Visible Emission Line Coronagraph (VELC) and was planned to launch in a 800 km low earth orbit.
- A Satellite placed in the halo orbit around the **Lagrangian point 1 (L1) of the Sun-Earth system has the major advantage of continuously viewing the Sun**without any occultation/ eclipses.
- Therefore, the Aditya-1 mission has now been revised to "Aditya-L1 mission" and will be inserted in a halo orbit around the L1, which is 1.5 million km from the Earth.
- The satellite carries additional six payloads with enhanced science scope and objectives.
- **Aditya-1 was meant to observe only the solar corona.**
- The outer layers of the Sun, extending to thousands of km above the disc (photosphere) is termed as the corona.
- It has a temperature of more than a million degree Kelvin which is much higher than the solar disc temperature of around 6000K.
- How the corona gets heated to such high temperatures is still an unanswered question in solar physics.
- **Aditya-L1** with additional experiments can now provide observations of **Sun's Corona (soft and hard X-ray, Emission lines in the visible and NIR), Chromosphere (UV) and photosphere (broadband filters).**
- In addition, particle payloads will study the particle flux emanating from the Sun and reaching the L1 orbit, and the magnetometer payload will measure the variation in magnetic field strength at the halo orbit around L1.
- These payloads have to be placed outside the interference from the Earth's magnetic field and could not have been useful in the low earth orbit.

INDIAN SPACE PROGRAM

- ISRO has also contributed to science and science education in the country. The Department of Space oversees a number of dedicated research centres and independent organisations

for remote sensing, astronomy and astrophysics, atmospheric sciences, and space sciences in general. the objectives of the Indian Space Program is twofold:

A. Space discovery and exploration through space missions.
B. Promotion of research and education related to space science in the country. E.g. Tele-education in remote areas in India.

Some of the other functions of the Indian Space Program are:

1. Resource management such as mineral resources, agriculture, marine resources etc.
2. Environment conservation.
3. Internal security and terrorism. E.g. use of IRNSS for regional security.
4. Weather forecasting.
5. Disaster Management.

COMMUNICATIONS SATELLITES INDIA

- Communications satellites allow radio, television, and telephone transmissions to be sent live anywhere in the world. The purpose of communications satellites is to relay the signal around the curve of the Earth allowing communication between widely separated points. Communication Satellites use Microwaves and Radio waves for transmitting signals.

Indian National Satellite (INSAT) Series

1. With nine operational communication satellites in Geo-stationary orbit, the Indian National Satellite (INSAT) system is one of the largest domestic communication satellite systems in the Asia-Pacific area.
2. INSAT System consists of 14 operational satellites, namely – INSAT-3A, 3C, 4A, 4B, 4CR, 3DR and GSAT-6, 7, 8, 10, 12, 14, 15 and 16.
3. Application of INSAT satellite includes:

I. Educational TV Services
II. Telemedicine Programme
III. Television
IV. Satellite-Aided Search and Rescue
V. Disaster management
VI. Helps in geopolitics like the SAARC satellite.
VII. Helps in the commercialization of space programs, like launching the communication satellites of Russia USA, etc.

INDIAN REMOTE SENSING SATELLITE (IRS)

- ISRO has deployed numerous operational remote sensing satellites since IRS-1A in 1988. India now operates one of the largest constellations of remote sensing satellites.
- IRS satellite consists of CARTOSAT, OCEANSAT & RISAT (Resource Sat) Satellites

Application of IRS satellites:

I. Disaster Management Support
II. BioResources and Environment survey and mapping e.g. RESOURCESAT
III. Cartography e.g. CARTOSAT
IV. Agriculture & Soil
V. Rural and Urban Development e.g. National Drinking Water mission

Important Milestones in the Indian Space Program

Phase I: 1960-70 (Incipient Stage)

I. Dr Vikram Sarabhai is regarded as a scientific visionary as well as the founding father of the Indian space programme.
II. He recognised the potential of satellites after the launch of Sputnik in 1957. Pt. Jawaharlal Nehru, India's first Prime Minister, who considered scientific advancement as an important component of India's future, placed space research under the jurisdiction of the Department of Atomic Energy in 1961.
III. Homi Bhabha, the father of India's atomic programme, then founded the Indian National Committee for Space Research (INCOSPAR) in 1962, with Dr Sarabhai as Chairman.
IV. The Indian space programme began establishing itself with the launch of sounding rockets in 1962, which was aided by India's geographical proximity to the equator.
V. Thumba Equatorial Rocket Launching Station (TERLS) was built near Thiruvananthapuram in south Kerala.
VI. India developed an indigenous technology of sounding rockets called the Rohini Family of sounding rockets.
VII. The India Space Research Organisation (ISRO) was established in 1969, and the Department of Space was established in 1972.

Phase II: 1970-80

I. Sarabhai had participated in an early NASA study on the viability of employing satellites for uses as diverse as direct television broadcasting.
II. India began developing satellite technology in anticipation of future remote sensing and communication requirements.
III. India's first venture into space occurred in 1975, with the launch of their satellite Aryabhata by a Soviet launcher.
IV. By 1979, the SLV was ready to launch from the Sriharikota Rocket Launching Station, a newly created second launch site (SRLS).
V. The first launch in 1979 failed due to a control malfunction in the second stage. This problem had been solved by 1980.
VI. The first indigenous satellite launched by India was called Rohini.

Phase III: 1980-90

I. Following the success of the SLV, ISRO was eager to begin work on a satellite launch vehicle capable of placing a truly useful satellite into polar orbit.
II. In 1987, the Augmented Satellite Launch Vehicle (ASLV) was tested, but the launch failed. After modest adjustments, another launch attempt was made in 1988, which also failed.

Phase IV: 1990-2000

I. It was not until 1992 that the first successful launch of the ASLV took place.
II. Since its first successful launch in 1994, the PSLV has become the workhorse launch vehicle, launching both remote sensing and communications satellites into orbit, establishing the world's largest cluster, and giving unique data to Indian industry and agriculture.

DEVELOPMENTS AFTER 2000

I. In 2001, the first development flight of the GSLV took place.
II. As the first attempt at exploring the solar system, India pursued a mission to send unmanned probes to the moon in 2008 namely Chandrayaan.
III. ISRO has entered the lucrative industry of launching foreign payloads from Indian soil using its rockets.

IV. After 2010, ISRO embarked on the following programmes: Polar Satellite Launch Vehicle (PSLV), Geosynchronous Satellite Launch Vehicle (GSLV), and next-generation GSLV Mark-III launch vehicle missions are part of the launch vehicle development programme.
V. The Earth Observation programme includes cutting-edge Indian remote sensing (IRS) satellites such as Resourcesat, Cartosat, Oceansat, Radar Imaging Satellite, Geo-Imaging Satellite, and weather/climate satellites such as INSAT-3DR missions.
VI. The satellite navigation programme consists of a constellation of seven Indian Regional Navigation Satellite System (IRNSS) satellites and an associated ground segment designed to deliver accurate positional and timing information.

INDIA'S MANNED MISSION TO SPACE

Gaganyaan is a mission by the ISRO scheduled to be launched in 2023. Under this mission:

I. Three flights will be sent into orbit.
II. There will be two unmanned flights and one human spaceflight.
- ❖ The Gaganyaan system module, known as the Orbital Module, would house three Indian astronauts, one of them will be a woman.
- ❖ For 5-7 days, it will circle the Earth in a low-Earth orbit at an altitude of 300-400 km.
- ❖ In addition, to assure crew safety during the Gaganyaan mission, ISRO will perform two unmanned 'Abort Missions' in 2022.

Scramjet (Supersonic Combusting Ramjet) engine

I. In August 2016, ISRO has successfully conducted the Scramjet (Supersonic Combusting Ramjet) engine test.
II. The Scramjet engine uses Hydrogen as fuel and Oxygen from the atmospheric air as the oxidiser.
III. This test was the maiden short-duration experimental test of ISRO's Scramjet engine with a hypersonic flight at Mach 6.
IV. ISRO's Advanced Technology Vehicle (ATV), a futuristic-sounding rocket, served as the solid rocket booster for the supersonic testing of Scramjet engines.
V. The new propulsion system will complement ISRO's reusable launch vehicle that would have a longer flight duration.

IN-SPACE:

1. IN-SPACe was launched to provide a level playing field for private companies to use Indian space infrastructure.
2. It serves as a single point of contact between the Indian Space Research Organization (ISRO) and anyone interested in participating in space-related activities or utilising India's space resources.

NEWSPACE INDIA LIMITED (NSIL):

1. It is a Central Public Sector Enterprise of the Government of India that was founded in 2019 and is managed by the Department of Space.
2. It is ISRO's commercial arm, and its major purpose is to enable Indian enterprises to engage in high-technology space-related operations.
3. It is headquartered in Bengaluru.

Indian Space Association (ISpA):

- ISpAaspires to be the collective voice of the Indian Space industry. ISpA will be represented by leading domestic and global corporations that have advanced capabilities in space and satellite technologies.

Amazonia-1:

- The 53rd flight of PSLV-C51 marked the first dedicated mission for New Space India Ltd (NSIL), the commercial arm of ISRO.
- Amazonia-1, the National Institute for Space Research (INPE) optical earth observation satellite, would offer users remote sensing data for monitoring deforestation in the Amazon region and analysing diverse agriculture across the Brazilian territory.

UNITYsat (three satellites):

They have been deployed to provide Radio relay services.

SDSAT:

- Satish Dhawan Satellite (SDSAT) is a Nano satellite intended to study the radiation levels/space weather and demonstrate long-range communication technologies.

Upcoming Missions:

Chandrayaan-3 Mission: Chandrayaan-3 is likely to be launched during the third quarter of 2022.

Three Earth Observation Satellites (EOSs):

1. **EOS-4 (Risat-1A) and EOS-6 (Oceansat-3)** — will be launched using ISRO's workhorse PSLV, and the third one, **EOS-2 (Microsat)**, will be launched in the first developmental flight of the Small Satellite Launch Vehicle (SSLV).
2. These satellites will be launched in the first quarter of 2022.
3. **Shukrayaan Mission:** The ISRO is also planning a mission to Venus, tentatively called Shukrayaan.
4. **Own Space Station**: India is planning to launch its own space station by 2030, joining the league of the US, Russia, and China to an elite space club

- **XpoSat:** Space observatory, XpoSat, designed to study cosmic x-rays.
- **Aditya L1 mission:** It will see an Indian spacecraft going 1.5 million km away to the L1 or Lagrangian point between the Sun and Earth.
- There are five Lagrangian points between any two celestial bodies on the satellite where the gravitational attraction of both bodies is equivalent to the force required to keep the satellite in orbit without spending fuel, implying a parking area in space.

GSLV MK III

On October 23, at 7 am, India's biggest satellite launch vehicle, the GSLV MkIII of the Indian Space Research Organization (ISRO) is scheduled to launch 36 satellites of the OneWeb communication constellation from Sriharikota, Andhra Pradesh, India's sole space launch station. With this, the GSLV MkIII will then enter the global market for commercial satellite launch services.

1. According to information from the ISRO, the "LVM3 - M2/OneWeb India-1 Mission" launch is slated on October 23, 2022, at 00:07 IST.
2. OneWeb, Network Access Associated Limited of the United Kingdom purchased the launch payload of GSLV mk III through New Space India Limited.

Significance

- ❖ This is the first time a commercial launch has been conducted using India's largest rocket - GSLV Mk III.
- ❖ Additionally, this will be the first time a rocket other than Polar Satellite Launch Vehicle (PSLV), India's workhorse, is being used to conduct a commercial launch.
- ❖ This will be the GSLV Mk III's second launch since carrying India's second lunar mission, Chandrayaan-2, after it entered the ISRO fleet after completing two development flights.

1. With fourteen launches so far, including the development flights, the other heavier launch vehicle, the GSLV, has a mixed success record.
2. Only eight of the missions, however, were a total success. None of these missions were carried out for profit.

ISRO and Commercial Satellite Launch Service

- ➢ In the recent past ISRO has emerged as a favourite candidate for the commercial satellite launch services in domestic as well as in international market.
- ➢ The expertise of ISRO to launch a satellite at low cost and reliability of ISRO workhorse PSLV in launching satellites in the orbit has made the ISRO a market favourite in the commercial satellite launch industry.
- ➢ The PSLV has carried out at least eight commercial-only launches since its initial operational flight.
- ➢ With the launch of at least 345 foreign satellites from 36 different nations, the vehicle has made a name for itself on the international stage.
- ➢ Its most significant flight was the 2017 PSLV-C37 mission, which placed 104 satellites in orbit (of which 101 were foreign commercial satellites).

GSLV Mk III

- ❖ Geosynchronous Satellite Launch Vehicle Mark III (GSLV Mk III) is the largest launch vehicle developed by India, which is currently in operation.
- ❖ This three-stage launch vehicle of the fourth generation has four liquid strap-ons.
- ❖ The third stage of the GSLV Mk III is the Indigenously developed, built and flight-tested cryogenic Upper Stage (CUS).

Features

1. Ability to lift and park satellite of 4.3 tons to GTO
2. 10 tons of payload capacity for LEO missions
3. Effective from a financial standpoint
4. enhanced operability, dependability, and redundancy control
5. Future payload expansion possibility with modest design adjustments
6. To assist the Indian Space Program's manned missions, such as the Gaganyaan mission

Operational History

I. In 2017, the GSLV-Mk III-D1, the first developmental flight of the GSLV Mk III, successfully launched the GSAT-19 satellite into a geosynchronous transfer orbit (GTO).
II. In 2018, GSAT-29, a high throughput communication satellite, was launched in GSLV MkIII-D2, the second developmental flight.
III. 2019, India's second lunar mission, Chandrayaan-2, was successfully launched into Earth parking orbit in 2019 by GSLV MkIII-M1.

GEOSYNCHRONOUS SATELLITE LAUNCH VEHICLE (GSLV)

- The ISRO designed, developed, and operates this space launch vehicle to put satellites and other spacecraft into geosynchronous transfer orbits (GTO).
- GSLV has the ability to launch a bigger payload into orbit than the Polar Satellite Launch Vehicle (up to 5,000 kg up to 37,000 km)

PSLV can carry up to 2000 kg into space up to 600-900 km.

I. While GSLV is intended to launch communication satellites, PSLV is primarily intended to transport earth observation or remote sensing satellites.
II. GSLV delivers satellites into a higher elliptical orbit - GTO.
III. GSLV is a 3-stage launcher with strap-on motors.
   - The first stage - uses the solid rocket motor with four liquid engine strap-on motors. This stage generates maximum thrust.
   - The second stage uses a liquid rocket engine which is known as Vikas engine.
   - The third stage uses a Cryogenic engine, which uses liquefied oxygen and hydrogen as fuel.

GSLV-D5 - launched in 2014 - was the first successful flight of the GSLV using the indigenous cryogenic engine (CE-7.5).

New Space India Limited (NSIL)

I. It is the new commercial arm of ISRO.
II. It is a completely Public Sector Undertaking of Government of India .
III. The Department of Space(DOS) has administrative control over it.
IV. Aim: The primary goal of NSIL is to increase industry involvement in Indian space programs.
V. Capital: NSIL is given a 100 crore rupee authorized share capital as well as a 10 crore rupee initial paid-up capital.

ROLES AND RESPONSIBILITY

1. Owning satellites for use in communications and earth observation, as well as offering space-based services
2. Building and deploying satellites in response to demand
3. Performing launch services for a customer's satellite
4. Building launch vehicles using Indian industry, and launching them in accordance with satellite customer demand
5. Commercial space-based services for communication and Earth observation satellites
6. Constructing satellites using Indian industry technology

LAUNCH VEHICLE MARK 3

1. OneWeb's 36 satellites were recently orbited successfully by the Launch Vehicle Mark 3 (LVM3 or GSLV Mark 3) rocket, the heaviest rocket ever built by the ISRO.
2. Powered by a constellation of 648 Low Earth Orbit (LEO) satellites, OneWeb is a global communications network.

LMV 3:

- The LVM3-M2 mission is a dedicated commercial mission for the company OneWeb, carried out by the Central Public Sector Enterprise(CPSE), NewSpace India Limited (NSIL).
- With 36 OneWeb Satellites to the LEO as the heaviest Payload Mass of LVM3 to date, it is the first multi-satellite mission.

- This most recent rocket can carry **8,000 kg of payloads into low-Earth orbit and 4,000 kg of satellites into geosynchronous transfer orbit**.
- It is a **three-stage launch vehicle** with **two solid propellant S200 strap-ons on each side and a core stage with an L110 liquid stage and a C25 cryogenic stage.**

Features:

1. LVM3's first commercial mission LVM3's first launch to LEO India's first rocket with a six-ton payload
2. First NSIL Mission with LVM3 First NSIL/Department of Space OneWeb Mission

TECHNICAL ACCOMPLISHMENTS:

1. Multiple satellite separation events must be handled.
2. Nominal mission duration has been increased.
3. Increasing the safe separation distance via C25 (cryo) stage re-orientation and velocity addition
4. Ensuring data availability for the duration of the mission
5. Development of a new payload adaptor and interface ring for satellite dispensers

OneWeb Constellation

- **OneWeb Constellation operates in an LEO Polar Orbit,** with satellites arranged in 12 rings (orbital planes), each with 49 satellites.
- The orbital planes are angled toward the poles (87.9 Deg.)
- The **orbital planes are 1200 kilometres above Earth**. Every **109 minutes, each satellite completes a full orbit around the Earth.**
- Because the earth rotates beneath satellites, they are constantly flying over new ground locations.

(SLV):

ISRO's first rocket was simply known as the SLV, or Satellite Launch Vehicle.

Augmented Satellite Launch Vehicle (ASLV)

- ASLV, came next after SLV
- **Both the SLV and the ASLV are capable of transporting small satellites weighing up to 150 kg to lower earth orbits.**
- Before PSLV arrived on the scene, ASLV operated until the early 1990s.

POLAR SATELLITE LAUNCH VEHICLE (PSLV):	**GSLV (GEOSYNCHRONOUS SATELLITE LAUNCH VEHICLE):**
1. PSLV launched for the first time in 1994 and has been ISRO's primary rocket ever since. Today's PSLV, on the other hand, is vastly improved and several orders of magnitude more powerful than those used in the 1990s. 2. It is the **first Indian launch vehicle to have liquid stages**. 3. **PSLV is ISRO's most dependable rocket to date**, with 52 of 54 flights successful. 4. It **successfully launched two spacecraft,**	1. The GSLV is a **much more powerful rocket designed to transport heavier satellites much further into space**. GSLV rockets have completed 18 missions to date, four of which were unsuccessful. 2. Lowering the Earth's orbits can require **10,000 kg of satellites**. 3. The **third stage of the GSLV Mk II is the indigenously developed Cryogenic Upper Stage (CUS).** 4. ISRO is now completely self-sufficient in satellite launch thanks to **Mk-III versions.** 5. Previously, it relied on the European Arianne launch

Chandrayaan-1 in 2008 and Mars Orbiter Spacecraft in 2013, both of which travelled to the Moon and Mars.	vehicle to deliver its heavier satellites into orbit. 6. The **GSLV Mark-III rocket launched the CHANDRAYAAN-2 MISSION to the moon in 2019,** marking the rocket's first operational flight. 7. The **GSLV Mark-III has been renamed Launch Vehicle Mark-III by ISRO.** 8. A GSLV, which stands for Geostationary Orbit (GEO), will continue to be used. **The LVM3 will travel everywhere—GEO, MEO, LEO, and missions to the moon and sun.**

Vyommitra

Vyommitra', **the humanoid** designed and developed by the ISRO has been successfully integrated with a computer 'brain' which enables it to 'read' control panels aboard and communicate with the ISRO ground stations.

1. The humanoid has been developed by the ISRO Inertial Systems Unit, Thiruvananthapuram.
2. VyomMitra is a half-humanoidand her body stops at the torso and has no legs.
3. The humanoid will simulate the human functions required for space before real astronauts take off.
4. She has been designed to resemble a human with facial expressionsand speech and sight.
5. Vyommitra is also set to get a digital twin. The 'twin' will undergo computer simulations where the control systems are tested for microgravity conditions.
6. Vyommitra will fly aboard the first unmanned test flight ahead of the crewed Gaganyaan flight expected in 2024.

ROHINI SOUNDING ROCKET

I. The Indian Space Research Organization (ISRO) hopes to achieve a remarkable feat — the **200th successful launch of the Rohini RH-200** sounding rocket in a row.
II. RH-200 is a **two-stage rocket capable of climbing to a height of 70 km** bearing scientific payloads.
III. It is **3.5-metre-tall** and is used by the ISRO for **atmospheric studies.**
IV. The Rohini RH-200 **has completed 198 consecutive successful flights.**
V. The 199th launch, from Thumba, will happen on October 7,2022 during the World Space Week celebrations.
VI. The **'200'** in the name **denotes** the **diameter of the rocket in mm.**
VII. The **ISRO** has launched more than **1,600 RH-200 rockets so far.**
VIII. Other operational Rohini variants are RH-300 Mk-II and RH-560 Mk-III.
IX. Over the years, the rocket has served as a flexible platform for experiments and testing out new technologies.

200th successful launch of the Rohini RH-200 sounding rocket in a row.

- RH-200 of the Rohini sounding rocket family has completed **198 consecutive successful flights.**
- The 199th launch will happen in October 2022 during the WORLD SPACE WEEK **(4th-10th October) celebrations.** The 200th will take place either towards the end of October or the beginning of November 2022.

SOUNDING ROCKET

- **A sounding rocket** is an instrument-carrying rocket designed to take measurements and perform scientific experiments during its sub-orbital flight.
- The rockets are used to launch instruments from 48 to 145 km above the surface of the Earth.

ROHINI (ROCKET FAMILY)

1. Rohini is a series of sounding rockets developed by the **Indian Space Research Organisation (ISRO)** for meteorological and atmospheric study.
2. These sounding rockets are capable of carrying payloads of 2 to 200 kilograms between altitudes of 100 to 500 kms.
3. The ISRO currently uses RH-200, RH-300, RH-300 Mk-II, RH-560 Mk-II and RH-560 Mk-III rockets, which are launched from the Thumba Equatorial Rocket Launching (TERLS) in Thumba and the Satish Dhawan Space Center in Sriharikota.

- The first sounding rocket to be launched from Thumba was the American Nike-Apache - on November 21, 1963.
- After that, two-stage rockets imported from Russia (M-100) and France (Centaure) were flown.
- The ISRO launched its own version - Rohini RH-75 - in 1967.

HYBRID PROPULSION SYSTEM

The Indian Space Research Organisation (ISRO) has successfully tested a hybrid propulsion system

HYBRID PROPULSION SYSTEM

- The 30 kN hybrid motor tested at ISRO Propulsion Complex (IPRC) at Mahendragiri in Tamil Nadu
- The test was supported by ISRO's Liquid Propulsion Systems Centre (LPSC).
- It uses a solid fuel and liquid oxidiser.

The motor used Hydroxyl-terminated polybutadiene (HTPB) as fuel and liquid oxygen (LOX) as the oxidiser.

1. In rocket engines, **oxidisers** supply the oxygen **needed for combustion**.
2. Conventional HTPB-based solid propellant motors used in rockets use **ammonium perchlorate as oxidiser**.
3. The hybrid system uses a Hydroxyl-terminated polybutadiene (HTPB)-based aluminised solid fuel and **liquid oxygen** (LOX) as the **oxidiser.**
4. The **ground-based test** was performed for 15 seconds on a 300-mm sounding rocket motor.

Benefits:

1. While **both** HTPB and LOX are **green**, the **cryogenic LOX is safer** to handle.
2. And unlike conventional solid motors, the hybrid technology **permits restarting and throttling capabilities** on the motor.
3. The hybrid system is **more efficient, "greener" and safer** to handle and paves the way for new propulsion technologies for future missions.

DARK SKY RESERVE IN LADAKH

- Recently, in a first-of-its-kind initiative, the DST has announced the setting up of **India's first Dark Sky Reserve in Hanle, LADAKH.**

DARK RESERVE

1. A Dark Sky Reserve is a **designation given to a place that** has policies in place to ensure that a tract of land or region **has minimal artificial light interference.**
2. The International Dark Sky Association is a U.S.-based non-profit that **designates places as** International Dark Sky Places, Parks, Sanctuaries and Reserves, depending on the criteria they meet.

KEY HIGHLIGHTS OF THE DARK RESERVE IN LADAKH

I. MoU for Setting up Dark Reserve: There was a three-way Memorandum of Understanding was signed among the Union Territory administration,LAHDC , Leh, and the Indian Institute of Astrophysics (IIA), Bengaluru, which uses and maintains the telescopes, for launching the Dark Space Reserve.

II. It will have activities to help in boosting local tourism and the economy through interventions of science and technology.

- **Promote Tourism:** To promote **Astro-tourism,** villages around Hanle will be encouraged to promote homestays equipped with telescopes that visitors can use to view the night sky.
- Villagers and residents will also be **trained to help visitors with astronomical observations.**
- There will be delineators on roads like you do outside observatories. People can come, park, observe the sky and stay in homestays.

Wildlife Awareness: A visitor centre would also be set up to inform people not only about astronomy but also about the **wildlife and plant life in the adjoining Changthang Wildlife Sanctuary.**

LADAKH -DARK RESERVE:

- **Cold Desert with Sparse Population:** The Indian Astronomical Observatory, the high-altitude station of IIA, is situated to the north of the Western Himalayas, at an altitude of 4,500 metres above mean sea level.
- Located atop **Mt. Saraswati in the Nilamkhul Plain in the Hanle Valley of Changthang,** it is **a dry, cold desert** with a sparse human population and has the Hanle monastery as its nearest neighbour.

I. **Clear Skies:** The cloudless skies and low atmospheric water vapour make it one of the best sites in the world for optical, infrared, sub-millimetre, and millimetre wavelengths.

II. **Other Telescopes situated in Hanle Observatory:** The Himalayan Chandra Telescope (HCT), High Energy Gamma Ray telescope (HAGAR), the Major Atmospheric Cherenkov Experiment Telescope (MACE) and GROWTH-India are prominent telescopes located at the Hanle observatory.

ISRO tests system recoverable rocket 'Inflatable Aerodynamic Decelerator (IAD)'

The Indian Space Research Organisation (ISRO) has successfully tested a technology that could aid the cost-effective recovery of spent rocket stages and safely land payloads on other planets.

IAD

1. IAD is a technique used for an **atmospheric entry payload**.
2. An **inflatable envelope and an inflatant** (anything that inflates the envelope, like air or helium) make up the inflatable aerodynamic decelerator.
3. While entering the atmosphere, it **inflates like a balloon and decelerates the lander.**
4. The inflatant is designed to fill the inflatable envelope to a condition such that it surrounds the payload meant to enter the atmosphere of a planet or satellite and causes aerodynamic forces to slow it down.
5. In simpler words, IAD is designed to increase drag upon entering the atmosphere of any planetary body, like Earth, Mars, or even Moon.
6. Its shape is maintained by a closed, gas-pressured body and the inflatant gas is also generated internally. Some versions also use ram air or both.

significance

1. Some space agencies, including NASA, have already successfully tested advanced versions of the technology, including the supersonic and hypersonic variants.
2. However, for near future missions of ISRO, the current version that it tested is perfect.
3. Its use was first proposed by NASA more than 50 years ago for planetary entries.

Minuscule of ISRO's IAD

- The IAD tested by ISRO was inflated at an **altitude of around 84 km** and the sounding rocket's cargo dropped through the atmosphere on it.
- It is fitted with a **booster motor**. It also has a **spin rocket** that is ejectable.
- The inflatable structure is made out of **Kevlar fabric**, which is a very strong synthetic fibre and also heat resistant to withstand atmospheric pressure and temperature changes.
- On top of it, it's coated with **polychloroprene**, an oil and wax resistant rubber, to **withstand extreme temperatures.**
- In the inflation system, it **uses compressed nitrogen** stored in a bottle.
- It has consistently **decreased the payload's velocity** through **aerodynamic drag** while maintaining the expected trajectory during the test flight.

ISRO INTEND TO USE IT

- The IAD will help ISRO in performing many space tasks effectively including recovery of spent stages of rockets, for landing payloads on missions to other planetary bodies.
- This is the first instance where an IAD has been specially created for spent stage recovery.
- So inter-planetary missions are certainly one aspect that ISRO wishes to explore.

INFLATABLE AERODYNAMIC DECELERATOR (IAD)

Indian Space Research Organisation (ISRO) has successfully demonstrated a new technology with I**nflatable Aerodynamic Decelerator (IAD**).

Inflatable Aerodynamic Decelerator (IAD) ;

- **Development** : It was designed, developed and successfully test-flown by ISRO's Vikram Sarabhai Space Centre (VSSC) on a **Rohini-300 (RH300 Mk II) sounding rocket** from the Thumba Equatorial Rocket Launching Station (TERLS).
- **Rohini** sounding rockets are routinely used for flight demonstration of new technologies being developed by ISRO as well as by scientists from India and abroad.

- As its name suggests, the IAD serves to decelerate an object plunging down through the atmosphere.
- It is a game-changer with multiple applications for future missions including to Mars and Venus.
- **Significance :** The news technology could aid cost-effective recovery of spent rocket stages and safely land payloads on other planets.
- It can also be used in ISRO's future missions to Venus and Mars.

Launching of ISRO's Virtual Space Museum "SPARK"

- While the country is celebrating Azadi Ka Amrit Mahotsav – the 75th year of Independence, ISRO has come up with an innovative idea of showcasing digital content pertaining to various ISRO missions in an interactive manner.
- The Virtual Space Museum "SPARK" was launched by Secretary, DOS / Chairman, ISRO on 10.08.2022 for the public use.
- The platform hosts several documents, images & videos related to ISRO launch vehicles, satellites and scientific missions. Chairman, ISRO & Directors
- of the various ISRO centres appreciated the initiative taken and suggested more non-sensitive digital content to be brought on this platform for use by different stakeholders. The beta version of the application can be accessed through ISRO website .

SSLV-D1/EOS-2 mission

- The SSLV D1/EOS-2 mission was carrying two satellites — the Earth Observation Satellite-2 (EOS-2 and AzadiSAT. However, the mission failed to place the satellites in their required orbits, and the satellites, as they were already detached from the launch vehicle, were lost.

DIMENSIONS OF THE ARTICLE:

1. What was the purpose of the SSLV-D1/EOS-2 mission?
2. Which part of the mission succeeded and where did it fail?
3. Difference between circular and elliptical orbits
4. What are the launch vehicles used by ISRO?

PURPOSE OF THE SSLV-D1/EOS-2 MISSION

I. The purpose of this mission was to place the two satellites in circular low-Earth orbits at a height of about 350 km above the Equator.
II. The mission aimed to place the EOS-2 in a circular low-Earth orbit at a height of about 350 km above the Equator and inclined at an angle of 37 degrees.

EOS-2 (135 kg):

- It was designed and developed by ISRO, offered advanced optical remote sensing operations.
- It would have operated in the infrared region and could have served many purposes, from imaging for climate studies to simply keeping an eye on Earth.

AZADISAT (8 KG):

- It was a collective of 75 tiny payloads weighing around 50 grams each, which were integrated by students.
- It carried tiny experiments which would have measured the ionising radiation in its orbit and also a transponder which worked in the ham radio frequency to enable amateur operators to access it.

MISSION SUCCESS - FAIL

1. The SSLV was composed of three stages powered by solid fuels and these three performed their function as planned.
2. However, when it came to the stage when the satellites had to be set in orbit, there was a glitch which resulted in the satellites being lost forever.
3. With a degree of openness that is unprecedented in ISRO, it was announced that there was a malfunctioning of a sensor which resulted in placing the satellites in an elliptical orbit, rather than a circular orbit.
4. The ellipse or oval shape of the elliptical orbit is elongated in one direction and compressed in another (the so-called major and minor axes, which are like two radii of the ellipse).
5. The shortest height above the Earth of this oval orbit was only about 76 km.

DIFFERENCE BETWEEN CIRCULAR AND ELLIPTICAL ORBITS

1. Mostly objects such as satellites and spacecrafts are put in elliptical orbits only temporarily.
2. They are then either pushed up to circular orbits at a greater height or the acceleration is increased until the trajectory changes from an ellipse to a hyperbola and the spacecraft escapes the gravity of the Earth in order to move further into space — for example, to the Moon or Mars or further away.
3. Satellites that orbit the Earth are mostly placed in circular orbits.
4. One reason is that if the satellite is used for imaging the Earth, it is easier if it has a fixed distance from the Earth.
5. If the distance keeps changing as in an elliptical orbit, keeping the cameras focussed can become complicated.

NEED TO DEVELOP AN SSLV WHEN WE HAVE SUCCESSFULLY USED PSLV AND GSLV

- The PSLV (Polar Satellite Launch Vehicle) and GSLV (Geosynchronous Satellite Launch Vehicle) are quite powerful and can carry huge loads.
- To place an Earth Orbiting Satellite in a low Earth orbit, one does not need such power horses.
- The SSLV can easily carry small-to-medium loads from 10 kg to 500 kg.
- It is less expensive.
- The three stages being powered by solid fuel is another advantage.
- Solid fuel is easier to handle, whereas handling the liquid propellants used in the PSLV and GSLV is more complex.

LONG MARCH 5B' ROCKET BY CHINA

Recently, China has successfully launched the **Long March 5B' rocket** and prototype spacecraft.

- It is being considered as China's successful step to operate a permanent space station and send astronauts to the Moon.
- India is also planning to launch its own space station.

1. A space station is a spacecraft capable of supporting crew members, designed to remain in space for an extended period of time and for other spacecraft to dock.
2. One fully functional space station in the Earth's lower orbit is the International Space Station and astronauts conduct different experiments in it.

- **Long March 5B' Rocket:**
  It was launched from the Wenchang launch site in the southern island of Hainan.
- It weighs 849 tonnes.

Unmanned Prototype Spaceship:

- It is expected to transport astronauts to a space station that China plans to complete by 2022 — and eventually to the Moon. It will have capacity for a crew of six.

Future Missions by China:

- The assembly of the Tiangong space station is expected to begin in 2020 and finish in 2022.
- China plans to send an astronaut to the Moon in about a decade and then build a base there.

- The United States is so far the only country to have successfully sent humans to the Moon.

INTERNATIONAL SPACE STATION (ISS)

I. ISS is a habitable artificial satellite - the single largest man-made structure in low earth orbit. Its first component was launched into orbit in 1998.
II. It circles the Earth in roughly 92 minutes and completes 15.5 orbits per day.
III. The ISS programme is a joint project between **five** participating space agencies: **NASA (United States), Roscosmos (Russia), JAXA (Japan), ESA (Europe), and CSA (Canada)** but its ownership and use has been established by intergovernmental treaties and agreements.
IV. It serves as a microgravity and space environment research laboratory in which crew members conduct experiments in biology, human biology, physics, astronomy, meteorology, and other fields.
V. Continuous presence at ISS has resulted in the longest continuous human presence in the low earth orbit.
VI. It is expected to operate **until 2030.**

Focus :-

1. Long March 5B rocket had been launched into space on April 29 for putting into orbit a core module of the new Tianhe space station, which is expected to become operational in 2022.
2. For days, there had been speculation on whether the debris would hit a populated area on the Earth's surface.

ROCKET CAUSE WORRY

1. When a rocket is launched, its discarded booster stages re-enter the atmosphere soon after liftoff and harmlessly fall into the ocean
2. In this case, however, a 10-floor large vehicle of the rocket weighing 18 metric tonnes went into orbit along with the section of the under-construction space station that it was carrying.
3. While in orbit, this vehicle kept rubbing against the air at the top of the atmosphere, and the resulting friction caused it to start losing altitude.
4. The piece hurtled through a low-Earth orbit at roughly 25,490 km/hr.

5. An “uncontrolled re-entry” thus became inevitable, but China did not admit this fact to the world until 8th May.
6. The chance of humans getting hurt were low because most of the debris burnt up in the atmosphere and large parts of the Earth are covered by oceans and massive land areas lie uninhabited.

NOTE :-

- When rockets carry their payload into space, their booster stages that reach orbit fire the engine again after completing their job so as to drop back to Earth and not remain in orbit.
- Space agencies plan this process to ensure that such rocket parts end up in uninhabited areas, such as the middle of the ocean.
- China chose not to do this for its Long March rocket, leading to its vehicle crashing back uncontrollably.

NASA’s InSight Mars Mission

- NASA's Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) lander touched down on Mars at the end of 2018.
- It is a two year mission that will study the deep interior of Mars to learn how all celestial bodies with rocky surfaces, including Earth and the Moon, formed.

- The InSight mission is part of NASA’s Discovery Program (1992).

I. InSight is the **first mission** dedicated to looking deep beneath the **Martian surface.**
II. Among its science tools are a seismometer for detecting quakes, sensors for gauging wind and air pressure, a magnetometer, and a heat flow probe designed to take the planet’s temperature.
III. It is being supported by a number of European partners, which include France’s Centre National d’Études Spatiales (CNES), the German Aerospace Center (DLR) and the United Kingdom Space Agency (UKSA).

LATEST FINDING

- Mars trembles more often than expected, but also more mildly. Mars doesn’t have tectonic plates like Earth, but it does have volcanically active regions that can cause rumbles.

NASA’S PERSEVERANCE ROVER:

NASA PRESERVERANCE ROVER has completed a full Earth year on Mars after its successful landing on February 19, 2021.

During this period on the Red Planet, the rover has completed many firsts from its ambitious to-do list:

I. Collected the first rock cores from another planet.
II. Served as a base station for Ingenuity helicopter.
III. Extracted oxygen from thin Martian air.
IV. It broke a record for the most distance driven by a rover on Mars in a single day by travelling almost 320 meters on February 14.
V. Tested the first prototype oxygen generator on the Red Planet, called MOXIE (Mars Oxygen In-Situ Resource Utilization Experiment).

1. NASA's PRESEVERANCE ROVER is exploring the Jezero Crater on Mars and attempting to collect its first rock samples.
2. It was launched in 2020 aboard a United Launch Alliance Atlas V.

MISSION SIGNIFICANT

- It carried a unique instrument, MOXIE OR MARS OXYGEN ISRO EXPERIMENT **:** which for the first time manufactured molecular oxygen on Mars using carbon dioxide from the carbon-dioxide-rich atmosphere (ISRU means In Situ Resource Utilization: or the use of local resources to meet human needs or requirements of the spacecraft).
- It carried **,** INGENUITY the first ever helicopter to fly on Mars.
- It is **the planned first step to bring back rock samples from Mars** for analysis in sophisticated laboratories on Earth: with the goal of looking for biosignatures: or signatures of present or past life.

These are some of the key mission objectives:

1. Look for signs of ancient microbial life.
2. Collect Martian rock and dust samples for later return to Earth.
3. Deliver an experimental helicopter.
4. Study the climate and geology of Mars.
5. Demonstrate technology for future Mars missions.

REASON FOR THE NEAR-TERM INTEREST IN MARS

- Mars is located in the very near backyard (about 200 million km away).
- It is a planet that humans can aspire to visit or to stay for a longer duration.
- Mars had flowing water and an atmosphere in the distant past: and perhaps conditions to support life.
- It also has implications for commercial travel.

SOLAR FLARE

1. Recently, a solar flare that occurred on the Sun triggered a magnetic storm and it arrived at the Earth in the early hours of November 4.
2. Scientists had predicted that the **magnitude of this storm** would be such as to **trigger spectacular displays of aurora** (the coloured bands of light seen in the North and South poles) in the high-latitude and polar regions, just in time for the Deepavali celebrations in India.
3. This prediction, which was based on models built by them and data from NASA's observatories, seems to have come true, as people from several countries were tweeting pictures of aurorae.

EFFECT ON ATMOSPHERE

- Judging by data from the **NASA DSCOVR satellite**, the scientists observed a **steep jump in transverse magnetic fields**, density and speeds of the plasma wind that are tell-tale signatures of the arrival of a coronal mass ejection shock front
- These observations are taken at **Lagrange Point L1**.

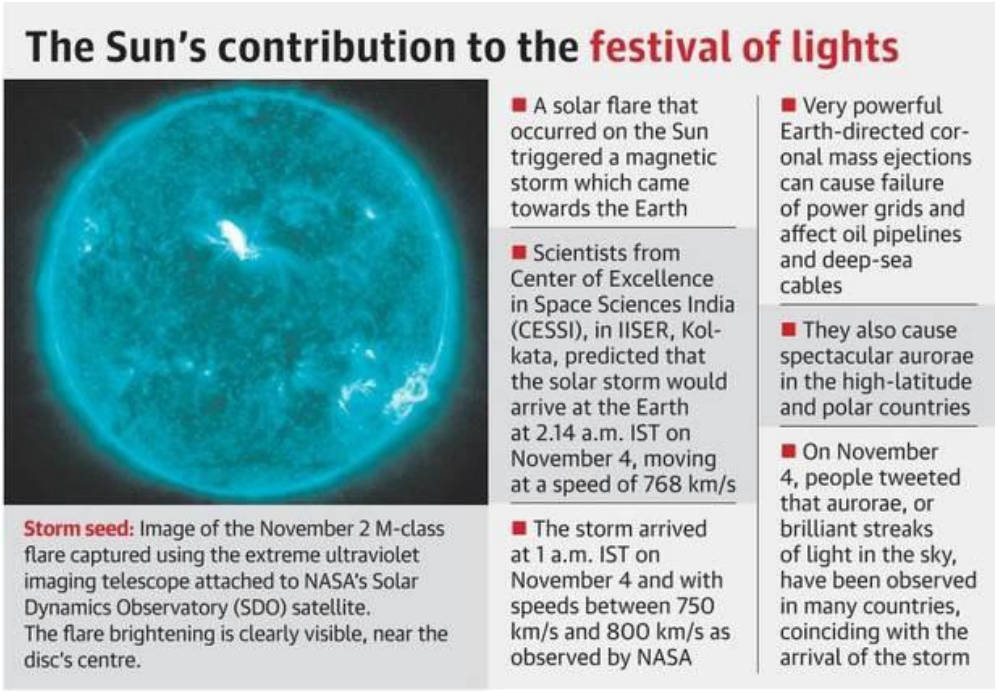
SUNSPOTS AND SOLAR FLARES

1. The solar magnetic cycle that works in the deep interior of the Sun creates regions that rise to the surface and appear like dark spots. These are the **sunspots**.
2. **Solar flares** are highly energetic phenomena that happen inside the sunspots.
3. In a solar flare, the energy stored in the sun's magnetic structures is converted into **light and heat energy**.
4. This causes the emission of high energy x-ray radiation and highly accelerated charged particles to leave the sun's surface.

Sometimes solar flares also cause hot plasma to be ejected from the Sun, causing a solar storm, and this is called **Coronal Mass Ejection (CME)**.

I. Coronal Mass Ejections can harbour energies exceeding that of a billion atomic bombs.
II. Very powerful Earth-directed coronal mass ejections can cause the **failure of power grids** and affect oil pipelines and deep-sea cables.
III. They can also **cause spectacular aurorae** in the high-latitude and polar countries.

- The **energy and radiation and high energy particles** emitted by flares can affect Earth bound objects and life on Earth – it can affect the electronics within satellites and affect astronauts.



SOLAR STORM PREDICTION

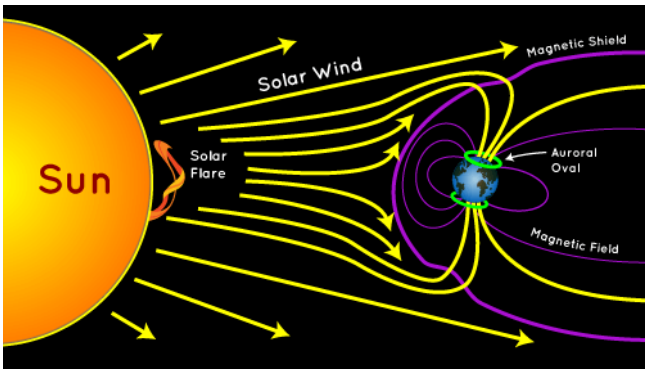
The process of prediction takes place in **two steps**:

STEP 1:

I. The researchers analyse the possibility of a strong solar flare from an active region – that is, clusters of sunspots – using a machine learning algorithm that has been developed in CESSI, IISER Kolkata.
II. This algorithm needs observations of the sunspot magnetic fields, from which we extract various parameters to train the algorithm.

STEP 2:

- Estimating the time of arrival on Earth of coronal mass ejections and forecasting the geomagnetic storm.
- The group uses the **near-Sun evolution** of the coronal mass ejections through European Space Agency's SOHO satellite and NASA's STEREO satellite to extract their speed.



AURORA

1. An aurora is a natural phenomenon that is characterised by a **display of a natural-coloured** (green, red, yellow or white) light in the sky.
2. It is a light show which is caused when **electrically-charged particles** from the sun collide with particles from gases such as oxygen and nitrogen present in the Earth's atmosphere.
3. Aurora is sometimes referred to as **'polar light'**.
4. It is predominantly seen in regions of high altitudes like the Arctic and Antarctic.

CAUSED BY:

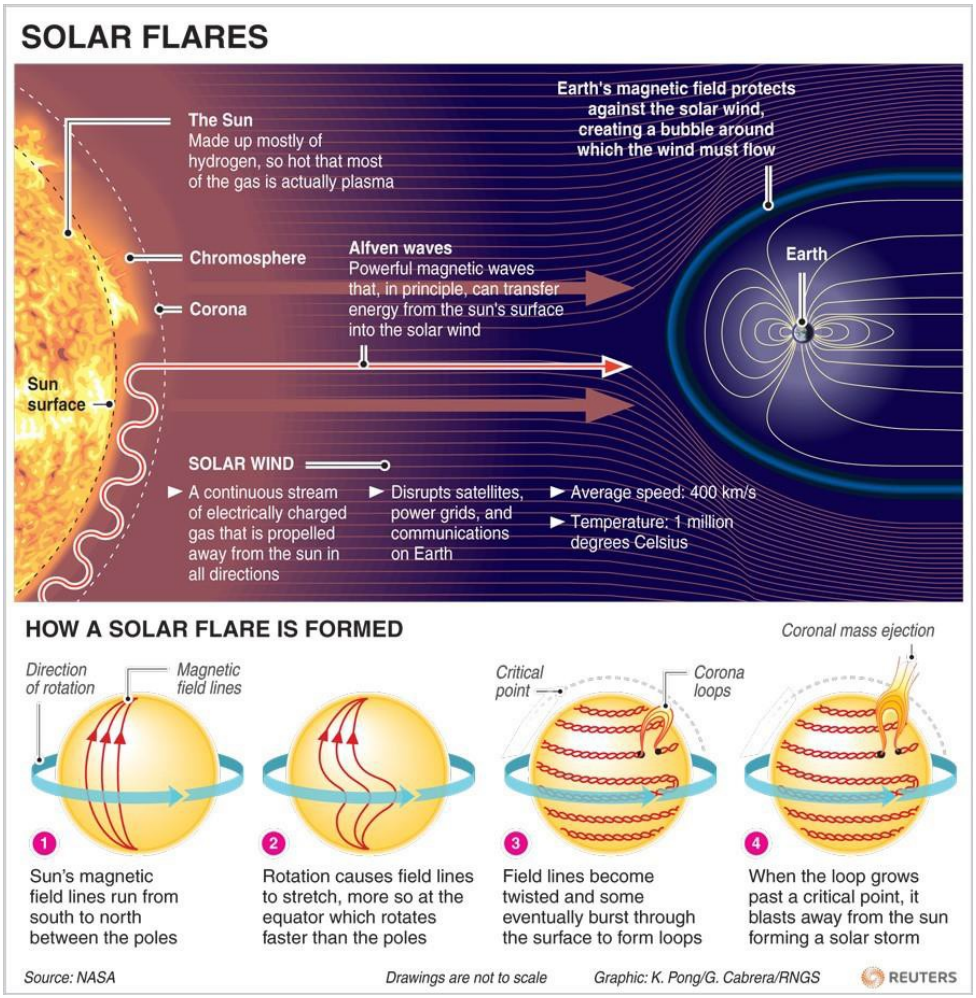
I. An aurora is caused by the **streams of electrified particles** (which are emitted by the sun) trapped in the magnetic field of the earth.

II. It is produced when this **magnetosphere is disturbed** by the solar wind carrying the charged particles.

- Auroras are seen in latitudes of around 70 degrees.
- They generally occur in a band known as the 'auroral zone'. The auroral zone is 3 to 6 degrees wide in latitude. It lies between 10 and 20 degrees from the geomagnetic poles.
- This is visible quite clearly during the night.
- Auroras can sometimes be seen at latitudes below the actual auroral zone. They can appear in various forms like streamers, patches, arcs, scattered light, diffused light etc.
- The brightest and the most distinctive of all forms of auroras are the ones that are curtain-like in the shape of an arc, extending in the east-west direction. This natural light effect is known as 'Aurora Borealis in northern altitudes, while the effect in the southern latitudes is known as 'aurora australis.
- Aurora borealis is also known as 'Northern lights'. Similarly, aurora australis is also known as 'Southern lights'.

NOTE;-

- Auroras are not just something that happens on Earth. If a planet has an atmosphere and magnetic field, they probably have auroras. Auroras on Jupiter and Saturn have been seen.



PSLV-C53 MISSION

- The **Indian Space Research Organisation (ISRO)** launched three satellites for Singapore from its Satish Dhawan Space Centre, Sriharikota.
- The PSLV-C53 mission lifted off at 06:02 pm to deploy the three satellites in Low Earth Orbit (LEO).

It carries three satellites to deploy them in Low Earth Orbit (LEO).

SATELLITES

I. DS-EO, a 365 kg and NeuSAR, a 155 kg satellite both belong to Singapore.
II. Third satellite is a 2.8 kg Scoob-1 of Nanyang Technological University (NTU), Singapore.

PSLV-C53 MISSION

I. It is the second dedicated commercial mission of NewSpace India Limited (NSIL).
II. It is designed to orbit DS-EO satellite along with two other co-passenger satellites from Singapore.
III. This is the 55th mission of PSLV and 15th mission using the PSLV-Core Alone variant.
IV. The mission proposes to demonstrate the utilisation of the spent upper stage of the launch vehicle as a stabilised platform for scientific payloads subsequent to the separation of the satellites.

FEATURES

I. A **four stage, 44.4 m tall PSLV-C53** has a lift-off mass of 228.433 t.
II. It would inject a **DS-EO satellite** into an orbit with semi-major axis of 6948.137 + 20 km, at an altitude of 570 km measured from the equator, with a low inclination of 10 deg. +0.20.

NEW POEM PLATFORM

- Recently, the ISRO achieved the feat of successfully launching the **PSLV Orbital Experimental Module or 'POEM'.**
- Besides this achievement, ISRO also launched three satellites from Singapore on the PSLV-C53.
- This was the second PSLV **mission of the year.** In February 2022, ISRO launched PSLV-C52 with theEOS-4 and two smaller satellites.
- This was the second dedicated commercial mission of NewSpace India Limited (NSIL), the commercial arm of ISRO.

SINGAPOREAN SATELLITES

- DS-EO: It carries an electro-optic, multispectral payload to provide full-color images for land classification and serve humanitarian assistance, and disaster relief needs.
- NeuSAR – It is Singapore's first small commercial satellite carrying a SAR (synthetic aperture radar) payload, which is capable of providing images day and night and under all weather conditions.
- SCOOB-I satellites – It is the first in the Student Satellite Series (S3-I), a hands-on student training program from the Satellite Research Centre (SaRC) at Singapore's NTU School of Electrical and Electronic Engineering.

KEY HIGHLIGHTS OF POEM

- **POEM (PSLV Orbital Experimental Module)** is an experimental mission by ISRO which performs **in-orbit scientific experiments** during the fourth stage of the Polar Satellite Launch Vehicle (PSLV) launch vehicle as an orbital platform.

A. The PSLV is a **four-stage rocket where the first three spent stages fall back into the ocean,** and the final stage (PS4) — after launching the satellite into orbit — ends up as space junk.
B. However, in PSLV-C53 mission, the spent final stage will be **utilised as a "stabilised platform" to perform experiments.**
1. It is the first time that the (fourth stage) PS4 stage would **orbit the earth as a stabilized platform.**
2. POEM has a dedicated **Navigation Guidance and Control (NGC)** system for attitude stabilization, which stands for controlling the orientation of any aerospace vehicle within permitted limits. The **NGC will act as the platform's brain to stabilize it with specified accuracy.**

it Carry

I. POEM carries six payloads including two from **Indian Space Start-ups, Digantara, and Dhruva Space** enabled through IN-SPACE and NSIL
II. POEM will derive its power from **solar panels** mounted around the PS4 tank, and a **Li-Ion battery**. It will **navigate using Four Sun Sensors, a Magnetometer, Gyros & NAVIC**
III. It also carries dedicated control thrusters using Helium gas storage. It is enabled with a telecommand feature.

OVERVIEW –ISRO

ISRO'S LAUNCH VEHICLES

- On February 14, the Indian **Space Research Organisation (ISRO)** launched its **first space mission** of the year. An earth observation satellite named **EOS-04** along with two other smaller satellites were launched into space using a **PSLV rocket.**

KEY POINTS:

- Launchers or Launch Vehicles or Rockets are used to carry spacecraft to space.

A. The rockets have powerful propulsion systems that generate the huge amount of energy required to lift heavy objects like satellites into space, overcoming the gravitational pull of the earth.

B. Satellites, or payloads, sit inside the rocket, and are ejected once they reach near their intended orbit in space.

- Most satellites have small propulsion systems and carry small amounts of fuel, because they encounter very little drag, or force, in outer space.
- Rockets have several detachable energy-providing parts.

A. They burn different kinds of fuels to power the rocket. Once their fuel is exhausted, they detach from the rocket and fall off, often burning off in the atmosphere due to air-friction, and getting destroyed.

B. Only a small part of the original rocket goes till the intended destination of the satellite.

C. Once the satellite is finally ejected, this last part of the rocket either becomes part of space debris, or once again burns off after falling into the atmosphere.

- Satellites carry one or more instruments that do the scientific work for which they are sent into space.

A. Their operational life sometimes extends up to decades.

B. But rockets, or launch vehicles, become useless after the launch. Their only job is to take the satellites to their intended orbits.

In order to achieve high accuracy in placing satellites into their orbits, a combination of accuracy, efficiency, power and immaculate planning are required.

Key Phrases: Indian Space Research Organisation, Launch Vehicles, Polar Satellite Launch Vehicle, Geosynchronous Satellite Launch Vehicle, Satellites or payloads, Sounding Rockets, Satellite Launch Vehicle, ASLV, Small Satellite Launch Vehicle, RLV-TD.

I. ISRO's Launch Vehicle Programme spans numerous centres and employs over 5,000 people.
II. Vikram Sarabhai Space Centre, located in Thiruvananthapuram, is responsible for the design and development of launch vehicles.
III. Liquid Propulsion Systems Centre and ISRO Propulsion Complex, located at Valiamala and Mahendragiri respectively, develop the liquid and cryogenic stages for these launch vehicles.
IV. Satish Dhawan Space Centre, SHAR, is the space port of India and is responsible for integration of launchers. It houses two operational launch pads from where all GSLV and PSLV flights take place.

LAUNCH VEHICLES USED BY ISRO

India has two operational launchers: Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV).

Sounding rockets 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.
- ISRO started launching indigenously made sounding rockets from 1965 and experience gained was of immense value in the mastering of solid propellant technology.
- In 1975, all sounding rocket activities were consolidated under the **Rohini Sounding Rocket (RSR) Programme.**
- RH-75, was the first truly Indian sounding rocket, followed by RH-100 and RH-125 rockets.

The first launch vehicle developed by ISRO was simply called SLV, or satellite launch vehicle.

- Satellite Launch Vehicle-3 (SLV-3) was India's first experimental satellite launch vehicle, which was an all solid, four stage vehicle weighing 17 tonnes with a height of 22m and capable of placing 40 kg class payloads in Low Earth Orbit (LEO).

It was followed by the Augmented Satellite Launch Vehicle or ASLV.

- These two could carry small satellites, weighing up to 150 kg, to the lower earth orbits.
- ASLV operated till the early 1990s before PSLV came on the scene.

PSLV's (Polar Satellite Launch Vehicle) first launch was in 1994, and it has been ISRO's main rocket ever since. Today's PSLV, however, is vastly improved and several times more powerful than the ones used in the 1990s.

- **Presently, it has three Variants:** PSLV - CA (Core Alone), PSLV-G, PSLV - XL.
- PSLV is the most reliable rocket used by ISRO till date, with 52 of its 54 flights being successful.
- The vehicle successfully launched two spacecraft – Chandrayaan-1 in 2008 and Mars Orbiter Spacecraft in 2013 – that later traveled to Moon and Mars respectively

GSLV (Geosynchronous Satellite Launch Vehicle) is much more powerful rocket, meant to carry heavier satellites much deeper into space.

I. This fourth generation launch vehicle is a three stage vehicle with four liquid strap-ons.The indigenously developed **Cryogenic Upper Stage (CUS),** which is flight proven, forms the third stage of **GSLV Mk II.**
II. Till date, GSLV rockets have carried out 18 missions, of which four ended in failure.
III. GSLV carried the Chandrayaan-2 mission, and is slated to take the Gaganyaan manned space mission as well.

The next variant of GSLV is GSLV Mk III, with indigenous high thrust cryogenic engine and stage, having the capability of launching 4 tonne class of communication satellites, to the geosynchronous transfer orbit, close to 36,000 km from earth's surface.

- It can take 10,000-kg satellites to the lower earth orbits. Mk-III versions have made ISRO entirely self-sufficient for launching its satellites.
- Before this, it used to depend on the European Arianne launch vehicle to take its heavier satellites into space.

ISRO has also developed a launch vehicle specifically for small and micro-satellites, called Small Satellite Launch Vehicle, or SSLV, and is targeted at rising global demand for the launch of such satellites.

I. SSLV is meant to offer cost-effective launch services for satellites up to 500 kg.
II. The inaugural SSLV launch is slated for March, 2022. It is supposed to carry an indigenous earth observation satellite EOS-03 into space.
III. The development and manufacture of the SSLV are expected to create greater synergy between the space sector and private industries – a key aim of the space ministry.
IV. One of the mandates of the newly-created ISRO commercial arm, **New Space India Limited (NSIL)** is to mass-produce and manufacture the SSLV and the more powerful PSLV in partnership with the private sector in India through technology transfers.

Reusable rockets: The future rockets are meant to be reusable. Only a small part of the rocket would be destroyed during the mission. The bulk of it would re-enter the earth's atmosphere and land very much like an airplane, and can be used in future missions.

- Reusable rockets would cut down on costs and energy, and also reduce space debris, which is becoming a serious problem because of the large number of launches.
- Fully-reusable rockets are still to be developed, but partially-reusable launch vehicles are already in use.
- ISRO has also developed a reusable rocket, called **RLV-TD (Reusable Launch Vehicle Technology Demonstrator)** which has had a successful test flight in 2016.
- The configuration of RLV-TD is similar to that of an aircraft and combines the complexity of both launch vehicles and aircraft.

CONCLUSION:

- The year's first successful launch laid the groundwork for 2022 where ISRO will look to regain launch momentum if missions that had been lost due to Covid-19 and successive lockdowns. Several missions that had been delayed will be aimed to return on track throughout the year.
- **Department of Space has planned 19 missions to be launched in 2022.** During the year, ISRO will lift off 08 launch vehicle missions, 07 spacecraft missions, and 04 technology demonstrator missions.

NURI: SOUTH KOREA'S FIRST HOMEGROWN SPACE ROCKET

- South Korea has launched its first ever space rocket on October 21, 2021. This is the first rocket completely developed and built in South Korea. However, it failed to successfully deploy a test satellite into orbit.
- The rocket is called as "Nuri".
- It is a 47-meter rocket that was lifted off, with bright yellow fire shooting from the engines.

- The rocket was launched from Naro Space Center, South Korea. This space centre is located on a small island on the southern coast of South Korea.

NURI –SOACECRAFT :

- Nuri is the South Korea's first space launch vehicle, that was developed and built completely using the South Korean technology. It is a three-stage rocket and is powered by five rocket engines for completing its first and second stages. Another engine is used in the final stage of the rocket. Rocket is designed to carry a payload of around 1.5 tons to an orbit between 600 to 800 kilometres above Earth.

FAILED MISSION :-

- This mission failed because the third-stage engine stopped burning some 50 seconds earlier than it was expected. This in turn prevented the payload from reaching its right speed for reaching into the orbit. Second attempt of the Nuri spacecraft have been planned for May.

PURPOSE:

- South Korea was earlier dependent on other countries for launching its satellites since early 1990s. Now it is trying to become the 10th country to send satellite into space using its own technology.

GAIA SPACE MISSION AND REVELATION ABOUT THE MILKY WAY

Recently, European Space Agency's star-mapping Gaia probe has released its third dataset.

Gaia space mission and revelation about the Milky Way

Recently, European Space Agency's star-mapping Gaia probe has released its third dataset.

MAJOR FINDINGS:

I. The probe **has revealed** an unexpected phenomenon called '**starquakes**', which are similar to earthquake-like movements but on the surface of stars.
II. The data has also **revealed the largest chemical map of the entire Milky Way**, showing the DNA of millions of stars.
III. It includes their age, mass, chemical composition, colour, temperature, and metal content.
IV. Besides, the new data has also made **discoveries about binary star systems, quasars, asteroids, and exoplanets.**

Gaia Mission:

A. Gaia is an ongoing astronomical observatory mission launched in December 2013 by the European Space Agency (ESA).
B. Objective: To create the most accurate and complete 3D map of the Milky Way by surveying 1% or one billion of the galaxy's 100 billion stars.
C. The spacecraft is strategically stationed 1.5 million km from the Earth, in the opposite direction of the sun, in an orbit around the gravitational parking point in space called the Lagrange 2 or L2.
D. Gaia can chart stars and objects as far as 30,000 lightyears.
E. Millions of observations made by Gaia is observed by the Gaia Data Processing and Analysis Consortium (DPAC), a group of 400 scientists.
F. Gaia's data release was planned in four tranches:

- ❖ The first two datasets were released in 2016 and 2018 respectively, the third set is the current one, and the final data will be released in 2030 after Gaia is done mapping the skies in 2025.

The Gaia data shows the radial velocity of 33 million stars which can help scientists **to figure out the trajectory of the stars and also their location of origin.**

NEW DATA REVEALED

STARQUAKES:

- ➢ Starquakes can be **likened to tsunamis or massive vibrations** on the surface of stars that can change their shape.
- ➢ Such starquakes were **also detected on the surface of stars** that should not have any such large-scale vibrations as per existing astronomical theories.

QUASARS:

A. Quasars are extraordinarily active and bright cores of galaxies powered by supermassive black holes.
B. These are the most luminous objects in the universe and are visible along its distant edges.
C. The new Gaia data has revealed the measurements of over a million confirmed quasars
D. The discovery of new quasars is significant as it helps to measure the most distant stretches of our universe.

STELLAR DNA:

A. The data shows chemical components, colours, brightness, velocity, temperatures, and positions of millions of stars.
B. The chemical composition of the stars also reveals what elements they contain.
C. Only light elements, hydrogen and helium, were formed during the Big Bang.
D. Chemical composition can be used to determine which stars were born in another galaxy and then migrated to the Milky Way.

BINARY STARS:

A. Binary star systems are two stars that orbit each other around a shared centre.
B. The new data has revealed the position, distance, orbits, and masses of over 8,00,000 binary star systems.
C. The data can be useful to calculate the mass of individual stars of the binary system, how stars work, and even discover if one of the two stars is an exoplanet.

GEOMAGNETIC STORM

Recently, Elon Musk's STARLINK has **lost dozens of satellites** that were caught in a geomagnetic storm a day after they were launched.

- ❖ The satellites were designed to burn up on reentry into the Earth's atmosphere, and did not create DEBRIS IN SPACE
- ❖ However, the loss of 40 satellites — most of a launch batch — in a single solar event has been described as "unheard of" and "huge".

Starlink

- Starlink is a **SpaceX project** to build a broadband network with a cluster of orbiting spacecraft that could eventually number thousands.
- The **Starlink satellites carry Hall thrusters**, which use electricity and krypton gas to generate an impulse, to manoeuvre in orbit, maintain altitude and guide the spacecraft back into the atmosphere at the end of their mission.
- The Starlink network is **one of several ongoing efforts** to start beaming data signals from space.

GEOMAGNETIC STORM

- It is also called a magnetic storm or solar storm.
- It is a major disturbance of Earth's magnetosphere that occurs when there is a very efficient exchange of energy from the solar wind into the space environment surrounding Earth.
- They occur during the release of magnetic energy associated with sunspots ('dark' regions on the Sun that are cooler than the surrounding photosphere) and can last for a few minutes or hours.
- The material associated with these eruptions consists primarily of protons and electrons with an energy of a few thousand electron volts.
    - This material, called plasma, moves through the interplanetary medium at speeds from less than 10 km (6 miles) per second to more than 2,000 km (1,200 miles) per second, so that the ejected material reaches Earth in approximately 21 hours.

I. The largest storms that result from these conditions are associated with solar **coronal mass ejections (CMEs)** where a **billion tons or so of plasma** from the sun, with its **embedded magnetic field, arrives at Earth.**
II. **Effect on Earth:**
III. **They** can hit operations of space-dependent services like **global positioning systems (GPS), radio, and satellite communications**.
IV. Aircraft flights, power grids, and space exploration programmes are vulnerable.

PREDICTING SOLAR STORMS:

- Solar physicists and other scientists use computer models to predict solar storms and solar activities in general.
- Current models are capable of predicting a storm's time of arrival and its speed.

But the storm's structure or orientation still cannot be predicted.

I. Solar Storms occur during the **release of magnetic energy** associated with SUNSPOTS ('dark' regions on the Sun that are cooler than the surrounding photosphere - the lowest layer of the solar atmosphere), and can last for a few minutes or hours.
II. A geomagnetic storm is a **major disturbance of Earth's** MAGNETOSPHERE that occurs when there is a very **efficient exchange of energy from the solar wind into the space environment** surrounding Earth.
III. The magnetosphere **shields our home planet from harmful solar and cosmic particle radiation,** as well as erosion of the atmosphere by the solar wind – the constant flow of charged particles streaming off the Sun.
IV. These storms **result from variations in the solar wind** that produce major changes in the currents, plasmas, and fields in Earth's magnetosphere.
    - The solar wind conditions that are effective for creating geomagnetic storms are sustained (for several to many hours) periods of high-speed solar wind, and most importantly, a

southward directed solar wind magnetic field (opposite the direction of Earth's field) at the dayside of the magnetosphere.

- This **condition is effective for transferring energy** from the solar wind into Earth's magnetosphere.

1. The largest storms that result from these conditions are associated with solar CORONAL MASS EJECTIONS where a billion tons or so of plasma from the sun, with its embedded magnetic field, arrives at Earth.
2. CMEs are large ejections of plasma and magnetic fields that **originate from the Sun's corona** (outermost layer).

IT AFFECT EARTH

CAN IMPACT SPACE WEATHER:

- Not all solar flares reach Earth, but solar flares/storms, **Solar Energetic Particles (SEPs),** high-speed solar winds, and **Coronal Mass Ejections (CMEs)** that come close can impact space weather in **near-Earth space and the upper atmosphere.**

Can Hit Operations of Space-Dependent Services:

- Solar storms can hit operations of space-dependent services like GPS radio, and satellite communications. Aircraft flights, power grids, and space exploration programmes are vulnerable.

Can Potentially Create Disturbances in the Magnetosphere:

1. **Coronal Mass Ejections (CMEs)** with ejectiles loaded with matter travelling at millions of miles an hour, **can potentially create disturbances in the magnetosphere,** the protective shield surrounding the Earth.
2. Astronauts on spacewalks face health risks from possible exposure to solar radiation outside the Earth's protective atmosphere.

Solar Storms Predicted

1. Solar physicists and other scientists use **computer models to predict solar storms** and solar activities in general.
2. Current models are **capable of predicting a storm's time of arrival** and its speed.
3. But the storm's structure or orientation still cannot be predicted.
4. Certain orientations of the magnetic field **can produce a more intense response** from the magnetosphere, and trigger more intense magnetic storms.
5. With the **increasing global dependence on satellites** for almost every activity, **there is a need for better space weather forecasts a**nd more effective ways to protect satellites.

BLACK HOLE

- Recently, the **National Aeronautics and Space Administration (NASA)** shared an audio clip of a supermassive black hole located 250 million light-years away.
- The black hole in the **Perseus galaxy cluster** has been associated with sound since 2003.

Sagittarius A* : Black Hole at Centre of Milky Way

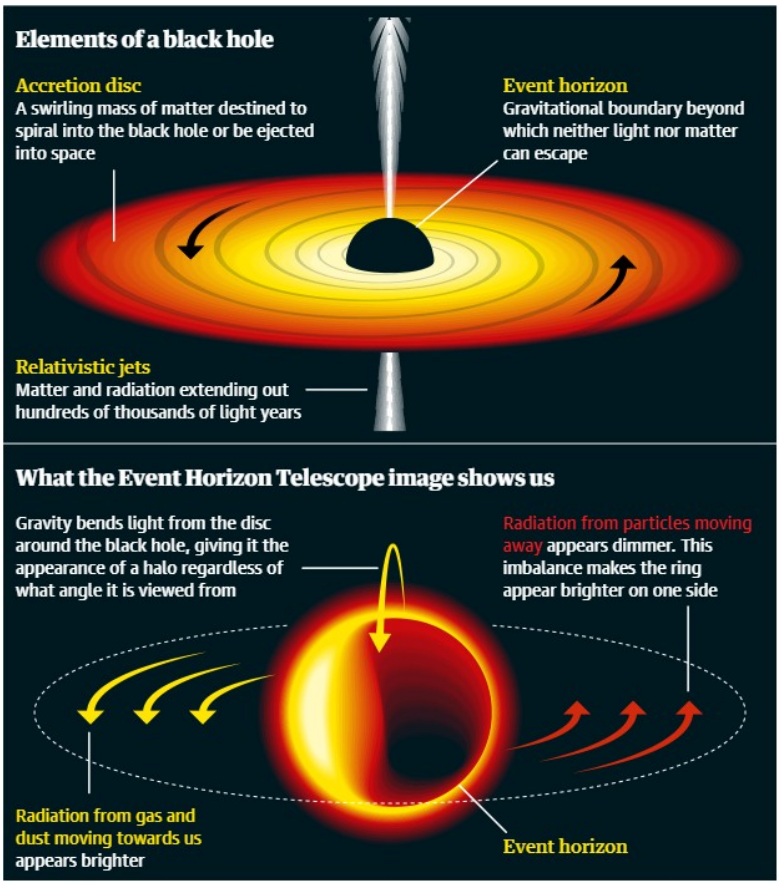
I. Recently, Scientists from the EVENT HORIZON TELESCOPE facility, revealed the first image of the black hole named Sagittarius A* at the centre of our galaxy - the Milky Way.

II. Nearly all galaxies have these giant black holes at their centre, where light and matter cannot escape, making it extremely hard to get images of them.
III. Researchers called the black hole "**the gentle giant in the centre of our galaxy**".

Black Hole Image Unveil

1. This image of the black hole referred to as **Sagittarius A* (Sagittarius A(asterisk))** gave further support to the idea that the compact object at the centre of our galaxy is indeed a black hole.
2. It is near the border of Sagittarius and Scorpius constellations. **It is 4 million times more massive than our sun.**
3. It strengthens Einstein's general theory of relativity that a point in space where matter **is so compressed as to create a gravity field from which even light cannot escape.**
4. The researchers said that imaging Sagittarius A*, the black hole at the centre of the Milky Way, was much more difficult than imaging M87.

❖ In 2019, the Event Horizon Telescope made history by releasing the first ever image of a black hole MESSIER-879 M-87) – the black hole at the centre of a galaxy M87, which is a supergiant elliptic galaxy.



➢ A black hole is a place in space where gravity pulls so much that even light cannot escape.
➢ The gravity is so strong because matter has been squeezed into a tiny space. This can happen when a star is dying.

Visibility:

1. Because no light can get out, they are invisible.
2. Space telescopes with special tools can help find black holes.
3. The gasses swirling around actually help in getting their images.

4. FOCUS :-

- ❖ Black holes can be big or small.
- ❖ Scientists think the smallest black holes are as small as just one atom. These black holes are very tiny but have the mass of a large mountain.
- ❖ Another kind of black hole is called "stellar." Its mass can be up to 20 times more than the mass of the sun.
- ❖ The largest black holes are called 'supermassive' and they have masses that are more than 1 million suns together.

SgrA*

- ➢ The supermassive black hole at the center of the Milky Way galaxy is called Sagittarius A.
- ➢ It has a mass equal to about 4 million suns and would fit inside a very large ball that could hold a few million Earths.

Black Holes Formation :-

1. Scientists think the smallest black holes formed when the universe began.
2. Stellar black holes are made when the center of a very big star falls in upon itself or collapses. When this happens, it causes a supernova. A supernova is an exploding star that blasts part of the star into space.
3. Scientists think supermassive black holes were made at the same time as the galaxy they are in.

SIGNIFICANCE OF THE RECENT FINDINGS

I. **Insight into space exploration**: The sound extracted from a black hole at the centre of the Perseus galaxy cluster gives us new insight into space exploration and research.
II. **It is a popular misconception that there is no sound in space**: It originates from the fact that most space is essentially a vacuum, providing no medium for sound waves to propagate through.
III. A galaxy cluster has copious amounts of gas that envelop the hundreds or even thousands of galaxies within it, providing a medium for the sound waves to travel.

PSLV-C54

I. Recently, the ISRO has successfully launched thePSLV- **C54** from the Satish Dhawan Space Centre in Sriharikota, Andhra Pradesh.
II. This was the 56th flight of PSLV, which marks the final mission for the year for PSLV-C54 rocket.

SATELLITES LAUNCHED

Nano Satellite-2 for Bhutan (INS-2B):

- ❖ **INS-2B satellite** is a collaborative mission between India and Bhutan with **two payloads.**
- ❖ **NanoMx**, a multispectral optical imaging payload developed by Space Applications Centre (SAC)
- ❖ **APRS-Digipeater** which is jointly developed by DITT-Bhutan and URSC was successfully deployed.

SIGNIFICANCE OF INS-2B:

- It will provide high-resolution images to Bhutan for the management of the country's natural resources.
- The launch of the new satellite is part of India's efforts to back Bhutanese King Jigme Khesar Namgyel Wangchuck's plans to use advanced technology, including ICT and space technology, for the development of Bhutan.
- The collaboration also fits in with India's "neighbourhood first" policy.

Anand:

- The Anand three axis stabilized Nano satellite is **a technology demonstrator for miniaturized electro-optical payload** and all other sub-systems like TTC, power, onboard computer and ADCS from Pixxel, India was also placed in the orbit successfully.

ASTROCAST:

1. Astrocast, a 3U spacecraft, is a technology demonstrator satellite for the Internet of Things (IoT) as the payload. There are 4 nos. of Astrocast Satellites in this mission. These spacecrafts are housed within an ISISpace QuadPack dispenser.
2. The dispenser protects the satellite from contamination.

THYMBOLT SATELLITES:

- The Thybolt is a 0.5U spacecraft bus that includes **a communication payload to enable rapid technology demonstration and constellation development for multiple users** from Dhruva Space using their own Orbital Deployer with a minimum lifetime of 1 year.

EOS-6:

- Earth Observation Satellite-06 (EOS-06) is the **Oceansat series' 3rd-generation satellite** envisaged to observe ocean colour data, sea surface temperature and wind vector data to use in oceanography, climatic and meteorological applications.
- The satellite also **supports value added products such as potential fishing zones using chlorophyll,** Sea Surface Temperature (SST) and wind speed and land based geophysical parameters.

DEFENCE TECHNOLOGY

INS VAGIR

- The **fifth Scorpene class conventional submarine** was commissioned into the Indian Navy as **INS Vagir** on 23rd January, 2023 in the presence of **Chief of Naval Staff Admiral R. Hari Kumar** at Naval Dockyard Mumbai.
- The **sixth and final Scorpène-class submarine** built in India under technology transfer is **currently undergoing sea trials and will be delivered to the Navy in 2024.**
- The **Navy now has 16 conventional and one nuclear submarine** in service.
- It consists of seven Russian Kilo class submarines, four German HDW submarines, five Scorpene class submarines, and the indigenous nuclear ballistic missile submarine INS Arihant.

I. Vagir was launched on November 12, 20 under Project 75 (P75), and was delivered to the Indian Navy on December 20, 22 following the completion of sea trials.
II. Vagir has the distinction of having the shortest build time of any indigenously manufactured submarine to date.

PROJECT 75

- Around the time of the Kargil War in the late 1990s, a three-decade plan for domestic submarine construction in cooperation with foreign parties took shape. This plan was known to have two independent series of submarine-building lines, codenamed Project 75 and Project 75I (approved in 2007).
- At an estimated cost of ₹ 43,000 crores, the project calls for the domestic manufacturing of six Scorpene-Class assault submarines, which weigh 1,500 tonnes and can dive to a depth of 300 metres fitted with the most advanced Air Independent Propulsion technology.
- The programme has enabled indigenous defence producers to collaborate with top international defence corporations in developing cutting-edge military platforms and lessen reliance on imports.
- A $3.75 billion agreement was inked in October 2005 under which the Mazagon Dock Shipbuilders Limited (MDL) was contracted to build six Scorpene submarines with technical support from the Naval Group of France.
- The first submarine in the series, INS Kalvari, entered service with the Indian Navy in December 2017, followed by INS Khanderi in September 2019, INS Karanj in March 2021, and INS Vela in November 2021.
- Vagsheer, the sixth and final submarine, is anticipated to be delivered to the Navy by the end of 2023.

INS VAGIR

I. Vagir is the fifth of the six diesel-electric attack submarines of the **Kalvari class** that had been planned under **Project 75**.
II. Vagir has been named after a predatory marine species called the Sand Fish that is found in the Indo-Pacific region.
III. In 1973, a Russian submarine was inducted into the Indian Navy and named INS Vagir. The vessel was later decommissioned in 2001.
IV. The new submarine is capable of operating in a wide range of naval combat including anti-warship and anti-submarine operations, intelligence gathering, surveillance and naval mine laying.
V. The submarine is armed with precision-guided missiles and has stealth features like advanced acoustic absorption techniques, low radiated noise levels, and hydro-dynamically optimised shape.
VI. The submarine is built to function in all operational environments and to cooperate with other members of a Naval Task Force.
VII. Torpedoes and tube-launched anti-ship missiles can be used to launch attacks, whether the target is above or below the surface.

SPECIFICATIONS OF VAGIR

I. The latest submarine is named after the former Vagir, a submarine that served in the Navy between 1973 and 2001 and performed a variety of operational missions.
II. The new Vagir's construction began in 2009, and it made its first sea voyage in February last year.
III. The submarine, also known as the Sand Shark, was delivered to the Indian Navy in December 2022.
IV. Vagir represents stealth and fearlessness, as it comes with features such as an advanced acoustic absorption technique.
V. Vagir will help the Indian Navy advance its maritime interests by performing a variety of missions such as anti-surface warfare, anti-submarine warfare, intelligence gathering, mine laying, and surveillance missions.

KALVARI CLASS

- Vagir is a Kalvari-class submarine, which also includes the INS Kalvari, INS Khanderi, INS Karanj, INS Vela, and INS Vagsheer.

- Kalvari and Khanderi were commissioned in 2017 and 2019, respectively, and Vela and Karanj were inducted in 2021.
- Vagir has now been commissioned, and Vagsheer was launched in 2022 and is expected to be inducted next year.
- The current Kalvari-class submarines are named after previously decommissioned classes of submarines called Kalvari, which included the Kalvari, Khanderi, Karanj, and Vela classes - comprising Vela, Vagir, and Vagshir.
- The now-decommissioned Kalvari and Vela classes were among the first submarines in the post-independence Indian Navy, belonging to the Foxtrot class of Soviet origin.
- Vagir, like Kalvari, is named after a predatory marine species, the Sand Fish. Khanderi was named after an Island Fort built by Chhatrapati Shivaji that played an important role in his Navy.
- Karanj is also named after an island located south of Mumbai.

SIGNIFICANCE

- Vagir will be the Navy's third submarine in less than 24 months. This is a significant accomplishment that demonstrates the maturation of India's shipbuilding industry and the maturation of our defense ecosystem.
- It is also a shining example of our shipyards' expertise and experience in constructing complex and complicated platforms.
- These aspects also serve to reaffirm the Indian Navy's unwavering commitment and steadfast determination to become a fully Atma Nirbhar force by 2047.

STRATEGIC IMPORTANCE

I. India currently operates one nuclear-powered Chakra submarine and two other nuclear-powered Arihant submarines, as well as submarines from three Diesel Electric classes — Kalvari, Shishumar, and Sindhughosh — some of which are aging.

II. The nuclear-powered and diesel-electric submarines play specific roles in Carrier Battle Groups, which are formations of ships and submarines led by Aircraft Carriers.

III. According to the basic principles of submarine deployment and the minimum requirement for India to create strategic deterrence, there is a specific number of submarines of both types that India must have in active service.

IV. India currently has fewer submarines than is required, with some more of both types under construction. India currently has a less-than-ideal number of submarines, with many new ones in various stages of construction.

V. In the late 1990s, around the time of the Kargil war, a three-decade plan for indigenous submarine construction took shape, which is known to have two separate series of submarine building lines – codenamed Project 75 and Project 75I – in collaboration with foreign entities.

VI. The Ministry of Defence is also known to have established a roadmap for indigenous design and subsequent construction of submarines, which will add to the Navy's arsenal.

FURTHER ENHANCEMENT

I. Vagsheer, the sixth and final Scorpene class submarine built by Mazgaon Dock Shipbuilders Limited (MDL), was launched into water in April 2022 and is expected to be delivered to the Navy by the end of 2023.

II. Six Scorpene submarines are being built by the MDL under Project-75, with technology transferred from the Naval Group of France under a $3.75 billion deal signed in October 2005. The project is about four years behind schedule.

III. The first submarine, INS Kalvari, was commissioned in December 2017;

- ❖ the second, INS Khanderi, in September 2019;
- ❖ the third, INS Karanj, in March 2021; and
- ❖ the fourth, INS Vela, in November 2021.

1. Similarly, the tender for six more advanced conventional submarines under Project-75 is in the Request For Proposal (RFP) stage but has been delayed.
2. Due to delays in submarine induction, the SSK-209s (German HDWs) and EKMs (Russian Kilos) are being put through the Medium Refit Life Certification process, which will give them an additional 10 to 15 years of life.
3. To increase endurance, the Navy has planned to install **Air Independent Propulsion (AIP)** modules on all Scorpene submarines as they undergo refit in the coming years, beginning with INS Kalvari.
4. The Defence Research and Development Organization is working on an indigenous AIP module.

INS MORMUGAO

- ❖ The second of the PROJECT-15B **stealth-guided missile** destroyers built by Mazagon Dock Shipbuilders Limited (MDSL), **INS Mormugao (Pennant D67),** was commissioned into the Indian Navy.

INS MORMUGAO

History: Named after the historic port city of Goa on the west coast.

1. Launched on September 17, 2016, and commenced sea trials in 2021, coinciding with 60 years of **Goa Liberation.**
2. The commissioning on 18 December is significant as it was the same date in 1961 when Operation Vijay was launched to **liberate Goa from Portuguese rule.**

- ❖ **Development:** With over **75% indigenous content,** all her major weapons and sensors have been developed and manufactured in India either directly through design and development by Indian Original Equipment Manufacturers (OEMs) or through strategic tie-ups and Transfer of Technology with reputed foreign OEMs.
- ❖ Specifications and weaponry: Measuring 163m in length and 17m in breadth with a displacement of 7,400 tonnes, INS Mormugao is packed with sophisticated state-of-the-art weapons and sensors such as Surface-to-Surface Missiles and Surface-to-Air Missiles.

1. The ship is fitted with a modern **Surveillance Radar** which provides target data to the gunnery weapon systems.
2. Its **Anti-Submarine Warfare** capabilities are provided by indigenously-developed Rocket Launchers, Torpedo Launchers, and ASW helicopters.
3. the ship is equipped to fight under **Nuclear, Biological and Chemical warfare conditions.**
4. It is propelled by four powerful Gas Turbines, in a Combined Gas and Gas configuration, capable of achieving speeds in excess of 30 knots.
5. The ship has enhanced stealth features resulting in a reduced Radar Cross Section.
6. INS Mormugao has a complement of about 300 personnel.

P-15B DESTROYERS

- P15B destroyers incorporate new design concepts for improved survivability, seakeeping, and maneuverability.
- Enhanced stealth has also been achieved, making the ships difficult to detect.
- With a significantly increased indigenous content, P15B destroyers are a hallmark of self-reliance in warship design and building and a shining example of 'Aatmanirbhar Bharat'

1. Recently, the first ship of the four Project-15B state-of-the-art stealth guided missile destroyers i.e. 'Y 12704 (Visakhapatnam)', was delivered to the Navy.
2. The ship is constructed using indigenous steel DMR 249A and is amongst the largest destroyers constructed in India.

FOCUS :-

India's Destroyer Construction Programme:

1. India's indigenous Destroyer construction programme commenced in the late 1990s with the three Delhi class (P-15 class) warships and this was followed by three Kolkata class (P-15A) destroyers commissioned a decade later.
2. Presently, under the P-15B (Visakhapatnam Class), a total of four warships are planned (Visakhapatnam, Mormugao, Imphal, Surat).
3. The Destroyers come next only to an Aircraft Carrier (INS Vikramaditya) in terms of their reach and endurance.

PROJECT-15B:

- **Four Guided missile Destroyers of Project 15B (P 15B)** are under construction at M/s Mazagaon Dock Shipbuilders Limited, Mumbai. The contract for construction of these four ships was signed in 2011.
- These ships are **amongst the most technologically advanced Guided Missile Destroyers** of the world, with **state-of-the-art weapon/sensor package**, advanced stealth features and a high degree of automation.

FEATURES OF THE P-15B SHIPS:

1. These ships are equipped with BRAHMOS CRUISE MISSILE and long-range **Surface-to-Air Missiles (SAM).**
2. The ship has several indigenous weapons systems like **medium range Surface-to-Air Missile (SAMs)**, indigenous torpedo tube launchers, anti-submarine indigenous rocket launchers and 76-mm super rapid gun mount.

<u>OTHER THREE SHIPS OF PROJECT 15B:</u>

1. The second ship of P15B, Mormugao was launched in 2016, and is being readied for harbour trials.
2. The third ship (Imphal) was launched in 2019, and is at an advanced stage of outfitting.
3. The fourth ship (Surat) is under block erection and will be launched within this current financial year (2022) .

Role of P-15B:

1. The **Indian Navy's responsibilities** to safeguard a large coastline of 7516 Kms and about 1100 offshore islands along with 2.01 million sq km EXCLUSIVE ECONOMIC ZONE have been enhanced in the present geopolitical scenario.
2. Destroyers like the P-15B class shall **play an important role** in the larger oceans of the **Indo-Pacific,** making the Indian Navy a potent force.
3. The guided missile Destroyers are deployed for various responsibilities like escort duties with the Carrier Battle Group **to protect the Naval fleet against any air, surface and underwater threats.**

OTHER RECENT PROJECTS:

- PROJECT -75 I ; It envisages indigenous construction of submarines equipped with the state-of-the-art AIP at an estimated cost of Rs. 43,000 crore.
- PROJECT-75 :It is a **programme by the Indian Navy** that entails building six Scorpene-Class attack submarines. The programme has been undertaken with transfer of technology from French company Naval Group (formerly known as DCNS) at the Mazagon Dock Limited (MDL).

INDIA'S MISSILE SYSTEMS

Recently, an updated version of the Pinaka Missile System, named Pinaka Mark-II rocket was successfully flight-tested from the Integrated Test Range, Chandipur, Odisha.

1. Indigenization of technology
2. Role of external state and non-state actors in creating challenges to internal security.
3. Challenges to internal security through communication networks, the role of media and social networking sites in internal security challenges, basics of cybersecurity; money-laundering and its prevention.
4. Security challenges and their management in border areas; linkages of organized crime with terrorism Various Security forces and agencies and their mandate.

We frequently notice news related to ballistic missiles, cruise missiles and various missile systems of India. Memorizing names and salient features of various Indian missiles is hard without having a broader understanding of the concept of ballistic missiles and cruise missiles, and major missile defense systems. It is better to give these concepts a holistic structure rather than learning them in bits and pieces.

- The use of missiles in India began in the Ancient period, **where the missile was called ASTRA.**
- The scriptures and epics like Ramayana and Mahabharata have mentioned the missiles which are controlled by mantras, which can be related to modern-day missile's mission control software.
- The **world's first rocket was used by Tipu Sultan in the Anglo-Mysore war against the British in 18th century AD.**
- The missiles/rockets used by Tipu Sultan were made of Bamboo or steel spears, cast iron chamber as propellant and gunpowder as the warhead.
- During British rule, the missile development technology was left behind due to various factors like colonialism, lack of resources, lack of research capabilities, etc.,

CLASSIFICATION OF INDIAN MISSILES:

Based on Type: Ballistic Missile vs. Cruise Missile

Ballistic Missile:

1. A ballistic missile follows a ballistic trajectory to deliver one or more warheads on a predetermined target.
2. A ballistic trajectory is the path of an object that is launched but has no active propulsion during its actual flight (these weapons are guided only during relatively brief periods of flight).
3. Consequently, the trajectory is fully determined by a given initial velocity, effects of gravity, air resistance, and motion of the earth (Coriolis Force).
4. Shorter range ballistic missiles stay within the Earth's atmosphere.
5. Longer-ranged intercontinental ballistic missiles (ICBMs), are launched on a sub-orbital flight trajectory and spend most of their flight out of the atmosphere.

Types of ballistic missiles based on the range:

Short-range (tactical) ballistic missile (SRBM):

- The range between 300 km and 1,000 km.

Medium-range (theatre) ballistic missile (MRBM):

- 1,000 km to 3,500 km.

Intermediate-range (Long-Range) ballistic missile (IRBM or LRBM):

- 3,500 km and 5,500 km.

Intercontinental ballistic missile (ICBM):

- 5,500 km +

CRUISE MISSILE:

- ✓ A cruise missile is a guided missile (target has to be pre-set) used against terrestrial targets.
- ✓ It remains in the atmosphere throughout its flight.
- ✓ It flies the major portion of its flight path at an approximately constant speed.
- ✓ Cruise missiles are designed to deliver a large warhead over long distances with high precision.
- ✓ Modern cruise missiles are capable of traveling at supersonic or high subsonic speeds, are self-navigating, and are able to fly on a non-ballistic, extremely low-altitude trajectory.

Types of cruise missiles based on speed:

Hypersonic (Mach 5):

- These missiles would travel at least five times the speed of sound (Mach 5). E.g. BrahMos-II.

Supersonic (Mach 2-3):

- These missiles travel faster than the speed of sound. E.g. BrahMos.

Subsonic (Mach 0.8):

- These missiles travel slower than the speed of sound. E.g. Nirbhay.

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

BALLISTIC MISSILE	CRUISE MISSILE
It is propelled only for a brief duration after the launch.	Self-propelled till the end of its flight.
Similar to a rocket engine.	Similar to a jet engine.
Long-range missiles leave the earth's atmosphere and reenter it.	The flight path is within the earth's atmosphere.
Low precision as it is unguided for most of its path and its trajectory depends on gravity, air resistance, and Coriolis Force.	Hits targets with high precision as it is constantly propelled.
It can have a very long-range (300 km to 12,000 km) as there is no fuel requirement after its initial trajectory.	The range is small (below 500 km) as it needs to be constantly propelled to hit the target with high precision.
The heavy payload carrying capacity.	Payload capacity is limited.
Can carry multiple payloads (Multiple Independently targetable Re-entry Vehicle)	Usually carries a single payload.
Developed primarily to carry nuclear warheads.	Developed primarily to carry conventional warheads.

Based on Launch Mode:

1. Surface to Surface
2. Surface to Air
3. Air to Air

4. Air to Surface
5. Surface to Sea
6. Anti-tank missiles

Based on Range:

1. Short-range missiles
2. Medium range missiles
3. Intermediate-range missiles
4. Inter-Continental ballistic missiles

Based on Propulsion:

1. Solid propulsion
2. Liquid propulsion
3. Hybrid propulsion
4. Ramjet
5. Scramjet
6. Cryogenic

Based on warhead:

1. Conventional
2. Strategic (Nuclear)
3. Based on the Guidance System
4. Wire guidance
5. Command Guidance

- Inertial Guidance
- Terrestrial Guidance
- Laser Guidance
- RF and GPS guidance

INTEGRATED GUIDED MISSILE DEVELOPMENT PROGRAMME (IGMDP):

- IGMDP was conceived by Dr. A P J Abdul Kalam to enable India to attain self-sufficiency in missile technology.
- IGMDP was conceived in response to the Missile Technology Control Regime that decided to restrict access to any technology that would help India in its missile development program.
- To counter the MTCR, the IGMDP team formed a consortium of DRDO laboratories, industries, and academic institutions to build these sub-systems, components, and materials.
- IGMDP was started in 1983 and completed in March 2012.
- Keeping in mind the requirements of various types of missiles by the defense forces, the development of five missile systems was taken up.

Prithvi:

Short-range surface-to-surface ballistic missile (Prithivi means Earth Surface to Surface)

Agni:

Intermediate-range surface-to-surface ballistic missile

Trishul:

Short-range low-level surface-to-air missile

Akash:

Medium-range surface-to-air missile (Akash means Sky Surface to Air)

Nag:

1. Third-generation anti-tank missile (Nag means Snake Nag slithers like a Snake to hit a tank!)
2. After its success, the Agni missile program was separated from the IGMDP upon realizing its strategic importance.

- Missile Technology Control Regime (MTCR)
- MTCR an informal grouping established in 1987 by Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States to limit the proliferation of missiles and missile technology.
- The MTCR seeks to limit the risks of proliferation of weapons of mass destruction (WMD).
- MTCR places particular focus on rockets and unmanned aerial vehicles capable of delivering a payload of at least 500 kg to a range of at least 300 km.
- The MTCR is not a treaty and does not impose any legally binding obligations.

India became its member in June 2016. India has been allowed to have its ballistic missiles able to deliver 500kgs payload with a range of 300kms.

BALLISTIC MISSILES INDIA:

Agni Missiles:

1. Ballistic missiles carrying nuclear warheads
2. Classified into three types viz. Medium Range Ballistic Missiles (MRBM), Intermediate-Range Ballistic Missiles (IRBM) and Intercontinental Ballistic Missiles (ICBM)
3. Agni-I, Agni-II, and Agni-III missiles were developed under the Integrated Guided Missile Development Program
4. Agni IV + Agni V – high accuracy Ring Laser Gyro based Inertial Navigation System (RINS) and the most modern and accurate Micro Navigation System (MINS)

Name	Type	Range (Km)	Status	Type
Agni I	MRBM	700-1200	Deployed	Surface to surface
Agni II	IRBM	2000-2500	Deployed	Surface to surface
Agni III	IRBM	3000-5000	Deployed	Surface to surface

Agni IV	IRBM	2500-3700	Deployed	Surface to surface
Agni V	IRBM	5000-8000	Tested	Surface to surface
Agni VI	IRBM	10000-12000	Under Development	Surface to surface

Prithvi Missiles:

1. Surface-to-surface short-range ballistic missiles (SRBM)
2. Dhanush is the naval variant of Prithvi Missiles – Sea to Surface
3. Prithvi-II – 1st missile developed by DRDO under IGMDP.

Name	Range (Km)
Prithvi I	150
Prithvi II	150-350
Prithvi III	350-650

Prahaar:

1. A solid-fuelled Surface-to-surface Missile with a range of 150 km
2. Equipped with omnidirectional warheads and could be used for striking both tactical and strategic targets
3. **India Sea-Based Nuclear-Armed Ballistic Missiles: Surface to Surface:**

Submarine-launched ballistic missiles (SLBM):

Name	Range (Km)
Dhanush	350
Sagarika	700

K4	3500
K5	600

SURFACE TO AIR MISSILES OF INDIA:

Name	Feature	Range
Akash	surface-to-air	30 km
Trishul	surface-to-air	12 km
Maitri	surface-to-air	15 km

AKASH AIR DEFENCE MISSILE SYSTEM :

1. Medium range Surface to air missile viz. approx. 35 km
2. Can employ multiple air targets while operating in fully autonomous mode
3. Can be launched from static or mobile platforms
4. Can carry conventional and nuclear warheads
5. It can operate in all weather conditions.
6. Developed under the integrated guided-missile development program by ISRO

LRSAM – INDIA-ISRAEL JOINT VENTURE MISSILE:

1. Long Range Surface to Air Missile (LRSAM) – called Barak 8 missile in Israel
2. Can take down an incoming missile as close as 500 meters away from the ship

ANTI TANK MISSILE INDIA:

Nag Missile:

1. "Fire-and-forget" anti-tank missile
2. An all-weather missile with a range of 3 to 7 km
3. Uses Imaging Infra-Red (IIR) guidance with day and night capability
4. Can be mounted on an infantry vehicle

NAG Missile Helina:

1. A variant of NAG Missile to be launched from Helicopter is being developed under the Project named HELINA (HELIcopter launched NAg)

Cruise Missiles India–

Brahmos Missiles

- Can be launched from submarines, ships, aircraft or land (Cruise Missiles)
- Presently the world's fastest cruise missile in operation (Brahmos)

- **Brahmos – Mach 2.8** Supersonic Cruise Missile developed in collaboration with Russia – 300 km
- **Brahmos 11- Mach 7** Hypersonic Cruise Missile in development collaboration with Russia.
- BRAHMOS is a joint venture between the Defence Research and Development Organisation of India (DRDO) and the NPOM of Russia.
- **Brahmos is named on the rivers Brahmaputra and Moskva.**
- It is a two-stage (solid propellant engine in the first stage and liquid ramjet in second) air to surface missile with a flight range of around 300 km.

Nirbhay:

1. 1st long-range subsonic cruise missile
2. Can be launched from land, sea, and air(Cruise missile)
3. Aring laser gyroscope for high-accuracy navigation and a radio altimeter for the height determination
4. **Strike range – 1000 km**
5. From Integrated Test Range at Wheeler Island, Chandipur, Orissa, by SFC monitored by DRDO

Dr. Abdul Kalam Island :

Formerly known as Wheeler Island, is an island off the coast of Odisha, India, approximately 150 kilometers (93 mi) east of the state capital Bhubaneshwar. The Integrated Test Range missile testing facility is located on the island. The island was originally named after English commandant Lieutenant Hugh Wheeler. On 4 September 2015, the island was renamed to honor the late Indian president, Dr. APJ Abdul Kalam.

AIR TO AIR MISSILE INDIA:

- **Astra Missile** – India's 1st Air to Air (BVR)
- Beyond Visual Range Air-to-Air Missile; smallest DRDO developed missile (3.8m)
- capable of engaging targets at varying range and altitudes allowing for engagement of both short-range targets (up to 20 km) and long-range targets (up to 80 km) using alternative propulsion modes

UNMANNED AERIAL VEHICLE:

Panchi:

1. The wheeled version of Unmanned Aerial Vehicle (UAV) Nishant capable of taking-off and landing using small airstrips
2. Have all the surveillance capabilities of UAV Nishant + longer endurance as it does not have to carry the airbags and parachute system as in the case of UAV Nishant.

Nishant UAV:

1. A multi-mission UAV with Day/Night operational capability, inducted in Army
2. Designed for battlefield surveillance, target tracking & localization, and artillery fire correction
3. Controlled from a user-friendly Ground Control Station + image processing system to analyze transmitted images from UAV

Anti-satellite weapons (ASAT):

1. In March 2019, India successfully tested its ASAT missile.
2. The ASAT missile destroyed a live satellite in Low Earth orbit (283-kilometre).
3. 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.

Pinaka Missile System:

1. Pinaka is an **indigenous multi-barrel rocket launch system,** which has been developed by the Defence Research and Development Organisation (DRDO) for the Indian Army.
2. Its weapon system has a state-of-the-art guidance kit bolstered by an advanced navigation and control system.
3. The **Pinaka Mark-II Rocket is modified as a missile by integrating with the navigation, control and guidance system to improve the accuracy and enhance the range.**
4. The navigation system of the missile is aided by the Indian Regional Navigation Satellite System **(IRNSS).**
5. It is an artillery missile system capable of striking into enemy territory up to a range of 75 kilometers with high precision.
6. The initial version of the weapon system was called Mark I, which had a range of 40 km. The upgraded version of Pinaka Mark II has an extended range of 70 to 80 km.

AGNI-5 BALLISTIC MISSILE

Recently, India successfully carried out the night trials of the Agni-5 nuclear-capable BALLISTIC MISSILE.

Features of the Missile

- Agni-5 is an **ingeniously built advanced surface-to-surface ballistic missile** developed under the IGMDP. It is a **fire-and-forget missile**, which cannot be stopped without an interceptor missile.
- The missile has the capability of hitting targets beyond the range of 5000 km and is crucial for India's self-defense systems.

AGNI MISSILES

- The Agni missile class is the backbone of India's nuclear launch capability, as are PRITHVI short-range ballistic missiles, submarine-launched ballistic missiles, and fighter aircraft.
- Agni-1 to 5 missiles are designed & developed byDRDO

Agni I: Range of 700-800 km. other ranges of agni missiles:

- Agni II: Range more than 2000 km.
- Agni III: Range of more than 2,500 Km
- Agni IV: Range is more than 3,500 km and can fire from a road mobile launcher.
- Agni-V: The longest of the Agni series, an Inter-Continental Ballistic Missile (ICBM) with a range of over 5,000 km.

INTEGRATED GUIDED MISSILE DEVELOPMENT PROGRAMME

1. IGMDP was the **brainchild of renowned scientist** Dr. apj abdhul kalam It was **intended to attain self-sufficiency** in the field of missile technology.

2. After keeping in mind, the requirements of various types of missiles by the defense forces, the program recognized the need to develop five missile systems.
3. The IGMDP formally got the approval of the Indian government in 1983.
4. It **brought together the country's scientific community,** academic institutions, R&D laboratories, industries and the three defence services in giving shape to the strategic, indigenous missile systems.

The missiles developed under IGMDP are:

- Short-range surface-to-surface ballistic missile – Prithvi
- Intermediate-range surface-to-surface ballistic missile – Agni
- Short-range low-level surface-to-air missile – Trishul
- Medium-range surface-to-air missile – Akash
- Third generation anti-tank missile – Nag

BRAHMOS

- The BrahMos is a ramjet supersonic cruise missile of a short-range developed by the Defence Research and Development Organisation and the **Russian Federation's NPO Mashinostroyeniya (NPOM)**. It is named after two major rivers of India and Russia: **Brahmaputra** and **Moskva.**
- In 1998, an intergovernmental agreement was signed between India and Russia, which led to the formation of BrahMos Aerospace. BrahMos Aerospace is a joint venture between the DRDO and NPOM. In the joint venture, Indian side holds a share of 50.5% and the Russian side 49.5%.
- The technology used in this joint venture is based on the Russian P-800 Oniks cruise missile and similar sea-skimming cruise missiles from Russia.
- The BrahMos supersonic cruise missile was first tested on **June 12, 2001** at Chandipur in Odisha. Since then it has been upgraded many times across various platforms, that is, the sea, land and air. When compared to subsonic cruise missiles, BrahMos has three times the speed, 2.5 times flight range and higher range.

TECHNICAL DETAILS OF BRAHMOS

BrahMos is a medium-range 2 stage missile. The propulsion of BrahMos can be explained as follows:

Stage 1	1. Solid Propellant Booster Engine 2. Is separated after it reaches MACH-1 or Supersonic speed
Stage 2	1. Liquid Ramjet Engine 2. Takes the missile close to MACH 3 in cruise phase

SPECIAL FEATURES OF BRAHMOS

1. Stealth Technology
2. Advanced guidance system
3. High Target Accuracy (irrespective of weather conditions)
4. Constant supersonic speed
5. Operates on '*Fire and Forget*' Principle
6. BrahMos can be launched from land, aircraft, ships, and even submarines.

7. One of the heaviest missiles, weighing up to 2.5 tonnes

BRAHMOS RECENTLY IN THE NEWS

1. In **December 2021**, the Defence minister of India laid the foundation for the BrahMos Aerospace cruise missile manufacturing unit in **Lucknow**. The setting up of the manufacturing unit will help in generating employment in and around the area.
2. On **January 11, 2022**, an advanced sea-to-sea variant of the BrahMos supersonic cruise missile was tested from the INS Visakhapatnam.
3. On **January 28, 2022**, **the Philippines** placed an order of $375 million for the BrahMos supersonic cruise missiles . It is the first export order from a foreign country.
4. On **May 12, 2022**, India successfully launched the **extended-range version** of the BrahMos missile for the first time from Su-30MKI fighter aircraft. With this maiden launch, India will be able to carry out precision strikes against a land or sea target over a long range from Su-30MKI fighter aircraft.

- BrahMos has been upgraded several times, with versions tested on land, air and sea platforms since its first lauch.
- The **first successful test in 2001** was conducted from a specially designed land-based launcher.

Background and development

A. In the early 1980s, the **Integrated Guided Missile Development Programme**, conceived and led by **Dr A P J Abdul Kalam,** started developing a range of missiles including **Prithvi, Agni, Trishul, Akash and Nag**, with a wide spectrum of capabilities and ranges.
B. In the early 1990s, India's strategic leadership felt the need for cruise missiles — **guided missiles that traverse the majority** of their flight path at almost constant speed and deliver large warheads over long distances with high precision.
C. The need was felt **primarily following the use of cruise missile**s in the Gulf War.

Signing the Agreement:

A. An Inter-Governmental Agreement was signed with **Russia in Moscow** in 1998 by Dr Kalam, who headed the **Defence Research and Development Organisation (DRDO),** and N V Mikhailov, Russia's then Deputy Defence Minister.
B. This led to the formation of **BrahMos Aerospace**, a joint venture between **DRDO and NPO Mashinostroyenia (NPOM)**, the Indian side holding **50.5% and the Russians 49.5%.**
C. In **1999**, work on development of missiles began in labs of **DRDO and NPOM** after **BrahMos Aerospace** received funds from the two governments.

Strategic significance

- BrahMos is a two-stage missile with a solid propellant booster engine.
- Its first stage brings the missile to supersonic speed and then gets separated.
- The liquid ramjet or the second stage then takes the missile closer to three times the speed of sound in cruise phase.
- The missile has a very low radar signature, making it stealthy, and can achieve a variety of trajectories.
- The 'fire and forget' type missile can achieve a cruising altitude of 15 km and a terminal altitude as low as 10 m to hit the target.
- Cruise missiles such as BrahMos, called "standoff range weapons", are fired from a range far enough to allow the attacker to evade defensive counter-fire.

- The BrahMos has three times the speed, 2.5 times flight range and higher range compared to subsonic cruise missiles.
- An extended range version of the BrahMos air-launched missile was tested from a Sukhoi-30 MKI recently.
- Recently, an advanced sea-to-sea variant of BrahMos was tested from the newly commissioned INS Visakhapatnam.

PRESENT AND FUTURE

- ✓ With requirements evolving in multi-dimensional warfare, the BrahMos is undergoing a number of upgrades and work is on to develop versions with higher ranges, manoeuvrability and accuracy.
- ✓ Versions currently being tested include ranges up to 350 km, as compared to the original's 290 km.
- ✓ Versions with even higher ranges, up to 800 km, and with hypersonic speed are said to be on cards.
- ✓ Efforts are also on to reduce the size and signature of existing versions and augment its capabilities further.

Versions

Versions deployed in all three Armed forces are still being tested regularly, and so are versions currently under development.

- ✓ **LAND-BASED:** The land-based BrahMos complex has four to six **mobile autonomous launchers**, each with three missiles on board that can be fired almost simultaneously.
- Batteries of the land-based systems have been deployed along I**ndia's land borders** in various theatres.
- The upgraded land attack version, with capability of cruising at **2.8 Mach,** can hit targets at a range up to **400 km** with precision.
- Advanced versions of higher range and speed up to 5 Mach are said to be under development.
- The ground systems of BrahMos are described as 'tidy' as they have very few components.

SHIP-BASED: The Navy began inducting **BrahMos on its frontline warships from 2005.** These have the capability to hit sea-based targets beyond the radar horizon.

A. The Naval version has been successful in sea-to-sea and sea-to-land modes.
B. The BrahMos can be launched as a single unit or in a salvo of up to eight missiles, separated by 2.5-second intervals.
C. These can target a group of frigates with modern missile defence systems.

- ❖ **AIR-LAUNCHED**: On November 22, 2017, BrahMos was successfully **flight-tested for the first tim**e from a **Sukhoi-30MKI** against a sea-based target in the Bay of Bengal. It has since been successfully tested multiple times.

1. B**rahMos-equipped Sukhoi-30s**, which have a range of 1,500 km at a stretch without **mid-air refuelling,** are considered key strategic deterrence for adversaries both along land borders and in the strategically important Indian Ocean Region.
2. The IAF is said to be integrating BrahMos with 40 Sukhoi-30 fighter jets across the various bases.

- ❖ **SUBMARINE-LAUNCHED:** This version can be launched from around 50 m below the water surface.
- ❖ The **canister-stored missile** is launched vertically from the pressure hull of the submarine, and uses different settings for underwater and out-of-the-water flights.

This version was successfully tested first in March 2013 from a submerged platform off the coast of Visakhapatnam.

INS ARIHANT: ANALYSIS

- India declared that its nuclear triad is operational after indigenous ballistic missile nuclear submarine INS Arihant conducted its first deterrence patrol.
- INS Arihant, a 6,000-tonne submarine is the lead ship of India's Arihant class of nuclear-powered ballistic missile submarines built under the Advanced Technology Vessel (ATV) project. About:
- **Power source:** INS Arihant is propelled by an 83 MW pressurised light-water reactor at its core with enriched uranium fuel.
  Builder: Shipbuilding Centre (SBC), Visakhapatnam. It's India's first indigenously built nuclear submarine.
  SSBN: It is a **'Ship Submersible Ballistic Nuclear Submarine' (SSBN).** SSBN's are those class of submarines which can go deep beneath the ocean making them virtually undetectable for months, they also carry nuclear-tipped ballistic missiles.

Armament:

1. It is capable of carrying ballistic missiles with nuclear warheads.

2. It is presently armed with the **K-15 Sagarika** missiles with a range of **750 km.**

3. Later, it will also be armed with **K-4 missiles**, being developed by the DRDO, which are capable of striking targets at a distance of up to **3,500 km.**

4. These 'K' series of missiles are named after former President APJ Abdul Kalam.

TIMELINE:

1. 1980s & 1990s: The Advanced Technology Project (ATV) project began in the 1980s, although actual construction started in late

2. 2009: First of the ATV Submarine was Launched by PM Manmohan Singh.

3. 2013: The nuclear reactor of the submarine went 'critical'.

4. 2016: According to Media Reports, Arihant was quietly commissioned into service in August 2016 by PM Modi but its induction was never officially acknowledged.

5. 2018 (November): INS Arihant conducted its first deterrence patrol. This means that Arihant is now prowling the deep seas carrying ballistic missiles equipped with nuclear warheads.

6. What next?
7. Besides INS Arihant, India has plans to build three more similar vessels under the ATV program, two of which will be larger in size and capable of being armed with longer range missiles.

8. The second submarine of its class, INS Arighat, is currently undergoing trials and expected to join service three years from now.

SIGNIFICANCE:

1. **Nuclear triad:** With its induction India completed its 'nuclear triad' i.e. India can launch nuclear missile from all three key defence bastions — land, air and sea. Triad is important because in an enemy strike, even if the other wings are destroyed, the third can launch a retaliatory strike thus providing a guaranteed **'second strike' capability** to the country.

2. **Stealth capability:** Due to satellites, other legs of our nuclear triad (missile sites and air-bases) remain exposed to enemy attack. However, being a SSBN, it can stay deep inside the ocean making them virtually undetectable for months.

3. **Part of Elite club:** INS Arihant places India in the league of select group of five Countries **— US, Russia, France, UK and China** — which can design, construct and operate Strategic Strike Nuclear Submarines.

4. **Boost to submarine fleet:** Adding Arihant is a boost to depleting submarine fleet of India.
   - In August 2016 it was reported that only seven submarines are available for deployment, though India owns 14 conventional submarines.

1. Further these submarines have to be split on either coast; are run on either battery or diesel; have already completed a life-span of 20 years or more, on average.

Countering Sino-Pak axis:

- In the words of PM Modi, while India "remains committed to the doctrine of Credible Minimum Deterrence and No First Use," the success of INS Arihant gives a fitting response to those who indulge in **'Nuclear Blackmail'.**

- It also comes against the backdrop of news reports of **presence of Chinese submarines in the Indian Ocean region.**

- **Indigenous:** Apart from its strategic significance, the Arihant is a live manifestation of PM Modi's "Make in India" vision as It is India's first indigenously built nuclear submarine.

CHALLENGES AND WAY AHEAD:

- However, India cannot afford to rest on its laurels, though. Much more needs to be done to deal with the challenges that lie ahead.

MORE SUBMARINES:

- Experts believe that **in addition to the 4 large SSBNs, India would require an inventory of at least 3-4 SSBNs to** maintain a real sea-based deterrence on the eastern and western seaboards.

- India will also need a force of 6 to 8 **tactical attack nuclear submarines (SSNs) for protection of SSBNs.**

- **Time Lag:** The entire process of developing INS Arihant till completion of deterrence patrol, took about 20 years. It is expected that, based on the experience gained, next lot of nuclear

submarines in this important programme shouldn't take as long.

- **Enhanced Missile range:** To retain its stealth and avoid detection, an SSBN needs to operate from a larger sea area, and hence would need a submarine-launched ballistic missile (SLBM) of 6,000-8,000-km range to counter regional powers.

- **The command and control structures** for an SSBN on a fully-loaded deterrence patrol **have to be robust and fool-proof,** because any error can lead to mass destruction.

- In short, India has a long way to go, though the INS Arihant deterrence patrol is a significant milestone.

SUBMARINE-LAUNCHED BALLISTIC MISSILE: K-4

- Recently, India successfully test-fired the **3,500-km range submarine-launched** BALLISTIC MISSILE , **K-4.**
- The test was carried out by the **DRDO** from a submerged pontoon (a flattish boat that relies on floats to remain buoyant) off the **Visakhapatnam coast (Andhra Pradesh).**

- A pontoon simulates the situation of a launch from a submarine.
- The **Circular Error Probability (CEP)** of the missile is much more sophisticated than Chinese missiles.

- The CEP determines the **accuracy of a missile.** The **lower the CEP, the more accurate the missile** is.
- After induction, these will be the chief support of the ARIHANT **class of indigenous Ballistic Missile Nuclear Submarines (SSBN).** It will give India the standoff capability to launch nuclear weapons submerged in Indian waters.

- INS Arihant, the **first and only operational SSBN,** is armed with **K-15 Sagarika missiles** with a range of 750 km.
- It means that the submarine has to move closer to the adversary's coast to launch the missile but the K-4 will be able to overcome that because of its range coverage.

SLBM LAUNCHED BY INS-ARIHANT

- The Ministry of Defence (MoD) announced that the indigenous Strategic Strike Nuclear Submarine INS Arihant had successfully launched a nuclear capable Submarine Launched Ballistic Missile (SLBM) in the Bay of Bengal with "very high accuracy".

INS ARIHANT:

1. It is India's first indigenous nuclear powered ballistic missile capable submarine.
2. Launched in 2009 and Commissioned in 2016, it is built under the secretive Advanced Technology Vessel (ATV) project.
3. INS Arihant and its class of submarines are classified as 'SSBN', which is the hull classification symbol for nuclear powered ballistic missile carrying submarines.
4. INS Arihant can carry a dozen K-15 missiles on board.
5. While the Navy operates the vessel, the operations of the SLBMs from the SSBN are under the purview of India's Strategic Forces Command, which is part of India's Nuclear Command Authority.

6. In November 2019, after INS Arihant completed its first deterrence patrol, the government announced the establishment of India's "survivable nuclear triad" — the capability of launching nuclear strikes from land, air and sea platforms.
7. The second submarine in the Arihant class is SSBN Arighat which was launched in 2017.
8. In addition, India operates 15 conventional diesel electric submarines (classified as SSK), and some more are on the way.

SLBM:

- The **Submarine Launched Ballistic Missiles (SLBMs), sometimes called the 'K' family of missiles**, have been indigenously developed by Defence Research and Development Organisation (DRDO).
- The family is codenamed after Dr APJ Abdul Kalam, the centre figure in India's missile and space programmes who also served as the 11th President of India.
- Because these missiles are to be **launched from submarines, they are lighter, more compact and stealthier than their land-based counterparts**, the Agni series of missiles which are medium and intercontinental range nuclear capable ballistic assets.
- Part of the K family is the SLBM K-15, which is also called B-05 or Sagarika. It has a range of 750 km.
- India has also developed and successfully tested K-4 missiles from the family, which have a range of 3,500 km.
- The tests conducted were a key step towards ultimately deploying K-4s on the INS Arihant.
- It is also reported that more members of K-family — reportedly carrying the code names K-5 and K-6, with a range of 5,000 km and 6,000 km respectively — are under development.

THE STRATEGIC SIGNIFICANCE:

I. The successful user training launch of the SLBM by INS Arihant is significant to prove crew competency and validate the SSBN programme.
II. **A robust, survivable and assured retaliatory capability is in keeping with India's 'no first use' commitment**.
III. These submarines can not only survive a first strike by the adversary, but can also launch a strike in retaliation, thus achieving '**Credible Nuclear Deterrence'.**
IV. The development of these capabilities is important in the light of **India's relations with China and Pakistan.**
V. China: The PLA Navy currently operates 6 nuclear-powered ballistic missile submarines (SSBNs) and 46 diesel-powered attack submarines (SSs).
VI. Pakistan: It Navy operates 5 diesel-electric submarines and 3 mini submarines of under 150 tonne displacement.

WEAPON SYSTEM BRANCH IN IAF

The government has approved the creation of a Weapon System branch for officers in the Indian Air Force (IAF) which will bring all weapon systems operators of the force under one roof.

I. This is the first time since Independence that a new operational branch is being created.
II. The IAF also unveiled a new digital camouflage uniform for its rank and file.
III. Creation of the new branch would entail unification of all weapon system operators under one entity dedicated to the operational employment of all ground-based and specialist airborne weapon systems.
IV. This will essentially be for manning of four specialised streams of Surface to Surface missiles, Surface to Air Missiles, Remotely Piloted Aircraft and weapon system operators in twin and multi crew aircraft.

V. Creation of this branch would result in savings of over ₹3,400 crore due to reduced expenditure on flying training.

LIGHT COMBAT HELICOPTER (LCH) 'PRACHAND'

- Recently, the indigenously developed Light Combat Helicopter (LCH) 'Prachand', meaning fierce was formally inducted into the 143
- Helicopter Unit 'Dhanush' of the Indian Air Force (IAF) at the Jodhpur Air Force Station. Light Combat Helicopter (LCH) 'Prachand'.

Light Combat Helicopter (LCH) 'Prachand'

- The LCH is the only attack helicopter in the world that can land and take off at an altitude of 5,000 metres (16,400 ft), which makes it ideal to operate in the high altitude areas of the Siachen glacier.
- It was officially renamed **"Prachand".**

DEVELOPMENT:

I. It is designed and manufactured by the Hindustan Aeronautics Limited (HAL) under project LCH.
II. It was conceptualised after the 1999 Kargil conflict.
III. The multi-role attack helicopter operates both in desert terrains and high-altitude sectors.

Features:

- This twin-engine helicopter is armed with anti-tank guided missile
- The LCH is the **only attack helicopter in the world** which can land and take off at an altitude of 5,000 meters with a considerable load of weapons and fuel.
- The **helicopter uses radar-absorbing material to lower radar signature** and has a significantly crash-proof structure and landing gear.
- A pressurised cabin offers protection from Nuclear, Biological and Chemical (NBC) contingencies.
- The **helicopter is equipped with a countermeasure dispensing system** that protects it from enemy radars or infrared seekers of enemy missiles.
- LCH is powered by **two French-origin Shakti engines** manufactured by the HAL.

Genesis:

I. It was during the 1999 Kargil war that the need was first felt for a homegrown lightweight assault helicopter that could hold precision strikes in all Indian battlefield scenarios.
II. This meant a craft that could operate in very hot deserts and also in very cold high altitudes, in counter-insurgency scenarios to full-scale battle conditions.
III. India has been operating sub 3 ton category French-origin legacy helicopters, Chetak and Cheetah, made in India by the Hindustan Aeronautics Limited (HAL).
IV. These single engine machines were, primarily, utility helicopters. Indian forces also operate the Lancer, an armed version of Cheetah.
V. In addition, the Indian Air Force currently operates the Russian origin Mi-17 and its variants Mi-17 IV and Mi-17 V5, with maximum take-off weight of 13 tonnes, which are to be phased out starting 2028.
VI. The government sanctioned the LCH project in October 2006 and HAL was tasked to develop it.

SIGNIFICANCE:

- The LCH has the **capabilities of combat roles such as destruction of enemy air defence,** counter insurgency warfare, combat search and rescue, anti-tank, and counter surface force operations.

'Dhruvastra' and air-to-air missile 'Mistral-2'.

- It is multi-role and can perform roles of Combat Search and Rescue (CSAR),
- Destruction of Enemy Air Defence (DEAD) and Counter Insurgency (CI) operations.

Flight Ceiling

- Its flight ceiling is the highest among all attack helicopters in the world.

PROJECT 17A 'TARAGIRI'

- **'Taragiri', the third stealth frigate of project 17A** was launched by Mazagon Dock Shipbuilders Ltd. (MDL) in Mumbai.
- The stealth vessel is expected to be commissioned into the Indian Navy in February 2023.

'TARAGIRI'

I. The keel of Taragiri was laid on September 10, 2020 and the ship is expected to be delivered by August 2025.
II. It is designed by the Indian Navy's in-house design organisation - Bureau of Naval Design.
III. The indigenously designed 'Taragiri' will have state-of-the-art weapons, sensors, an advanced action information system, an integrated platform management system, world-class modular living spaces, a sophisticated power distribution system, and a host of other advanced features.
IV. It will be fitted with a supersonic surface-to-surface missile system and the ship's air defence capability is designed to counter the threat of enemy aircraft and anti-ship cruise missiles will revolve around the vertical launch and long range surface to air missile system,

PROJECT 17A OF THE INDIAN NAVY

1. **Project 17 Alpha frigates (P-17A)** were launched by the Indian Navy in 2019.
2. The project is aimed to construct a series of stealth guided-missile frigates, which are currently being constructed by two companies - Mazagon Dock Shipbuilders (MDL) and Garden Reach Shipbuilders & Engineers (GRSE).
3. These guided-missile frigates have been constructed with a specific stealth design, which has radar-absorbent coatings and is low-observable which can make its approach undetectable for the enemies.
4. The **first stealth ship launched under Project 17A was the Nilgiri**, which was launched in 2019 and is expected to be commissioned in the Indian Navy by the end of this year.

Udaygiri, the second ship, was launched in May 2022, and will likely be commissioned in 2024.

QUICK REACTION SURFACE TO AIR MISSILE (QRSAM) SYSTEM

- Defence Research and Development Organisation (DRDO) and Indian Army have successfully completed six flight-tests of Quick Reaction Surface to Air Missile (QRSAM) system.

- All the mission objectives were met establishing pin-point accuracy of the weapon system with state-of-the-art guidance and control algorithms including warhead chain.

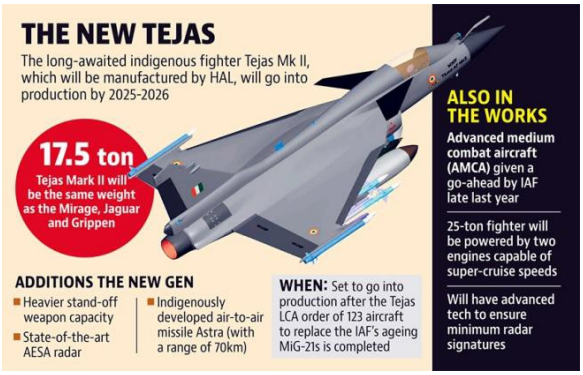
Quick Reaction Surface to Air Missile (QRSAM) system

1. It is a short-range surface-to-air missile (SAM) system.
2. Designed and developed by DRDO to provide a protective shield to moving armoured columns of the Army from enemy aerial attacks.
3. QRSAM is a canister-based system – stored and operated from specially designed compartments.
4. The system is capable of detecting and tracking targets on the move and engaging targets with short halts.
5. Can operate on the move with search and track capability & fire on short halt
6. The entire weapon system has been configured on mobile and is capable of providing air defence on the move.
7. It has a range of 25 to 30 km.
8. It also consists of two radars – Active Array Battery Surveillance Radar and Active Array Battery Multifunction Radar – with one launcher.
9. Both radars have 360-degree coverage with "search on move" and "track on move" capabilities.
10. The system uses a single-stage solid propelled missile and has a mid-course inertial navigation system with two-way data link and terminal active seeker developed indigenously by DRDO.

LCA-Mk2 and AMCA

According to the Aeronautical Development Agency (ADA), LCA Tejas-Mk2 will be rolled out in 2022 and the first flight in early 2023. Advanced Medium Combat Aircraft (AMCA) will be rolled out in 2024 and first flight in 2025.

- Simultaneously, the project for development of a twin engine deck based fighter jet meant to fly from the Navy's aircraft carriers is also making progress.
- ADA is an **autonomous body** of the **Ministry of Defence.**



LCA-Mk2:

- It is a **4.5 generation aircraft** which will be used by the Indian Air Force.
- It is a **replacement for the Mirage 2000 class of aircraft.**
  It has got a bigger engine and can carry **6.5 tonnes of payload.**
- The technology is already developed in LCA

- The LCA programme began in the 1980s to replace India's ageing MiG-21 fighters.
- The LCA is being designed and developed with **ADA as the nodal agency** and **State-owned** HAL being the principal partner.
- Its production is likely to start somewhere around 2025.

VARIANTS OF TEJAS

- **Tejas Trainer:** 2-seater operational conversion trainer for training air force pilots.
- LCA NAVY: Twin- and single-seat carrier-capable for the Indian Navy.
- **LCA Tejas Navy MK2**: This is phase 2 of the LCA Navy variant.
- LCA-TEJAS MK-1: This is an improvement over the **LCA Tejas Mk1** with a higher thrust engine **(Air Force)**.
- **LCA Tejas Mk-2**: Following the Mk-1A is the Mk-2 which will provide a high degree of manoeuverability.

ADVANCED MEDIUM COMBAT AIRCRAFT (AMCA):

- It is a fifth generation aircraft. And will be used by the Indian Air Force.
- It is a stealth aircraft, i.e. designed for stealth and unlike the LCA, which is designed for maneuverability.
- It has a unique shape to achieve low radar cross-section and has an internal carriage of weapons.
- When the external weapons are removed, this aircraft has enough fuel and weapons inside to do a very capable operational role in stealth mode.

Range:
Over 1,000 km up to 3,000 km in different modes.

Variants and Engine:

- It has two variants Mk-1 and Mk-2, While AMCA Mk-1 will have an imported engine, same as LCA Mk-2, the AMCA Mk-2 will have an indigenous engine.

Manufacturing:

- The manufacturing and production of the aircraft will be through a SPECIAL PURPOSE VEHICLE , which will also have participation of private industry.

INS VIKRANT: INDIA'S INDIGENOUS MOVE

- INS Vikrant, INS Vikramaditya, Indo-Pak War 1971, Hambantota Port, Bio-Technical Weapons, Multi-Function Radars, Defence Public Sector Units (DPSUs), SRIJAN Portal, Project 75I, Positive Indigenisation List(Defence Procurement Policy), Aircraft Carriers Across the Globe

1. From the first indigenous **warship INS Ajay in 1960**, to the first indigenous frigate INS NILAGIRI in 1968, the commissioning of the first **indigenously designed and built aircraft carrier,** INS VIKRANT is a significant punctuation in India's pursuit of self-reliance.
2. At **45,000 tonnes,** Vikrant is the **largest naval ship to be designed and built in India**, and with this accomplishment, the country joins the band of nations that have demonstrated

such capability with major countries like **United States (US), the United Kingdom (UK), France, Russia, Italy, and China.**

3. While the ABSORPTION has matured, a large gap still exists in the development of **critical technologies, Hi-Tech components, weapons and advanced manufacturing processes.**
4. It is imperative to identify relevant **demand-side functional domains** and technologies to channel indigenous efforts towards attaining **sustainable self-reliance in cutting-edge defence technologies.**

Significance of INS Vikrant in India's Maritime Security

Vikrant (which means courageous) is named after **India's first aircraft carrier,** bought from the UK and **commissioned in 1961.**

1. The first INS Vikrant was a major symbol of national pride and played an important role in several military operations including the **1971 Indo-Pak War** before being **decommissioned in 1997.** Now India's first homemade aircraft carrier will carry the name of her illustrious predecessor.
2. After its induction, the warship will be a key component of the Indian Navy's push to establish itself as a BLUE WATER FORCE one with the ability to project its power on distant seas.
3. It is especially important amid **India's bid to be a NET SECURITY PROVIDER IN THE INDIAN OCEAN REGION** where it faces China, whose navy is focused on aircraft carriers and has already inducted two vessels.
4. With the commissioning of **INS Vikrant**, India will have two operational aircraft carriers (the other one is INS-VIKRAMADITYA) , which will bolster the maritime security of the nation.

Other Aircraft Carriers Across the World

I. USA: USS Gerald R Ford Class
II. China: Fujian
III. United Kingdom: Queen Elizabeth Class
IV. Russia: Admiral Kuznetsov
V. France: Charles De Gaulle
VI. Italy: Cavour

Challenges of Indigenisation for Indian Navy

I. **Dependence on Import For Subsystems and Components**: Any warship has three components, from design to final operational induction (FLOAT, MOVE, FIGHT).
II. Indian Navy has been able to achieve about **90% indigenisation in the 'FLOAT' category,** followed by about **60% in 'MOVE' category** depending upon the type of propulsion.
III. However, **in the 'FIGHT' category** we have achieved **only about 30% indigenisation. Imports make up the remainder.**
IV. **Growing Chinese Influence in the Indian Ocean:** Building on its antipiracy missions, China has emerged as a strong partner for the islands and littoral countries of the Indian Ocean including its **recent vessel deployment in HAMBANTOTA –SRILANKA**
V. **Cost and Time Overruns:** The Navy suffers from cost and time overruns throughout most production projects, for example, **INS Vikramaditya** was inducted into service more than 10 years after it was purchased.
VI. **Outdated Submarines:** A submarine fleet is considered indispensable to support the Navy's aircraft carriers, among other duties.

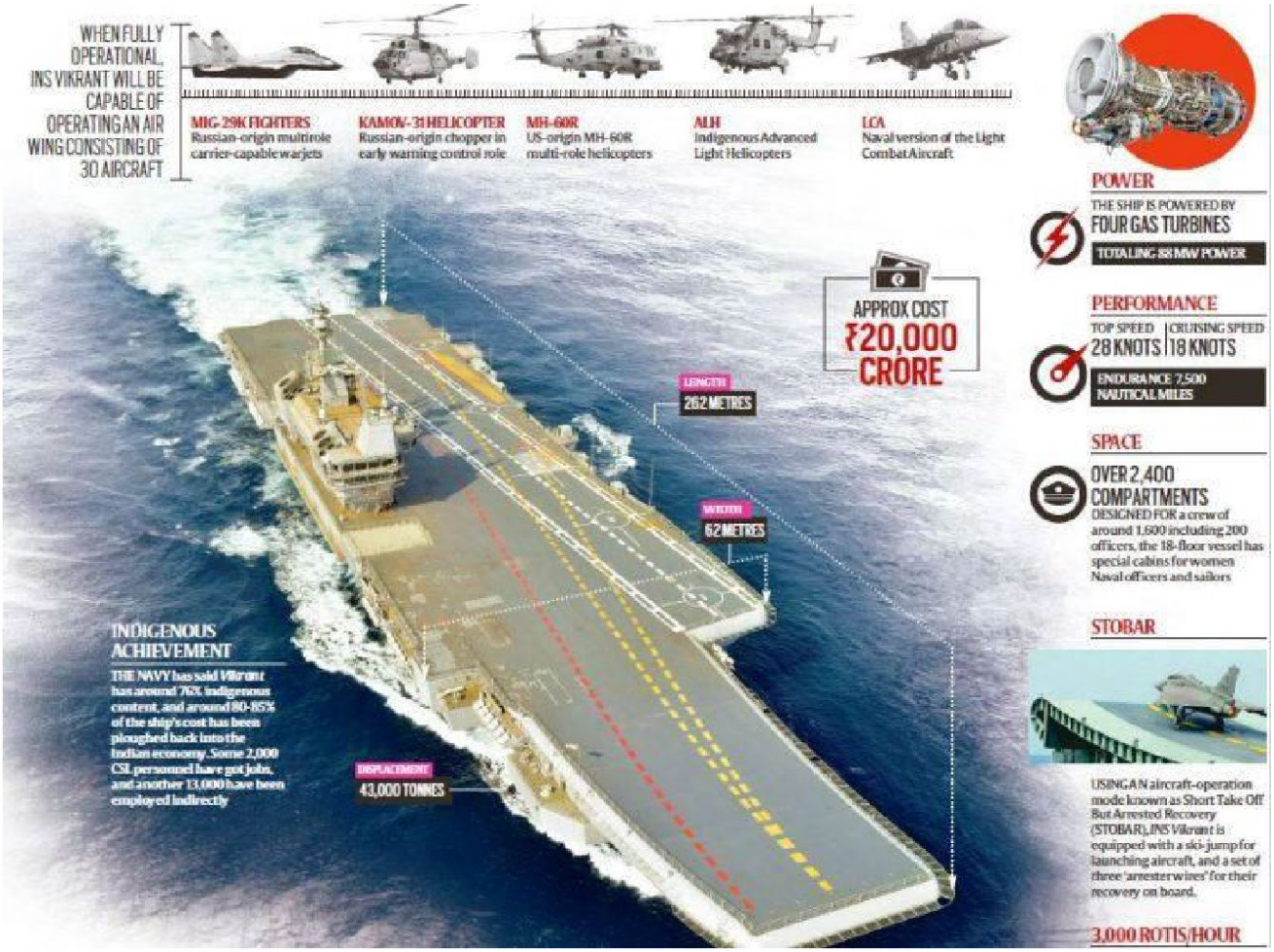
VII. Currently, the **Navy employs 15 conventional SUBMARINES**, each of which requires **breaking surfaces to charge its batteries,** making them **prone to detection** every time they are launched.

INS VIKRANT: FIRST INDIGENOUS AIRCRAFT CARRIER

- Recently, the Prime Minister of India commissioned India's first indigenous aircraft **carrier Indian Naval Ship (INS) Vikrant** in Kochi.
- Currently, India has **two aircraft carriers** (**INS Vikramaditya** (from Russia) & **INS Vikrant** (present one).

1. The Prime Minister also unveiled the **new Naval Ensign 'Nishaan'** during the commissioning of the indigenous **aircraft carrier INS Vikrant**.
2. Naval Ensigns are flagging that naval ships or formations bear to **denote nationality**.
3. The **current Indian Naval Ensign** consists of a **St. George's Cross** -- a red cross with a white background.
4. St. George was a **Christian Warrior Sain**t who is believed to have been a crusader during the third crusade.
5. In 2001 the George's Cross was replaced with the naval crest in the middle of the white flag while the Tricolour retained its place on the top left corner.
6. The Indian Naval Ensign has changed multiple times since Independence.

FACTS SHEET ABOUT INS VIKRANT



Origin:

- The name 'INS Vikrant' originally belonged to India's first aircraft carrier which was acquired from the UK, and played a vital role in the 1971 War with Pakistan before it was decommissioned in 1997.

DESIGN & DEVELOPMENT:

1. By the Indian Navy's in-house Warship Design Bureau (WDB) and built by Cochin Shipyard Limited, a Public Sector Shipyard under the Ministry of Ports, Shipping & Waterways.
2. It has been built with state-of-the-art automation features and is the largest ship ever built-in maritime history of India.

OPERATIONAL CAPABILITY:

1. The ship is capable of operating an air wing consisting of 30 aircraft comprising MiG-29K fighter jets, Kamov-31, MH-60R multi-role helicopters, in addition to indigenously manufactured **Advanced Light Helicopters (ALH) and Light Combat Aircraft (LCA) (Navy).**
2. The ship can accommodate an **assortment of fixed-wing and rotary aircraft.**
3. The warship will also offer an **"incomparable military instrument with its ability to project Air Power over** long distances, including offensive, Air Interdiction, Anti-Surface Warfare, defensive Counter-Air, Airborne Anti-Submarine Warfare and Airborne Early Warning.

NEED & SIGNIFICANCE

1. With the commissioning, India has joined the elite group of nations (**US, Russia, France, the UK and China)** having capability to indigenously design and build an Aircraft Carrier.
2. It is a shining example in the nation's quest for **'Atma Nirbhar Bharat'** and 'Make in **India Initiative,**' with more than **76 per cent indigenous content."**
3. It is especially important amid India's bid to be a net security provider in the Indian Ocean region & upholder of Sea Lines of Communication (SLOCs) where it faces China.
4. The two aircraft carriers can be **deployed, one in East Coast** (BOB & Malacca Strait) & 2nd one for **west Coast** (Arabian Sea, Pak Coast & West Asia).
5. **Naval forces** can use this for dispensing humanitarian relief & disaster relief (in peacetime)

Way Ahead & Conclusion

1. Considering current geopolitical & strategic importance along the maritime domain, India needs at least 3 carriers.
2. India's stake in the I**OR is greater than in the high Himalayas**; India being the only member country of QUAD.
3. The Navy shall be organised, trained & equipped for the peacetime promotion of national security interests & prosperity of India & for prompt combat incidents to operations at Sea.

VERTICAL LAUNCH SHORT RANGE SURFACE TO AIR MISSILE

- Recently, Vertical Launch Short Range Surface to Air Missile (VL-SRSAM) was successfully flight-tested by Defence Research & Development Organisation (DRDO) and the Indian Navy from an Indian Naval Ship at Integrated Test Range (ITR), Chandipur off the coast of Odisha.

1. VL-SRSAM has been designed and developed jointly by three facilities of the DRDO for **deployment of Indian Naval warships.**

2. The missile has the **capability of neutralizing various aerial threats** at close ranges including sea-skimming targets.
3. **Sea skimming** is a technique many anti-ship missiles and some fighter or strike aircraft use **to avoid radar and infrared detection.**

DESIGN:

- The missile has been designed to strike high-speed airborne targets **at the range of 40 to 50 km and at an altitude of around 15 km.**
- Its design is based on ASTRA MISSILE which is a **Beyond Visual Range Air to Air missile.**
- Astra ("weapon") is India's first air-to-air all weather beyond-visual-range active radar homing air-to-air missile, developed by the Defence Research and Development Organization.
- A Beyond-Visual-Range missile (BVR) is an air-to-air missile that is capable of engaging at ranges of 20 nautical miles or beyond.

Features:

- Cruciform wings: They are four small wings arranged like a cross on four sides and give the projective a stable aerodynamic posture.
- Thrust Vectoring: It is the ability to change the direction of the thrust from its engine, control the angular velocity and the attitude of the missile.
- Thrust is the force which moves an aircraft through the air.
- Canisterised system: The inside environment is controlled, thus making its transport and storage easier and improving the shelf life of weapons.

Naval Warfare

- **It is a combat in and on the sea, the ocean**, or any other battlespace involving a major body of water such as a large lake or wide river.

Defence Mechanism:

- CHAFF-It is a **countermeasure technology** used worldwide to protect naval ships from enemy's radar and **Radio Frequency (RF) missile seekers.**
- Missiles to counter Anti-Ship missiles:

These systems have to have a swift detection mechanism and quick response to warships.

Vertical Launch Short Range Surface to Air Missile (VL-SRSAM) was successfully flight-tested by Defence Research & Development Organization (DRDO) and the Indian Navy from an Indian Naval Ship at Integrated Test Range (ITR), Chandipur off the coast of Odisha.

1. It is a quick reaction surface-to-air-missile indigenously designed and developed by DRDO for the Indian Navy, is meant for neutralizing various aerial threats at close ranges, including sea-skimming targets.
2. Sea skimming is a technique many anti-ship missiles and some fighter or strike aircraft use to avoid radar and infrared detection.
3. The missile has been designed to strike high-speed airborne targets at the range of 40 to 50 km and at an altitude of around 15 km.
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Features:

1. **Cruciform wings:** They are four small wings arranged like a cross on four sides and give the projective a stable aerodynamic posture.
2. **Thrust Vectoring:** It is the ability to change the direction of the thrust from its engine, control the angular velocity and the attitude of the missile.
3. **VL-SRSAM is a canisterised system**, which means it is stored and operated from specially designed compartments. In the canister, the inside environment is controlled thus making its transport and storage easier and improving the shelf life of weapons.

HELLFIRE R9X MISSILE

- Recently, the US military used its 'secret weapon' — the **Hellfire R9X missile** – to **kill Al Qaeda chief** Ayman al-Zawahiri in Kabul.

HELLFIRE R9X MISSILE

1. It is a **variant** of the original Hellfire missile family.
2. Better known in military circles as the **AGM-114 R9X**
3. **Developed by:** Lockheed Martin and Northrop Grumman (US)
4. **In Active Service:** since 2017

FEATURES:

I. Known to cause minimum collateral damage while engaging individual targets.
II. This weapon does not carry a warhead and instead deploys razor-sharp blades at the terminal stage of its attack trajectory.

Working:

I. Blades help it to break through even **thick steel sheets** and cut down the target using the kinetic energy of its propulsion without causing any damage to the persons in the general vicinity or to the structure of the building.
II. The blades pop out of the missile and cut down the intended target **without causing the massive damage** to the surroundings which would be the case with a missile carrying an explosive warhead.

HELLFIRE MISSILE FAMILY

I. Hellfire is actually an acronym for Heliborne, Laser, Fire and Forget Missile
II. It was developed in the US initially to target tanks from the Apache AH-64 attack helicopters.
III. Usage:

- Used in **conventional form** with warheads
- Traditionally used from helicopters, ground-based vehicles, and sometimes small ships and fast moving vessels.
- Later, the usage also spread to ground and **sea-based systems** and **drones**.
- Armed with Combat Unmanned Aerial Vehicles or drones that the US Military uses in **offensive military operations** around the world.

Other Hellfire missile variants: 'Longbow' and 'Romeo' apart from the 'Ninja'.

Previously Used:

I. In 2017, the 'Ninja Missile' was reportedly used to kill the then No. 2 leader of Al Qaeda in Syria.
II. It was also used against other targets in Syria at around the same time.
III. It has also been used against Taliban targets in Afghanistan in 2020 and again in 2022.

INDIA'S DEFENCE PROGRAM

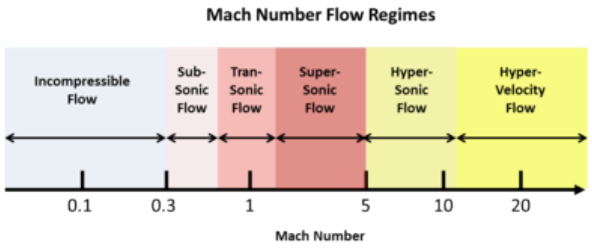
Missiles and Missile Defence Systems

There are 2 kinds of Missiles, Ballistic and Cruise.

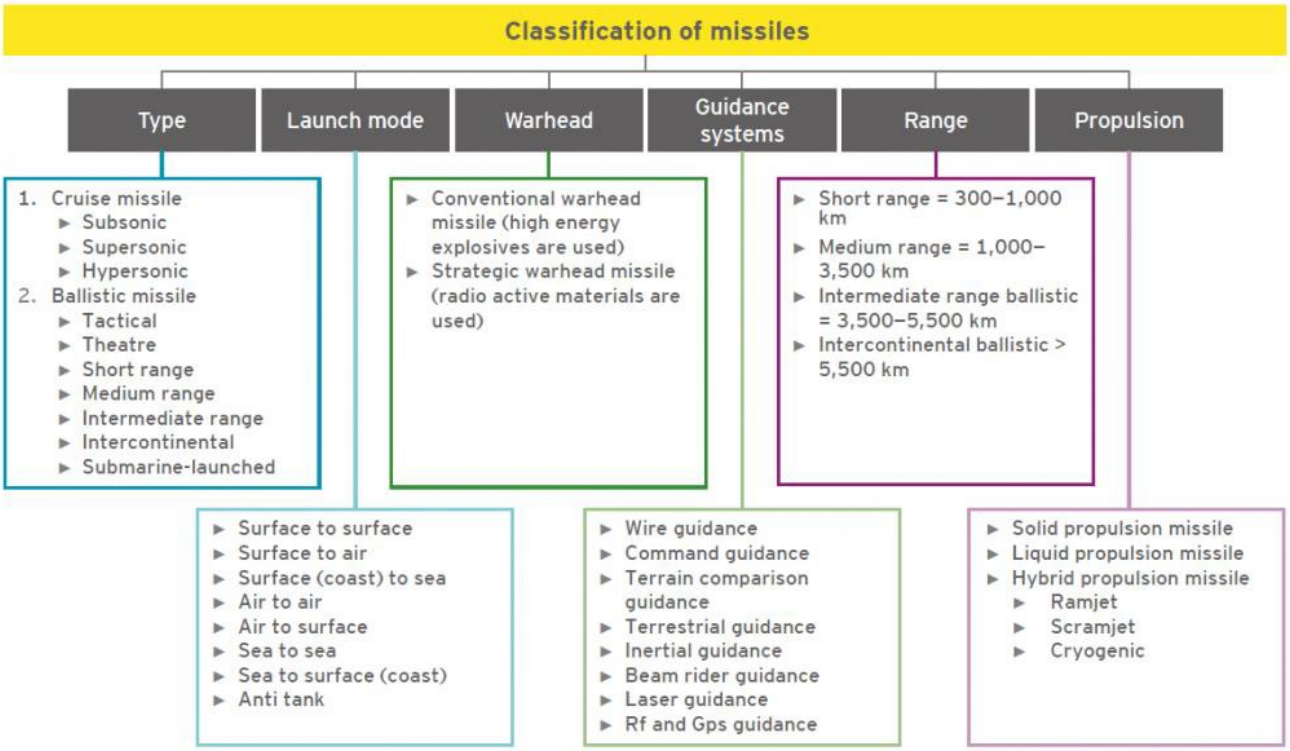
BALLISTIC MISSILES	CRUISE MISSILES
t follows a ballistic trajectory with the objective of delivering one or more warheads to a predetermined target.	It is a guided missile that remains in the atmosphere and flies the major portion of its flight path at approximately constant speed.
Target is predetermined. Fit for large targets.	Target can be mobile. More appropriate for small mobile targets.
Guided only during relatively brief periods of flight and the rest of its trajectory is unpowered and governed by gravity.	Are self-navigating
High altitude. Easy to track	Able to fly in extremely low-altitude trajectory. Makes it difficult to track

The speed of Missiles are measured in Mach Number.

Mach Number = Object Speed/Speed of Sound.



The following is a very comprehensive chart describing the various kinds of classifications that exist of missiles.



Source: Q-Tech Synergy

	Type	Launch Mode	Nuclear Capable	Range	Comments
Prithvi I	SRBM	Surface to Surface		150 Km	
Prithvi II	SRBM	Surface to Surface		350 Km	
Prithvi III	SRBM	Surface to Surface		600 Km	
Dhanush	Naval variant of Prithvi III	Sea to Sea/Surface		350 Km	
Akash	Short Range	Surface to air		30 Km	
Trishul	Short range for Navy	Surface to air		9 Km	
Astra	Beyond visual range AA Missile	Air to Air		80 Km	
MICA	Beyond visual range AA Missile	Air to Air			
Nag	Fire and forget, anti tank, guided	Surface to surface, Air to surface		4 Km	
Brahmos	Cruise missile	Land, Naval, Air		300 Km	with Russia
Nirbhay	Stealth, subsonic, Cruise. Long range	Land, Naval, Air		1000 Km	
Shaurya	Hypersonic, Canister launched	Surface to Surface		700-1900 Km	
Agni I	MRBM, Single Stage	Surface to Surface	Y	1250 Km	
Agni II	IRBM, Two Stage	Surface to Surface	Y	3000 Km	
Agni III	IRBM, Two Stage	Surface to Surface	Y	5000 Km	
Agni IV	IRBM, Two Stage	Surface to Surface		4000 Km	
Agni V	ICBM, 3 stage (can carry 1 nuclear warheads)	Surface to Surface	Y	8000 Km	Can be made vertical in three minutes and fired from a roadside in a town.
Agni VI	ICBM, 4 stage (can carry multiple nuclear warheads)	Surface to Surface		12000 Km	Under Development
Surya	ICBM, 3 stage (can carry 1 nuclear warheads)	Surface to Surface	Y	12,000-16,000 kilometers	Under Development
Prahaar	Tactical Ballistic Missile, Quick reaction, Omnidirectional warhead	Surface to surface		150 Km	
Barak 1	SRSAM, (short range surface to air missile) , Ship Defense	Ship to air, Ship to surface		12 Km	
Barak 8	LRSAM, Ship Defense + with Israel	Ship to air, Ship to surface		90 Km	
K4	SLBM (Submarine launched ballistic missile)	Under water to surface		3500 Km	Develop 2nd strike capabilities.
K5	SLBM				Under Development by DRDO
Sagarika (K15)	SLBM	Under water to surface		700 Km	version of the land-based Shaurya missile. integrated with Arihant class submarine
Dhanush Howitzer	long-range artillery gun				
Advanced Towed Artillery Gun System (ATAGS					
Prithvi Air Defence (PAD) / Pradyumna Ballistic Missile Interceptor	Missile Defense System				
Advanced Air Defence (AAD)/Ashwin Ballistic Missile Interceptor	Missile Defense System				
PDV	Missile Defense System				PDV is intended to replace the existing PAD in the PAD/AAD combination

FORMIDABLE ARSENAL

SURFACE-TO-SURFACE MISSILES

Short Range Ballistic Missiles

Prithvi-I	150 km	1,000 kg
Prithvi-II	250 km	500 kg
Prithvi-III	350 km	1,000 kg
Dhanush	350 km	1,000 kg
Agni-I	700 km	1,000 kg
Shaurya	700 km	1,000 kg
Prahaar	150 km	200 kg

Intermediate Range Ballistic Missiles (IRBMs)

Agni-II	2,000 km	1,000 kg
Agni-III	3,000 km	2,000-2,500 kg
Agni-IV	4,000 km	1,000 kg

Intercontinental Range Ballistic Missiles (ICBMs)

Agni –V	5,000 km	1,500 kg ((3-10 MIRV))
Agni-VI (Under Development)	6,000	1,000 kg (10 MIRV)
Surya (Under Development)	10,000 km	1,000 kg (10 MIRV)

Km denotes the range of the missile and kg is the payload

SUBMARINE LAUNCHED BALLISTIC MISSILES

K-15 Sagarika (B-05)	750 km	500 kg
K-4	3,000 km	1,000 kg

CRUISE MISSILES

Subsonic Cruise Missiles

Nirbhay	750-1,000 km	500 kg

Supersonic Cruise Missiles

BrahMos	290 km	300 kg

Hypersonic Cruise Missiles

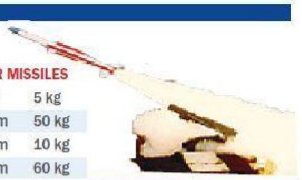
BrahMos-II	290 km	300 kg

AIR-TO-AIR MISSILE

Astra 80-110 km 15kg

SHORT RANGE SURFACE-TO-AIR MISSILES

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



ANTI-TANK GUIDED MISSILES

Nag Anti-tank guided missile	7 km	8 kg
Helina (Helicopter launched Nag missile)	7 km	8 kg

ANTI-BALLISTIC MISSILES

Prithvi Air Defence Missile
(Exo-atmospheric at 50-80 km altitude)
2,000 km DM (Proximity)

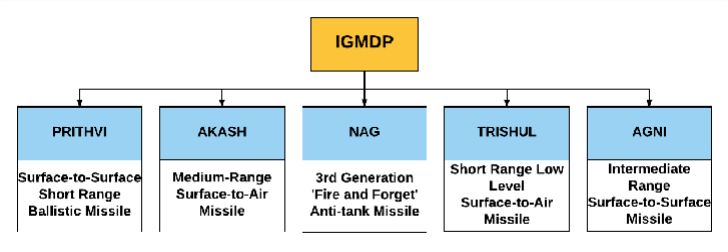
Advanced Air Defence Missile
(Endo-atmospheric at 15-30 km altitude)
150-200 km DM (Hit-to-kill)

Prithvi Defence Vehicle
(Exo-atmospheric at more than 120 km altitude)
2,000-3,000 km DM (Proximity)

DM: Detonation Mechanism

Compiled by Hemant Kumar Rout

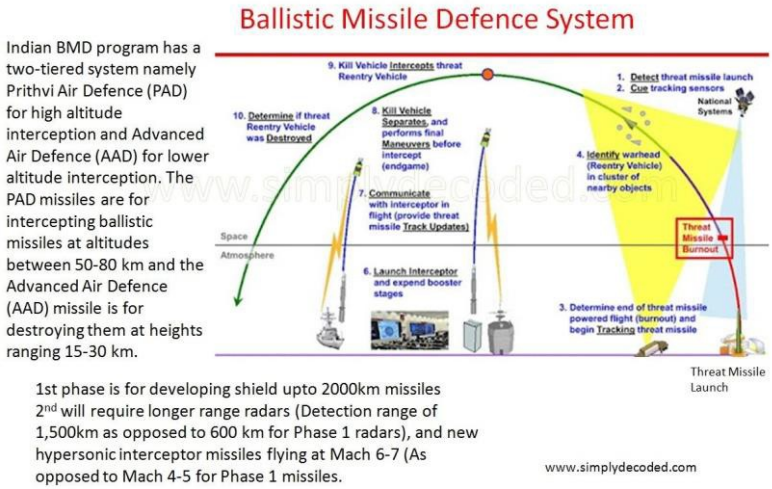
Integrated Guided Missile Development Program(IGMDP)



TIMELINE OF INDIA'S MISSILE DEVELOPMENT PROGRAM

BALLISTIC MISSILE DEFENCE

- A 2-tier system, being developed by DRDO, that provides a multi-layered shield against ballistic missile attacks.



Surveillance Technologies

- **NETRA** – It is a first indigenously developed airborne early warning and control system (AEW&C), mounted on a Brazilian Embraer-145, developed by Defense Research and Development Organization (DRDO).

1) AEW&C is also called eye-in-the-sky which is capable of long-range surveillance and a force multiplier.

   • India is only 4th such nation after United States, Russia and Israel that have such technology on their own.

1) Important features of NETRA are:
   • Range of 200 kms (Capability to detect aerial threats from incoming aircraft and missiles).
   • 240 degrees coverage (simultaneously scan the area on both sides of aircraft)
   • State of the art active electronically scanned radar and Secondary surveillance radar.
   • Electronic and communication counter measures.
   • Line of sight and beyond line of sight data link.
   • Voice communication system and self-protection suit.

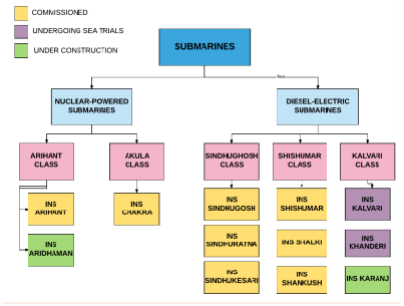
1. **Rustom-2 –** Rustom-2 is medium-altitude long-endurance drone (MALE) designed and developed by Aeronautical Development Establishment (ADE) of the DRDO, Hindustan Aeronautics Ltd and Bharat Electronics.
    I. It can fly up to an altitude of 22,000 feet and has endurance of over 20 hours.
    II. It can carry variety of payloads like Electronic Intelligence (ELINT), Synthetic Aperture Radar (SAR), Communication Intelligence (COMINT) and Situational Awareness Payloads (SAP) for performing missions even during the night.
    III. It will be used by all three services of Indian armed forces, primarily for intelligence, surveillance and reconnaissance (ISR) operations.
    IV. Rustom 2 can fly missions on manual as well as autonomous modes.

2. <u>NAVY SHIPS</u>

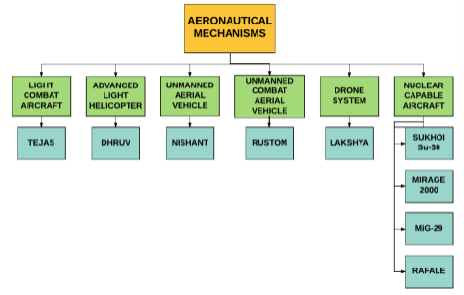
Aircraft Carrier		
INS Vikrant(R11)		1st carrier. Now has been scrapped.
INS Viraat		2nd carrier -Originally commissioned in 1959 by British Royal Navy -Longest serving carrier in the world
INS Vikramaditya		Modified Kiev Class from Russia
INS Vikrant(2013) - vikrant class		First indigenous carrier built by India
INS Vishaal		CATOBAR, Nuclear Propulsion
Destroyer		
INS Mysore, Delhi and Mumbai	Delhi Class	Project 15
INS Rajput, Rana, Ranjeet, Ranvir, Ranvijay	Rajput Class	
INS Chennai, INS Kolkata, INS Kochi	Kokata Class	INS Chennai - Supersonic surface-to-surface BrahMos missiles and Barak-8 long range surface-to-air missiles. Project 15A.
INS Mormugao INS Visakhapatnam INS Paradip and porbandar	Visakhapatnam Class	Sealth guided missile destroyers. Project 15B - 4 ships being constructed.
Frigate		
Talwar		improvement of Krivak class used by Russia
Shivalik Satpura Sahayadri	Shivalik	Project 17
Project 17A		Garden Reech and Masagaon Project 17 Shivalik-class frigate for the Indian Navy
Brahmaputra		INS Betwa is a Brahmaputra-class guided missile frigate. It tipped over in December.
Godavari		

Patrol Vessels		
INS Sumitra	Saryu Class	Went to australia. Operation Raahat - South Sudan
Aryaman and Atulya		Indian Coast Guard Ships, the eighteenth and nineteenth in the series of twenty Fast Patrol Vessels (FPVs)
Sarathi		It is an Indian Coast Guard Ship commissioned recently. It is the third ship in the series of 6 Offshore Patrol Vessel(OPV).
Tarasa followed by Tihayu	Car Nicobar Class	Fleet 2 latest entrant
Amphibious warfare ship		
INS Jalashwa	Austin class	Transport dock
INS Shardul, INS Kesari and INS Erawat	Shardul Class	South China Sea issue with Erawat
Cheetah, Gulgar & Kumbhir	Kumbhir Class	
INS Magar & INS Gariyal	Magar Class	
Auxiliary Ship		
Research Vessels		
Training Vessels		
INSV Mahadei		All women ship. Sailed to Mauritius. Also Goa to Capetown
Torpedo recovery vessel		
Astradharini		
Corvette - Anti-submarine warfare		
Veer		
Khukri		
Abhay		
Kora		
INS Kamorta, INS Kadmatt and INS Kiltan. INS Kavaratti is under construction	Kamorta Class	

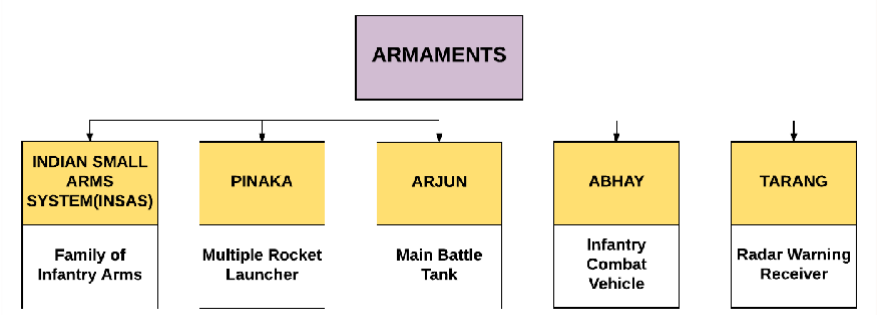
SUBMARINES



3. AERONAUTICAL MECHANISMS



4. Armaments



INSTITUTIONAL FRAMEWORK

Ministry of Defence

The primary responsibility is to counter insurgency and ensure external security of India.

It comprises of 4 departments:

1. **Dept. of Defence**: It deals with the three services(Army, Air Force, Navy & Coast Guard) and various Inter-Service Organisations
2. **Dept. of Defence Production**: It deals with framing of policy directions on defence and security related matters and communicating them for implementation to Service Headquarters and other organisations
3. **Dept. of Defence Research and Development**: It advises the Govt. on scientific aspects of military equipment and logistics
4. **Dept. of Ex-Servicemen Welfare**: It deals with resettlement, welfare and pensionary matters of Ex-Servicemen

DEFENCE RESEARCH AND DEVELOPMENT ORGANISATION(DRDO)

1. Design, develop and lead to production of state-of-the-art sensors, weapon systems, platforms and allied equipment for our Defence Services.
2. Provide technological solutions to the Services to optimise combat effectiveness and to promote well-being of the troops.
3. Develop infrastructure and committed quality manpower and build strong indigenous technology base.
4. It works under the Dept. of Defence Research and Development

DEFENCE PRODUCTION

1. Hindustan Aeronautics Limited(HAL)

1. It is engaged in the design, development, manufacture, repair and overhaul of aircrafts, helicopters engines and their accessories
2. It is responsible for the development of Dhruv, an Advanced Light Helicopter(ALH)

2. Bharat Electronics Limited(BEL)

- It is engaged in the design, development and manufacture of state-of-the-art electronics equipment components for the use of Defence Services

3. Mazagon Dock Limited(MDL)

1. It is the premier defence shipyard in the country located in Mumbai.
2. It is engaged in the production of warships, submarines, missile boats, destroyers etc.
3. Scorpene-class Submarines are being developed here under the Project 75I. Other defence production units include Bharat Earth Movers Ltd., Goa Shipyard Ltd., Bharat Dynamics Ltd. etc.

BIO -TECHNOLOGY

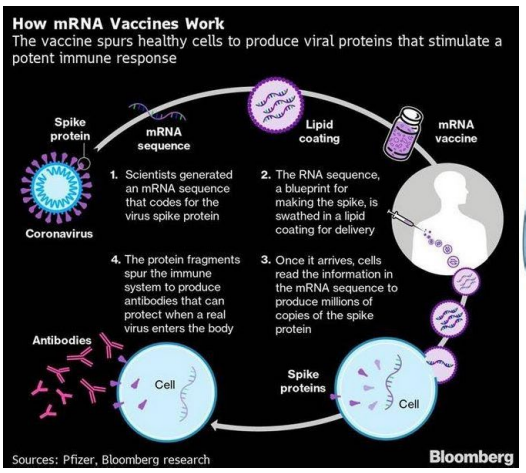
mRNA Vaccines

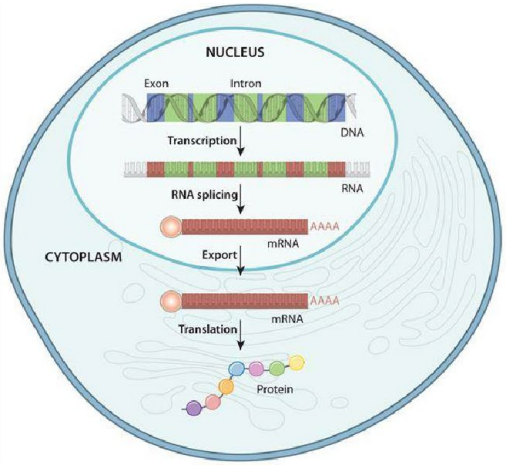
A Pune-based bio-pharma company is currently is likely to develop India's first mRNA COVID-19 vaccine.

mRNA

1. Messenger RNA (mRNA) is a single-stranded RNA (Ribo Nucleic Acid) molecule that is complementary to one of the DNA strands of a gene.
2. The mRNA is an RNA version of the gene that leaves the cell nucleus and moves to the cytoplasm where proteins are made.
3. During protein synthesis, an organelle called a ribosome moves along the mRNA, reads its base sequence, and uses the genetic code to translate each three-base triplet, or codon, into its corresponding amino acid.

M RNA- vaccines





- Such vaccines make use of the messenger RNA molecules that tell the body's cells what proteins to build.
- The mRNA, in this case, is coded to tell the cells to recreate the spike protein of the coronavirus SARS-CoV-2, which causes Covid-19.
- It is the spike protein — which appears as spikes on the surface of the coronavirus — that initiates the process of infection; it allows the virus to penetrate cells, after which it goes on to replicate.
- A coronavirus vaccine based on mRNA, once injected into the body, will instruct the body's cells to create copies of the spike protein.
- In turn, this is expected to prompt the immune cells to create antibodies to fight it.
- These antibodies will remain in the blood and fight the real virus if and when it infects the human body.

TYPES OF VACCINE

(1) VECTOR VACCINE:

1. In this type of vaccine, genetic material from the COVID-19 virus is placed in a modified version of a different virus (viral vector).
2. When the viral vector gets into your cells, it delivers genetic material from the COVID-19 virus that gives your cells instructions to make copies of the S protein.
3. Once your cells display the S proteins on their surfaces, your immune system responds by creating antibodies and defensive white blood cells.
4. If you later become infected with the COVID-19 virus, the antibodies will fight the virus.

(2) PROTEIN SUBUNIT VACCINE:

1. Subunit vaccines include only the parts of a virus that best stimulate your immune system.
2. This type of COVID-19 vaccine contains harmless S proteins.
3. Once your immune system recognizes the S proteins, it creates antibodies and defensive white blood cells.
4. If you later become infected with the COVID-19 virus, the antibodies will fight the virus.

RIBO NUCLEIC ACID (RNA)

- RNA is an important biological macromolecule that is present in all biological cells.
- It is principally involved in the synthesis of proteins, carrying the messenger instructions from DNA, which itself contains the genetic instructions required for the development and maintenance of life.
- In some viruses, RNA, rather than DNA, carries genetic information.
- The type of RNA dictates the function that this molecule will have within the cell.
- Aside from the coding region of messenger RNA (mRNA) molecules that will be translated into proteins, other cellular RNA elements are involved in different processes.

RNA Vaccine: -

- Unlike a conventional vaccine, RNA vaccines present an mRNA sequence (the molecule that purports to form cells), which is coded for a disease-specific antigen, once antigen produced within the body , The immune system develops to protect against diseases .
- RNA vaccines develop more rapidly than conventional vaccines. It is also safe for patients as they are not produced using infectious substances.
- The production of RNA vaccines is laboratory-based, and the process can be standardized and extended to speed up the diagnosis in large outbreaks and epidemics.
- RNA vaccines for infectious diseases and cancer are among the most recent for which many early-stage clinical trials have been conducted, some research has been done to find out the potential of RNA vaccines for allergies.

Working procedure of RNA vaccine: -

1. Conventional vaccines usually contain inactive disease-causing organisms or proteins made by the pathogen (antigen). They stimulate the body's immune response, so it is stimulated to react more rapidly and effectively when exposed to an infectious agent in the future.
2. But RNA vaccines work differently. They follow the process that cells use to make proteins. Cells use DNA to make messenger RNA (mRNA) molecules, which would then be used to make proteins.. An RNA vaccine contains an mRNA strand that codes for a disease-specific antigen. The mRNA strand is inside the cells of the body, where cells use genetic information to generate antigens. This antigen is then displayed on the cell surface, where it is recognized by the immune system.

RNA Vaccine and its Use

- A major advantage of RNA vaccines is that RNA can be produced at a low value and faster rate than conventional vaccine production using readily available material from templates in DNA, using chicken eggs or other mammalian cells may be required.

RNA vaccines can be used in different ways:

- Needle-syringe injection
- Through injection into blood, muscles, lymph nodes or organs directly;
- Or through a nasal spray.

- ❖ The optimal route for vaccine delivery is not yet known. The exact manufacturing and delivery process of RNA vaccines can vary by type.

Types of RNA Vaccines

I. Non-replicating mRNA
II. Self-replicating mRNA
III. In vitro dendritic cell non-replicating mRNA vaccine

BENEFITS

The advantages of mRNA vaccines over traditional approaches are:

I. RNA vaccines are not made with pathogenic particles or inactive pathogens, so are non-infectious. The RNA does not integrate itself into the host genome and the RNA is removed in the vaccine after the protein is formed.
II. According to preliminary clinical trial results, these vaccines produce a reliable immune response and are tolerated by healthy individuals with few side effects.
III. Its manufacturing method is cheaper and faster than the conventional vaccine.

SIGNIFICANT CHALLENGES

The challenges related to mRNA vaccines are as follows.

- ❖ The mRNA strand in the vaccine may precipitate an unexpected immune response. To reduce this, the mRNA vaccine sequence may affect the heredity of mammalian cells.
- ❖ The vaccine's access to cells is extremely challenging because RNA in the body soon disintegrates.
- ❖ The storage of RNA vaccines needs to be very low temperature. Therefore, it will be stored only in those places where cold storage chain will exist.

THE CONCLUSION

- ❖ The corona-affected world needs an effective vaccine as soon as possible. RNA vaccines may be helpful in this situation. But this is a subject related to genetic sequencing, so it is necessary that after testing the process of all stages of vaccine production, it should be brought for use of people.

NI-KSHAY MITRAS INITIATIVE

- ❖ The initiative ensures three-pronged support includes: Nutritional, Additional diagnostic, and Vocational support.
- ❖ The programme was brought in to fill the critical ``community'' elements into India's fight towards the **Pradhan Mantri TB Mukt Bharat Abhiyaan** aimed at **eliminating TB by 2025.**
- ❖ The **NIKSHA 2.0 portal** provides additional patient support to TB patients to take advantage of **Corporate Social Responsibility (CSR) opportunities** to improve treatment outcomes, enhance community participation and fulfill India's commitment to TB eradication.
- ❖ **Ni-kshay Mitra (Donor)** for this programme includes co-operative societies, corporates, elected representatives, individuals, institutions, non-governmental organisations, political parties and partners who can support by adopting the health facilities (for individual donor), blocks/urban wards/districts/States for accelerating the response against TB to complement the government efforts.

- ❖ The support provided to the patient under this initiative is in addition to the free diagnostics, free drugs and Ni-kshay Poshan Yojana provided by the National TB Elimination Programme (NTEP) to all the TB patients notified from both the public and the private sector.

TB-PREVELENCE IN INDIA :-

1. India has the **world's highest tuberculosis (TB) burden**, with an estimated 26 lakh people contracting the disease and approximately 4 lakh people dying from it every year.
2. The economic burden of TB in terms of the loss of lives, income and workdays is also substantial.
3. TB usually affects the most economically productive age group of society resulting in a significant loss of working days thereby pushing the TB patients further into the vortex of poverty.

TUBERCULOSIS

Tuberculosis (TB) is an infectious disease caused by **Mycobacterium** tuberculosis.

- ❖ It commonly affects the lungs, but can also affect other parts of the body.
- ❖ It is a **treatable and curable disease.**
- ❖ **Transmission**: TB is **spread from person to person through the air.** When people with lung TB cough, sneeze or spit, they propel the TB germs into the air.
- ❖ **Symptoms: Common** symptoms of active lung TB are cough with sputum and blood at times, chest pains, weakness, weight loss, fever and night sweats.
- ❖ **Vaccine:** Bacille Calmette-Guérin (BCG) is a vaccine for TB disease.

STATISTICS:

1. A total of 1.5 million people died from TB and an estimated 10 million people fell ill with tuberculosis (TB) worldwide **in 2020**.
2. **India** has the **world's highest tuberculosis (TB) burden,** with an estimated 26 lakh people contracting the disease and approximately 4 lakh people dying from the disease every year.

CHALLENGES FOR INDIA:

- ❖ Major challenges to control TB in India include poor primary health-care infrastructure in rural areas of many states; unregulated private health care leading to widespread irrational use of first-line and second-line anti-TB drugs; poverty; lack of political will; and, above all, corrupt administration.

PRADHAN MANTRI TB MUKT BHARAT ABHIYAAN

1. It has been envisioned to bring together all community stakeholders to support those on TB treatment and accelerate the country's progress towards TB elimination.
2. This is aimed at working towards TB elimination from the country by 2025.

COMPONENTS OF THE SCHEME:

- ➢ The **Ni-kshay Mitra initiative** which forms a vital component of the `Abhiyaan' is also launched along with the Abhiyaan.
- ➢ This portal provides a platform for donors to provide various forms of support to those undergoing TB treatment.
- ➢ The **three-pronged support** includes:

1. Nutritional,

2. Additional diagnostic, and
3. Vocational support.

Adoption Provision for Corporates and NGOs:

1. Under the scheme, individuals, NGOs and corporates can adopt TB patients by committing support for 1-3 years.
2. To join the initiative, they have to register on the site, which has an anonymous list of TB patients, categorized according to the primary health centres, blocks, districts and states.
3. The sponsors can select the number of patients as per their capacity.

MONTHLY FOOD BASKET:

MONTHLY FOOD BASKETS FOR TB PATIENTS

	FOR ADULTS	FOR CHILDREN
Cereals/millets	3kg	2kg
Pulses	1.5 kg	1kg
Vegetable cooking oil	250g	150g
Milk powder/ Milk/ Groundnut	1kg/ 6litres/ 1kg	750g/ 3.5litres / 0.7kg
Eggs (optional)	30 nos	30 nos

SIGNIFICANCE

1. **Vocational Training:** The sponsors may offer vocational training to family members of the TB patient.
2. **Financial support:** Most of the TB patients are breadwinners, and this puts financial strain on their families. If a family member is trained in a vocation, they will be able to continue earning.

TUBERCULOSIS (TB)

Number of cases:

- India detects 20-25 lakh TB cases every year, and nearly 4 lakhs die of it. At present, 13.5 lakh are undergoing TB treatment, of whom 9.26 lakh have already consented to being **adopted** under the initiative.

Cause:

- It is caused by **Mycobacterium tuberculosis (bacteria)** and it most often affects the lungs.

Transmission:

- TB is spread through the air when people with lung TB cough, sneeze or spit.
- A person needs to inhale only a few germs to become infected.
- With TB infection, a person gets infected with TB bacteria that lie inactive in the body. This infection can develop into TB disease if their immune system weakens.

Symptoms:

- Prolonged cough, chest pain, weakness/fatigue, weight loss, fever, etc.
- Often, these symptoms will be mild for many months, thus leading to delays in seeking care and increasing the risk of spreading the infection to others.

- ❖ Most people have the TB bacteria in the body but it gets activated if nutrition is poor and the immune system is impaired.

Diagnosis:

- ➢ In the case of suspected lung TB disease, a sputum sample is collected for testing for TB bacteria.
- ➢ For non-lung TB disease, samples of affected body fluids and tissue can be tested.
- ➢ WHO recommends rapid molecular diagnostic tests as initial tests for people showing signs and symptoms of TB.
- ➢ Other diagnostic tools can include sputum smear microscopy and chest X-rays.

TREATMENT:

1. Both TB infection and disease are curable using antibiotics.
2. It is treated by the standard 6-month course of 4 antibiotics. Common drugs include **rifampicin and isoniazid.**
3. In drug-resistant TB, the TB bacteria do not respond to the standard drugs. Its treatment is longer and more complex. It is treated by Bedaquiline.
4. In case of infection (where the patient is infected with TB bacteria but not ill), TB preventive treatment can be given to stop the onset of disease. This treatment uses the same drugs for a shorter time.

CHALLENGES

1. **Drug resistance:** Adherence to TB medication for several months is a challenge, but, if not done, can lead to drug resistant forms of the disease (XDR TB).
2. **Proper diagnosis:** Many people in rural areas have extra-pulmonary TB in the stomach, brain, or bone. If their lungs are clear they are not diagnosed with TB. Therefore, diagnosis happens at the end of the disease.
3. **Experts on non-pulmonary TB** are not included in policy making, programme implementation and in peripheral health centers.

EFFORTS TAKEN

GLOBAL EFFORTS:

1. **Global Tuberculosis Programme** and Report, **1+1 initiative** & Multisectoral Accountability Framework for TB by WHO.
2. Ending the **TB epidemic by 2030** under **UN SDG target 3.3**.
3. **Moscow Declaration** to End TB.

INDIAN EFFORTS:

1. The government aims to have a **TB-free India by 2025**, five years ahead of the global target of 2030.
2. **National Tuberculosis Elimination Programme:** National Strategic Plan to end TB by 2025 under pillars of Detect-Treat-Prevent-Build (DTPB).
3. **Universal Immunisation Programme.**
4. **Revised National TB Control Programme** under the National Health Mission.
5. **NIKSHAY portal** and TB Sample Transport Network.
6. Development of National Framework for Gender-Responsive approach to TB.

WAYFORWARD:-

1. The programme will provide the **much-needed nutritional support** to the people and will also connect the community.
2. The **peripheral healthcare system** needs to be strengthened, doctors who can treat extra-pulmonary TB need to be increased, and pharmacies need to report people who come to get the medicine so cases are not missed.
3. **Timely and proper treatment** can stop drug-resistance.

GENETICALLY MODIFIED (GM) CROPS

- GM-CROPS are derived from plants whose **genes are artificially modified,** usually by inserting **genetic material** from another organism, in order to give it new properties, such as **increased yield, tolerance** to a HERBICIDE,RESISTANCE to **disease** or DROUGHT or **improved nutritional value.**
- Earlier, India approved the commercial cultivation of only one GM crop, BT.COTTON but GEAC has recommended GM Mustard for commercial use.

GM MUSTARD

1. DMH-11 is an indigenously developed transgenic mustard. It is a genetically modified variant of Herbicide Tolerant (HT) mustard.
2. DMH-11 is a result of a cross between Indian mustard variety 'Varuna' and East European 'Early Heera-2' mustard.
3. It contains two alien genes ('barnase' and 'barstar') isolated from a soil bacterium called Bacillus amyloliquefaciens that enable breeding of high-yielding commercial mustard hybrids.
4. Barnase in Varuna induces a temporary sterility because of which it can't naturally self-pollinate. Barstar in Heera blocks the effect of barnase allowing seeds to be produced.
5. DMH-11 has shown approximately 28% more yield than the national check and 37 % more than the zonal checks and its use has been claimed and approved by the GEAC.
6. "Bar gene" maintains the genetic purity of hybrid seed.

BARNASE/BARSTAR SYSTEM :-

1. The hybrid seed production requires an efficient male sterility and fertility restoration system.
2. The currently available conventional cytoplasmic-genetic male sterility system in mustard has limitations of breakdown of sterility under certain environmental conditions leading to lowering of seed purity.
3. The genetically engineered barnase/barstar system provides an efficient and robust alternative method for hybrid seed production in mustard.
4. In India, the Centre for Genetic Manipulation of Crop Plants (CGMCP) has made a successful attempt with some alterations in the barnase/ barstar system which culminated in the development of GM mustard hybrid MH11 which has undergone the required regulatory testing processes during 2008-2016.

GM MUSTARD IS NECESSARY

1. India's import of edible oils is on continuous rise to meet the domestic demand. It ultimately led reduction forex. GM Mustard is essential to reduce the forex drain on Agri-import.

2. Productivity of oilseed crops viz., soybean, rapeseed mustard, groundnut, sesame, sunflower, safflower and linseed in India is much lower than the global productivity of these crops.
3. Crossing of genetically diverse parents results in hybrids with increased yield and adaptation

SAFETY CONCERNS ASSOCIATED WITH DMH-11

1. The safety of **three genes** used in the creation of the technique **Barnase, Barstar and Bar** is being questioned.
2. Field trials for **three years (two years of BRL-I and one year of BRL-II)** have been conducted to assess the impact on **human health and environment** as per the stipulated guidelines and applicable rules.
3. It is important to note that comprehensive research on the toxicity, allergenicity, compositional analysis, field trials, and environmental safety studies of GM mustard has shown that **they are safe for food and feed usage as well as for production.**
4. **DMH-11** has **"Bar gene"** which is responsible for herbicide tolerance. Effectiveness of **"Bar Gene"** is under question as per herbicide tolerance is concerned.

SIGNIFICANCE OF GENETICALLY MODIFIED CROPS

1. Crossing of **genetically diverse plants** results in **hybrids** with **increased yield** and **adaptation**, a phenomenon known as **hybrid vigor heterosis** which has been widely exploited in crops like rice, maize, pearl millet, sunflower and many vegetables.
2. It has been convincingly demonstrated that hybrids in general show **20-25% higher yield** over the **conventional varieties** across the crops.
3. **Hybrid technology** can play an important role in **enhancing the productivity** of **rapeseed mustard** in the country.

The genetic engineering appraisal committee (GEAC), India's biotechnology regulator has approved the environmental release and cultivation by farmers of DMH-11.It is a genetically modified (GM) hybrid mustard developed by scientists at Delhi University.

GM CROPS

THE BENEFITS OF GM CROPS	**DRAWBACKS WITH GM CROPS**
1. Better Pest and Disease Resistance. 2. Greater tolerance of stress, such as drought, low temperatures or salt in the soil. 3. High yield and faster growth, they can be cultivated and harvested in areas with shorter growing seasons. 4. More nutritious, and tastier. 5. May be possible produce medicines or even vaccines. 6. Can be made resistant to specific herbicides.	1. Can cause Unpredictable side effects. 2. Can cause ecological damage. 3. Lead to over use of herbicides. 4. Not accessible to every poor farmers. 5. Problem with Intellectual property rights.

THE STATUS OF GM VARIETIES IN INDIA

1. The country has yet to approve commercial cultivation of a GM food crop.

2. **BT Cotton:** BT cotton was first used in India in 2002.
3. **The only genetically modified cash crop under commercial cultivation in India is cotton.**
4. Now it's being grown by Indian farmers on some 11 million hectares.
5. Only 1/3rd of the kapaas or raw un-ginned cotton harvested by farmers.
6. Remaining 2/3rd comprises the seed that is crushed to extract oil.
7. Cotton-seed oil is, indeed, India's second largest indigenously produced oil today after mustard.
8. The de-oiled cake or meal remaining after oil extraction is, likewise, fed to milch animals.
9. During its introduction it was found to be promising for many farmers but after few years it created distress among the farmers.
10. It **failed to fulfil its promises** such has high yield, pest resistance, drought resistance.
11. The **seed prices are determined by corporates** which is highly expensive for the farmers.
12. Many hectares of the land has been spoiled by this seeds.
13. **BT Brinjal:** The GEAC in 2007, recommended the commercial release of Bt Brinjal.
14. It was developed by Mahyco (Maharashtra Hybrid Seeds Company) in collaboration with the Dharward University of Agricultural sciences and the Tamil Nadu Agricultural University.
15. BT brinjal was overturned in February 2010 by the then Environment Minister who assumed the role of regulator and ordered a suspension on the transgenic vegetable's cultivation.

BENEFITS OF GM MUSTARD

- GEAC has recently given a green signal for taking a decision on commercialization.
- Indigenously developed seeds, the patent remains with government unlike with cotton it remains with corporates.
- India Plans for food fortification to achieve SDG, this will help to achieving its goal.
- Yields are expected to rise by up to 30 per cent.
- India imports 15 million tonnes (Mt) of edible oils worth almost $11 billion annually, Mustard oil production from this variety of crop will save a lot on Foreign exchange exchequer.

WAY FORWARD

1. Environment ministry is the final conclusive authority in this regard.
2. If the Minister's consent is obtained, GM mustard would be the first transgenic food crop to be allowed for commercial cultivation in Indian fields and would be a gateway for several genetically-modified food crops in India.
3. Many of the GM crops in world today are cultivated for animal feed, the effects of GM crops on Humans are yet undiscovered.
4. It is to be noted that many Developed countries closed their doors for GM foods.
5. The legal and regulatory status of GM foods varies by country, with some nations banning or restricting them, and others permitting them with widely differing degrees of regulation.
6. GM varieties should be promoted in a responsible way, and lot of awareness need to be created among the stake holders.
7. Other than bio-safety concerns, transgenic technology is necessary for India to be scientifically relevant as well as have better seeds to address threats from climate change.

ELIMINATION OF MEASLES AND RUBELLA BY 2023

- The Government decided to reset the Measles-Rubella elimination target to 2023 as COVID 19 pandemic stole two years from the programme.

MEASLES AND RUBELLA

❖ **Measles-** Measles (also called **rubeola**) is a very contagious respiratory viral infection that causes a total-body skin rash and flu-like symptoms. ❖ It is transmitted person-to-person via droplets when infected people sneeze or cough. ❖ Initial symptoms usually occur 10–12 days after infection and comprise high fever, runny nose, bloodshot eyes and **Koplik's spots** (tiny white spots on the inside of the mouth). ❖ Several days later, a rash develops and the most severe complication includes blindness, encephalitis (an infection that causes brain swelling), severe diarrhea and pneumonia. There is no specific medical treatment.	➢ **Rubella-** Rubella is a viral disease caused by the rubella virus that mostly affects the skin and lymph nodes. ➢ In kids, rubella (commonly called **German measles or 3-day measles**) is usually a mild illness. ➢ But the infection is dangerous for pregnant women because it can cause serious health problems in their babies. ➢ Rubella is transmitted in airborne droplets from the nose, mouth or throat of infected people.

THE VACCINATION

1. The MR vaccine is a combined product, targeting two diseases in one shot.
2. Two doses of MR vaccine should be given at 9-12 months and 16-24 months of age.
3. However, if a child misses the scheduled dose, MR vaccine can be given till 5 years of age.
4. For epidemiological reasons, rubella vaccination had to cover children up to 15 years.
5. The same vaccine is being given in routine Universal Immunisation Programme (UIP) of India.

ELIMINATION OF THE DISEASES ❖ **Elimination of measles**- In the pre-vaccination era, while polio paralysed about 1% of all children before the age of five, measles actually killed 1% of all under-five children. ❖ The case-fatality rate of measles was about 10%-15%. ❖ Children who recovered would have lost weight as well as the steady momentum of cognitive development and academic performance. ❖ Measles affects the immune system rendering the child vulnerable to other infectious diseases, leading to high mortality over the next two to three years.	1. **Elimination of rubella-** If a pregnant woman gets infected, the virus has a tendency to cross the placenta and damage the developing fetus's eyes, brain, heart and other tissues. 2. Affected babies are born with severe birth defects such as cataracts, deafness, heart defects and developmental delay which is called as congenital rubella syndrome (CRS).

EFFORTS WERE TAKEN BY THE GOVERNMENT TO ELIMINATE MEASLES AND RUBELLA

Every year in India nearly 2.7 million children get measles and over 40,000 children are born with birth defects caused by Congenital Rubella Syndrome.

1. MR elimination is defined as zero transmission of measles and rubella viruses, evidenced by zero clinical disease, sustained over three years.
2. The two arms of intervention are vaccination and surveillance.
3. The Government decided to eliminate measles and rubella from India by the year 2020, having missed the earlier set target of 2015.
4. In 2017, the government aimed to create a very high level of vaccination-induced immunity against both diseases, by inoculating MR vaccine.
5. School registration and attendance are high in all States and so the opportunity was seized to vaccinate children in schools.
6. But due to a lack of information given to the public there was much anxiety and antipathy towards the programme in the minds of parents and school authorities.
7. Also, the COVID-19 pandemic stole two years from the programme resetting the MR elimination target to 2023.
8. In spite of the pandemic, nationally, the UIP has maintained about 85% MR second dose coverage below five years.
9. The cooperation of parents, health-care personnel at all levels, opinion leaders, influencers, media, NGOs play a key role in making the district-by-district programme a story of success.

OMICRON

- The recently identified **B.1.1.529 strain of Covid-19** has been declared as a variation of concern by the World Health Organization. The virus was discovered for the first time in Southern Africa, and it has been named **Omicron.**
- **Omicron,** along with the globally dominant Delta and its weaker rivals Alpha, Beta, and Gamma, is put in the most troublesome category of Covid-19 variants.
- **There are a lot of mutations in this variant. Some of these are concerning because they could allow new variants to avoid immunity gained from a previous infection or a vaccine.**
- However, no accurate estimates exist of how much more transmissible the Omicron variety is compared to prior viral strains.
- Apart from South Africa, Omicron has been found in Israel by people coming from Malawi, Botswana, Belgium, and Hong Kong.

NOMENCLATURE

- To avoid stigmatizing the countries that initially discovered the mutations, the WHO opted to name them after letters of the Greek alphabet.
- Instead of **Nu or Xi**, the two letters between Mu and Omicron, WHO chose Omicron. Because of the following reasons:

1. In China, **Xi** is a common surname (to avoid offending any cultural, social, national, regional, professional, or ethnic groups).
2. It's possible that **Nu** could be mixed up with the **word 'new.'**

THE SITUATION IN INDIA

1. According to **seroprevalence studies**, a large section of the population has already been exposed to the virus, offering some protection against future infections. In addition, the immunization effort has gained momentum.

2. Approximately 44 percent of Indian people have had all of their vaccinations, and 82 percent have had at least one dose.
3. Prior infection followed by one or two doses of vaccine, according to scientists, may have a greater protective impact than two doses of vaccination alone.

THE VARIANTS OF CONCERN

1. There is evidence of **increased transmissibility, more severe disease** (e.g., increased hospitalizations or deaths), a significant **reduction in neutralization by antibodies** generated during the previous infection or vaccination, **reduced effectiveness of treatments or vaccines, or diagnostic detection failures** for this variant.
2. The new Variants have the potential to start a fresh wave of epidemic transmission.
3. The World Health Organization (WHO) has identified five variants of concern:

- In November 2021, **Omicron (B.1.1.529)** was identified in southern Africa.
- **Delta (B.1.617.2)** is a virus that emerged in India in late 2020 and has since spread around the world.
- **Gamma (P.1)**emerged in late 2020 in Brazil.
- In early 2020, **Beta (B.1.351)** emerged in South Africa.
- **Alpha (B.1.1.7)** emerged in late 2020 in the United Kingdom.

WAY FORWARD

- In light of the variations, India should take a risk-based and scientific approach to travel restrictions.
- **Public Health Measures are Still Vital:** New developing variants indicate that public health measures are still important. Distancing, masking, avoiding congested spaces, and proper ventilation area few examples.
- **Lesson Learned:** The pandemic has shown us in India the crucial relevance of biomedical research and capacity building in saving lives and growing the economy.

ANTIMICROBIAL RESISTANCE: THE SILENT THREAT

Antimicrobial

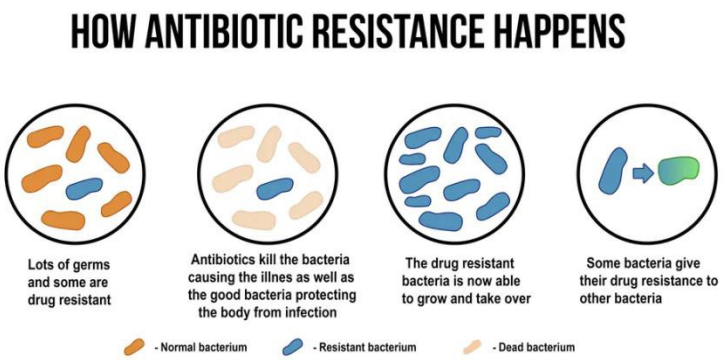
Antimicrobials - including antibiotics, antivirals, antifungals and antiparasitics - are medicines used to prevent and treat infections in humans, animals and plants.

According to the **World Health Organization (WHO), Antimicrobial resistance (AMR)** is one of the greatest challenges of the 21st century.

- Since January 2020, there have been over three million deaths globally on account of COVID-19, starkly exposing the vulnerabilities of health systems to infectious disease.
- As serious as the current health and economic crisis is, COVID-19 can be the **harbinger of future crises**. And, one such major crisis is **Antimicrobial Resistance (AMR).**
- This could be the greatest challenge of the 21st century as amidst the pandemic there are **rampant use of antibiotics** (For example: Azithromycin & other antibiotics used by most of the people.)

ANTIMICROBIAL RESISTANCE (AMR)

- Antimicrobial Resistance (AMR) occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines making infections harder to treat and increasing the risk of disease spread, severe illness and death.

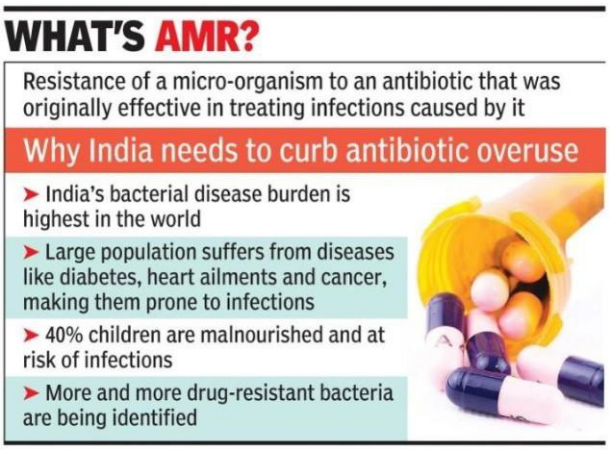


EMERGENCE AND SPREAD OF AMR

- AMR occurs naturally over time, usually through genetic changes.
- Antimicrobial-resistant organisms are found in people, animals, food, plants and the environment (in water, soil and air).
- They can spread from person to person or between people and animals, including from food of animal origin.
- The main drivers of antimicrobial resistance include the **misuse** and **overuse of antimicrobials**, **lack** of **access to clean water**, **sanitation and hygiene (WASH)** for both humans and animals**, poor infection** and **disease prevention** and **control** in healthcare facilities and farms, **poor access** to **quality, affordable medicines**, **vaccines and diagnostics,** lack of **awareness and knowledge**, and lack of enforcement of legislation.

FACTORS CAUSING AMR IN INDIA

1. **Inappropriate consumption** of broad-spectrum (last resort) antibiotics is high because of changing prescription practice in the healthcare system due to the **non-availability of a narrow spectrum of antibiotics.**
2. Inappropriate antibiotic use among the general public like **Self-medication** to avoid the financial burden.
3. The large proportion of **sewage** is **disposed of untreated** into receiving water bodies, leading to gross contamination of rivers with antibiotic residues, antibiotic-resistant organisms.



CHALLENGES POSED BY AMR

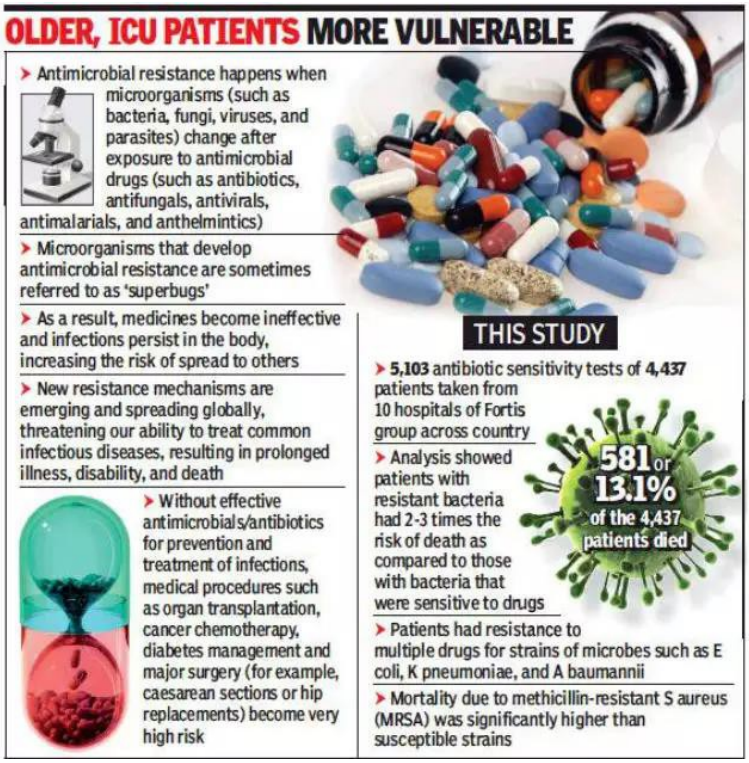
1. Antibiotic resistance is emerging as the threat to successful treatment of infectious diseases, organ transplantation, cancer chemotherapy and major surgeries.

2. The issue of AMR causes out of pocket expenditure on health care, especially on medicines. The use of high order drugs or second-line expensive antibiotics pushing treatment cost high.
3. Neonates and elderly both are prone to infections and are vulnerable.

GLOBAL CONCERNS

1. It is a global health and development threat.
2. WHO has declared that AMR is one of the top 10 global public health threats facing humanity. AMR is already responsible for up to 7,00,000 deaths a year.
3. Unless urgent measures are taken to address this threat, we could soon face an unprecedented health and economic crisis of 10 million annual deaths and costs of up to $100 trillion by 2050.
4. Antibiotics are becoming increasingly ineffective as drug resistance spreads globally leading to more difficult to treat infections and death.

- ❖ All these effects will be felt globally, but the scenario in the **low- and middle-income countries (LMICs)** of Asia and Africa is even more serious.
- ❖ LMICs have significantly driven **down mortality** using cheap and easily available antimicrobials. In the absence of new therapies, health systems in these countries are at severe risk of being overrun by untreatable infectious diseases.



CONCERNS REGARDING AMR

1. **Life-threatening Condition:** The growth of AMR has proved to be a **major challenge in the treatment of sepsis,** which is a life-threatening condition and, unfortunately, the failure of antibiotics is **leading to deaths which are preventable.**

2. **Reduction in Medical Advances:** AMR is also **undermining and undoing medical advances made over decades,** especially for high-burden diseases like TB and various cancers.
3. **Achievements of Goals:** It is putting the gains of the Millennium Development Goals at risk and **endangers achievement of the** SDG
4. Increase in Superbugs: Untreated wastewater from medical facilities is awash with chemical compounds that **promote superbugs.**
5. **Expanding with Time:** The concoction of **self-medication and over the counter (OTC) antibiotic availability** has led to one of the **highest rates of antibiotic resistance** in the world.

REASONS FOR THE SPREAD OF AMR

Antibiotic consumption in humans

- Unnecessary and injudicious use of antibiotic fixed dose combinations could lead to emergence of bacterial strains resistant to multiple antibiotics.

Social factors

- Include self-medication.
- Access to antibiotics without prescription.
- Lack of knowledge about when to use antibiotics.

Cultural Activities

- Mass bathing in rivers as part of religious mass gathering occasions.

Antibiotic Consumption in Food Animals

- Antibiotics which are critical to human health are commonly used for growth promotion in poultry.

Pharmaceutical Industry Pollution

- The wastewater effluents from the antibiotic manufacturing units contain a substantial amount of antibiotics, leading to contamination of rivers and lakes.

Environmental Sanitation

- Untreated disposal of sewage water bodies - leading to contamination of rivers with antibiotic residues and antibiotic-resistant organisms.

Infection Control Practices in Healthcare Settings

- A report on hand-washing practices of nurses and doctors found that only 31.8% of them washed hands after contact with patients.

VARIOUS INITIATIVES ADOPTED IN THIS ASPECT

Global Efforts	**INDIA'S INITIATIVE**
❖ **Global Action Plan on Antimicrobial Resistance (GAP):** Globally, countries committed to the framework set out in the **Global Action Plan1 (GAP) 2015** on AMR during the 2015 World Health Assembly and committed to the development and implementation of multisectoral national action plans.	1. To prevent the Over the counter sales of antibiotics, the **central drug standard control organization(CDSO)** prohibits medical stores from selling 24 key antibiotics without a doctor's

- **Tripartite Joint Secretariat on Antimicrobial Resistance:** Tripartite joint secretariat (FAO, OIE and WHO) has been established and is hosted by WHO to drive multi-stakeholder engagement in AMR.
- **Interagency Coordination Group (IACG) on AMR**: It was convened by the Secretary-General of the United Nations after the **UN High-Level Meeting on Antimicrobial Resistance in 2016.**

The IACG brought together partners across the UN, international organizations and individuals with expertise across human, animal and plant health, as well as the food, animal feed, trade to formulate a plan for the fight against antimicrobial resistance.

- **World Antimicrobial Awareness Week (WAAW):** WAAW was previously called the **World Antibiotic Awareness Week**. From 2020, it will be called the World Antimicrobial Awareness Week.
- It is a global campaign that aims to **raise awareness of antimicrobial resistance worldwide**.
- **Global Antimicrobial Resistance and Use Surveillance System (GLASS):** WHO launched it **in 2015** to continue filling knowledge gaps and to inform strategies at all levels.
- GLASS has been conceived to progressively incorporate data from surveillance of AMR in humans, surveillance of the use of antimicrobial medicines, AMR in the food chain and the environment.
- **Global Antibiotic Research and Development Partnership (GARDP):** A **joint initiative of WHO and the Drugs for Neglected Diseases Initiative (DNDi)**, GARDP encourages research and development through public-private partnerships.
- By 2025, the partnership aims to develop and deliver five new treatments that target drug-resistant bacteria identified by WHO as posing the greatest threat.
- **Country wise initiatives:**A multi-sectoral $1 billion **AMR Action Fund** was launched in **2020** to support the development of **new antibiotics**, and the U.K. is trialling a subscription-based model for paying for **new antimicrobials** towards ensuring their commercial viability.

1. **Peru's efforts** on patient education to reduce unnecessary antibiotic prescriptions.
2. **Australian regulatory** reforms to influence prescriber behaviour, and initiatives to increase the use of point-of-care diagnostics, such as the **EU-supported VALUE-Dx programme**.
3. **Denmark's reforms** to prevent the use of antibiotics in livestock have not only led to a significant reduction in the prevalence of resistant microbes in animals, but also improved the efficiency of farming.

prescription.

2. **India's Red Line campaign**: Which demands that prescription-only antibiotics be marked with a red line, to discourage the over-the-counter sale of antibiotics– is a step forward.
3. **National Health Policy, 2017**, terms antimicrobial resistance as one of the key healthcare issues and prioritizes the development of guidelines regarding antibiotic use and check on restricting the growth of antibiotics.
4. **The National Action Plan on Antimicrobial Resistance (NAP-AMR) 2017** has assigned coordinated tasks to multiple government agencies involving health, education, environment, and livestock to change prescription practices and consumer behaviour and to scale up infection control and antimicrobial surveillance.
5. FSSAI has set certain guidelines limiting the antibiotics in food products such as fish and honey.

CONCLUSION & WAY FORWARD

- Till now, there are **two major possible solutions** to combat the AMR menace:
- **Discovery of new drugs**, before the emergence of resistance in germs; and prudent use of available antibiotics.

The discovery of a new drug is an expensive and unpredictable process, the estimated cost for developing a new antibiotic exceeds $1 billion.

- The **second solution** is the best possible solution i.e. to use the available antibiotics carefully to ensure their efficacy for as long as possible.

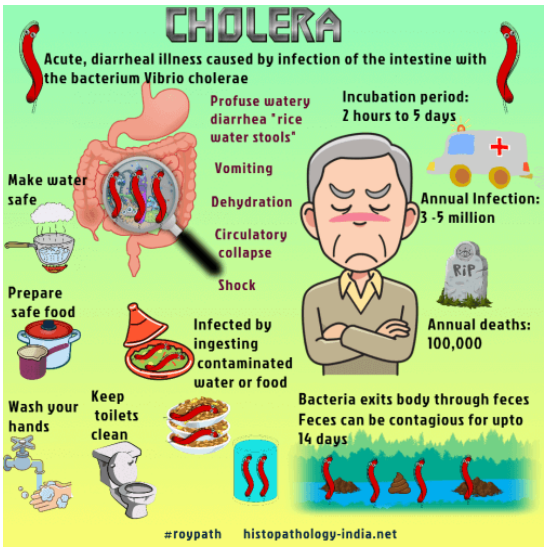
Other steps: AMR requires a united multisectoral approach.

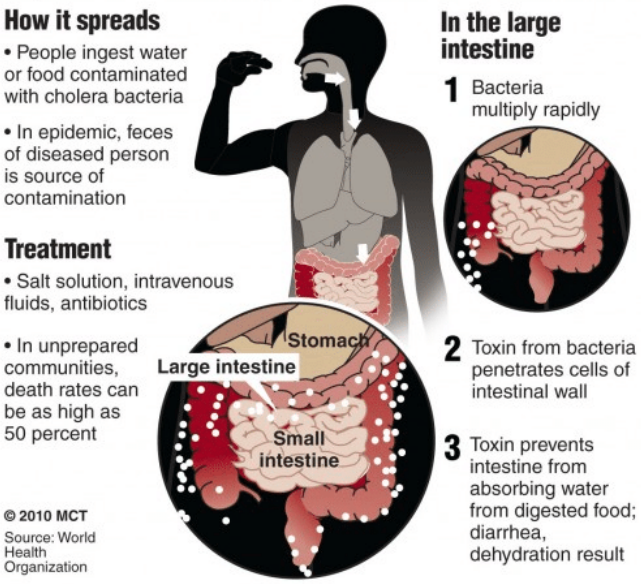
1. Efforts to control prescription through provider **incentives** should be accompanied by efforts to **educate consumers** to **reduce inappropriate demand**, issue standard treatment guidelines.
2. **Policy alignment** is also needed much beyond the health system. Solutions in clinical medicine must be integrated with improved surveillance of AMR in agriculture, animal health and the environment.

CHOLERA

- Recently, several countries across the world have **reported a surge in cholera cases** this year raising concerns about a global resurgence of the disease.
- These include **Kenya, Malawi, Haiti and the Philippines.**

CHOLERA





- ❖ Cholera is a bacterial disease usually spread through contaminated water. It causes severe diarrhea and dehydration.

Symptoms:

- ➢ Severe watery diarrhea accompanied by vomiting which can quickly lead to dehydration.

Spread:

- ➢ The risk of a cholera epidemic is highest when poverty, war or natural disasters force people to live in crowded conditions without adequate sanitation.

Prevalence:

- ➢ Modern sewage and water treatment have virtually eliminated cholera in industrialized countries. But cholera still exists in Africa, Southeast Asia and Haiti.

Prevention and control:

- ➢ A multifaceted approach is key to control cholera, and to reduce deaths. A combination of surveillance, water, sanitation and hygiene, social mobilization, treatment, and oral cholera vaccines are used.

Researchers identified the decline of antimicrobial resistance in Cholera-Causing Bacteria.

FINDINGS

- ❖ More than two hundred serogroups of Cholera bacterium are known, of which only O1 and O139 Genomes are known to cause such infection that leads to EPIDEMICS & PABDEMICS.
- ❖ Researchers studied the genome of O139 and traced the reason for its dying down after taking over from O1.
- ❖ Two key genomic evolutionary changes took place in O139, the first related to the type of cholera toxin it produced and the second related to a loss of AMR
- ❖ Two main modifications were in the cholera toxin genes and in the Antimicrobial Resistance (AMR) portfolio.
- ❖ With the reduction in AMR capacity of O139, it potentially lost its competitive advantage against the O1.

1. It is a life-threatening infectious disease and a public health hazard.
2. Cholera is an acute, diarrheal illness caused by infection of the intestine with the bacterium *Vibrio cholerae*.
3. The infection is often mild or without symptoms, but sometimes can be severe.

RECOMMENDATIONS

1. Continuous surveillance is necessary to monitor if any of the serotypes and serogroups are gaining antibiotic resistance over time and may become major outbreak lineages at any time.
2. To stay ahead of the curve and ensure best public health outcome, it is important that vaccines and treatments are regularly re-evaluated for efficiency to any newly evolving variants.

NOBEL PRIZE IN MEDICINE 2022

- The 2022 Nobel Prize for Physiology or Medicine has been awarded to **Swedish geneticist Svante Pääbo** for his research in the field of genomes of **extinct hominins and human evolution.**

FOCUS :-

- Awarded by: The Royal Swedish Academy of Sciences in Stockholm.
- Awarded for: Dr. Svante Pääbo's discoveries in developing new and innovative methodologies to extract clean DNA from thousands of years old fossils and reading genetic information contained in it.
- Relevance: It will help in understanding the influence of archaic gene sequences from extinct human ancestors over the physiology of present-day humans. For example-
- Denisovans gene EPAS1 confers an advantage for survival at high altitudes which is common among present-day Tibetans.
- Neanderthal genes affect our immune response to different types of infections.

GENOME SEQUENCING

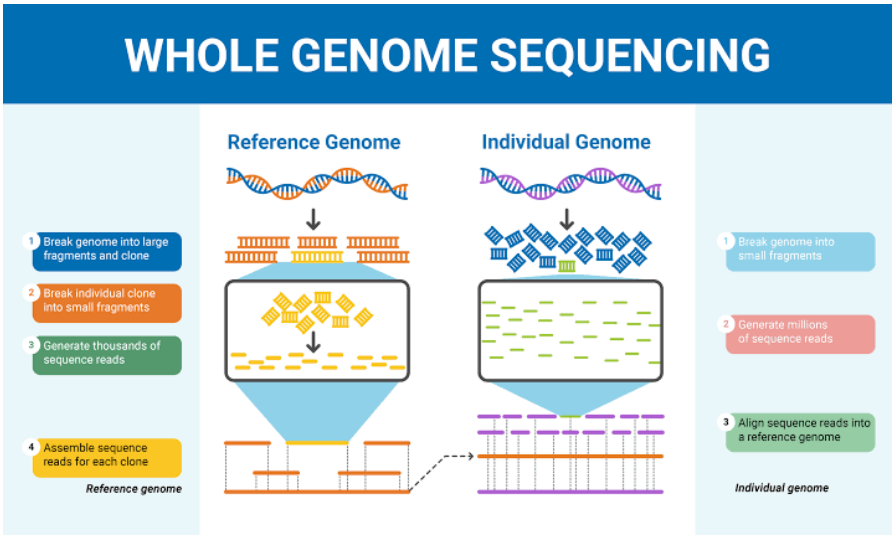
- It refers to sequencing the entire genome of an organism (DNA/RNA based) with the help of many high throughput sequencing and data handling technologies.

MAJOR GENOME SEQUENCING METHODS:

I. **The clone-by-clone method:** The **"clone-by-clone"** approach involves first breaking the genome up into relatively large chunks, called clones, about 150,000 base pairs (bp) long. Scientists use genome mapping techniques to figure out where in the genome each clone belongs.

II. **Whole genome sequencing (WGS):** It does not require a genome map and is a faster method of sequencing.

III. It is not suitable for larger genomes like eukaryotic genomes as they have a number of repetitive DNA sequences in which the assembling process is challenging.



- **Utility of both**: To speed up the genome sequencing process, advantages of both methods are used.

GENOME INDIA PROJECT

- **Genesis**: Cataloging the Genetic Variation in Indians project was sanctioned by the Department of Biotechnology (DBT) in January, 2020 to 20 institutions from varied disciplines across the country.
- **The proposed target:** Whole Genome Sequencing (WGS) for a total 10,000 individuals representing the country's diverse population in 3 years.

OBJECTIVES:

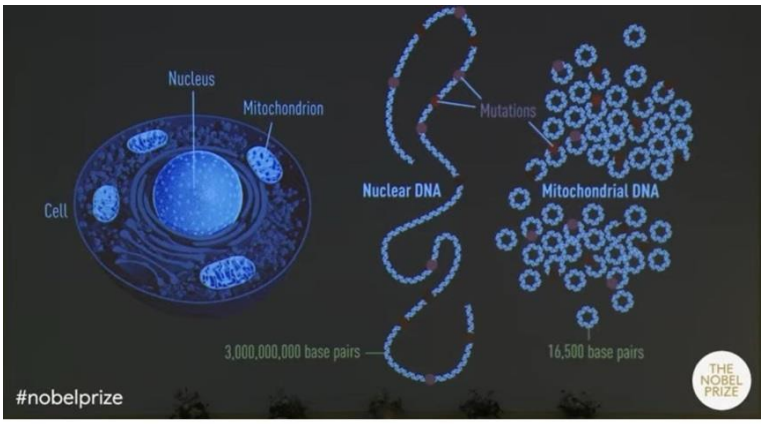
I. To harness the information generated from WGS in facilitating future human genetics research in India with greater precision.
II. To design a genome wide association array for the Indian population to develop precision healthcare and diagnostics for major diseases at affordable costs.

- **The data security and sharing measures** for this project will be governed by the rules and regulations formulated by the Government of India.
- The personal information of all individuals consenting to participate in the study will be stripped off from any further records in this project.
- This process of de-identification ensures that the personal information of the participants is not compromised.

Additionally, ethical measures are strictly adhered to in order to maintain data security and protection.

DR. SVANTE PÄÄBO'S RESEARCH OVERVIEW

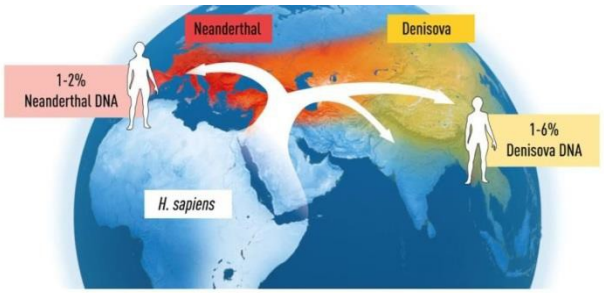
- **Discovery of Denisovans:** Denisova were a previously unknown hominin. He concluded that gene transfer occurred from Denisovans to Homo sapiens after they migrated out of Africa around 70,000 years ago.



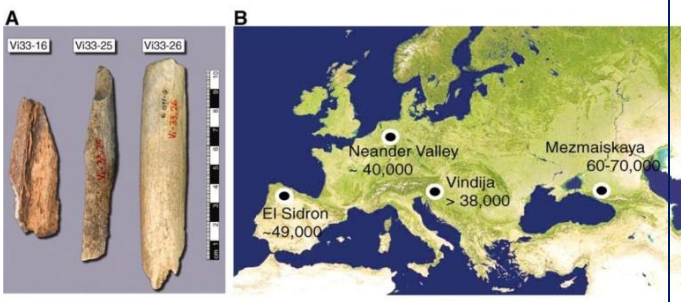
Nuclear DNA and mitochondrial DNA. | Photo Credit: Screenshot via Nobel Prize on YouTube

I. **The genome sequencing of Neanderthal**: Extinction of Neanderthals around 30,000 years ago was concluded after his sequencing of mitochondrial DNA from a 40,000-year-old bone and comparison with contemporary humans and chimpanzees.
II. **Neanderthals** are the closest relatives of the present-day human species. They lived in Europe and West Asia – as far as southern Siberia and Middle East
III. **Publishing of 1st Neanderthal genome sequence in 2010**: Neanderthal DNA sequences exhibit closer similarity with the DNA of contemporary humans originating from Europe or

Asia than to contemporary humans originating from Africa. It suggests interbreeding and co-existence between Neanderthals and Homo sapiens.



Possible interbreeding, and how the world was populated | Photo Credit: The Nobel Foundation



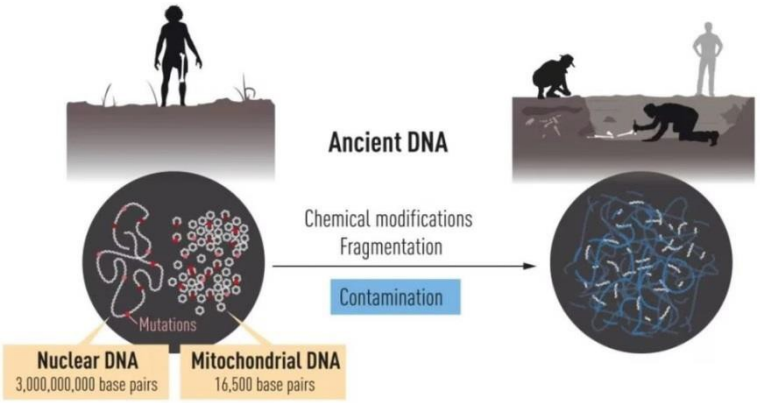
A. The three bones from Vindija from which Neandertal DNA was sequenced. B. Map showing the four archaeological sites from which bones were used and their approximate dates (years B.P.) | Photo Credit: Science.org

- **Divergence of DNA sequence:** He found greater divergence of the Neanderthal genome to the human reference genome as compared to any of the 5 present-day human genomes. These are-

I. San from Southern Africa
II. Yoruba from West Africa
III. Papua New Guinean
IV. Han Chinese
V. French from Western Europe

IMPORTANCE OF THE RESEARCH:

I. **Study of human evolution**: He researched hominins which are extinct members of the human lineage and ancient gene flow across human evolution. It will also help in the recognition of the field of evolutionary biology.
II. **Paleogenomics**: Dr. Pääbo's research has resulted in the rise of a new scientific discipline called paleogenomics. It is the study and analysis of genes of ancient or extinct organisms.
III. **Technological complexity:** It is not easy to amplify and sequence ancient DNA because it is highly fragmented and full of contamination from microbes like fungi and bacteria. Also, ancient DNA is not preserved well in tropical weather conditions like Africa and India.



DNA location and contamination | Photo Credit: The Nobel Foundation

Better Funding: The renewed interest in the field will hopefully lead to better funding and more opportunities for researchers.

NOBEL PRIZES 2022 IN SCIENCES

The Nobel Prizes 2022 have been announced. The Prizes have been awarded for pioneering research in various fields in sciences and for efforts in furthering peace.

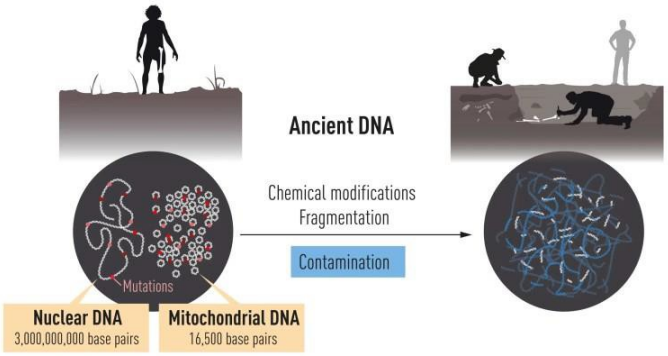
1. The first Nobel Prizes were awarded in Stockholm, Sweden in 1901 on the 5th death anniversary of Alfred Nobel. Swedish inventor Alfred Nobel invented dynamite and other high explosives.
2. Originally, the prize was awarded in the fields of Physics, Chemistry, Physiology or Medicine, Literature, and Peace. Later in 1968, a sixth prize was added in the field of economic sciences, but it is not officially called Nobel Prize (Sveriges Riksbank Prize in Economic Sciences).
3. Prizes may be given only to individuals, except the Peace Prize, which may also be conferred upon an institution. However, maximum of 3 individuals can share a prize.

NOBEL PRIZE IN MEDICINE OR PHYSIOLOGY, 2022

I. The Nobel Prize in Medicine (Physiology) 2022 has been awarded to Svante Paabo. He has been credited with developing **methodologies to extract 'clean' DNA from thousands of years old human fossils**, and reading the genetic information they contain.

II. Earlier, scientists were dependent on the genomes of present day human beings and extrapolating the information into the past. This method is called deduction. This is a scientifically valid exercise, but it is indirect and involves uncertainties. Paabo developed methodologies that have eliminated deductions, and **rely on direct observation**. For example, he realised that one particular skull bone, called petrous, preserves DNA better than the rest of the body.

III. There are extreme technical challenges in his work because with time DNA becomes chemically modified and degrades into short fragments. Only trace amounts of DNA are left after thousands of years. Exposure to the natural environment leads to contamination with DNA from bacteria and contemporary humans. This makes research complex.



SIGNIFICANCE

- **First**, Svante Pääbo established an entirely new scientific discipline, called **paleogenomics**, that focuses on studying the DNA and genetic information of extinct hominins through reconstruction.
- **Second**, Pääbo's discoveries have established a unique method, which is **utilized extensively** by the scientific community to **better understand human evolution and migration**.
- **Third**, Pablo's work enabled the revelation and understanding of how **gene transfer had occurred from hominins** (now-extinct species of apes that are believed to be related to modern humans) **to Homo sapiens** following their migration out of Africa around 70,000 years ago. It helped in greater understanding about how ancient gene sequences from past ancestors (apes) have shaped modern human physiology including immune systems.
- **Fourth**, his work also led to the sensational **discovery of a previously unknown hominin**, which has been named **Denisova**.

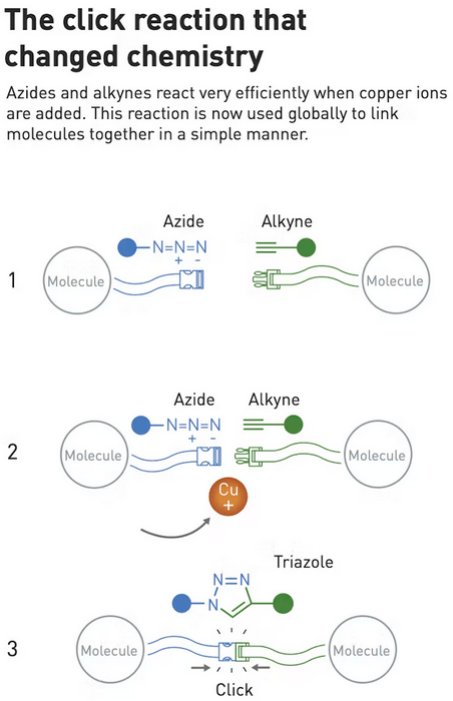
NOBEL PRIZE IN CHEMISTRY, 2022

- The Nobel Prize 2022 in Chemistry has been awarded to three scientists, Carolyn Bertozzi and Barry Sharpless of the United States and Morten Meldal of Denmark.
- Barry Sharpless and Morten Meldal have been awarded the Nobel Prize in Chemistry 2022 because they brought chemistry into the era of functionalism and **laid the foundations of Click Chemistry**. Carolyn Bertozzi took click chemistry to a new dimension and began using it to map cells. Her bio-orthogonal reactions have contributed to **more targeted cancer treatments**, among many other applications.

CHEMISTRY

- Chemists often try to **recreate complex chemical molecules found in nature**. This has applications in multiple fields including in the field of medicine e.g., to target and block pathogens in cells. However, this process is generally **complicated** and **time-consuming**.
- Click Chemistry is a way of generating products that follow examples in nature. It is based on the premises that it is easier to produce complex molecules starting with smaller and simple molecules that have a tendency to bond together or easily react with each other. In other words, scientists should look for molecules that **easily fit into each other, or 'click' with each other**. It makes the resultant chemical reaction more efficient. This approach may **avoid many unnecessary side reactions** with a **minimal loss of material**. The idea is also to not generate the exactly same complex molecule, but to find molecules that fulfil the same functions as complex molecule.

- This click approach emphasised the need to **replicate nature's efficiency**, not its processes, or products. The name 'click 'has been taken from the click sound that airline seat belts make when they are fastened.



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SIGNIFICANCE

1. **First**, the concept of click chemistry is extremely beneficial to the pharmaceutical industry because it **reduces waste produced during chemical reactions**.
2. **Second**, Meldal through his experiments came up with the useful chemical structure called triazoles, which are stable and are found in pharmaceuticals, dyes and agricultural chemicals.
3. **Third**, Bertozzi has continuously improved her approach over the years. Her works **show promise in treating late-stage cancer**. Clinical studies of anti-cancer medicines inspired by her work are now undergoing clinical trials.

- Nobel Prize in chemistry, 2022 was awarded to scientists Carolyn R. Bertozzi, Morten Meldal and K. Barry Sharpless for their development of '**click chemistry'** and '**bioorthogonal chemistry'**.
- So let us assess their applications of 'Click chemistry' and understand how it works.

I. Click chemistry is a method for attaching a '**probe' or 'substrate'** of interest to a specific biomolecule, a process called **bio-conjugation.**

II. The possibility of attaching **fluorophores** and other reporter molecules has made click chemistry a very powerful tool for **identifying, locating, and characterizing** both old and new biomolecules.

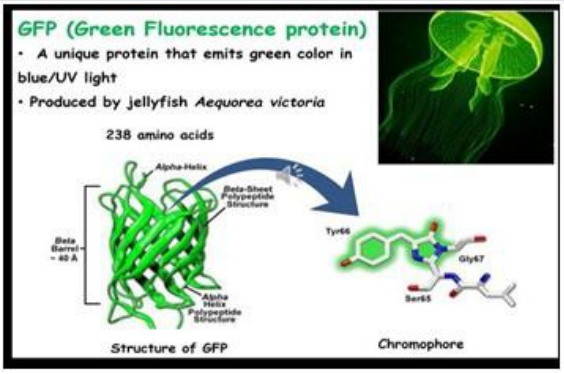
- Fluorophores are microscopic molecules, which may be proteins, small organic compounds, or synthetic poly wavelengths and emit light of longer wavelengths.

1. One of the earliest and most important methods in bioconjugation was to express a reporter on the same open reading frame as a biomolecule of interest.
2. Notably, **GFP was first** (and still is) expressed in this way at the **N- or C- terminus** of many proteins. However, this approach comes with several difficulties.

3. For instance, GFP is **a very large unit** and can often affect the folding of the protein of interest.
4. To overcome these challenges, chemists have opted to proceed by identifying pairs of **bioorthogonal reaction partners**, thus allowing the use of small exogenous molecules as **biomolecular probes**.

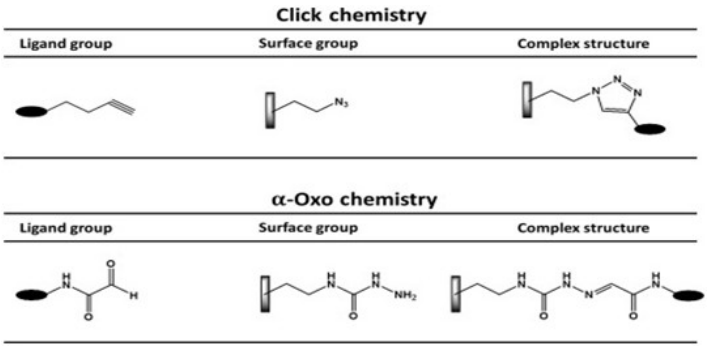
Bio-orthogonal Chemistry:

- Bioorthogonal chemistry represents a class of high-yielding chemical reactions that proceed rapidly and selec without side reactions towards endogenous functional groups.



APPLICATIONS

- Click chemistry, is a way of building molecules like snapping Lego blocks together.
- It takes **two molecules** to click, so researchers refer to each one as '**click partners'**.
- It is a term that was introduced by **B. Sharpless in 2001** to describe reactions that are high yielding, wide in scope, create only by-products that can be removed without chromatography, are stereospecific, simple to perform, and can be conducted in easily removable or benign solvents.
- The click reaction has proven to be **very useful for modifying functional biomolecules because of its high chemoselectivity**.
- Biologic oligomers and polymers, such as peptides, nucleic acids, and carbohydrates, have been modified by using the copper-catalyzedazide-alkyne cycloaddition click reaction.



- Click chemistry is the **1,3-dipolar cycloaddition of an azide and alkyne to form 1,2,3-triazole**, which has been applied for a wide range of applications due to its simple workup and purification steps, rapidly creating new products.
- For a reaction to be considered a click reaction, it **must satisfy certain**

characteristics:

- modularity

- insensitivity to solvent parameters
- high chemical yields
- insensitivity towards oxygen and water
- regiospecificity and stereo specificity
- A large thermodynamic driving force (>20 kcal/mol) to favour a reaction with a single reaction product. A distinct exothermic reaction makes a reactant "spring-loaded".

The process would preferably:

I. have simple reaction conditions
II. use readily available starting materials and reagents
III. use no solvent or use a solvent that is benign or easily removed (preferably water)
IV. provide simple product isolation by non-chromatographic methods (crystallisation or distillation)
V. Have high atom economy.

Is Click Chemistry irreversible-

- 'Click chemistry' allows for the linking together of chemical modules, however, there are currently no methods that also allow for facile **'de-clicking'** to unlink them.

Additional applications include:

1. Two-dimensional gel electrophoresis separation
2. Modification of natural products and pharmaceuticals
3. Drug discovery
4. Modification of DNA and nucleotides by triazole ligation
5. Polymers and biopolymers
6. Surfaces
7. Material science
8. Nanotechnology etc.

LIMITATIONS:

- Limitations emerge from the chemistry of the probe to its target. In order for this technique to be useful in biological systems, click chemistry must run at or near biological conditions, produce little and (ideally) non-toxic byproducts, have (preferably) single and stable products at the same conditions, and proceed quickly to high yield in one pot.

NOBEL PRIZE IN PHYSICS, 2022

- The Nobel Prize 2022 for Physics has been awarded to three scientists, Alain Aspect, John F Clauser and Anton Zeilinger, for their work on quantum mechanics. They have been awarded for their experiments with **entangled photons**, establishing the violation of Bell inequalities and **pioneering quantum information science**.

QUANTUM ENTANGLEMENT

- Quantum Entanglement has been an intensely debated phenomena in Physics. Albert Einstein had described this as 'Spooky Action at a Distance' (i.e., scary or ghostly). According to the **Special Theory of Relativity**, **no signal or information can travel faster than the speed of light in vacuum**. However, in the Quantum Entanglement phenomena, **information between 'entangled particles' seems to violate this principle** (travel faster than light). It had been proposed (in 1930s by Einstein among others) that the phenomena of entanglement is not 'real' and there was something missing in the conception of Quantum Mechanics. In 1964, a physicist John Bell showed mathematically what was required to be done by

experimentalists to establish the phenomenon of entanglement. He proposed the **Bell's Inequality**, which if maintained in the results of the experiment, would mean that Einstein was right (i.e. Entanglement is not 'real'). If violated, it would prove the predictions of Quantum Theory.

- Aspect, Clauser and Zeilinger conducted a series of experiments on **entangled quantum states**, where **two separate particles behave like a single unit**. Clauser and Zeilinger worked on Bell's ideas, and their measurements **supported quantum mechanics by violating a Bell Inequality**. The experiments of three scientists have conclusively established that the **'entanglement' phenomenon observed in quantum particles is real**, and not a result of any 'hidden' or unknown forces. Their work has demonstrated a phenomenon called **quantum teleportation**, which makes it possible to move a quantum state from one particle to one at a distance.

NON-COMMUNICABLE DISEASES

- The World Health Organisation (WHO) has released a report: 'Invisible numbers – the true scale of non-communicable diseases' on non-Communicable diseases

I. WHO has launched a **portal**, which, for the first time, **brings together all WHO data** related to NCDs for 194 countries.

II. President of the Public Health Foundation of India had described NCDs as a **public health emergency in slow motion.**

FINDINGS OF THE REPORT:

- NCDs led to 66% of deaths in India in 2019
- Further there was a 22 per cent probability of death between the age of 30 and 70
- Over 60.46 lakh people died due to NCDs in India in 2019.
- Every two seconds, one person under the age of 70 dies of a non-communicable disease (NCD) with 86 per cent of those deaths occurring in low- and middle-income countries.
- Non-communicable disease deaths are due to cardiovascular diseases (over 25 lakhs deaths), chronic respiratory disease (over 11 lakhs deaths), diabetes (around 3.5 lakhs deaths), chronic obstructive pulmonary disease and cancer.
- Diabetes of Type 2 nature accounts for more than 95 per cent of global cases caused due to– tobacco use, unhealthy diet, harmful use of alcohol, physical inactivity, and air pollution.
- Cancer causes one in six deaths – 9.3 million people a year — and 44 per cent of cancer deaths could have been prevented or delayed by eliminating risks to health.
- Chronic obstructive pulmonary disease kills 4.1 million people a year i.e., cause of one in 13 deaths.
- Covid-19 highlighted the links between NCDs and infectious disease, as in the early months of the pandemic, 75 per cent of countries reported disruption to essential NCD services.

TYPE 2 DIABETES:

I. Diabetes is one of the **most common** NCDs

II. Type 2 diabetes is a **chronic condition** that affects the **way the body processes blood sugar (glucose).** With type 2 diabetes, the body **either doesn't produce enough insulin, or it resists insulin.**

III. It is characterized by **high blood sugar, insulin resistance, and relative lack of insulin**.

IV. Type 2 diabetes primarily occurs as a result of **obesity, lack of exercise, excessive use of alcohol and tobacco** and **unhealthy lifestyle.**

V. **Symptoms** include increased thirst, frequent urination, hunger, fatigue, and blurred vision.

VI. **Treatments** include diet, exercise, medication, and insulin therapy.

STATUS OF NON-COMMUNICABLE DISEASES (NCDS) IN INDIA

- According to the study report "India: Health of the Nation's States"- The India State-Level Disease Burden Initiative in 2017 by Indian Council of Medical Research (ICMR), it is estimated that the proportion of deaths due to Non-Communicable Diseases (NCDs) in India have increased from 37.9% in 1990 to 61.8% in 2016. The four major NCDs are cardiovascular diseases (CVDs), cancers, chronic respiratory diseases (CRDs) and diabetes which share four behavioral risk factors –unhealthy diet, lack of physical activity, and use of tobacco and alcohol.
- The detailed proportion changes in Disability Adjusted Life Years (DALYs) number for the leading individual causes of these NCDs among women from 1990 to 2016 are given in the table below:

Name of NCD	**Proportion of changes in DALYs number**
	1990
Cardiovascular diseases(IHD)	2.9%
Chronic respiratory diseases (CRDs)	2.7%
Diabetes	0.7%
Cancer (Breast)	0.7%

- Health is a state subject. The Department of Health & Family Welfare, Government of India, however, provides technical and financial support to the States/UTs under the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS), (launched in 2010) as part of National Health Mission (NHM), based on the proposals received from the States/UTs and subject to the resource envelope. The programme focuses on strengthening infrastructure, human resource development, health promotion & awareness generation for prevention, early diagnosis, management and referral to an appropriate level of healthcare facility for treatment of the Non-Communicable Diseases (NCDs).
- Under NPCDCS, 677 NCD clinics at District level, 187 District Cardiac Care Units, 266 District Day Care Centres and 5392 NCD clinics at Community Health Centre level have been set up to ensure the treatment of common NCDs.
- A population-based initiative for prevention, control and screening for common Non-Communicable Diseases (NCDs) i.e. diabetes, hypertension and common cancers has been rolled out in the country under NHM and also as a part of Comprehensive Primary Health Care. Under the initiative, persons more than 30 years of age are targeted for their screening for the common NCDs, in which there is focus on screening of breast cancer and cervical cancer among women. Screening of these common NCDs is an integral part of service delivery under Ayushman Bharat – Health and Wellness Centres.

- Preventive aspect of NCDs is strengthened under Comprehensive Primary Health Care through Ayushman Bharat Health Wellness Centre scheme, by promotion of wellness activities and targeted communication at the community level. Other initiatives for increasing public awareness about NCDs and for promotion of healthy lifestyle includes observation of National & International Health Days and use of print, electronic and social media for continued community awareness. Furthermore, healthy eating is also promoted through FSSAI. Fit India movement is implemented by Ministry of Youth Affairs and Sports, and various Yoga related activities are carried out by Ministry of AYUSH. In addition, NPCDCS gives financial support under NHM for awareness generation (IEC) activities for NCDs to be undertaken by the States/UTs as per their Programme Implementation Plans (PIPs).

LUMPY SKIN DISEASE

- Lumpy skin disease is caused by the lumpy skin disease virus(LSDV) which affects the lymph nodes of the infected animal(like Cattles).It belongs to the genus capripoxvirus, a part of the poxviride family.

OTHER DISEASES SPREAD BY POXVIRIDE FAMILY

- Smallpox and MONKEYPOX viruses are also a part of the same family. And the LSDV shares antigenic similarities with the sheeppox virus and the goatpox virus or is similar in the immune response to those viruses.

It is not a Zoonotic virus, meaning the disease cannot spread to humans. It is contagious vector-borne disease spread by vectors like mosquitoes, some biting flies, and ticks and usually affects host animals like cows and water buffaloes.

LUMPY SKIN DISEASE SPREAD

- According to the United Nations Food and Agriculture Organisation (FAO), infected animals shed the virus through oral and nasal secretions which may contaminate common feeding and water troughs.
- Thus, the lumpy skin disease can either spread through direct contact with the vectors or through contaminated fodder and water. Studies have also shown that it can spread through animal semen during artificial insemination.
- LSD affects the lymph nodes of the infected animal, causing the nodes to enlarge and appear like lumps on the skin, which is where it derives its name from. The cutaneous nodules, 2–5 cm in diameter, appear on the infected cattle's head, neck, limbs, udder, genitalia, and perineum. The nodules may later turn into ulcers and eventually develop scabs over the skin.

SYMPTOMS

- High fever, sharp drop in milk yield, discharge from the eyes and nose, salivation, loss of appetite, depression, damaged hides, emaciation (thinness or weakness) of animals, infertility and abortions.
- The incubation period or the time between infection and symptoms is about 28 days according to the FAO, and 4 to 14 days according to some other estimates.

GEOGRAPHICAL DISTRIBUTION

- The Lumpy Skin Disease was first observed in Zambia in 1929, subsequently spreading to most African countries extensively, followed by West Asia, South-eastern Europe, and Central Asia, and more recently spreading to South Asia and China in 2019.

- As per the FAO, the Lumpy Skin Disease is currently endemic in several countries across Africa, parts of the West Asia (Iraq, Saudi Arabia, Syrian Arab Republic), and Turkey.

LUMPY SKIN DISEASE: SPREAD IN INDIA

- The spread in South Asia first affected Bangladesh in July 2019 and then reached India in August that year, with initial cases being detected in Odisha and West Bengal.
- The FAO points out: "The long porous borders between India, Nepal and Bangladesh allow for a significant amount of bilateral and informal animal trade, including cattle and buffaloes."
- This, the UN body says, may have contributed to the spread of LSD in July-August 2019 between Bangladesh and India. While the 2019 outbreak later subsided, the recent spread in India began in June this year.

Consuming the milk of affected cattle

I. Studies say that it has **not been possible to ascertain** the presence of viable and infectious LSDV virus in milk derived from the infected animal.
II. FAO notes, that a large portion of the milk in Asia is **processed** after collection and is either **pasteurised** or boiled or dried in order to make milk powder.
III. This process ensures that the **virus is inactivated** or destroyed.
IV. Joint Director at the Indian Veterinary Research Institute (IVRI) told PTI that, " there is no problem in the quality of milk even if you have it after boiling or without boiling".

ECONOMIC IMPLICATIONS OF LUMPY SKIN DISEASE ON DAIRY SECTOR

- The spread of the lumpy skin disease can lead to "substantial" and "severe" economic losses according to FAO and the World Organisation for Animal Health **Milk reduction:** Lumpy Skin Disease leads to reduced milk production as the animal becomes weak and also loses appetite due to mouth ulceration.

I. **Animal wasting:** The income losses can also be due to poor growth, reduced draught power capacity and reproductive problems associated with abortions, infertility and lack of semen for artificial insemination.
II. **Impact of trade ban:** Movement and trade bans after infection also put an economic strain on the whole value chain.

LUMPY SKIN DISEASE: INDIA IS AT HIGHER RISK

I. India is the world's largest milk producer at about 210 million tonnes annually.
II. India also has the **largest headcount of bovines.**
III. In Rajasthan, which is witnessing the worst impact of LSD, it has led to reduced milk production, which lessened by about three to six lakh litres a day.
IV. Reports indicate that milk production has also gone down in Punjab owing to the spread of the lumpy skin disease.
V. According to FAO, the lumpy skin disease threatens the livelihoods of smaller poultry farmers significantly.
VI. Notably, farmers in Uttar Pradesh and Punjab have incurred losses due to cattle deaths and are seeking compensation from their State governments.

CURRENT SPREAD IN INDIA

I. Lumpy Skin Disease has **infected over 16 lakh cattle** in 197 districts as of September 11.
II. Of the nearly 75,000 cattle that the disease has killed, more than 50,000 deaths, mostly cows, have been reported from Rajasthan.

GOVERNMENT INITIATIVES:

- The Union Ministry of Fisheries, Animal Husbandry and Dairying informed that the '**Goat Pox Vaccine**' is very effective against LSD.
- It is being used across affected States to contain the spread.

The affected States have put movement bans in place and are isolating infected cattle and buffaloes, spraying insecticides to kill vectors like mosquitoes, with some affected States such as Maharashtra, Rajasthan, Delhi, and Uttar Pradesh also setting up dedicated control rooms and helpline numbers to guide farmers whose cattle have been infected.

WAY FORWARD

The FAO has suggested a set of spread-control measures for LSD, which involves:

I. Vaccination of susceptible populations with more than 80% coverage.
II. Movement control of bovine animals and quarantining.
III. Implementing biosecurity through vector control by sanitising sheds and spraying insecticides.
IV. Strengthening active and passive surveillance.
V. Spreading awareness on risk mitigation among all stakeholders involved, and
VI. Creating large protection and surveillance zones and vaccination zones

- In a major breakthrough, two institutes of the Indian Council of Agricultural Research (ICAR) have developed an indigenous vaccine for LSD, which the Centre plans to commercialise and roll out in the next three to four months.
- The vaccine is based on LSD virus samples from cattle in Ranchi afflicted in the 2019 outbreak and experimental trials conducted on animals afflicted in the ongoing 2022 outbreak with the vaccine have revealed encouraging results, ICAR and the Ministry of Agriculture have stated.

NATIONAL LIST OF ESSENTIAL MEDICINES (NLEM)

- The new National List of Essential Medicines (NLEM) has now been brought under the Drug Prices Control Order, which fixes ceiling prices for these essential formulations based on average cost to retailers.

National List of Essential Medicines (NLEM)

I. It is one of the key instruments in a balanced healthcare delivery system of a country which inter alia includes accessible, affordable quality medicine at all the primary, secondary, tertiary levels of healthcare.
II. The first National List of Essential Medicines of India was prepared and released in 1996.
III. It focuses on three aspects - cost, safety and efficacy.
IV. It comprised 384 drugs across 27 categories.
V. **Purpose :** The primary purpose of NLEM is to promote rational use of medicines considering the three important aspects i.e., cost, safety and efficacy.
VI. It also helps in optimum utilisation of healthcare resources and budget; drug procurement policies, health insurance; improving prescribing habits; medical education and training for UG/PG; and drafting pharmaceutical policies.

- Recently, The Union Health Ministry launched the new **National List of Essential Medicines (NLEM)**, where 384 drugs have been included in this list with addition of 34 drugs, while 26 from the previous list have been dropped.

As per the WHO Essential Medicines are those that satisfy the priority health care needs of the population.

NATIONAL LIST OF ESSENTIAL MEDICINES (NLEM)

- The National List of Essential Medicines (NLEM) is a list released by the **Ministry of Health and Family Welfare.**
- The medicines listed in the NLEM are sold below a price ceiling fixed by the NPPA
- In India, it was framed on the lines of the **Essential Medicines List (EML)** released by the WHO.

PAST EXPERIENCE :-

- The **Ministry of Health and Family Welfare** prepared and released the first National List of Essential Medicines of India in 1996 consisting of 279 medicines. This list was subsequently revised in 2003, 2011, 2015 and 2022.

Purpose:

- Guide safe and effective treatment of priority disease conditions of a population.
- Promote the rational use of medicines.
- Optimize the available health resources of a country. It can also be a guiding document for:
- State governments to prepare their list of essential medicines
- Procurement and supply of medicines in the public sector.

CRITERIA FOR A MEDICINE TO BE INCLUDED IN NLEM

Several factors are looked at before including a drug in the NLEM. These are:

- **Essentiality**: A medicine may be essential considering the population at large and should fit into the definition mentioned earlier.
- **Changing disease burden:** With time, the disease burden keeps changing in the country. At one point, TB might be more important to tackle. At the next moment, another disease like Covid-19 may become more important. So, the prevalent disease is considered while preparing the list.
- **Efficacy and Safety:** The medicine must have "unequivocal" evidence of efficacy and wider acceptance based on its safety to be included in the list.
- **Cost-Effectiveness:** The total price of the treatment must be considered while including the drug in NLEM. Only unit price may not be the best benchmark for this.
- **Fixed Dose Combinations (FDCs):** The single-dose medicines are considered for inclusion in NLEM. FDCs are only included if they have a proven advantage concerning the therapeutic effect.
- **Turnover:** High sales turnover alone is not considered a good benchmark for inclusion in the NLEM. Other factors are also required to be essentially considered for it.

MEDICINE DELETED FROM NLEM

- A drug is deleted from the list if it gets banned in India. Also, it is removed if reports of concerns about drug safety emerge.
- If medicine with better efficacy or favourable safety profile and better cost-effectiveness is now available, then it is removed from NLEM.

ESSENTIAL MEDICINE LIST (EML)

- The list is made with consideration of disease **prevalence, efficacy, safety and comparative cost-effectiveness** of the medicines.
- Such medicines should be available in such a way that an individual or community can afford them.
- The WHO EML is updated every two years by the Expert Committee on Selection and Use of Essential Medicines.
- The first country in the world to compose its EML was Tanzania in 1970. Then in 1975, the **WORLD HEALTH ASSEMBLY** requested WHO to assist member states in selecting and procuring essential medicines, assuring good quality at a reasonable cost.
- Subsequently, the **first WHO model list of essential medicines was published in the year 1977 which contained 186 medicines.**
- It stated that essential medicines were "of **utmost importance, basic, indispensable and necessary for the health and needs of the population"** and the criteria for selection were based on efficacy, safety, quality and total cost.

INDIA'S FIRST INTRA-NASAL COVID-19 VACCINE APPROVED

- Recently, the Drugs Controller General of India (DCGI) gave emergency approval to Bharat Biotech's intranasal COVID-19 vaccine- BBV154 (iNCOVACC).
- This makes it India's first approved needle free nasal vaccine for primary immunisation against COVID-19 in the 18+ age group.
- It has been given approval only for primary immunisation, meaning it can be given to the unimmunised to protect against Covid-19 and not as a booster dose.

INTRANASAL VACCINE

- It is a vaccine administered to a person via the nose and does not require a needle.
- It induces immunity through the inner surface of the nose, which naturally comes in contact with many airborne microbes.

Benefits

I. Needle-free administration eliminates issues associated with needle injury and infection risk.
II. No need for trained healthcare workers for administration of vaccines.
III. Easy to deploy for mass immunisation campaigns.
IV. Production can be scaled up easily to meet random global demand.
V. Higher compliance and suitable for use in children as well as adults.

Drawbacks

- There is very little evidence to back the effectiveness of this route of delivery so far. For example- some nasal flu vaccines have not been successful.
- Despite the theoretical advantages, the intranasal approach for vaccination is largely unproven. This concept has been tested quite extensively in animals, but is still largely untested for humans.
- Even after rollout of the oral polio vaccines, there were some cases, it still caused the disease after the weakened virus in the product mutated.

Bharat Biotech's intranasal COVID-19 vaccine

1. It is ChAd36-SARS-CoV-S Covid-19 (Chimpanzee Adenovirus Vectored) recombinant nasal vaccine. Its commercial name is BBV154 (iNCOVACC).

2. It is developed by Bharat Biotech with technology in-licensed from Washington University-St Louis. Its development was partly funded by the Department of Biotechnology's Covid Suraksha programme.
3. It uses a modified chimpanzee adenovirus vector, which cannot replicate in the body, to carry the Covid spike protein to induce immunity.
4. It has been designed to not only protect against infection but also reduce transmission of the virus.

A. **Working Mechanism:** As it is given nasally, it triggers an immune response in the mucosal membrane. It produces local antibodies in the upper respiratory tract which may provide the potential to reduce infection and transmission.
B. **Efficacy:** It was found to be safe, well-tolerated, and immunogenic in a phase III trial of nearly 4000 participants across 14 sites in India. No side effects or adverse reactions were reported from its usage in any of the undertrial patients. It was also found to be safe and effective when used as a booster dose in participants who have received Covaxin or Covishield as their primary vaccine.
C. **Benefits:** It can be delivered in a needle-free manner. It will do away with the need for needles and syringes currently required for all the Covid-19 vaccines available.

- It has the double benefit of enabling faster development of variant specific vaccines and easy nasal delivery that enables mass immunization to protect from emerging variants of concern.
- It produces local antibodies in the upper respiratory tract, which may provide the potential to reduce infection and transmission. It is stable at 2-8°C, which makes it easy to store and distribute.

India's COVID-19 Vaccination Status

1. According to the Government's CoWIN portal- India so far has administered a total of 213 crore vaccine doses, of which 102 crore are first doses. Nearly 98% of the adult population in India have received at least one dose.
2. Currently, Covishield, Covaxin and Corbevax are part of the Government's Covid immunisation drive. Vaccines like Covovax and Sputnik are also available at private centres.

CRISPR-CAS9 FOR SICKLE-CELL ANAEMIA

Union Budget 2023: What is sickle cell anaemia; can it be eliminated?

- A blood test can determine whether you have SCD or sickle cell trait. All states now check babies as part of their screening programmes, allowing treatment to begin as soon as possible
- Finance Minister Nirmala Sitharaman announced her government's plan to launch a mission to eliminate **sickle cell anaemia** by 2047. Presenting the Union Budget for 2023-24 in the Lok Sabha on Wednesday, Sitharaman said

that **"A mission to eliminate sickle cell anaemia by 2047 will be launched. It will entail awareness creation, universal screening of seven crore people in the age group of 0-40 years in affected tribal areas and counselling through collaborative efforts of central ministries and state governments."**

- Hailing the announcement as a "bold step", medical experts said that such a step by the ruling government would lead to more inclusive **development**. "This goes hand in hand with the budget's focus on inclusive development, said Shanay Shah, President, Shalby Hospitals.

POSSIBLE TO ELIMINATE SICKLE CELL ANAEMIA

1. “It is possible but a herculean task. We need to screen all population for sickle cell trait especially high risk communities.
2. Individuals will sickle cell trait should not marry each other since there is a 25 per cent chance of having a baby with sickle cell disease.
3. If they get pregnant, then we need to screen foetus for sickle cell disease and terminate the pregnancy if parents wish,”
4. “partially possible” to eliminate the disease by public awareness because it is caused by a “consanguineous marriage which can be avoided.”
5. For the unversed, Sickle cell disease (SCD) is an inherited group of blood disorders that is genetic in nature. It is usually transferred from the parents to the child during birth i.e. both parents can be carriers of SCDs.
6. “The sickle cells die prematurely, resulting in a chronic lack of red blood cells. Furthermore, as they pass through small blood arteries, they become caught and obstruct the blood flow. This can result in discomfort as well as other dangerous consequences (health issues) such as infection, acute chest syndrome, and stroke,”
7. While healthy RBCs are round in shape, move through small blood vessels, and carry oxygen to all parts of the body, in someone who has SCD, the RBC becomes sticky and hard and assumes a C-shape, similar to that of a farm tool ‘sickle’,

SYMPTOMS OF SICKLE CELL ANAEMIA

1. Babies with sickle cell anaemia may not exhibit symptoms for several months after birth. The symptoms of anaemia, however, include excessive weariness or fussiness, excruciatingly swollen hands and feet, and jaundice. “Babies may also suffer spleen damage, which weakens their immune system and increases their susceptibility to bacterial infections. People with sickle cell anaemia may have various and increasingly significant medical problems as they age, which occur when organ tissues do not receive enough oxygen,”

PROCEDURE FOR DIAGNOSING SICKLE CELL DISEASE (SCD)

- A blood test can determine whether you have SCD or sickle cell trait. All states now check babies as part of their screening programmes, allowing treatment to begin as soon as possible.
- *People who are considering having children can get the test to determine the likelihood of their offspring having SCD.
- *SCD can also be diagnosed before a baby is born. A sample of amniotic fluid (the fluids in the sac around the foetus) or placental tissue is used in this test (the organ that brings oxygen and nutrients to the baby).
- extended family screening is recommended for people who are carriers, who have a family history of sickle cell diseases.

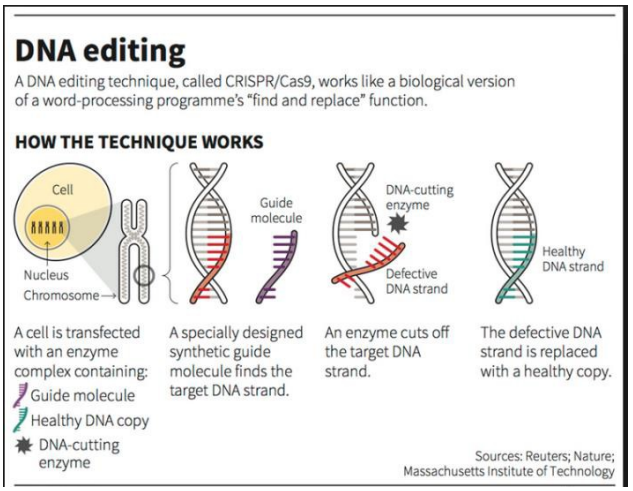
TREATMENT THERAPIES ARE AVAILABLE FOR SICKLE CELL DISEASE (SCD)

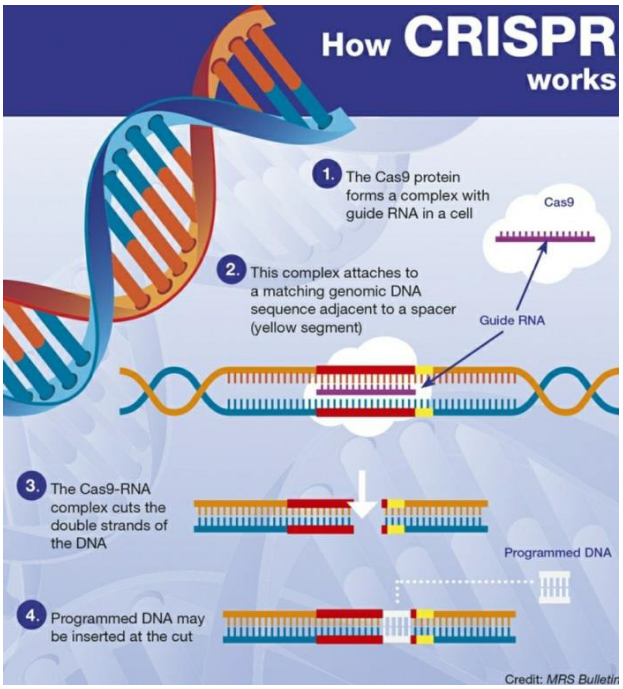
- SCD can only be cured by bone marrow or stem cell transplantation, Dr Mule noted. “These transplants are normally reserved for children with severe SCD since they are hazardous and can have substantial adverse effects. The bone marrow must be a close match for the transplant to succeed. A brother or sister is usually the ideal donor,”

1. India approved a 5-year project to **develop CRISPR to cure** Sickle-Cell Anaemia in 2021.
2. Sickle cell anaemia is the first disease that is being targeted for CRISPR-based therapy in India.
3. The pre-clinical phase (trials on animal subjects) is about to begin.

CRISPR TECHNOLOGY

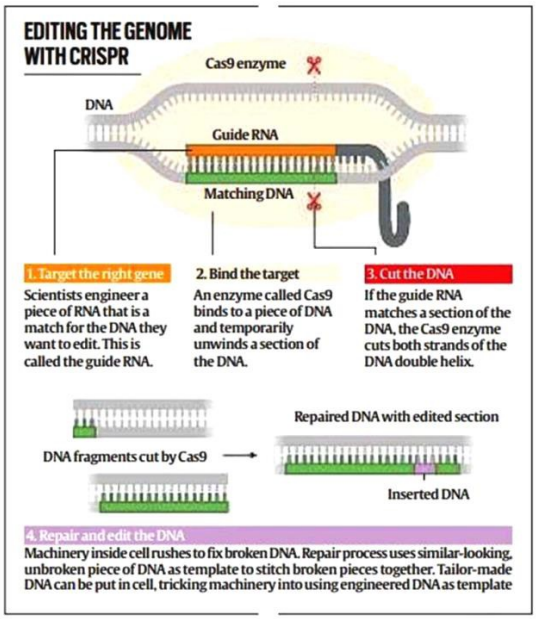
A. Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) is a GENE EDITING TECHNOLOGY which replicates natural defence mechanism in bacteria to fight virus attacks, using a special protein called Cas9.
B. It usually involves the introduction of a new gene, or suppression of an existing gene, through a process described asGENETIC ENGINEERING
C. CRISPR technology does not involve the introduction of any new gene from the outside.

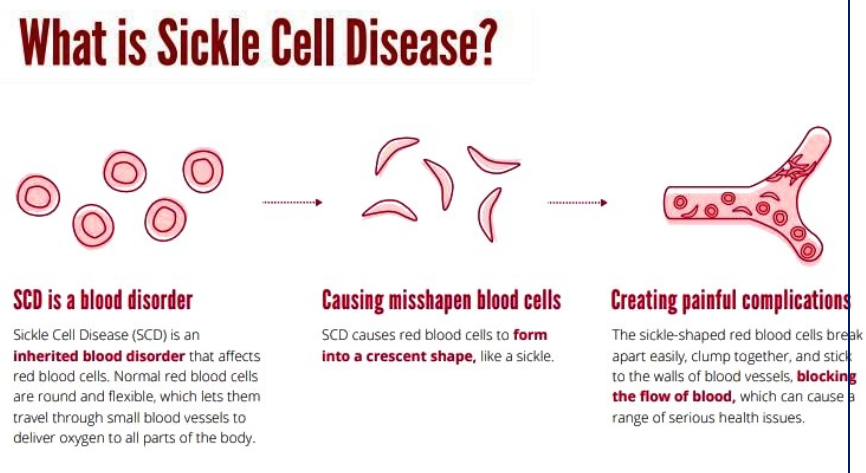




CRISPR-Cas9 technology is often described as 'Genetic Scissors'.

1. Its mechanism is often compared to the '**cut-copy-paste',** or **'find-replace'** functionalities in common computer programmes.
2. A **bad stretch** in the DNA sequence, which is the cause of disease or disorder, is **located, cut, and removed and then replaced with a 'correct' sequence.**
3. The tools used to achieve this are biochemical i.e., specific protein and RNA molecules.
4. The technology **replicates a natural defence mechanism in some bacteria** that uses a similar method to **protect itself from virus attacks.**





MECHANISM:

1. The first task is to identify the particular sequence of genes that is the cause of the trouble.
2. Once that is done, an RNA molecule is programmed to locate this sequence on the DNA strand, just like the 'find' or 'search' function on a computer.
3. After this Cas9 is used to break the DNA strand at specific points, and remove the bad sequence.
4. A DNA strand, when broken, has a natural tendency to re-attach and heal itself. But if the auto-repair mechanism is allowed to continue, the bad sequence can regrow.
5. So, scientists intervene during the auto-repair process by supplying the correct sequence of genetic codes, which attaches to the broken DNA strand.
6. It is like cutting out the damaged part of a long zipper, and replacing it with a normally functioning part.
7. The entire process is programmable, and has remarkable efficiency, though the chances of error are not entirely ruled out.

Significance of CRISPR-based Therapeutic Solutions

1. **Specific Treatment:** CRISPR aids in the disease treatment by **correcting the underlying genetic problem**. CRISPR-based therapeutic solutions are not in the form of a pill or drug. Instead, **some cells of every patient are extracted, the genes are edited** in the laboratory, and the **corrected genes** are then **re-injected into the patients.**
2. **What is to be edited, and where, is different in different cases. Therefore, a specific solution needs to be devised for every disease** or disorder that is to be corrected.
3. The solutions could be **specific to particular population or racial groups,** since these are also dependent on genes.
4. The changes in genetic sequences remain with the individual and are not passed on to the offspring.

Permanent Cure of Genetic Diseases/Anomalies: A vast number of diseases and disorders are genetic in nature i.e.; they are caused by unwanted changes or mutations in genes.

- These include common blood disorders like sickle cell anaemia, eye diseases including colour blindness, several types of cancer, diabetes, HIV, and liver and heart diseases. Many of these are hereditary as well.
- CRISPR opens up the possibility of finding a permanent cure for many of these diseases.
- Deformities like stunted or slow growth, speech disorders, or inability to stand or walk arise out of abnormalities in gene sequences.
- CRISPR presents a potential treatment for the cure of such abnormalities as well.

RELATED ETHICAL DILEMMA

CRISPR's power to induce dramatic changes in an individual which can be potentially misused.

1. In 2018, a **Chinese researcher** disclosed that he had CRISPR aids in the disease treatment by **correcting the underlying genetic problem.**
2. This was the **first documented case of creating a 'designer baby',** and it **caused widespread concern in the scientific community.**
3. Preventive interventions **to obtain special traits is not something that scientists currently want** the technology to be used for.
4. Also, because the changes were made in the embryo itself, the **new acquired traits were likely to be passed on to future generations.**

5. Though the technology is fairly accurate, it is **not 100% precise, and could induce a few errors as well, making changes in other genes.** This has the **possibility of being inherited by successive generations.**

SICKLE CELL ANAEMIA

- It is an **inherited blood disease** which is most common among people of African, Arabian and Indian origin.
- It is a group of disorders that **affects hemoglobin, the molecule in red blood cells that delivers oxygen to cells throughout the body.**
- People with this disease have **atypical hemoglobin molecules called hemoglobin S,** which can **distort red blood cells into a sickle, or crescent shape.**
- This **blocks blood flow and oxygen** from reaching all parts of the body.

SYMPTOMS:

1. It can cause severe pain, referred to as **sickle cell crises.**
2. Over time, people with sickle cell disorders can experience **damage to organs including the liver, kidney, lungs, heart and spleen. Death can also result** from complications of the disorder.

Treatment:

Medication, blood transfusions and rarely a bone-marrow transplant.

RABIES

World Rabies Day is observed every year on **28th September** to raise awareness about the **world's deadliest infectious disease** and **bring together partners** to enhance prevention and control efforts worldwide.

Rabies

- It is a zoonotic viral disease.
- It is caused by the Rabies virus, of the Lyssavirus genus, within the family Rhabdoviridae.

It is a ***Ribonucleic Acid (RNA) virus*** that is present in the saliva of a rabid animal (dog, cat, monkey, etc).

1. Rabies is 100% fatal but 100% vaccine-preventable.
2. 33% of global rabies deaths are recorded in India.

Common Vectors/ Reservoirs of Virus

- The most common reservoir of the virus is ***the domestic/street dog*** especially in South Asia and Africa.
- ***More than 99% of human deaths due to rabies*** are caused by dog-mediated rabies.
- In developed nations like the USA, animals that transmit rabies are bats, foxes, raccoons, and skunks.
- Most mammals can carry the virus and hence can cause the disease.

It ***spreads by the bite of a rabid animal*** that leads to the deposition of the saliva and the virus in the wound.

- ❖ The ***incubation period*** varies from 4 days to 2 years or sometimes even more.
- ❖ **The *incubation period*** means the time interval between the bite and the occurrence of symptoms/signs of the disease.

2022 marks the 16th World Rabies Day.

1. 28th September marks the anniversary of **Louis Pasteur's** death, the French chemist and microbiologist, **who developed the first rabies vaccine.**
2. In 2007, the **first World Rabies Day (WRD)** was organised by the two founding partners namely:
3. **Alliance for Rabies Control (ARC)**
4. **Centre for Disease Control and Prevention, Atlanta (CDC)**

Theme 2022:

A. The theme of World Rabies Day 2022 is: **"One Health, Zero Death".**
B. The theme will highlight the connection of the environment with both people and animals.
1. Rabies is a vaccine-preventable, zoonotic, viral disease.
2. It is caused by a **Ribonucleic Acid (RNA)** virus that is **present in the saliva** of a rabid animal (dog, cat, monkey, etc).
3. It is **invariably transmitted** following a **bite of an infected animal** that leads to **deposition of the saliva and the virus in the wound.**
4. Once clinical symptoms appear, rabies is virtually 100% fatal. The death invariably **occurs in four days to two weeks** due to **cardio-respiratory failure.**
5. In up to 99% of cases, domestic dogs are responsible for rabies virus transmission to humans.
6. The incubation period varies from 2–3 months but may vary from 1 week to 1 year, or rarely even more.

Treatment:

A. It is important to remove the virus from the wound as early as possible by immediately washing the wound with water and soap followed by application of antiseptics that reduce/eliminate chances of nerve infection.
B. Rabies can be prevented by vaccinating pets, staying away from wildlife, and seeking medical care after potential exposures before symptoms start.

Symptoms: 1. The **first symptoms of rabies may be similar to flu** and may last for a few days, which includes: 2. Fever, Headache, Nausea, Vomiting, Anxiety, Confusion, Hyperactivity, Difficulty swallowing, Excessive salivation, Hallucinations, Insomnia. **3. India's Initiatives for Cure Against Rabies:** **Symptoms** 1. Fever, Headache, Nausea, Vomiting 2. Anxiety, Confusion, Hyperactivity, Hallucinations, Insomnia 3. Difficulty swallowing 4. Excessive salivation 5. Partial paralysis 6. Fear brought on by attempts to drink fluids because of difficulty swallowing water, etc.	**<u>CONTROL AND PREVENTION OF RABIES</u>** 1. Get rabies vaccination to prevent the infection. 2. Vaccinating your pet against the disease. 3. Maintain distance from the wild animals. 4. Wash wounds with soap and water and maintain good hygiene. 5. Keep your pets away from the other stray dogs. 6. Prevent bats from wandering around your campuses and living places.

The death invariably occurs in 4 days to 2 weeks due to cardio-respiratory failure.	

NATIONAL ACTION PLAN FOR DOG MEDIATED RABIES ELIMINATION BY 2030:

1. It is a multi-pronged strategy based on ONE HEALTH APPROACH
2. The concept of One Health recognizes that the health of people is **closely related** with the health of animals, plants and their shared environment.
3. In One Health approach, **multiple sectors communicate and work together** at the local, regional, national, and global levels with the goal of achieving optimal health outcomes.

- **Mission:** To **achieve zero human deaths** due to dog-mediated Rabies by 2030.

Principles:

1. **Prevention:** Introduce **cost-effective public health intervention techniques** to improve accessibility, affordability, and availability of post-exposure prophylaxis to all people in need.
2. **Promotion:** Improve **understanding of rabies** through advocacy, awareness, education and operational research.
3. **Partnership:** Provide **coordinated support for the anti-rabies drive** with the involvement of community, urban and rural civil society, government, private sectors and international partners.

Death of a 12-year-old girl in Kerala from rabies, despite having multiple inoculations of the rabies vaccine.

1. From 2016-18, around 300 laboratory-confirmed rabies deaths were reported in India. The WHO says India is endemic for rabies and accounts for **36% of the world's deaths**.
2. As per available information, Rabies causes **18,000-20,000 deaths every year**.
3. About **30-60%** of reported rabies cases and deaths in India occur in **children** under the age of 15 years, as bites that occur in children often go unrecognised and unreported, it notes.

- Rabies is a disease that is caused by a family of viruses called the **lyssaviruses** and found in a range of **mammals**.
- The virus targets the **central nervous system** and is **nearly 100% fatal** to the host animal if it succeeds in infecting it.
- It is most likely to spread to people from the **bite of an infected dog or a cat** as they are the most common pets.

SIGNIFICANCE OF RABIES VACCINE

A. The vaccine is made up of an **inactivated virus** that is expected to induce the body into **producing antibodies** that can neutralise the live virus in case of infection.
B. There is **no single-shot** rabies vaccine or one that offers permanent immunity.
C. Administering a **vaccine**, even after being bitten by a rabid animal, is **effective** because the virus is slow-moving and it can be several weeks before the disease manifests into a fatal encephalitis.
D. A shot of rabies **immunoglobulin** (rabies-antibodies against the virus derived either from people or horses) followed by a **four-week course of anti-rabies vaccine,** is nearly **guaranteed** to prevent rabies.
E. There are mainly two ways of administering the rabies vaccine – firstly, **post-exposure prophylaxis** (PEP) which is given to persons who have been exposed via a bite to an animal

suspected to be infected. The vaccines are administered either into the muscles, or into the skin.

F. Secondly, **Pre-Exposure Prophylaxis** (PrEP) which is given ahead of time to persons who have a high risk of being infected, such as veterinarians.
G. The advantage of a PrEP is that if bitten, one doesn't need an immunoglobulin injection, and two subsequent shots of the vaccine will suffice for full protection, unlike the four-course prescription in the case of PEP.
H. However, the **WHO doesn't recommend PrEP** as a general preventive.

Rabies vaccines in India

A. There are at least six rabies vaccines approved for India and all contain inactivated virus made of **duck, chicken or human cell cultures.**
B. They are marked as safe, efficacious and with long immunity.
C. They are available for **free in government dispensaries** .

Concerns

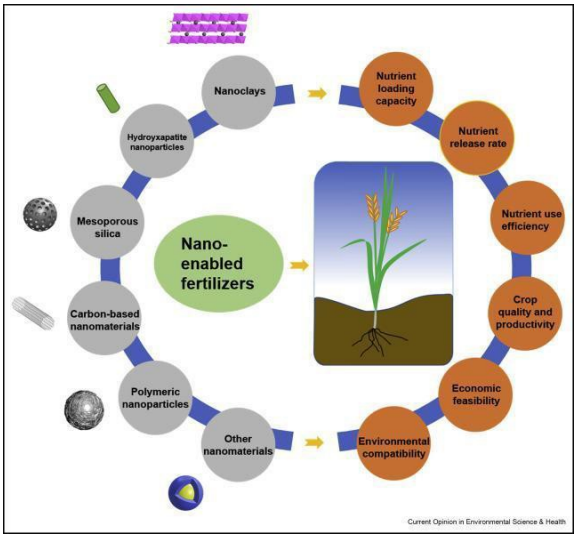
A. Hospitals running out of vaccines
B. Knowledge about vaccines and treatment is still inadequate in India.
C. No centralised database of vaccine availability is maintained.
D. Requirement of multiple shots of vaccine as well as immunoglobin makes sticking to the schedule challenging.

WAY FORWARD

A. India has **committed to eliminate the disease by 2030** which requires vaccination of dogs who are deemed responsible for 99% of all rabies infections in people
B. Hence, the government in its 2021 plan, called the **'National Action for Plan — Rabies Elimination'**, aims to **vaccinate at least 70% of all dogs** in a defined geographical area annually for three consecutive years.
C. With this, a degree of herd immunity is expected leading to eventual elimination within eight years. Rather than inoculate all dogs, the plan is to identify 'rabies hotspots' in the country and target them.

NANO UREA FERTILISER

Recently, the Ministry of Chemicals and Fertilizers allowed commercial use of Nano urea.



Meaning: Nano urea is a liquid fertilizer developed by **IFFCO**. It is an **alternative** to conventional urea.

- It is essentially urea in the form of a nanoparticle.
- Urea is a chemical nitrogen fertilizer, white in colour, which artificially provides nitrogen, a major nutrient required by plants.
- **Aim**: It aims to reduce farmers' dependence on packaged urea.
- **Fertiliser Control Order (FCO) 1985**: It is based on **existing rules** that provisionally allow fertilizers to be used based on data from **only two cropping seasons.**
- **The usual practice for recommending or rejecting a new fertilizer** for commercial use **required three seasons** of independent assessment by the Indian Council of Agricultural Research (ICAR), but in the case of nano urea this was reduced to two.
- **Production data**: By FY25, around 440 million bottles of 500 ml nano urea will be produced. This will be equivalent to around 20 million tonnes of urea. It will take care of the 9 million tonnes that India imports annually.
- **Central Public Sector Undertaking (CPSU): National Fertilizers Limited (NFL)** and **Rashtriya Chemicals and Fertilizers Limited (RCF)** have signed Non Disclosure Agreement & Memorandum of Understanding with IFFCO to transfer the technology of Nano Urea.
- This is aimed at **increasing the indigenous production of Nano Urea.**
- **Import data**: The country's domestic urea production is around 26 million tonnes, while demand is around 35 million tonnes. And, the gap is met through imports.
- The government will **save foreign exchange** of Rs 40,000 crore approximately per annum after replacing the conventional urea with the Nano Urea.
- The **import of urea may not be required after 2023-24.**

POTENTIAL BENEFITS

A. **It has a shelf life of a year**: and farmers need not be worried about "caking" when it comes in contact with moisture.
B. **Pricing**: It comes in a half-litre bottle priced at Rs 240, and carries no burden of subsidy currently.
C. By contrast, a farmer pays around Rs 300 for a 50-kg bag of heavily subsidised urea.
D. **Efficiency**: The conventional urea has an efficiency of about 25 percent; the efficiency of liquid nano urea can be as high as 85-90 per cent.
E. **Absorption:** Liquid nano urea is sprayed directly on the leaves and gets absorbed by the plant.
F. Fertilisers in nano form provide a targeted supply of nutrients to crops, as they are absorbed by the stomata, pores found on the epidermis of leaves.
G. **Lower subsidy Bill**: It will reduce the country's subsidy bill and it is aimed at **reducing the unbalanced and indiscriminate use of conventional urea**.
H. **Other benefits**:
I. Application of Nano Urea results in **better crop productivity.**
J. This is regarded as an **excellent alternative to chemical fertilisers** because it promotes growth and reduces environmental pollution.
K. Nano-fertilisers also **reduce the crop cycle period and increase crop yield.**

L. The unique properties of nanoparticles, such as **high absorption** capacity, the **increased surface to volume ratio**, and **controlled-release** kinetics to targeted sites, make them a **potential plant growth enhancer.**

Limitations of Nano-Fertilisers

1) Lack of a nano-fertiliser **risk management system**
2) **Lack of production and availability of nano fertilisers in required quantities**. This limits the wider scale adoption of nano-fertilisers as a source of plant nutrients.
3) **The high cost** of nano fertilisers
4) **Lack of standardisation in the formulation process**. This brings about different results of the same nanomaterial under various pedoclimatic conditions.

Difference between Nano urea and conventional urea

Properties	Nano fertilizers	Conventional fertilizers
Solubility and dispersion of mineral micronutrients	Improve solubility and dispersion of insoluble nutrients in soil, reduce soil absorption and fixation and increase the bioavailability	Less bioavailability to plants due to large particle size and less solubility
Nutrient uptake efficiency	Might increase fertilizer efficiency and uptake ratio of the soil nutrients in crop production and save fertilizer resource	Bulk composite is not available for roots and decrease efficiency
Controlled-release modes	Release rate and release pattern of nutrients for water-soluble fertilizers might be precisely controlled through encapsulation in envelope forms	Excess release of fertilizers may produce toxicity and destroy ecological balance of soil
Effective duration of nutrient release	Nanofertilizers can extend effective duration of nutrient supply of fertilizers into soil	Used by the plants at the time of delivery, the rest is converted into insoluble salts in the soil
Loss rate of fertilizer nutrients	Reduce loss rate of fertilizer nutrients into soil by leaching and/or leaking.	High loss rate by leaching, rain off and drift.

WAY FORWARD

1) Department has also issued guidelines for development of entrepreneurs for drone spraying of liquid fertilisers.
2) Use of Nano Urea is promoted through different activities such as awareness camps, webinars, nukkad nataks, field demonstrations, kisan sammelans and films in regional languages etc.
3) The Prime Minister recently inaugurated the country's first liquid nano urea plant at Kalol.

TOMATO FLU

Recently, some parts of Kerala reported **Tomato Flu** among children under five years of age.

A. The infection has been named 'tomato flu' because of the red, painful blisters that appear on a patient's body and gradually enlarge to the size of a tomato.
B. The 'tomato flu' is caused by Coxsackievirus A 16.
C. It belongs to the Enterovirus family.
D. The enteroviruses are an ancient and important group of RNA VIRUSES
E. Humans are the only hosts for the enteroviruses (NPEVs).
F. The infectious disease is caused by intestinal viruses and is rare in adults as they usually have immune systems strong enough to defend them from the virus.

TRANSMISSION:

- Tomato flu is **very contagious** and children are at increased risk of exposure to tomato flu as viral infections are common in this age group and spread is likely to be through close contact.
- If the outbreak of tomato flu in children is not controlled and prevented, **transmission might lead to serious consequences** by spreading in adults as well.

SYMPTOMS:

A. The primary symptoms observed in children with tomato flu are like those of CHIKUNGUNYA which include **high fever, rashes, and intense pain in joints.**

B. As with other viral infections, further symptoms include fatigue, nausea, vomiting, diarrhoea, dehydration, swelling of joints, body aches, and common INFLUENZA-like symptoms, which are similar to those manifested in dengue.

TREATMENT:

- This flu is a self-limiting one and there is no specific drug for this.
- The treatment for tomato flu is similar to the treatment of chikungunya, dengue and hand, foot, and mouth disease.
- Patients are advised to isolate, rest, plenty of fluids, and hot water sponge for the relief of irritation and rashes.

3D PRINTING

- Researchers from Hyderabad have 3D-printed an artificial cornea and transplanted it into a rabbit's eye.
- 3D printing uses computer-aided design (CAD) to create three-dimensional objects through a layering method.

Principle

A. In 3D printing, a 3D printer makes a three-dimensional object from a CAD (computer-aided design) file.

B. The creation of a **3D printed object is achieved using additive processes**.

C. In an additive process an object is created by **laying down successive layers of material until the object is created**.

D. **Each of these layers can be seen as a thinly sliced cross-section of the object**.

E. 3D printing **enables us to produce complex shapes** using less material than traditional manufacturing methods.

WORKING OF A 3-D PRINTER

1. A typical 3D printer is very much like an inkjet printer operated from a computer.
2. It builds up a **3D model one layer at a time**, from the bottom upward, by repeatedly printing over the same area in a method known as **fused depositional modeling (FDM)**.
3. **Working entirely automatically**, the printer creates a model over a period of hours by turning a 3D CAD drawing into lots of **two-dimensional, cross-sectional layers**—effectively separate 2D prints that sit one on top of another.

"INK" DOES A 3D PRINTER USE

- Where an inkjet printer sprays liquid ink and a laser printer uses solid powder, a **3D printer uses neither**.
- The 3-D printer **deposits layers of molten plastic or powder and fuses them together (and to the existing structure) with adhesive or ultraviolet light**.

The most common 3D printing raw materials are the commodity thermoplastic polymers:

1. Acrylonitrile butadiene styrene (ABS)
2. Polylactic acid (PLA)
3. Polyethylene terephthalate glycol-modified (PETG).

ADVANTAGES OF 3D PRODUCTION PROCESS

A. **Faster production** – 3D printing can manufacture parts within hours, which speeds up the prototyping process. This allows for each stage to complete faster.
B. **Better quality products** – 3D printing produces a consistent quality of product.
C. **Great for design and product testing** – 3D printing is one of the best tools for product design and testing. It offers opportunities to design and test models to allow refinement with ease.
D. **Cost-effective** – 3D printing, can be a cost-effective means of production. Once the model is created, the process is usually automated, and raw material waste tends to be limited.
E. **Product designs are almost infinite** – The possibilities of 3D printing are almost limitless.
F. **3D printers can print using various materials** – Some 3D printers can actually blend or switch between materials. In traditional printing, this can be difficult and expensive.
G. **Environmentally Friendly** – As this technology reduces the amount of material wastage used this process is inherently environmentally friendly.
H. **Advanced Healthcare**: 3D printing is being used in the medical sector to help save lives by **printing organs for the human body such as livers, kidneys and hearts**. Further advances and uses are being developed in the healthcare sector

DISADVANTAGES

- **Reduction in Manufacturing Jobs:** There could be potential reduction in human labour, since most of the production is automated and done by printers.
- **Limited Materials:** 3D Printing can create **items in a selection of plastics and metals**. But the available selection of raw materials is not exhaustive. This is due to the fact that not all metals or plastics can be temperature controlled enough to allow 3D printing. In addition, many of these printable materials cannot be recycled and very few are food safe
- **Restricted Build Size**: 3D printers currently have small print chambers which restrict the size of parts that can be printed. Anything bigger will need to be printed in separate parts and joined together after production. This can increase costs and time.
- **Design Inaccuracies:** Some printers having **lower tolerances**, meaning that final parts may differ from the original design.
- **Part Structure:** With 3D printing parts are produced **layer-by-layer**. Although these layers adhere together it also means that they can **delaminate under certain stresses or orientations**.

3D printing has the potential to democratize the production of goods, from food to medical supplies, to great coral reefs. In the future, 3D printing machines could make their way into homes, businesses, disaster sites, and even outer space.

As this technology spreads, it could help connect marginalized and difficult-to-reach populations with essential products. All in all, this emerging technology has the potential to revolutionize our societies, and transform the development sector.

SYNTHETIC EMBRYOS

Synthetic embryos, Fertilization, Stem cells, Tissues, Specialized cells, Embryonic stem cells, Adult stem cells, Bone marrow, Blood cells, Infertility, IVF, Contraceptives, disease, Organs, Organoids, New Drugs and Clinical Trial Rules, 2019.

Context:

Recently, Scientists have developed synthetic mouse embryos from stem cells without a dad's sperm or a mom's egg. These lab-created embryos mirror natural mouse embryos upto 8 days after fertilisation, containing the same body structures, including beating heart. This development will lay the foundation for creating synthetic embryos for research in future.

- Melbourne, Aug 7, biologists have grown mouse embryo models in the lab without the need for fertilised eggs, embryos, or even a mouse – using only stem cells and a special incubator.
- This achievement, published in the journal Cell by a team led by researchers from the Weizmann Institute of Science in Israel, is a very sophisticated model of what happens during early mouse embryo development - in the stage just after implantation.

SYNTHETIC EMBRYOS

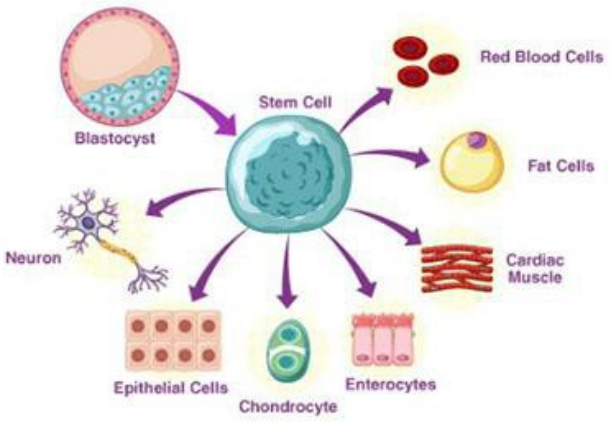
- Synthetic embryos are embryos, which are **created without fertilization.**
- Such embryos (also known as artificial embryos) **do not require an egg or sperm cell** to facilitate their creation. Instead, these e**mbryos rely on self-assembling stem cell** structures to mimic the natural process of early human development.
- Currently, synthetic embryos were **95% equivalent to real mouse embryos** in terms of internal structure and cell genetic profiles.

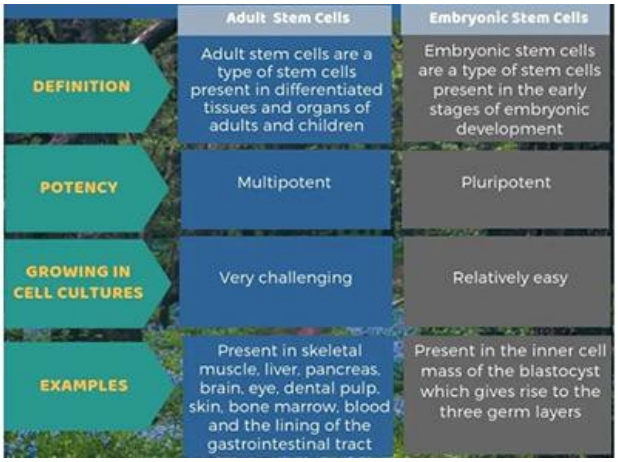
EMBRYO

1. An embryo is the early stage of the development of a multicellular organism.
2. In organisms that reproduce sexually, embryonic development is the part of the life cycle that begins just after the fertilization of the female egg cell by the male sperm cell.
3. The resulting fusion of these two cells produces a single-celled zygote that undergoes many cell divisions that make cells known as blastomeres.
4. In humans, an embryo is a term applied to the unborn child until the end of the seventh week following conception; from the eighth week, the unborn child is called a fetus.
5. In other multicellular organisms, the word "embryo" can be used more broadly to describe any early developmental or life cycle stage before birth or hatching.

STEM CELLS

- Stem cells are special human cells that are able to develop into many different cell types.
- They can range from muscle cells to brain cells.
- In some cases, they can also fix damaged tissues.
- Under the right conditions in the body or a laboratory, stem cells divide to form more cells called daughter cells.
- These daughter cells become either new stem cells or specialized cells (differentiation) with a more specific function, such as blood cells, brain cells, heart muscle cells or bone cells.
- No other cell in the body has the natural ability to generate new cell types.





STEM CELLS COME FROM

There are several sources of stem cells:

EMBRYONIC STEM CELLS:	**ADULT STEM CELLS:**
1. These stem cells come from embryos that are 3 to 5 days old. At this stage, an embryo is called a blastocyst and has about 150 cells. 2. These are pluripotent stem cells, meaning they can divide into more stem cells or can become any type of cell in the body. 3. This versatility allows embryonic stem cells to be used to regenerate or repair diseased tissue and organs.	1. These stem cells are found in small numbers in most adult tissues, such as bone marrow or fat. 2. Compared with embryonic stem cells, adult stem cells have a more limited ability to give rise to various cells of the body. 3. Adult stem cells are multipotent. It means they can develop only into closely related cell types. 4. For instance, researchers thought that stem cells residing in the bone marrow could give rise only to blood cells.

MODEL EMBRYOS IS IMPORTANT

Embryo models could improve health in five ways. Like.

Treating infertility:

- It is thought that at least **40% of pregnancies fail by 20 weeks and that 70% of those** that fail to do so at implantation.
- Embryo models could give researchers a **better understanding of implantation and gastrulation,** and lead to better infertility treatments.

Improving In vitro fertilization:

1. Only around 20% of IVF procedures result in a birth.
2. Using stem-cell models, researchers could optimize implantation and minimize cellular abnormalities, such as an aberrant number of chromosomes. As well as safeguarding the health of children conceived in vitro, this could reduce the number of procedures.

DESIGNING NEW CONTRACEPTIVES:

A. Embryo-model work could improve drugs that prevent implantation (as the oral contraceptive pill or intrauterine devices do, in part).
B. Women and health professionals need drugs and devices that are easier to use and that have fewer side effects.

PREVENTING DISEASE:

- Subtle cell abnormalities can alter development of the placenta and restrict embryo growth, affecting the baby's birth weight and propensity for chronic diseases (such as those of the heart) decades later.
- Entities based on stem cells could help researchers to pinpoint the genetic and epigenetic changes involved, and assess the effects of diets or drugs.

CREATING ORGANS:

Mini brains, livers, kidneys and other organoids made from stem cells are highly simplified.

- In March 2019, the Union Health Ministry notified the 'New Drugs and Clinical Trial Rules, 2019', which state that **stem-cell-derived products are to be used as "new drugs".** This means that any doctor who uses stem cell therapy needs to take permission from the government.
- In India as well as globally, **only blood stem cells from bone marrow** to treat blood cancers and different blood disorders are permitted. The clinical use in any other disease or use of any stem cells other than these is still in the research stage.

APPLICATIONS OF STEM CELLS IN THE MEDICAL FIELD

- The human body uses the adult stem cells as a part of its repair system to heal injuries and damages. It is also used to replenish the tissues.
- So, stem Cells have emerged at the core of the new field of medicine which is known as Regenerative Medicine.
- They have the potential to reduce the need for organ transplants and other related surgeries. They could also be used to regenerate organs.
- **Stem cell therapy:** It is a major application of stem cells. It is the use of stem cells in medicine to treat or prevent a disease or medical condition or regenerate damaged tissues.
- This therapy can be allogeneic (donor donates stem cells to the patient) or autologous (in this case patient gets stem cells from his/her own body).
- Mesenchymal stem cell therapy was used to repair the lungs of a baby in 2019.
- **Bone marrow transplantation**: It is the most widely used type of stem cell therapy. It is used for treating cancers of the blood or bone marrow, like leukaemia.
- **Treatment of diseases:** Stem cell based therapies are being explored as an option for the treatment of cardiovascular diseases, cancers, diabetes and neurodegenerative diseases like Alzheimer and Parkinson.
- **Research of Genetic Disease:** Stem cells are now widely used in research to find the causes of genetic defects, the mechanism behind cancers and various diseases, etc.
- **Development of new drugs:** Stem cells are also being used for testing the safety and efficacy of new drugs. For this ability of stem cells such as formation of new blood vessels, cell differentiation and multiplication and also inhibition of inflammatory response are used. For example, stem cell based drug CAStem was reportedly successful in curing COVID-19 in animal experiments.

CLASSIFICATION BASED ABILITY TO DEVELOP INTO DIFFERENT SPECIALISED CELLS

- **Totipotent stem cells:** They can transform into all kinds of cells in the human body.
- **Pluripotent stem cells:** They can transform themselves into any type of cell in the human body except those kinds that are required to support and develop a foetus in the womb. iPSCs and ESCs are pluripotent stem cells.
- **Multipotent Stem Cells:** They can give rise to only a few distinct types of cells.

NATIONAL HEALTH AUTHORITY WILL LEVERAGE COWIN

The National Health Authority (NHA) plans to use the CoWIN platform for the universal immunization program for vaccinating children and pregnant women against preventable diseases.

- Given that **only 10,000 private hospitals are part of Ayushman Bharat Pradhan Mantri Jan Arogya Yojana (AB-PMJAY),** the government's focus is to increase their participation under the Centre's flagship health scheme.

UNIVERSAL IMMUNISATION PROGRAMME

1. Immunization Programme in India was introduced in 1978 as 'Expanded Programme of Immunization' (EPI) by the **Ministry of Health and Family Welfare,** Government of India.
2. In 1985, the program was modified as the **'Universal Immunization Programme' (UIP)** to be implemented in a phased manner to cover all districts in the country by 1989-90 with one of the largest health programs in the world.
3. The program now consists of vaccination for **12 diseases- tuberculosis, diphtheria, pertussis (whooping cough), tetanus, poliomyelitis, measles, hepatitis B, diarrhoea, Japanese encephalitis, rubella, pneumonia (Haemophilus influenzae type B) and Pneumococcal diseases (pneumococcal pneumonia and meningitis).**

CoWIN platform turned out to be a Succes story

- The CoWIN platform has been able to scale rapidly with the increasing pace of vaccination.
- With a phased rollout of the vaccination program, the CoWIN platform has **scaled quickly in an agile manner.**
- This is evident from the platform's multi-fold scale-up from 2-3 million vaccinations daily during phases 1 and 2 to a **global high of 25 million vaccinations in a day during phase 3.**
- There were multiple private and government applications **(Umang, Arogya Setu),** which have integrated with APIs of CoWIN and provided vaccination registration services.
- CoWIN is a powerful example of **how digital technology can expand public health programs and reflects the strides India continues to make in digital technology for public services.**

National Health Authority (NHA), CoWIN platform, Universal immunization program, Vaccination, Ayushman Bharat – Pradhan Mantri Jan Arogya Yojana (AB-PMJAY), Missing Middle, Insurance penetration in India.

provisions are being made in CoWIN for the vaccination of children and adolescents

1. From January, the policy for vaccination administration enabled the inclusion of the adolescent population. Initially, it was for the age groups 15-17, followed by age groups of 12-14.
2. For those belonging to the 12-17 age group, Covaxin, Corbevax and Covovax have been approved and digitally-enabled for seamless registrations and recording through CoWIN.
3. Additionally, six members can be registered on one mobile number, allowing parents to add their children to their registered CoWIN accounts.

4. Furthermore, discussions are on to repurpose CoWIN platform to accommodate the universal immunization program for providing vaccination to children and pregnant mothers against preventable diseases.

OTHER COUNTRIES SHOWN INTEREST IN ADOPTING THIS TECHNOLOGY

- India decided to adopt a **completely digital approach** while planning its vaccination strategy.
- This helped people prove that they have been vaccinated, **easing the renewal of socio-economic activities in a phased manner.**
- **A safe, secure, and trustworthy** proof helped people establish when, where, and by whom they have been vaccinated.
- The **digital approach** also helped **track the usage of vaccination and minimize wastage.**
- India is providing the **CoWIN platform free of cost to nations interested in adopting** and customizing it.
- **Over 140 countries attended the CoWIN Global Conclave** to learn about this technology.
- After the conclave, nearly a dozen countries expressed interest in **exchanging learnings and best practices on digital administration** of the covid vaccination program.

INDIA PLAN TO EXPAND THE BENEFITS OF AB-PMJAY

1. PMJAY is catering to a population of 107.4 million families included in the Socio-Economic Caste Census (SECC) 2011.
2. The scheme has been implemented in 33 states and Union territories.
3. States/UTs, in alliance with state health insurance schemes, have further extended the beneficiary base to 145 million families.
4. Since 2021, the AB-PMJAY platform is being used to extend healthcare benefits to other categories of beneficiaries.
5. The Employees' State Insurance Scheme is now operational through the AB-PMJAY platform (IT system, hospital network) in 157 districts.
6. Benefits under AB-PMJAY have also been extended to building and construction workers in Bihar, Chandigarh, Nagaland, and Uttar Pradesh.
7. Discussions are going on with nodal ministries to cover vulnerable sections like manual scavengers and transgender people.
8. With AB-PMJAY adopting a zero-tolerance approach towards fraud and abuse, 210 hospitals that engaged in unethical practices, including denial of treatment to the scheme beneficiaries, have been removed, while approximately 50,000 suspect transactions were cancelled.
1. WHO's health financing profile for 2017 shows 67.78% of total expenditure on health in India was paid out of pocket, while the world average is just 18.2%
2. According to National Health Accounts estimates the rise in government contribution to the total health expenditure from 29% in 2013-'14 to 41% in 2017-'18, led to a decline in household out-of-pocket expenditure by the household 64% to 49% in the same period.

INDIA'S HEALTH INSURANCE SCENARIO:

1. The Ayushman Bharat – Pradhan Mantri Jan Arogya Yojana (AB-PMJAY) and State Government extension schemes, provide comprehensive hospitalization cover to the **bottom 50% of the population – around 70 crore individuals.**
2. Around **20% of the population– 25 crore individuals –are covered through social health insurance, and private voluntary health insurance.**
3. The remaining 30% of the population is devoid of health insurance; the actual uncovered population is higher due to **existing coverage gaps in PMJAY and overlap between schemes.**

'Missing Middle'

1. Financial distress due to hospitalization is not **restricted to poor families alone.**
2. Any family not covered under a health insurance scheme will have to confront catastrophic health expenses.
3. Unfortunately, many such **"non-poor" families cannot afford the premiums chargeable for commercial health insurance policies.**
4. This section of society is referred to as **'Missing Middle'** and **comprises informal sector workers, self-employed, small business owners, etc.**
5. According to the NITI Ayog report **at least 30% of the population, or 40 crore individuals – is called the missing middle.**

How needs of 'Missing Middle' are being catered to?

1. NHA is exploring options to extend healthcare protection to the **"Missing Middle".**
2. A **pilot project is being launched wherein insurance providers can use the AB-PMJAY platform to cover different population groups.**

WAY FORWARD:

1) There is a need for designing a low-cost comprehensive health insurance product for the missing middle. The government and the private sector will need to come together in this endeavour.
2) Private sector ingenuity and efficiency are required to reach the missing middle and offer compelling products.
3) The government has an important role to play in increasing consumer awareness and confidence, modifying regulations for standardized product and consumer protection, and potentially offering a platform to improve operational efficiency.

BIOLOGICAL CLOCKS - NOBEL PRIZE FOR MEDICINE

- Jeffrey C. Hall, Michael Rosbash & Michael W. Young are to be jointly awarded the 2017 "Nobel Prize for Medicine".
- The award is for their work in discovering the mechanisms controlling the internal clocks in living organisms.

1) The trio's work was in 'Chrono Biology' – A science that examines periodic phenomena in living organisms in relation to nature.
2) They made significant contributions in unravelling the genetic coding and protein pathways that regulate the circadian rhythm.
3) This rhythm is what tells us when it is time to eat, sleep or wake up - even when we have no bedside alarm.

THE ACHEIEVEMENTS OF THE TRIO

1) Isolation of a gene called **'Period'** in fruit-flies that disrupted its circadian clock was the most important acheivement.
2) **PER –** A protein named 'PER' that serves as a functional communicator for the 'Period Gene' was discovered.
3) PER was found to accumulate at night & diminish during the day.

4) **Timeless –** A second gene called 'Timeless' that acts through its 'TIM protein' in conjunction with 'PER' was also identified.
5) This was found to cause the seesawing of cellular protein levels.
6) **Doubletime -** A third gene called 'Doubletime' was discovered to be the regulator of the frequency of the oscillations.

IMPLICATIONS

1) The current research has added significantly to the science that studies the linkages between sleep & metabolic activity.
2) The impact of smartphone & other gadgets in disrupting circadian rhythms is already being studied extensively.
3) There is more clarity now, in the link between peak physical performance in sport and the time of the day.
4) Circadian rhythm may well hold the key to future breakthroughs in the modulation and treatment of various diseases.

Daylight Saving Time (DST) is the practice of turning the clock ahead as warmer weather approaches and back as it becomes colder again.

A. The purpose of doing so is that people will have one more hour of daylight in the afternoon and evening during the warmer season of the year.
B. The daylight saving time is followed in over 70 countries on various dates.
C. **India does not follow daylight saving time;** countries near the Equator do not experience high variations in daytime hours between seasons.

History of Day Light Saving

1) Initially, it was followed by a group of Canadians on July 1, 1908, when residents of Port Arthur, Ontario, turned their clocks forward by an hour. Other locations in Canada soon followed suit.
2) However, **globally Germany and Austria introduced DST on April 30, 1916, the rationale being to minimize the use of artificial lighting to save fuel during World War I.**

<u>DAYLIGHT SAVING TIME ACTUALLY SAVE ENERGY</u>

A. A century ago, when DST was introduced, more daylight did mean less use of artificial light. But modern society uses so many energy-consuming appliances all day long that the amount of energy saved is negligible.
B. There is also a disadvantage of DST which includes disruption of the body clock or circadian rhythm.

<u>Circadian Rhythm</u>

A. Circadian rhythm is the 24-hour cycle that tells our bodies when to sleep, rise, and eat—regulating many physiological processes.
B. Internal body clock is affected by environmental cues, like sunlight and temperature, and determines whether one feels wide-awake and energized or tired.

C. Jeffrey C. Hall, Michael Rosbash, and Michael W. Young, who studied the molecular mechanisms controlling circadian rhythm, were awarded the 2017 Nobel Prize in the category of physiology or medicine.

WORLD'S LARGEST BACTERI-

A. The bacteria Thiomargarita magnifica is 5000 times larger than the average bacteria and it can grow up to 2 cm in length.
B. In the test tube, the bacteria looks like white eyelashes and specialist 3D microscope images have proved that the entire filament is indeed a single cell.

i. The bacterium — named **Thiomargarita magnifica**, or "magnificent sulfur pearl" — clinging to sunken mangrove leaves in the archipelago of Guadeloupe in 2009.
ii. The bacterium is roughly the shape and size of an eyelash.
iii. The bacteria appeared as long translucent centimeter-long strings on decaying leaf matter in the water.
iv. Most bacteria are microscopic, but this one is so big it can be seen with the naked eye.
v. The bacterium also has a complex membrane organization and a predictable life cycle.

Different from other bacteria's:

i. Bacteria are commonly thought to be "bags of enzymes," where there is no nucleus or Golgi apparatus or any other organelles, and DNA simply floats freely through the cell.
ii. However, T. magnifica not only contains DNA within a membrane, but also ribosomes—which create proteins—cohabitating with the genome.
iii. The cell has a structure that's unusual for bacteria.
iv. One key difference: It has a large central compartment, or vacuole, that allows some cell functions to happen in that controlled environment instead of throughout the cell.

Guadeloupe archipelago in the French Caribbean:

1) Guadeloupe, the French Caribbean tropical islands in the Lesser Antilles in the Eastern Caribbean is situated just north of Dominica and southeast of Puerto Rico.
2) Caribbean mangrove swamps are packed with organic matter, with microbes in the sediment degrading this matter and producing high concentrations of sulfur.
3) The sulfur-rich environment offers an energy source for bacteria like Thiomargarita magnifica.
4) The researchers named its DNA-bearing organelles "pepins" after a French word for small seeds inside fruits.

BREAST CANCER DRUG TRIAL RESULTS IN 'UNHEARD-OF' SURVIVAL RATES

The new study, presented at the annual meeting of the American Society of Clinical Oncology and published Sunday in the New England Journal of Medicine, would change how medicine was practiced, cancer specialists said.

- New data on a breast cancer treatment from AstraZeneca and the Japanese drug maker Daiichi Sankyo brought a standing ovation from cancer doctors attending their annual meeting in Chicago on Sunday. And with good reason.
- The drug, Enhertu, enabled women with advanced breast cancer to live six months longer than others treated with conventional chemotherapy. Oncologists call the results "practice changing" for metastatic breast cancer.

The subject of the spiraling costs of cancer medicines and their implications have been highlighted in a recent report-Cancer Care Plan and Management, by the Rajya Sabha's Standing Committee on Health.

1. It is one of the most dreaded diseases of human beings and is a major cause of death all over the globe.
2. **More than a million Indians suffer from cancer** and a large number of them die from it annually.
3. Mechanisms and development of cancer or oncogenic transformation of cells, its treatment and control have been some of the most intense areas of research in biology and medicine.

Cancer Care Plan and Management report:

- **About 40% of cancer hospitalization cases** are financed mainly through borrowings, sale of assets and contributions from friends and relatives".
- **Average out of pocket spending** on cancer care is too high
- **Spending for cancer care in private facilities** is about three times that of public facilities.
- **The Committee has highlighted** the seriousness of problems concerning the treatment of cancer
- **The estimated incidence in India** was nearly **4(one point four) million in 2020.**

IMPACT ON SURVIVAL RATES:

1. In breast cancer: The five-year survival rates in India and South Africa are 65% and 45%, respectively
2. In high-income countries, it is nearly 90%.
3. World Health Organization (WHO) report on pricing of cancer medicines and its impacts: The cost of a course of standard treatment for early stage HER2 (human epidermal growth factor receptor) positive breast cancer would be equivalent to about 10 years of average annual wages in India and South Africa and 7(one years in the United States.
4. According to WHO: The costs associated with other medical care and interventions (such as surgical interventions and radiotherapy) and supportive care would make overall care more unaffordable.

<u>Treatment protocol for breast cancer:</u>

- **CDK (cyclin-dependent kinase) inhibitors** constitute a major therapeutic tool, especially for metastatic breast cancer.
- Drugs used:

1. Ribociclib
2. Palbociclib
3. Abemaciclib

They help in slowing the spread of cancer cells in the body.

A month's treatment using these drugs: ranges between **₹48,000** and **₹95,000**.

REASON FOR HIGH COST OF CANCER DRUGS:

1. **Argument advanced by the large pharmaceutical companies:** They spend over **$3 billion** in bringing a new molecule to the market, which they must recoup in order to remain in the market for innovation.
2. **The WHO report:** spending on research and development may bear little or no relationship to how pharmaceutical companies set cancer medicine prices.
3. **Profit**: Companies set prices with an eye to maximize profits.
4. **Intellectual property protection:** Pharma companies in the developed world have persuaded their governments to strengthen the rights that they derive from patents and other forms of intellectual property rights.
5. They exercise monopoly control over their products.

PATENT RIGHTS OVER THE MEDICINE:

1. Patent rights over a medicine last until the expiry of its patent term after which generic competition leads to a reduction in its price.
2. In the case of several non-communicable diseases, including cancer: Even before the generic producers enter the market, newer therapies could be introduced as standard care for treatment.
3. In the case of pharmaceutical patents: Leading firms in the industry obtain patents on incremental innovations involving older medicines ("evergreening" of patents), extending their monopoly rights over the medicines.

IMPACT OF PATENT RIGHTS ON THESE DRUGS:

1. **The lack of access t**o these critical medicines.
2. **Financial crisis**: Pushed the life of patients and their families into deep financial stress
3. **Article 21**: It has a jeopardized right to live with dignity, a fundamental right guaranteed under Article 21**.**

Global stand on IPR:

1. **TRIPS Agreement:** In 2001, Trade Ministers of WTO member countries endorsed the Declaration on TRIPS Agreement and Public Health that recognised the right of every country to grant CLs.
2. Advanced countries had opposed the use of this instrument.

Example:

- **The United States:** Trade administration's annual review of the state of intellectual property protection and enforcement by the U.S.'s trading partners, namely, the Special 301 Report.
- **European Union**: It backed the use of CLs for increasing domestic production of COVID-19 vaccines and medicines by developing countries.

COMPULSORY LICENSING;-

t allows governments to license ***third parties*** (that is, parties other than the patent holders) to produce and market a patented product or process without the consent of patent owners.

Any time after ***three years from date of sealing of a patent***, application for compulsory license can be made, provided:

I. Reasonable requirements of the public have not been satisfied.
II. Patented invention is not available to public at a reasonably affordable price

III. Patented inventions are not carried out in India.
IV. Compulsory Licencing is regulated under the ***Indian Patent Act, 1970.***
V. The TRIPS Agreement does not specifically list the reasons that might be used to justify compulsory licensing.
VI. Doha Declaration on TRIPS and Public Health confirms that countries are free to determine the grounds for granting compulsory licenses, and to determine what constitutes a national emergency.

Ever greening:

- It is the practice of companies filing for an extension of a patent with minor process or product modifications just before the original patent expires at the end of 20 years.

ASTRAZENECA'S BREAST CANCER DRUG ENHERTU SHOWS PROMISING RESULTS IN PATIENTS

1. The drug, which generated sales of $214 million in 2021, belongs to a class of therapies called antibody drug conjugates.
2. The study included 1,600 women with early breast cancer who were planned to be treated with surgery. (File)
3. Astra Zeneca said a late-stage trial had confirmed the benefit of breast cancer drug Enhertu in patients with an advanced form of the disease who had been previously treated with another therapy.
4. In a 600-patient trial called DESTINY-Breast02, Enhertu -developed with Japan's Daiichi Sankyo (4568.T) – was compared against a treatment pre-determined by physicians in people with HER2-positive metastatic breast cancer, as reported by Reuters.
5. The trial evaluated a similar breast cancer patient population as the DESTINY-Breast01 mid-stage trial, which was the basis for initial approvals in Europe and several other countries, AstraZeneca said as quoted by Reuters.
6. In the DESTINY-Breast02 study, Enhertu met the main goal of statistically significant and clinically meaningful improvement in progression-free survival, a measure of how long a person can live without their disease worsening. The drug also improved overall survival, a key secondary goal.
7. Meanwhile, detailed results will be presented at an upcoming scientific conference. The HER2 protein contributes to the growth and spread of breast cancer. About one in five patients with breast cancer are considered HER2-positive, according to AstraZeneca.

- AstraZeneca's shares were up about 2% on Monday morning, while Daiichi's shares jumped about 15%.
- Earlier this month, AstraZeneca and Daiichi secured U.S. approval specifically targeting patients with so-called HER2-low breast cancer,, paving the way for billions in sales. Enhertu's first approval came in late 2019, as a third-line treatment for breast cancer patients with HER2-positive disease, in the United States.
- It has since also secured multiple approvals in other breast cancer settings, as well as forms of lung and gastric cancer.
- The drug, which generated sales of $214 million in 2021, belongs to a class of therapies called antibody drug conjugates. It comprises a monoclonal antibody chemically linked to a cell-killing chemotherapy drug. AstraZeneca secured partial rights to the Daiichi Sankyo compound three years ago in a deal worth up to $6.9 billion.

MONKEYPOX

Recently, the US started surveillance on people travelling from Nigeria, who may have had contact with the individuals infected with Monkeypox.

1. It is **a viral zoonotic diseases** (transmission from animals to humans) and is identified as a pox-like disease among monkeys **hence it is named Monkeypox.** It is **endemic to Nigeria.**
2. It is **caused by monkeypox virus,** a member of the **Orthopoxvirus genus in the family Poxviridae.**
    - The natural host of the virus remains undefined. But the disease has been reported in many animals.
      Animals known to be sources of Monkeypox virus include monkeys and apes, a variety of rodents (including rats, mice, squirrels and prairie dogs) and rabbits.

Outbreaks:

1. It was first reported in 1958, in monkeys in the **Democratic Republic of Congo (DRC)** and in humans in 1970, also in the DRC.
2. In 2017, Nigeria experienced the largest documented outbreak, 40 years after the last confirmed case.
3. Subsequently, the disease has been reported in **many West and Central African countries.**

SYMPTOMS:

- Infected people break out in a rash that looks a lot like chicken pox. But the fever, malaise, and headache from Monkeypox are usually more severe than in chicken pox infection.
- In the early stage of the disease, Monkeypox can be distinguished from smallpox because the lymph gland gets enlarged.

TRANSMISSION:

1. Primary infection is through direct contact with the blood, bodily fluids, or cutaneous or mucosal lesions of an infected animal. Eating inadequately cooked meat of infected animals is also a risk factor.
2. Human-to-human transmission can result from close contact with infected respiratory tract secretions, skin lesions of an infected person or objects recently contaminated by patient fluids or lesion materials.
3. Transmission can also occur by inoculation or via the placenta (congenital monkeypox).

VULNERABILITY:

It spreads rapidly and **can cause one out of ten deaths** if infected.

TREATMENT AND VACCINE:

- There is no specific treatment or vaccine available for Monkeypox infection. In the past, the anti-smallpox vaccine was shown to be 85% effective in preventing Monkeypox.

- But the world was declared free of smallpox in 1980 so the vaccine isn't widely available anymore.
- Currently, there is no global system in place to manage the spread of Monkeypox, with each country struggling to contain any outbreak whenever it occurs.
- With the WHO declaring monkeypox as a Public Health Emergency of International Concern (PHEIC) and cases rising globally to around 19,179 in 78 countries as of July 27, governments around the world are initiating steps towards developing or even sourcing a vaccine against monkeypox.

VACCINES FOR MONKEYPOX

1. The monkeypox virus belongs to a family of viruses called orthopoxviruses, which is different from that of the coronaviruses.
2. According to the WHO, it is a viral zoonosis — a virus transmitted to humans from animals — with symptoms similar, but less severe to smallpox.
3. It is also an enveloped double-stranded DNA virus, unlike the RNA virus, that makes it far more stable and less prone to rapid mutations.
4. There are two distinct genetic clades of the monkeypox virus: the central African (Congo Basin) clade and the West African clade.
5. The Congo Basin clade has historically caused more severe disease and was thought to be more transmissible.

VACCINE

1. There is yet no dedicated monkeypox vaccine
2. In 2019, the USFDA, approved the **JYNNEOS vaccine** for the **prevention of smallpox, monkeypox** and other diseases caused by orthopoxviruses, including **vaccinia virus**.

JYNNEOS WORK

1. JYNNEOS, developed by Danish biotechnology company, Bavarian Nordic, contains a live vaccinia virus that does not replicate efficiently in human cells.
2. The vaccinia virus is the smallpox virus but made incapable of replicating within the body. It is administered as two injections 28 days apart. The immune response takes 14 days after the second dose.
3. The vaccine's effectiveness was inferred only indirectly by comparing the immunogenicity of JYNNEOS to a licensed smallpox vaccine (ACAM2000) based on a laboratory test called the Plaque Reduction Neutralisation Test (PRNT).
4. This test evaluates what quantity of the vaccine was needed to kill the virus made to replicate in a petri-dish.
5. There is no data yet on JYNNEOS' effectiveness. This is because smallpox has been eradicated and the monkeypox outbreak has risen too rapidly for a traditional phase 3 trial to have evaluated the vaccine's effectiveness.

INDIA

- Health Ministry officials said **discussions were in progress** with international and local companies for a vaccine.
- The genomic sequence of the Indian strain has a **85% match with the West African strain circulating globally.**
- The ICMR has **invited tenders from local companies to develop a vaccine**.

ORTHOPOXVIRUS

1. Orthopoxvirus is a genus of viruses in the family Poxviridae and subfamily Chordopoxvirinae.
2. Vertebrates, including mammals and humans, and arthropods serve as natural hosts.
3. There are 12 species in this genus. Diseases associated with this genus include smallpox, cowpox, horsepox, camelpox, and monkeypox.
4. The most widely known member of the genus is Variola virus, which causes smallpox.
5. It was eradicated globally by 1977, through the use of Vaccinia virus as a vaccine.
6. The most recently described species is the Alaskapox virus, first isolated in 2015.

WAY FORWARD

1. Improved surveillance and response, raise awareness of the disease and avoid contact with wild animals, especially monkeys.
2. Any animals that might have come into contact with an infected animal should be quarantined, handled with standard precautions and observed for monkeypox symptoms for 30 days.
3. It is important to refocus attention on other diseases. There is a drop in the number of reported cases of endemic diseases as people are not seeking care in health facilities, owing to covid-19.

GUIDELINES FOR SAFETY ASSESSMENT OF GENOME EDITED PLANTS, 2022

- Recently ,the Department of Biotechnology (DBT) issued guidelines easing norms for research into **Genetically Modified (GM) crops** and circumventing challenges of using foreign genes to change crops profile.

MAJOR HIGHLIGHTS

- The **'Guidelines for Safety Assessment of Genome Edited Plants, 2022'** exempt researchers who use gene editing technology to modify the genome of the plant from seeking approvals from the **Genetic Engineering Appraisal Committee (GEAC).**
- The guidelines provide a road map for the s**ustainable use of genome editing technologies** and **applicable to public and private sector research institutions** engaged i**n research and development and handling of genome edited plants.**
- The guideline aligns and harmonises India's regulatory framework on genome editing with other mega food producing countries from Latin America, North America, Africa and Asian countries.

ENVIRONMENT MINISTRY NOTIFICATION

1. It had exempted certain types of genome-edited crops from the stringent biosafety regulations applicable to genetically-modified (GM) crops.
2. The ministry had exempted site directed nuclease **(SDN) 1 and 2 genomes from rules 7-11 of the Environment Protection Act,** thus avoiding a long process for approval of GM crops through the Genetic Engineering Appraisal Committee (GEAC).

SIGNIFICANCE

- These guidelines are expected to bring **transformational change in product development and commercialisation** and would contribute **towards increasing farmer's income.**
- It will **accelerate agriculture and good trade** of such products.

Concerns raised by Environmentalist groups

- Environmentalist groups have opposed this exception for gene-edited crops.
- Gene editing is included in **genetic engineering.** Therefore, there is no question of **giving exemptions to particular kinds of genome edited** plants from the regulatory purview.
- Gene editing techniques involve **altering the function of gene**s and can cause "large and **unintended consequences**" that can change the **"toxicity and allergenicity" of plants**. "
- They have demanded that these exemptions be withdrawn.

GENETICALLY MODIFIED CROPS

- **Conventional plant** breeding involves c**rossing species of the same genus** to provide the offspring with the desired traits of both parents.
- The GM plants that have usually come for such scrutiny are those that involve **transgenic technology or introducin**g a gene from a different species into a plant, for instance BT-cotton, where a gene from soil bacterium is used to protect a plant from pest attack.

GM CROP ALLOWED IN INDIA:

1. Bt cotton, the only GM crop that is allowed in India, has two alien genes from the soil bacterium Bacillus thuringiensis (Bt) that allows the crop to develop a protein toxic to the common pest pink bollworm.
2. On the other hand, Bt cotton is derived with the insertion of an additional gene, from another soil bacterium, which allows the plant to resist the common herbicide glyphosate.

Bt Brinjal:

- In Bt brinjal, a gene allows the plant to resist attacks of fruit and shoot borer.

DMH 11 Mustard:

- In DMH-11 mustard, developed by Deepak Pental and colleagues in the South Campus of the University of Delhi, genetic modification allows cross-pollination in a crop that self-pollinates in nature.

Global variants:

- Across the world, GM variants of maize, canola and soybean, too, are available.

ADVANTAGES OF GM CROPS

1. It can feed a rapidly increasing population because it shows dramatically increased yields.
2. It can produce more in small areas of land.
3. It improves production and raises the farmer's income.
4. It reduces the use of pesticides and insecticides during farming that might be great moves for the betterment of the food supply.

THE LEGAL POSITION OF GENETICALLY MODIFIED CROPS IN INDIA

1. In India, the **Genetic Engineering Appraisal Committee (GEAC)** is the apex body that allows for the commercial release of GM crops.

2. In 2002, the GEAC had allowed the commercial release of Bt cotton.
3. More than 95 per cent of the country's cotton area has since then come under Bt cotton.
4. Use of the unapproved GM variant can attract a jail term of 5 years and a fine of Rs 1 lakh under the **Environmental Protection Act,1989**.

GENETIC ENGINEERING APPRAISAL COMMITTEE (GEAC)

- It functions under the Ministry of Environment, Forest and Climate Change (MoEF&CC).

COMPOSITION

1. It is chaired by the Special Secretary/Additional Secretary of MoEF&CC and co-chaired by a representative from the Department of Biotechnology (DBT).
2. Presently, it has 24 members and meets every month to review the applications in the areas indicated above.

FUNCTIONS

1. As per Rules, 1989, it is **responsible for appraisal of activitie**s involving large scale use of hazardous microorganisms and recombinants in research and industrial production from the environmental angle.
2. It is also **responsible for appraisal of proposals relating** to release of **genetically engineered (GE) organisms** and products into the environment including experimental field trials.
3. It e**valuates research into GM plants and recommends**, or disapproves, their release into farmer fields.
4. The final call however is taken by the Environment Minister as well as States where such plants could be cultivated.
5. The Environment Ministry too has sanctioned this exemption.

FARMERS ROOTING FOR GM CROPS

1. **Reduced cost of production:** In the case of cotton, farmers cite the high cost of the wedding, which goes down considerably if they grow Ht Bt cotton and use glyphosate against weeds. Brinjal growers in Haryana have rooted for Bt brinjal as it reduces the cost of production by cutting down on the use of pesticides.
2. **Currently being used illegally:** Unauthorised crops are widely used. Haryana has reported farmers growing Bt brinjal in pockets which had caused a major agitation there. In June last year, in a movement led by Shetkari Sanghatana in Akola district of Maharashtra, more than 1,000 farmers defied the government and sowed Ht Bt cotton.

Issues /Concerns related to GM Crops

1) **Health Hazards:** Several studies in Bt crops show that there are many potential health hazards. Itching skin, eruptions on the body, swollen faces, etc., have been reported, correlated with levels of exposure to Bt Cotton.
2) **The decline in Fertility:** Farmers from various parts of the country have reported a decline in their soil productivity after growing Bt Cotton. Many groups are also studying the decline in fertility and milk yield of cattle due to GM Cottonseed cattle feed.

3) **Inadequate Safety Assessments:** The current safety assessments are inadequate to catch most of the harmful effects from the GM crops. Moreover, the regulatory regime in India about GM crops has never been assessed thoroughly about the GM risk assessment in Indian conditions.
4) **Pesticides Resistance:** Apprehension has been expressed that the target pest would grow resistant to the Bt toxin with time. Not enough studies on soil ecology have been done to understand the impact of Bt toxin.
5) **Pricing Policy:** The pricing policy has also been questioned. Cost-recovery would be much higher for Bt seeds due to the research and marketing involved.
6) **Patent & Litigation:** Moreover, Patent infringement is a big concern of agribusiness. Litigation on the part of the company about pricing and use of GM seeds is not new.

Wayforward :

1) GM foods have the potential to solve many of the world's hunger and malnutrition problems.
2) It could help in protecting and preserving the environment by increasing yield and reducing reliance upon chemical pesticides.
3) At the same time, the challenges need to be addressed by governments, especially in the areas of safety testing, regulation, industrial policy and food labelling.

GENOME EDITING

Recently, the Government has allowed genome-edited plants without the cumbersome GMO (Genetically Modified Organisms) regulation at the GEAC.

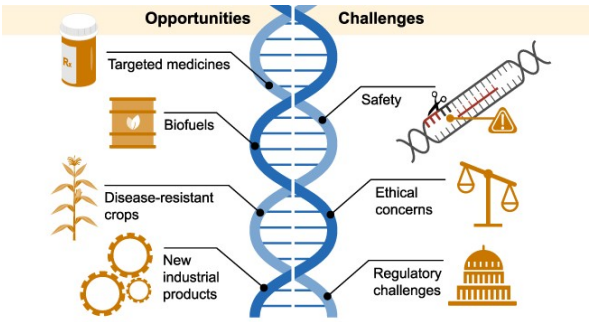
I. The government has **exempted Site Directed Nuclease (SDN) 1 and 2 genomes from Rules 7-11 of the Environment Protection Act**, thus allowing it to avoid a long process for approval of GM crops through the Genetic Engineering Appraisal Committee (GEAC).
II. The **Institutional BioSafety Committee (IBSC)** under the Environment Protection Act would now be entrusted to certify that the genome edited crop is devoid of any foreign DNA.

GENETIC ENGINEERING APPRAISAL COMMITTEE

- It functions under the Ministry of Environment, Forest and Climate Change (MoEF&CC).
- It is responsible for the appraisal of activities involving large-scale use of hazardous microorganisms and recombinants in research and industrial production from the environmental angle.
- The committee is also responsible for the appraisal of proposals relating to the release of genetically engineered organisms and products into the environment including experimental field trials.
- GEAC is chaired by the Special Secretary/Additional Secretary of MoEF&CC and co-chaired by a representative from the Department of Biotechnology (DBT).

GENOME EDITING

- Genome editing (also called GENE EDITING) is a group of technologies that give scientists the ability to change an organism's DNA.
- These technologies allow genetic material to be added, removed, or altered at particular locations in the genome.



- ❖ Advanced research has allowed scientists to develop the highly effective CRISPR -associated proteins based systems. This system allows for targeted intervention at the genome sequence.
- ❖ This tool has opened up various possibilities in plant breeding. Using this tool, agricultural scientists can now edit the genome to insert specific traits in the gene sequence.
- ❖ Depending on the nature of the edit that is carried out, the process is divided into three categories — SDN 1, SDN 2 and SDN 3.

1. **Site Directed Nuclease (SDN) 1 introduces** changes in the host genome's DNA through small insertions/deletions without introduction of foreign genetic material.
2. **In SDN 2**, the edit involves using a small DNA template to generate specific changes. Both these processes **do not involve alien genetic material** and the end result is indistinguishable from conventionally bred crop varieties.
3. **The SDN3 process involves larger DNA elements or full length genes of foreign origin** which makes it similar to Genetically modified organisms (GMO) development.

Govt Exempts Genome-edited Plants from Biosafety Regulations

- ➢ The Centre has exempted plants under SDN1 and SDN2 categories from concerned biosafety regulations, potentially helping in faster development of new varieties

Context:

1. Notifying the **rules for manufacture, use, import, export and storage of genetically-engineered "organism of cells"**, the Ministry of Environment on Wednesday said plants under **SDN1 and SDN2 categories** are exempted from concerned biosafety regulations, potentially helping in **faster development of new varieties.** However, such genome-edited plants will have to follow other applicable laws/acts/rules.
2. In its order, the Ministry of Environment, Forest and Climate Change said that Department of Biotechnology and Department of Agriculture Research and Education had recommended that the **"SDN1 and SDN2 Genome Edited Products free from exogenous introduced DNA be exempted from biosafety assessment."**
3. It is a **recognition of the potential of genome editing technology in agriculture.** The notification paves a path for Department of Biotechnology **to approve and notify the guidelines on Genome Edited Plants, which was pending since early 2020.**

Department of Biotechnology, Department of Agriculture Research and Education, DNA, biosafety assessment, Genome Edited Plants, site directed nuclease (SDN) or sequence specific nuclease (SSN), CRISPR, Genetically modified organisms, foreign genes, cry1Ac and cry2Ab, traditional breeding.

GENOME EDITING

1. Genome editing (also called **gene editing)** is a group of technologies that give scientists the **ability to change an organism's Deoxy-Ribonucleic Acid (DNA).**
2. These technologies allow **genetic material to be added, removed, or altered at particular locations in the genome.**
3. A decade ago, **scientists in Germany and the US discovered a technique** which allowed them to **'cut' DNA strands and edit genes.** For agriculture scientists this process allowed them to bring about desired changes in the genome by using **site directed nuclease (SDN) or sequence specific nuclease (SSN).** Nuclease is an enzyme which cleaves through nucleic acid — the building block of genetic material.
4. Advanced research has allowed scientists to develop the highly effective clustered regularly interspaced **palindromic repeat (CRISPR) -associated proteins based systems.** This system allows for targeted intervention at the genome sequence. This tool has opened up various possibilities in plant breeding. Using this tool, agricultural scientists can now edit genome to insert specific traits in the gene sequence. Depending on the nature of the edit that is carried out, the process is divided into **three categories — SDN 1, SDN 2 and SDN 3.**
5. SDN1 introduces changes in the host **genome's DNA through small insertions/deletions without introduction of foreign genetic material.** In the case of SDN 2, the **edit involves using a small DNA template to generate specific changes.** Both these processes do not involve alien genetic material and the end result is indistinguishable from conventionally bred crop varieties.
6. SDN3 process involves larger DNA elements or full length genes of foreign origin which makes it **similar to Genetically modified organisms (GMO) development.**
7. The first two, which **largely involve "knocking off" or "overexpressing" certain traits in a genome without any insertion of gene material from outside,** will be covered by the new changes.
8. The third, which **involves insertion of foreign genes,** will be treated as GMO.

GENE EDITING DIFFERENT FROM GMO DEVELOPMENT

1. **Genetically modified organisms** (GMO) involves modification of the genetic material of the host by introduction of a **foreign genetic material. In the case of agriculture, soil bacteria is the best mining source** for such genes which are then inserted into the host genome using genetic engineering. For example, in case of cotton, introduction of **genes cry1Ac and cry2Ab mined from the soil bacterium Bacillus Thuringiensis (BT)** allow the native cotton plant to generate endotoxins to fight pink bollworm naturally. BT Cotton uses this advantage to help farmers naturally fight pink bollworm which is the most common pest for cotton farmers.
2. The basic difference between **genome editing and genetic engineering** is that while the former **does not involve the introduction of foreign genetic material,** the latter does. In the case of agriculture, both the techniques aim to **generate variants which are better yielding and more resistant to biotic and abiotic stress.** Before the advent of genetic engineering, such variety improvement was done through **selective breeding which involved carefully crossing plants with specific traits to produce the desired trait in the offspring.** Genetic engineering has not only made this work more accurate but has also allowed scientists to have greater control on trait development.

REGULATORY ISSUES WHICH HAVE PREVENTED WIDER ADOPTION OF THIS TECHNIQUE

- Across the world, GM crop has been a topic of debate, with many environmentalists opposing it on the grounds of bio safety and incomplete data. In India, the introduction of GM crops is a laborious process which involves multiple levels of checks. The Genetic Engineering Appraisal Committee (GEAC), a high power committee under the

Ministry of Environment, Forest and Climate Change, is the regulator for introduction of any GM material and in case of agriculture multiple field trials, data about biosafety and other information is necessary for getting the nod before commercial release of any GM crop. Till date the only crop which has crossed the regulatory red tape is Bt cotton.

- Scientists both in India and across the world have been quick to draw the line between GM crops and genome edited crops. The latter, they have pointed out, has no foreign genetic material in them which makes them indistinguishable from traditional hybrids. Globally, European Union countries have bracketed genome edited crops with GM crops. Countries like Argentina, Israel, US, Canada, etc have liberal regulations for genome edited crops.
- Last year, a group of eminent agricultural scientists had written to Prime Minister Narendra Modi voicing their concern about what they said was a move to put the issue of genome edited crops to the back burner. Back then, the central government had invited suggestions and objections from states and Union Territories about the issue and put on hold field trials of such crops. The signatories, many of whom were Padma awardees, had categorically said that the variants developed through SDN1 and SDN2 techniques do not have any alien DNA and as such can be treated as other hybrids.

BENEFIT OF THIS EXEMPTION:

- The limited benefit of this policy decision is that genome edited SDN1/SDN2 category plants will be absolved from the cumbersome GMO regulatory system after evaluation of molecular data by IBSC/RCGM under EPA Rules 1989 and subsequently under the Seed Act, a unique dual regulatory system ensuring biosafety and benefits of technology for the welfare of small growers.
- Experts said while genetically modified (GM) crops are objected to as genes of others are mixed in developing new varieties, in the case of genome-editing, it is just a process of correcting some bad elements and therefore does not find any opposition.
- There are some varieties of crops like paddy and banana that have been developed using the genome-editing technology and once the guidelines are issued, it will pave the way for their commercial release.
- It will not only help increase food production, but also ensure environmental sustainability. Crops can be developed with better water use efficiency.

GENE EDITING DIFFERENT FROM GMO DEVELOPMENT

1. Genetically Modified Organisms (GMO) involves modification of the genetic material of the host by introduction of a foreign genetic material.
2. In the case of agriculture, soil bacteria is the best mining source for such genes which are then inserted into the host genome using genetic engineering.
1. For example, in case of cotton, introduction of genes cry1Ac and cry2Ab mined from the soil bacterium Bacillus Thuringiensis (BT) allow the native cotton plant to generate endotoxins to fight pink bollworm naturally.
2. BT-COTTON uses this advantage to help farmers naturally fight pink bollworm which is the most common pest for cotton farmers.
3. The basic difference between genome editing and genetic engineering is that while the former does not involve the introduction of foreign genetic material, the latter does.
4. In the case of agriculture, **both the techniques aim to generate variants which are better yielding and more resistant to biotic and abiotic stress.**
5. Before the advent of genetic engineering, such variety improvement was done through selective breeding which involved carefully crossing plants with specific traits to produce the desired trait in the offspring.

6. Genetic engineering has not only made this work more accurate but has also allowed scientists to have greater control on trait development.

REGULATORY ISSUES PREVENTING THE TECHNIQUE

- Across the world, GM crops have been a topic of debate, with many environmentalists **opposing it on the grounds of bio safety and incomplete data.** In India, the introduction of GM crops is a laborious process which involves multiple levels of checks.
- Till date the only crop which has crossed the regulatory red tape is Bt cotton.
- Scientists both in India and across the world have been quick to draw the line between GM crops and genome edited crops. The latter, they have pointed out, has no foreign genetic material in them which makes them indistinguishable from traditional hybrids.
- Globally, EU countries have bracketed genome edited crops with GM crops. Countries like Argentina, Israel, US, Canada, etc have liberal regulations for genome edited crops.

WAY FORWARD:

- Over the past several decades, **traditional breeding that depends on access to plant populations with sufficient variability** has made great contributions to agriculture. However, this variability is mainly derived from spontaneous mutations or from mutations that are induced by chemical mutagens or physical irradiation.
- Such mutations are usually **rare and occur at random.** Moreover, many types of **variation might not arise in elite varieties, and consequently time-consuming,** laborious breeding programs are needed to introduce desirable alleles into elite crops. By contrast, **genome editing as an advanced molecular biology technique** can produce precisely targeted modifications in any crop.

STEM CELL

Recently, Doctors in Mumbai used stem cell therapy to **save life of a premature baby boy,** who was suffering from a chronic lung disease.

STEM CELL

I. Stem cells are the body's raw materials — cells from which all other cells with specialized functions are generated.
II. Under certain conditions in the body or a laboratory, stem cells divide to form more cells called daughter cells.
   - These daughter cells either become **new stem cells (self-renewal)** or become **specialized cells (differentiation)** with a more specific function, such as blood cells, brain cells, heart muscle cells or bone cells.
   - No other cell in the body has the natural ability to generate new cell types.

STEM CELL THERAPY

I. Stem cell therapy, also known as **regenerative medicine,** promotes the repair response of diseased, dysfunctional or injured tissue using stem cells or their derivatives.
II. Stem cells can then be **implanted into a person.** For example Mumbai baby boy was injected with 40 million stem cells and gradually the lungs began to repair. In this case, doctors used mesenchymal stem-cell therapy (these are adult stem cells and are different from Embryonic stem cells) on an experimental basis
   - In March 2019, the Union Health Ministry had notified the NEW DRUGS AND CLINICAL TRIAL RULES-2019 the which state that stem-cell **derived products are to be used as "new**

drugs". "This means that any doctor who uses stem-cell therapy needs to take permission from the government.

CLINICAL TRIAL REGULATIONS IN INDIA

I. **Central Drugs Standard Control Organization (CDSCO)** which comes under the Ministry of Health and Family Welfare is the main body which works on development of regulatory procedures and standards for drugs, cosmetics, diagnostics and devices.
II. It lays down regulatory **guidance by amending acts and rules**; and regulates new drug approval process.
III. Its main objective is to standardize clinical research and bring safer drugs to the Indian market.
IV. The **Drug Controller General of India (DCGI)** is responsible for giving regulatory permissions for the conduct of clinical trials and is responsible for approval of marketing licenses for drugs in India.

DIFFERENT TYPES OF STEM CELLS:

Embryonic stem cells:

- These types of cells supply new cells for an embryo as it grows and develops into a baby.
- These cells are said to be pluripotent, which means they can change into any cell in the body.

Adult stem cells

- Adult cells supply new cells as an organism grows and replace cells that get damaged.
- These cells are said to be multipotent, which means they can only change into some cells in the body, not any cell, for example, blood cells and skin (epithelial) cells can replace their kind only.

INDUCED PLURIPOTENT STEM CELLS

I. 'iPS cells', are stem cells that scientists make in the laboratory.
II. 'Induced' signifies that they are made in the lab by taking normal adult cells, like skin or blood cells, and reprogramming them to become stem cells.
III. Just like embryonic stem cells, they are pluripotent so they can develop into any cell type.

STEM CELL THERAPY:

1. Stem cell therapy, also known as **regenerative medicine,** promotes the repair response of diseased, dysfunctional, or injured tissue using stem cells or their derivatives.
2. Stem cells may be one of the ways of generating new cells that can be transplanted into the body to replace the damaged or lost cells.

Adult stem cells are currently being used to treat some conditions, for example:

1. **Blood stem cells** are used as a source of healthy blood cells for people with blood conditions, such as **thalassemia**, and **cancer patients** who have lost their blood stem cells during treatment.
2. **Skin stem cells** can be used to generate new skin for people with severe burns.
3. Some people with **Age-Related Macular Degeneration (AMD)** lose their sight because cells in the retina of the eye called retinal pigment epithelium (RPE) cells stop working. Scientists are using **induced pluripotent stem cells** to produce new RPE cells in the lab that can be put into a patient's eye to replace the damaged cells.

Stem cells could be used to generate new organs for use in transplants:

1. Damaged organs are replaced by obtaining healthy organs from a donor, however, donated organs may be 'rejected by the body as the immune system may detect it as a FOREIGN BODY.
2. Induced pluripotent stem cells generated from the patient could be used to grow new organs that would have a lower risk of being rejected.

REGULATIONS IN INDIA:

1. In March 2019, the Union Health Ministry had notified the NDCTR-2019 **'** which state that stem-cell-**derived products are to be used as "new drugs".** This means that any doctor who uses stem-cell therapy needs to take permission from the government.
2. In India as well as globally, **only blood stem cells from bone marrow to treat blood cancers and different blood disorders are permitted.** The clinical use in any other disease or use of any stem cells other than these is still in the research stage.

CHALLENGES FACED AND WAY FORWARD:

- Stem cells undoubtedly offer tremendous potential to treat many human diseases and to repair tissue damage resulting from injury or ageing.
- The danger lies in the mix of desperate patients, enthusiastic scientists, ambitious clinicians, and commercial pressures.
- Internationally agreed, and enforced, regulations are essential to protect patients from the dangers of stem cell tourism, whereby treatments that have not been approved in one country are freely available in another.

RICE FORTIFICATION

- The recent report flagged the risk of fortified rice for some that can create **adverse health issues**.
- **Prepared by:** Jointly by the **Alliance for sustainable and holistic agriculture** (Asha Kisan Swaraj) and the **Right to Food campaign, Jharkhand** where fortified Rice is being distributed under **central government-funded schemes** such as
- Public distribution systems.
- PM Poshan (erstwhile mid-day meal scheme at schools) and
- Integrated Child Development Scheme

KEY FINDINGS

1. **Distribution must stop:** Distribution of iron-fortified rice through government schemes **as a silver bullet to curb anaemia** must stop in states such as Jharkhand which have large tribal populations that suffer from **sickle cell anaemia, thalassaemia and tuberculosis**.
2. For such people, an overload of iron can create adverse health issues.
3. **No education to functionaries:** Neither field functionaries nor beneficiaries had been educated about the potential harms and there were no warning labels despite the food regulator's rules on fortified foods.
4. **No consent:** Consent is not being obtained from beneficiaries.
5. **No information/awareness:** PDS dealers and frontline workers have not been informed beforehand about the potentially harmful effects of fortified rice.
6. **Iron absorption problem:** Thalassaemia, Sickle cell anaemia and malaria or conditions where there is already excess iron in the body whereas TB patients are unable to absorb iron.

7. **Affects:** Consumption of iron-fortified foods among patients with these diseases can **reduce immunity and functionality of organs**.
8. **Health issues in Jharkhand:**

- ❖ Jharkhand is an **endemic zone** of sickle cell disorder and thalassaemia with a prevalence of 8 to 10% which is twice the national average.
- ❖ Jharkhand is also an **endemic zone for malaria**, in 2020 the state ranked third in the country in malaria deaths.

FOOD FORTIFICATION

1. According to WHO, the practice of **adding vitamins and minerals** to commonly consumed foods during processing improves their nutritional value.
2. It allows food manufacturers to **voluntarily fortify foods** available in the marketplace.
3. **Rice Fortification:** It is a process of adding micronutrients like iron, folic acid and vitamin B12, which is an effective, preventive and cost-efficient complementary strategy to address the nutrition problem within a short period.

NEW RICE FORTIFICATION SCHEME

- ➢ Fortified rice will be supplied across the Targeted Public Distribution System (TPDS) under the National Food Security Act (NFSA). The supply will also be done under Integrated Child Development Services (ICDS), *Pradhan Mantri Poshan Shakti Nirman*-PM POSHAN and other welfare schemes in a phased manner by 2024.
- ➢ The cost of rice fortification, estimated at around Rs 2,700 crore per annum, will be borne by the Union Government as part of a food subsidy.
- ➢ The programme has been divided into **three phases**: **(a) Phase 1**: Distribution under ICDS and PM POSHAN in India by March 2022. The first phase, which started in October 2021, is presently under implementation; **(b) Phase 2**: TPDS and other welfare schemes in districts with a high number of children showing stunted growth (total 291) to be brought under the scheme by March 2023; **(c) Phase 3**: The remaining districts to be brought under the scheme by March 2024.
- ➢ Any rice fortified with iron also needs to carry a note of caution advising that 'People with thalassemia may take it under medical supervision'.

BENEFITS OF FORTIFICATION

1. Eliminates **malnutrition and nutritional deficiencies**. The Copenhagen Consensus estimates that every 1 Rupee spent on fortification results in 9 Rupees in benefits to the economy.
2. Provides **extra nutrition** at affordable costs.
3. Wide-scale production of fortified foods can help **improve the overall nutritional problem** of a country, by catering to both the poor and the wealthy.
4. The inherent characteristics of the food remain the same even after fortification. This means that the **original taste, texture, and appearance are unchanged**.
5. It does not require any changes in the **food habits and patterns** of people.

CHALLENGES

1. Only a **handful of nutrients** are added in the process of fortification.
2. Fortified food products **fail to reach the poorest segments** of society (Low Purchasing Power), who are among the worst section affected by nutritional deficiencies.
3. Fortified foods could lead to a **nutritional overdose.**

4. In the long run, one will need a substantial diet, which **limits the potential** of fortified foods in lower segments of society.

GOVERNMENT STEPS

- ✓ In 2018, FSSAI notified standards of fortification for **five staple product** categories — **milk, edible oil, rice, flour and salt** ('F+' logo to be displayed on labels).
- ✓ In January 2021, the FSSAI issued a **draft regulation** for mandatory fortification of edible oil and milk with Vitamin A and D.
- ✓ **Milk Fortification Project:** By the National Dairy Development Board (NDDB) in collaboration with the World Bank.

The Cabinet Committee on Economic Affairs has approved supply of fortified rice in all States and Union Territories (UTs) by 2024 in a phased manner.

Fortified Rice will be supplied throughout the TPDS under the:

- ✓ NATIONAL FOOD SECURITY ACT
- ✓ INTEGRATED CHILD DEVELOPMENT SCHEME
- ✓ PM-POSHAN
- ✓ Other Welfare Schemes (OWS)

Phases of implementation

The following three phases are envisaged for full implementation of the initiative:

1. **Phase-I:** Covering ICDS and PM POSHAN in India all over by March, 2022 which is under implementation.
2. **Phase-II:** Phase I above plus TPDS and OWS in all Aspirational and High Burden Districts on stunting (total 291 districts) by March 2023.
3. **Phase-III:** Phase II above plus covering the remaining districts of the country by March 2024.

FORTIFICATION

The Food Safety and Standards Authority of India (FSSAI) has explicitly defined fortification.It involves deliberate increasing of the content of essential micronutrients in a food so as to improve the nutritional quality of food and to provide public health benefit with minimal risk to health.

Types of food fortification

Food fortification can also be categorized according to the stage of addition:

- ➢ Commercial and industrial fortification (wheat flour, cornmeal, cooking oils)
- ➢ Biofortification (breeding crops to increase their nutritional value, which can include both conventional selective breeding, and genetic engineering)
- ➢ Home fortification (example: vitamin D drops)

FORTIFICATION -RICE

1. Various technologies are available to add micronutrients to regular rice, such as coating, dusting, and 'extrusion'.
2. The last mentioned involves the production of fortified rice kernels (FRKs) from a mixture using an 'extruder' machine.
3. It is considered to be the best technology for India.
4. The fortified rice kernels are blended with regular rice to produce fortified rice.

TECHNOLOGY TO PRODUCE FRK

1. Dry rice flour is mixed with a premix of micronutrients, and water is added to this mixture.
2. The mixture is passed through a twin-screw extruder with heating zones, which produces kernels similar in shape and size to rice.
3. These kernels are dried, cooled, and packaged for use. FRK has a shelf life of at least 12 months.
4. As per guidelines issued by the Ministry of Consumer Affairs, Food and Public Distribution, the shape and size of the fortified rice kernel should "resemble the normal milled rice as closely as possible".
5. According to the guidelines, the length and breadth of the grain should be 5 mm and 2.2 mm respectively.

RICE HAVE TO BE FORTIFIED IN THE FIRST PLACE

1. India has very high levels of malnutrition among women and children.
2. According to the Food Ministry, every second woman in the country is anaemic and every third child is stunted.
3. Fortification of food is considered to be one of the most suitable methods to combat malnutrition.
4. Rice is one of India's staple foods, consumed by about two-thirds of the population. Per capita rice consumption in India is 6.8 kg per month.
5. Therefore, fortifying rice with micronutrients is an option to supplement the diet of the poor.

standards for fortification

1. Under the Ministry's guidelines, 10 g of FRK must be blended with 1 kg of regular rice.
2. According to FSSAI norms, 1 kg of fortified rice will contain the following: iron (28 mg-42.5 mg), folic acid (75-125 microgram), and vitamin B-12 (0.75-1.25 microgram).
3. Rice may also be fortified with zinc (10 mg-15 mg), vitamin A (500-750 microgram RE), vitamin B-1 (1 mg-1.5 mg), vitamin B-2 (1.25 mg-1.75 mg), vitamin B-3 (12.5 mg-20 mg) and vitamin B-6 (1.5 mg-2.5 mg) per kg.

fortified rice have to be cooked differently

1. The cooking of fortified rice does not require any special procedure.
2. The rice needs to be cleaned and washed in the normal way before cooking.
3. After cooking, fortified rice retains the same physical properties and micronutrient levels as it had before cooking.

INDIA'S CAPACITY FOR FORTIFICATION

1. At the time of the PM's announcement last year, nearly 2,700 rice mills had installed blending units for the production of fortified rice.
2. India's blending capacity now stands at 13.67 lakh tonnes in 14 key states, according to figures provided by the Ministry.
3. FRK production had increased rapidly from 7,250 tonnes to 60,000 tonnes within 2 years.

BENEFICIARY DISTINGUISH BETWEEN FORTIFIED RICE AND REGULAR RICE

Fortified rice will be packed in jute bags with the logo ('+F') and the line "Fortified with Iron, Folic Acid, and Vitamin B12".

ADVANTAGES OFFERED

1. **Health:** Fortified staple foods will contain natural or near-natural levels of micro-nutrients, which may not necessarily be the case with supplements.
2. **Taste:** It provides nutrition without any change in the characteristics of food or the course of our meals.
3. **Nutrition:** If consumed on a regular and frequent basis, fortified foods will maintain body stores of nutrients more efficiently and more effectively than will intermittently supplement.
4. **Economy:** The overall costs of fortification are extremely low; the price increase is approximately 1 to 2 percent of the total food value.
5. **Society:** It upholds everyone's right to have access to safe and nutritious food, consistent with the right to adequate food and the fundamental right of everyone to be free from hunger

ISSUES WITH FORTIFIED FOOD

1. **Against nature:** Fortification and enrichment upset nature's packaging. Our body does not absorb individual nutrients added to processed foods as efficiently compared to nutrients naturally occurring.
2. **Bioavailability:** Supplements added to foods are less bioavailable. Bioavailability refers to the proportion of a nutrient your body is able to absorb and use.
3. **Immunity issues:** They lack immune-boosting substances.
4. **Over-nutrition:** Fortified foods and supplements can pose specific risks for people who are taking prescription medications, including decreased absorption of other micro-nutrients, treatment failure, and increased mortality risk.

WAY AHEAD

- **Right to Informed food choice:** The right to inform choices about one's food is a basic right there right to know what one is consuming is also a basic right.
- Universal certification along with proper monitoring is the answer for nutrition deficiencies.
- There is a need for precision because nutrients taken in excess can adversely affect people.

CHIMERIC ANTIGEN RECEPTOR (CAR)-T CELL T THERAPY

- Recently, the researchers have said that **India's first indigenously developed Chimeric Antigen Receptor (CAR)-T Cell T therapy** for specific types of cancer patients has **shown promising results** and could be the **safest therapy** in this category so far.

CAR-T CELL THERAPY

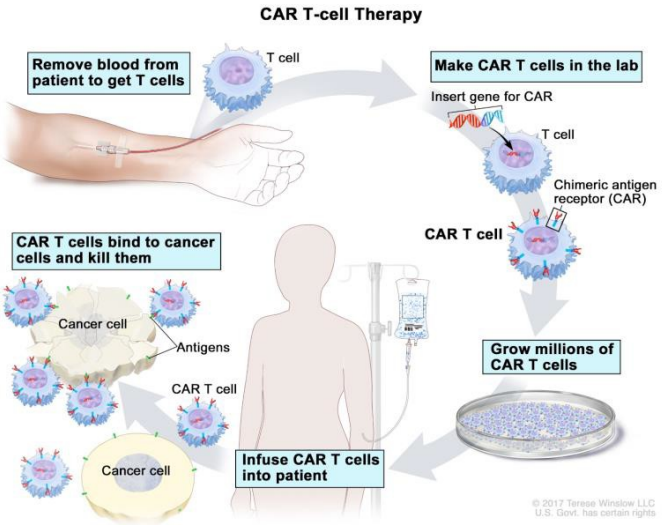
1. **CAR-T cells** are a patient's own immune cells that are **genetically engineered** in the laboratory to **fight cancer.**
2. CAR-T cell is a **prospective therapy** that has ushered in a **new era of curing refractory and stubborn cancers.**
3. **CAR T cell therapy is used as third or second-line treatment** for patients of specific types of cancers of blood and lymph nodes. In India, those willing to undergo this treatment have to travel to other countries, mostly the US.
4. **T-cell receptor is widely used in developed nations** for immunotherapy during cancer treatment.
5. However, the technology was not available in India yet.

WORK

1. The therapy targets leukaemia and lymphoma.
2. Leukaemia is cancer of blood-forming tissues, including bone marrow.
3. Lymphoma is a cancer of the lymphatic system, which is part of the body's germ-fighting network.

It uses lentiviral technology.

- In gene therapy, this is a method of **inserting, modifying, or deleting genes** in organisms using lentivirus, a family of viruses responsible for diseases such as AIDS (acquired immunodeficiency syndrome).
- As part of the treatment, a specific type of **white blood cells called T cells are changed in the lab** so they can find and destroy cancer cells.
- It is also sometimes referred to as a **type of cell-based gene therapy** because it **involves altering genes inside T cells** to help them attack cancerous cells.



<u>TYPES OF CANCER CAN IT BE USED</u>

1. The therapy is mostly effective in **blood cancer and lymphoma** (cancer beginning in the cells of the lymph system).
2. In India, about 40,000-50,000 patients of these cancers are diagnosed every year.
3. Anti-cancer CAR-T therapy reengineers T cells to kill tumors — and researchers are expanding the limited types of cancer it can target.

<u>CAR-T therapy:</u>

1. It is made up of two parts – CAR and T.
2. T refers to cytotoxic **T cells** are a particular kind of white blood cells (WBC)
3. CAR-T cell therapy starts with doctors isolating a patient's T cells from a sample of their blood.
4. These T cells are genetically engineered in lab to produce a **chimeric antigen receptor, or CAR**.
5. CARs are **synthetic** receptors specifically designed to **redirect T cells** from their usual targets have them recognize and hone in **on tumor cells**.
6. On the **outside of a CAR is a binder** that allows the T cell to stick to tumor cells.
7. Binding to a tumor cell activates the engineered **T cell to kill** and produce **inflammatory cytokines** proteins that support T cell growth and function and boost their cancer-killing abilities.

8. These CAR-T cells are then stimulated to divide into large numbers over seven to 10 days, then given back to the patient via infusion.
9. The **infusion process** usually takes place at a hospital where clinicians can monitor for signs of an **overactive immune response** against tumors, which can be **deadly** for the patient.

SOLID TUMORS:

1. While CAR-T cell therapy has seen **success in blood cancers**, it has faced **hurdles** when fighting what are called **solid tumor cancers** like pancreatic cancer and melanoma.
2. Unlike cancers that begin in the blood, these types of cancers grow into a solid mass that produces a microenvironment of molecules, cells and structures that **prevent T cells from entering into the tumor and triggering an immune response.**
3. Here, even CAR-T cells engineered to specifically target a patient's unique tumor are unable to access it, suppressing their ability to kill tumor cells.
4. So, a new synthetic receptor that complements the first CAR design is developed.
5. This receptor, called **synthetic Notch receptor, or synNotch,** is based on the natural form of Notch in the body, which plays an important role in **organ development** across many species.

SYNNOTCH VS CAR:

1. Like CARs, the outside of **synNotch has a binder** that allows T cells to stick to tumor cells.
2. Unlike CARs, the inside of **synNotch has a protein** that is released when a T cell binds to the tumor – This protein, or transcription factor, allows researchers to **better control** the T cell by inducing it to produce a specific protein.
3. While, CAR binds to both tumor and healthy cells and induce T cells to kill both; synNotc ensure that **engineered T cells are only activated when bound to a tumor cell** and **not healthy cells**.
4. Because T cells now require both CAR and synNotch receptors to recognize tumors, this increases the precision of T cell killing.

Uniqueness of synNotch:

1. Use synNotch to improve CAR-T cell activity against solid tumors by inducing them to **produce more inflammatory cytokines**, **such as IL-2**, that enable them to kill tumor cells.
2. These cytokines are highly toxic, there is a limit to how much IL-2 a patient can safely tolerate, limiting their use as a drug.
3. Using synNotch, when a CAR-T cell encounters a tumor, it **produces IL-2 within the tumor** instead of outside it, **avoiding causing harm** to healthy cells.
4. **SynNotch modified CAR-T cells were able to trigger IL-2 production without causing toxicity to healthy cells in the rest of the body.**
5. Because synNotch is able to bypass the barriers tumors put up, it is able to help T cells amp up and maintain the amount of IL-2 they can make, allowing the T cells to keep functioning even in a hostile microenvironment.
6. It is being used to treat **lymphoma and multiple myeloma**, and has shown remarkable response rates where other treatments have failed.

SIGNIFICANCE

<u>HCAR19 therapy</u>

- The participants received autologous HCAR19 therapy (humanised CAR 19 therapy developed by IIT Bombay and it was observed that there were **no dose-limiting**

toxicities and **only low grade Cytokine Release Syndrome (CRS)** was seen in 40 percent of participants.

No neurotoxicity syndrome

- None of the participants had immune effector cell-associated neurotoxicity syndrome.

Safer version

- Overall, the novel humanised HCAR19 tested in phase one clinical trials for adult lymphoma was found to be safe and has shown promising early signs of activity.

No deaths

- Post-CAR-T cell therapy none of the participants required ICU admission and there were no CAR-T treatment related deaths.

THERAPY IN INDIA/ WAY FORWARD

Two start-ups

- ImmunoACT along with Immuneel Therapeutics are two startups currently working to make CAR T cell therapy available in India.

Low cost therapy

- Both of these companies have said the therapy would be available in the country at a fraction of cost charged for the treatment in the developed countries like the US where it can cost about Rs 2-3 crore.

INFORMATION & COMMUNICATION TECHNOLOGY

QUANTUM COMPUTING

1. Quantum computing is the use of quantum-mechanical phenomena such as superposition and entanglement to perform computation. A quantum computer is used to perform such computation, which can be implemented theoretically or physically. The field of quantum computing is actually a sub-field of quantum information science, which includes quantum cryptography and quantum communication.
2. Quantum computing was started in the early 1980s when physicist Paul Benioff proposed the first quantum mechanical model of the turing machine. Richard Feynman and Yuri Manin then expressed the idea that a quantum computer had the potential to simulate things that a classical computer could not. In 1994, Peter Shor published an algorithm that is able to efficiently solve some problems that are used in asymmetric cryptography that are considered hard for classical computers.
3. There are currently two main approaches to physically implementing a quantum computer: analog and digital. Analog approaches are further divided into quantum simulation, quantum annealing, and adiabatic quantum computation. Digital quantum computers use quantum logic gates to do computation. Both approaches use quantum bits or qubits.
4. The phrase “quantum supremacy” was coined in 2011 by John Preskill, Professor of Theoretical Physics at the California Institute of Technology in a talk he delivered on the benefits of using quantum hardware over traditional computers.

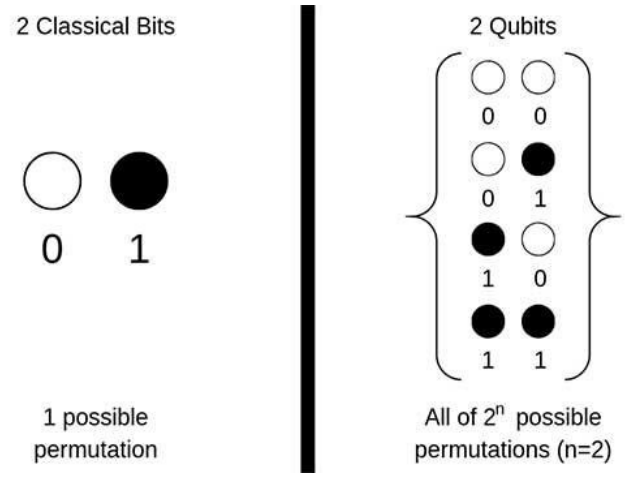
5. Quantum supremacy refers to a quantum computer solving a problem that cannot be expected of a classical computer in a normal lifetime. This relates to the speed at which a quantum ocmputer preforms.

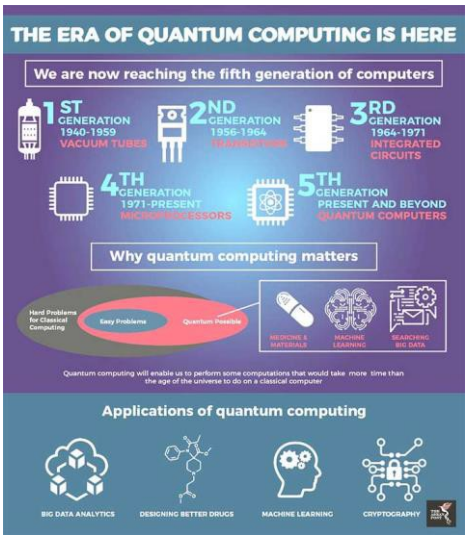
Google's Quantum Breakthrough

1. Last Month, an historic claim from Google was accidentally (and briefly) posted online: its Artificial Intelligence (AI) Quantum research group had achieved "quantum supremacy," an important step towards ultra-powerful computers that can solve problems deemed impossible for current machines by using quantum physics.
2. The big reveal was somewhat thwarted by contributing researchers at NASA, who accidentally made a draft paper available. Not prone to understating its successes, Google made its bold assertion in the title of its research paper: "Quantum supremacy using a programmable superconducting processor."
3. Though the paper was quickly taken down, copies of it were archived and are floating around the web.
4. Before the inadvertent announcement about supremacy, Google was already leading the pack in terms of the sheer size of its quantum computer.
5. Last year it revealed a new 73-qubit computer, putting it ahead of closest rival IBM, which happened to announce its own development of a 53-qubit computer on September 18. For its supremacy demonstration, however, Google used a different, smaller computer, named Sycamore.
6. As described in the leaked paper, Google used a 53-qubit processor (originally 54 qubits, but one qubit let the team down) to perform a sampling task. Now it appears that Google has reached this particular milestone ahead of its competitors.
7. The draft paper details how Google researchers used a quantum processor called Sycamore containing 53 functioning qubits to solve a random sampling problem that would have taken the world's best supercomputers 10,000 years to work out. It took Sycamore just three minute and 20 seconds. Google, which partnered with NASA for this project, did not respond to requests for comment.
8. For Ares, the Google news is exciting, but it's important not to expect useful quantum computers any time soon. The largest quantum computer to date is Google's 72-qubit processor called Bristlecone, and that hasn't even demonstrated quantum supremacy. We're a really long way off the millions of qubits we'll need to crack difficult quantum problems.

'QUANTUM SUPREMACY'

- ✓ Quantum supremacy is the point at which quantum computers can solve problems that are practically unsolvable for "classical" (nonquantum) computers to complete in any reasonable timeframe. In principle, even the simplest universal computer can solve anything that is computable given infinite time to do so. So, "supremacy" s i a attmer of hwo quickly and reliably a computer can solve a problem. The purpose is to built a quantum device that can do at least one thing which is outside the reach of classical machines.
- ✓ It is generally believed that at least 49 qubits are required to cross the quantum supremacy line. Qubits behave very differently to bits in classical computers. Bits represent either a "1" or a "0," and computers read and perform operations on one bit at a time. In contrast, qubits can represent a combination state made up of both "1" and "0," due to the peculiar quantum effects in which properties like particle position, direction, and momentum are not well-defined. This allows for a system to be in multiple states at the same time, called quantum indeterminacy.





QUANTUM THEORY

- Quantum theory's development began in 1900 with a presentation by Max Planck to the German Physical Society, in which he introduced the idea that energy exists in individual units (which he called "quanta"), as does matter. Further developments by a number of scientists over the following thirty years led to the modern understanding of quantum theory.
- The Essential Elements of Quantum Theory:

1. Energy, like matter, consists of discrete units, rather than solely as a continuous wave.
2. Elementary particles of both energy and matter, depending on the conditions, may behave like either particles or waves.
3. The movement of elementary particles is inherently random, and, thus, unpredictable.
4. The simultaneous measurement of two complementary values, such as the position and momentum of an elementary particle, is inescapably flawed; the more precisely one value is measured, the more flawed will be the measurement of the other value.

<u>Quantum Experiments Using Satellite Technology (QuEST) Project:</u>

- QuEST launched in 2017, is being implemented by Raman Research Institute or RRI in collaboration with ISRO.It is carried out by Raman Research Institute's quantum information and computing or QuIC lab, is India's first ever project on satellite based long distance quantum communications.
- The results of the project were seen in february 2021 when a team of researchers led by Professor Urbasi Sinha demonstrated a communication between two structures 50 metres apart. The use of quantum key technology was done in this experiment.
- ISRO has demonstrated the same thing now. It demonstrated free space quantum communication over 300 metres.
- On 19th March, ISRO demonstrated the technology enabling secure communication between buildings located in SAC campus in Ahmedabad.
- These buildings were 300 metres apart. The testing was carried out at night to avoid interference due to direct sunlight.
- As per ISRO a number of key technologies were developed indigenously to accomplish the success of this experiment. It included-

1. Indigenously developed NAVIC receiver for time synchronization between the transmitter and receiver modules
2. Gimbal mechanism systems instead of bulky large-aperture telescopes for optical alignment

3. As per the statement released by ISRO, “this is a major milestone achievement for unconditionally secured satellite data communication using quantum technologies.”

QUANTUM COMPUTING

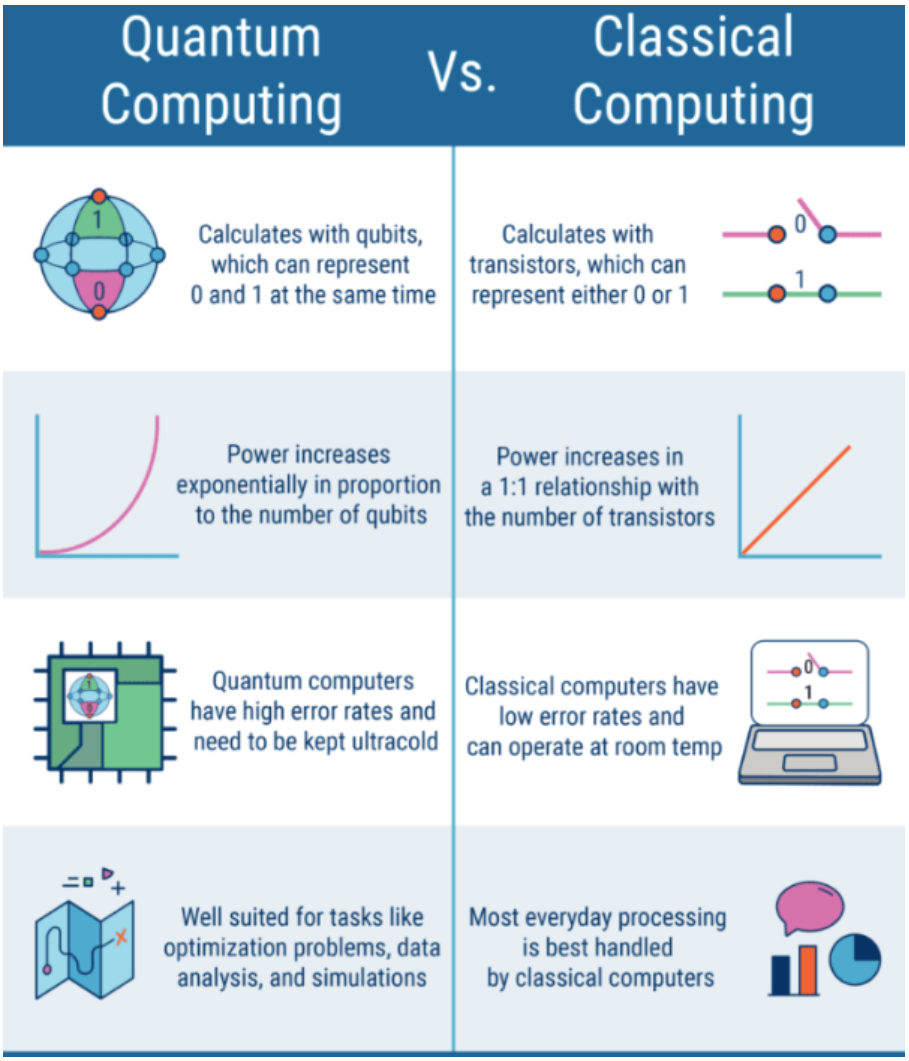
1. It is a type of computation that harnesses the collective properties of quantum states, such as superposition, interference, and entanglement, to perform calculations. It harnesses the phenomena of quantum mechanics to deliver a huge leap forward in computation to solve complex problems.
2. Quantum mechanics is a science that describes the unique behavior of matter and energy at the atomic and subatomic level.

Quantum Computing works on:

A. ‘**Superposition**‘ meaning they can exist in multiple states (both 0,1 at the same time) at the same time. It is unlike classical computers where information is processed in ‘bits’ or 1s and 0s, following classical physics.
B. ‘**Entanglement**‘ where two or more particles are inextricably linked and mirror each other exactly, even when separated by great physical distance.

QUANTUM COMPUTERS BETTER THAN CONVENTIONAL SUPERCOMPUTERS

A. Conventional computers (in common use like homes/offices) and Supercomputers process information with **bits** (ones and zeroes). Quantum computers, on the other hand, use quantum bits or **qubits** that can process the ones and zeroes simultaneously due to a property known as superposition. This allows them to process a lot more information than conventional computers
B. Conventional Supercomputers combine processing power of thousands of computers. However, supercomputers aren’t very good at solving certain types of problems e.g., Supercomputers don’t have the working memory to hold the myriad combinations of real world problems. Supercomputers have to analyze each combination one after another, which can take a long time.
C. On the other hand, the computing power of quantum computers increases exponentially (by a factor of 2) with increase in qubits e.g., In October 2019, Google said it had performed a calculation on a quantum processor in 300 seconds that would have been **practically impossible** to achieve with the algorithms available at the time.



CLASSICAL COMPUTERS VS QUANTUM COMPUTER

1. It just means the moment that a quantum computer completes a task that conventional computers find impossible. Classical computers transmit bits of information as electrical pulses encoded numerically as a 0 or a 1. In quantum computers, individual atoms, electrons, or particles of light carry information in quantum bits, or qubits. Following principles of quantum mechanics, these particles can exist in 0, 1, or various probabilities of being either 0 or 1, called superposition. With qubits in superposition and communicating with each other through a property called entanglement, quantum computers can solve a problem by examining multiple solutions simultaneously. The result is extra computing power and speed.
2. But keeping the "quantumness" in qubits is a big challenge. Multiple qubits need to interact with each other to solve problems in a quantum computer, but any interaction with other particles causes them to lose their quantum states. Once a qubit settles into either a 0 or 1, it acts just like a bit in a classical computer. As the result of research over the past decade, scientists can now build qubits that remain connected 10,000 times longer than before. But still less than 10 qubits can be uflly quantumly ocnnected.

COMPUTERS FINALLY GOING QUANTUM

1. In 2018, tech giant 'Microsoft' hired a handful of quantum physicists, including one from the Kavli Institute of Nanoscience in the Netherlands, to help build a prototype quantum computer – a machine that would harness the bizarre behavior of matter at extremely small scales to solve some of the hardest problems in science. Other companies are also working to commercialize quantum computers. IBM is planing to have a commercially available quantum processor in the cloud within a few years. Intel, Google and smaller start-ups also developing similarly powerful devices are beginning to transform their quantumcomputing palns ni to erality.
2. If one of these teams of physicists and engineers wins the race to build the world's first quantum computer, it would outcompute classical computers by a long shot and help tackle currently unsolvable problems in fields ranging from finance to cybersecurity, and from drug development to quantum physics itself.
3. But there are still major technical challenges to overcome, including how to scale up current designs to link hundreds or thousands of quantum bits (qubits), the basic information carriers in a quantum computer, and how to control qubits' strange behavior.

APPLICATIONS

1. Despite hitting the milestone, it's likely that quantum computers capable of tackling practical tasks are still years away. However, once developed, the computers are expected to have huge implications for areas as diverse as cryptography, chemistry, AI and machine learning. Google expects the power of quantum computers to expand at a "double exponential rate," whereas traditional computers have long been pegged to Moore's Law, which saw power double every 18 months or so.
2. Quantum physics had already transformed society. It has led to the laser and transistor and all of our modern technologies today. We are now on the brink of the second quantum revolution as we begin to harness all of the power of the quantum world. Quantum information processing will not only transform communication and security, but will impact healthcare, climate modeling, scientific research and machine learning.
3. Overall, from managing money to massive datasets, quantum computing's applications are seemingly endless. Advances in machine learning and optimization could boost efficiency dramatically. Biomedical and chemical simulations could help us land more drug discoveries and uncover new medical treatments in record time. Advanced computing power could lead to more than just innovation; it also could lead to lessened risk. Indeed, enhanced financial services could fundamentally change how we invest.

WAY FORWARD

- Besting conventional computers at solving a real-world problem—a feat that some researchers refer to as "quantum advantage." The hope is that quantum computers' immense processing power will help uncover new pharmaceuticals and materials, enhance artificial-intelligence applications, and lead to advances in other fields such as financial services, where they could be applied to things like risk management.
- It could take quite a few years for quantum computers to achieve their full potential. Universities and businesses working on them are facing a shortage of skilled researchers in the field—and a lack of suppliers of some key components. But if these exotic new computing machines live up to their promise, they could transform entire industries and turbocharge global innovation.

QUANTUM KEY DISTRIBUTION (QKD)

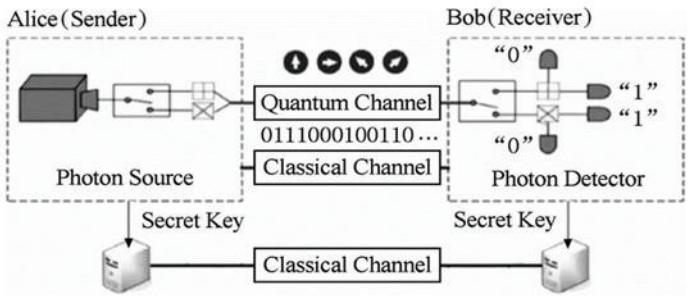
Recently, a joint team of experts from the Defence Research and Development Organisation (DRDO) and Indian Institute of Technology (IIT) Delhi demonstrated the Quantum Key Distribution (QKD) link.

1. It was done for a distance of over 100 kilometres between Prayagraj and Vindhyachal in Uttar Pradesh..
2. The technological breakthrough of demonstrating a QKD Link was achieved over the commercial-grade optical fibre already available in the field.

❖ With this success, the country has demonstrated indigenous technology of secure key transfer for bootstrapping military-grade communication security key hierarchy.

INTERNATIONAL STANDARDS:

The demonstration performance parameters were closely monitored and were found to be repetitively within the reported international standards.



QUANTUM KEY DISTRIBUTION (QKD)

❖ QKD is primarily a mechanism to undertake secure communication, which utilises a **cryptographic protocol** involving various components of quantum mechanics.

PROCESS:

❖ The technology enables two communicating sides to come up with random secret keys shared by both of them and known exclusively to them, so only they can use it to encrypt and decrypt messages, thus achieving a very highly-secure communication.

KEY SHARING:

1. The distribution of encryption keys is the crucial factor for this. Sharing of keys over the air or wired links requires encryption, which in turn requires encryption keys to be pre-shared.
2. Quantum-based communication offers a robust solution to sharing the keys securely.

Use:

❖ Secure communications are vital not just for the defence and strategic agencies across the globe but also for various civilian applications.

Indian agencies:

❖ DRDO has undertaken multiple projects for the development of this technology.

SIGNIFICANCE

1. This technology will enable security agencies to plan a suitable quantum communication network with indigenous technology backbone.
2. Highly secured military grade communications could occur now.

OTHER ACHIEVEMENTS BY DRDO

Shorter distance feat:

- A similar demonstration was held over a shorter distance in December 2020, when the technology was tested for communication between two DRDO facilities in Hyderabad—the Defence Research and Development Laboratory (DRDL) and Research Centre Imarat (RCI)—over a distance of 12 km.

Quantum Random Number Generation (QRNG):

1. DRDO Young Scientist Laboratory for Quantum Technologies (DYSL-QT), a DRDO facility based in Mumbai, developed a Quantum Random Number Generation (QRNG).
2. It has the ability to detect random quantum events and convert those into a stream of binary digits.
3. The QRNG system developed by DYSL-QT passed the global randomness testing standards of NIST and Die-harder Statistical Test Suites at the speed of around 150 kbps after post-processing.
4. The generated random numbers were also evaluated and verified using DRDO's indigenously developed Randomness Testing Statistical Test Suite of Scientific Analysis Group.

With this development, India has entered the club of countries that have the technology to achieve the generation of random numbers based on the Quantum Phenomenon.

GLOBAL AND DOMESTIC FOOTING

GLOBAL:	**INDIA:**
➢ Most of the large economies and defence powers across the world are in the process of formulating dedicated plans for the development of quantum technologies. ➢ These countries include the US, Canada, several European countries, China, Japan and South Korea. International symposium on Quantum Information Technology: ➢ It was held in Pune in 2019 and saw participation of key defence, civilian and academic and strategic entities of the country.	❖ India has seen significant policy decisions and budget allocation for the sector. ❖ **China's angle:** ❖ Developments in India need to be seen especially in the context of several claims made by China. China has said that it has achieved multiple breakthroughs in the quantum technology domain that included: ❖ The world's first quantum satellite, ❖ The world's first optical quantum computing machine prototype and ❖ A 2000 km long quantum communication link between Beijing and Shanghai. ❖ China's 13th and 14th five-year plans give high priority to quantum technology. ❖ In the context of China's progress—or claims thereof—in quantum technology, India's efforts, though significant, are scattered in nature.

CHALLENGES

China's growth:

1. China is leading the race. It established the first Quantum Satellite Network and distributed entangled photons between three terrestrial base stations separated by 1200 km.
2. Quantum is at the heart of China's 13th five-year plan.
3. Chinese dominated in Quantum Computing patents in the last four years.
4. Global investments in quantum computing are also growing in their favour.

Funding in India:

1. India has a mix of private and government sector investments.
2. And neither is sufficient for the growth required to beat China.

Absence of Roadmap:

- There is an absence of a quantum roadmap.
- There is no visibility in quantum efforts and successes.

Lacking Skill Set:

- There is a lack of required skill power.

APPLICATIONS OF QUANTUM COMPUTING

1. **Artificial Intelligence (AI) and Machine Learning (ML)**: Quantum computers' abilities to parse through massive data sets, simulate complex models, and quickly solve optimization problems have drawn attention for applications within artificial intelligence. Quantum computing has the potential to enhance the pace of AI/ML.
2. **Computational Chemistry**: There are many problems in finding the right catalyst or process to develop a new material, or an existing material more efficiently. A quantum computer can be used to simulate the quantum mechanical processes that occur. Potential applications include: **(a)** Finding new materials that can achieve a room temperature superconductor; **(b)** Finding a catalyst that can improve the efficiency of carbon sequestration; **(c)** Developing a new battery chemistry that can significantly improve the performance over today's lithium-ion batteries.
3. These applications can have uses in agriculture, manufacturing and industrial design sectors.
4. **Financial Portfolio Optimisation**: Finding the optimum mix for a basketful of investments based upon projected returns, risk assessments, and other factors is a daily task within the finance industry. By utilizing quantum technology to perform these calculations, improvements can be achieved in both the quality of the solutions as well as the time to develop them.
5. **Logistics and Scheduling**: Many common optimisations used in industry can be classified under logistics and scheduling. Quantum computing can make logistics more efficient. For example: **(a)** Airlines can figure out how to stage their airplanes for the best service at the lowest cost; **(b)** Factory managers can minimize cost, time and maximize output.
6. **Cyber Security:** Cyber security is becoming a larger issue every day as threats around the world are increasing their capabilities and we become more vulnerable as we increase our dependence upon the digital system. Various techniques to combat cyber security threats can be developed using some of the quantum machine learning approaches to recognize the threats earlier and mitigate the damage that they may do.

INDIA FOCUS ON QUANTUM COMPUTING

1. **Industrial revolution 4.0:** Quantum computing is an integral part of Industrial revolution 4.0. Success in it will help in Strategic initiatives aimed at leveraging other Industrial revolution

4.0 technologies like the Internet-of-Things, Machine Learning, robotics, and artificial intelligence across sectors and lay the foundation of the Knowledge economy.

2. **Growing Demand**: According to the The Quantum Revolution in India, The quantum ecosystem in India is growing at an accelerated pace with support from government agencies and participation from the academia, service providers, and the start-up community.
3. **Economic Benefits**: The adoption of quantum technologies across industries could potentially add US$ 280–310 billion value to the Indian economy by 2030. Manufacturing, high-tech, banking, and defence sectors will remain at the forefront of quantum-led innovation, according to the Nasscom-Avasant report.

STEPS HAVE BEEN TAKEN TO PROMOTE QUANTUM COMPUTING IN INDIA

- **The National Mission on Quantum Technologies and Applications (NM-QTA)**: It is a government of India programme that aims to create a workforce of over 25,000 in India over the next 5-7 years. It has a total budget outlay of ₹8,000 crore for a period of five years.
- The next generation transformative technologies that will receive a push under this mission include quantum computers and computing, quantum communication, quantum key distribution, encryption, quantum devices, quantum sensing and so on.
- The areas of focus for the Mission will be in fundamental science, translation, technology development, human and infrastructural resource generation, innovation and start-ups to address issues concerning national priorities.
- **QuEST**: The Department of Science and Technology launched the Quantum-Enabled Science and Technology (QuEST) initiative to invest INR 80 crores to lay out infrastructure and to facilitate research in the field.
- **'Quantum Computer Simulator (QSim) Toolkit'**: It provides the first quantum development environment to academicians, industry professionals, students, and the scientific community in India.

Other Efforts: Scientists from two Ahmedabad-based laboratories of the Department of Space jointly demonstrated quantum entanglement with real-time QKD between two buildings separated by a distance of 300 metres.

ASSOCIATED CHALLENGES

- **First**, quantum computers are highly prone to interference that leads to errors in quantum algorithms running on it. Thus it can give erroneous results. Scientists are working to improve accuracy e.g., Google has announced plans to have fault-tolerant quantum-computing hardware by 2030
- **Second**, most quantum computers cannot function without being super-cooled to a little above absolute zero since heat generates error or noise in qubits. Expanding quantum computing will increase ecological footprint.
- **Third**, finding the right talent is another big hurdle as there is an acute shortage of candidates with doctorates in quantum physics, engineering, and statistics.
- **Fourth**, a comprehensive multi-stakeholder network is amiss. It is not clear whether India will focus on near-term quantum applications or long-term applications or both. Translating research into real-world applications should be at the core of India's quantum efforts.
- **Fifth**, metrics to assess the outcomes of India's quantum efforts are not clearly defined. Merely achieving quantum supremacy will not necessarily safeguard India's national interests.
- **Sixth**, India lacks the capability to domestically manufacture most of the components/hardware used in quantum computing. It is another strategic sector where India is import-dependent.

APPROACH -

1. **First**, India should cooperate with the private sector and friendly nations who are working to address the critical bottlenecks of quantum computing e.g., Tech Mahindra's research and development arm, Makers Lab, announced it has set up a quantum centre of excellence called QNxT in Finland to leverage the country's expertise in quantum computing.
2. **Second**, the Indian government had announced NM-QTA in 2020 but it is yet to get Cabinet clearance. This should be quickly approved and implemented.
3. **Third**, the Government should also make sure that educational programs surrounding quantum computing and technology are provided with adequate support and completed on time e.g., the Defence Institute of Advanced Technology (DIAT) in Pune, launched an MTech in quantum computing in 2020. IBM has partnered with top-tier academic institutions in India to provide access to IBM quantum systems, while Microsoft Garage India has joined hands with IIT Roorkee to conduct lectures on quantum computing for an entire semester.
4. **Fourth**, the funding support towards the technology also needs to be augmented. According to McKinsey, China and the European Union have taken a lead in public funding for quantum computing with investments worth US$ 15 billion and US$ 7.2 billion, respectively. The US, the UK and India follow but with much lesser spending.

Way Ahead

- India's **Union Budget of 2020-21** saw the allocation of Rs 8,000 crore towards the National Mission on Quantum Technologies and Applications.
- While India has come a long way in quantum technology since 2019, more can be done to bring all the efforts together.

DEEPFAKE TECHNOLOGY

- The **Cyberspace Administration of China**, the country's cyberspace watchdog, is rolling out new regulations to restrict the use of **deep synthesis technology** and curb disinformation.
- The policy requires deep synthesis service providers and users to ensure that any doctored content using the technology is explicitly labelled and can be traced back to its source.

DEEP SYNTHESIS

Deep synthesis is defined as the use of technologies, including deep learning and augmented reality, to generate text, images, audio and video to create virtual scenes.

1. One of the most notorious applications of the technology is **deepfakes,** where synthetic media is used to **swap the face or voice** of one person for another.
2. **Deepfakes** are getting harder to detect with the advancement of technology.

Deepfake Technology

- DT is a method for manipulating **videos, images, audios** utilizing powerful computers and deep learning.
- It is used to generate **fake news** and **commit financial fraud** among other wrong doings.

It overlays a digital composite over an already-existing video, picture, or audio; CYBERCRIMINALS use AI TECHNOLOGY

Origin of the Word:

- The term **deepfake** originated in **2017**, when an anonymous Reddit user called himself **"Deepfakes."**
- This user manipulated **Google's open-source, deep-learning technology to** create and post **pornographic videos.**

Misuse:

1. **Deepfake technology** is now being used for **nefarious purposes** like scams and hoaxes, celebrity pornography, **election manipulation**, social engineering, **automated disinformation attacks,** identity theft and financial fraud etc.
2. Deepfake technology has been used to impersonate notable personalities like former U.S. Presidents Barack Obama and Donald Trump, India's Prime Minister Narendra Modi, etc.

COUNTRIES DOING TO COMBAT DEEPFAKES

EUROPEAN UNION:

1. The **European Union** has an updated **Code of Practice** to stop the spread of disinformation through deepfakes.
2. The **revised Code** requires tech companies including **Google, Meta,** and **Twitter** to take **measures** in **countering deepfakes** and **fake accounts** on their platforms.
3. They have **six months** to implement their measures once they have signed up to the Code.
4. If found **non-compliant**, these companies can face fines as much as **6%** of their annual global turnover, according to the updated Code.
5. Introduced in **2018**, the **Code of Practice** on Disinformation brought together for the first-time worldwide industry players to commit to counter disinformation.

United States:

A. The **U.S.** introduced the **bipartisan Deepfake Task Force Act** to assist the Department of Homeland Security (DHS) to **counter deepfake technology.**

B. The measure directs the **DHS** to conduct an annual study of **deepfakes** assess the technology used, track its uses by foreign and **domestic entities**, and come up with available countermeasures to tackle the same.

C. **California and Texas** have passed laws that criminalize the publishing and distributing of deepfake videos that intend to influence the outcome of an election. The law in Virginia imposes criminal penalties on the distribution of nonconsensual deepfake pornography.

INDIA:

- In India, however, there are no legal rules against using deepfake technology.
- However, specific laws can be addressed for misusing the tech, which include Copyright Violation, Defamation and cyber felonies.

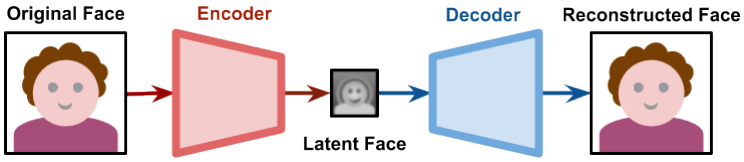
DEEPFAKES

- Digital media such as video, audio, and photographs that have been artificially intelligently edited and manipulated are known as deep fakes.
- In essence, it is a hyper-realistic computer fabrication. **Deepfakes** are made to hurt people and organizations. A perfect storm has formed to democratize the production and manipulation of media thanks to the availability of commodity cloud computing, open-source.

- AI algorithms, copious data, and enormous media. Deepfakes are the name for this fake media content. The ease with which false information, celebrity pornography, etc. are distributed online has attracted attention.
- It creates a fake version of authentic or original audio-visual content by overlaying fresh audio or visuals on top of an already-existing media file.
- The number of deep fake movies online has nearly tripled in just nine months when the AI Company Deep trace found 15,000 of them in September 2019. Surprisingly, 96% of them were pornographic, and 99% of them resembled renowned women's faces more than porn stars.

ITS WORKING PROCESS

- The generator and discriminator, two AI algorithms that compete with one another, are used to produce deep false content.
- The discriminator's job is to determine if the bogus multimedia content generated by the generator is fabricated or real.
- Together, the generator and discriminator form a generative adversarial network (GAN). Every time the discriminator correctly identifies the false material, it provides the generator with crucial information about how to improve the following deep fakes.
- Establishing a GAN begins with determining the intended output and producing a training dataset for the generator.
- When the generator's output starts to reach an acceptable level, video clips can be fed into the discriminator.



DEEPFAKES

MAJOR VICTIM:

A. Deepfake's first instance of malevolent use was discovered in porn. Sensity.ai reports that over 135 million people have viewed sexual movies, accounting for 96% of deep fakes. Deepfake pornography only appeals to females. Threatening, intimidating, and psychologically damaging pornographic deepfakes are all possible. It turns women into sexual objects, which causes mental distress, and can also have indirect effects like job loss and financial loss.
B. Deepfake can make someone appear to engage in deviant conduct and say deplorable things that they never would have. Even if the victim was able to disprove the hoax using an alibi or another method, the damage may have been done by that point.
C. A malevolent nation-state might use Deepfake as a potent instrument to compromise public safety, sow doubt and turmoil in the target nation, and further its own agenda. Trust in institutions and diplomacy can be damaged by deep fakes.
D. Non-state actors, such as insurgent groups and terrorist organizations, might utilize deep fakes to portray their enemies as making inflammatory comments or acting provocatively in order to incite anti-state feelings among the populace.
E. Another issue with **deepfakes** is the liar's dividend, in which an unfavorable reality is discounted as fake news or deepfake. Deepfakes themselves provide more weight to denials than they otherwise would.
F. Deep fakes, fake news, and alternative facts can all be used as weapons by leaders to attack legitimate media and the truth.

Concerns of deep fake:

A. The financial system as a whole is affected by Deepfake's financial fraud.
B. In the age of fake news, the security of cyber networks and the reliability of online information are also in jeopardy.
C. People would find it harder to recognize a hoax if phishing attempts included deep fakes.
D. Deep fakes can be used in any country to undermine democratic processes like elections.
E. Since it may be used to create fake pornographic videos and make politicians appear to say things they did not, there is a significant potential for harm to individuals, groups, and societies.
F. Because deep fakes are so common, the public is so skeptical that any legitimate evidence of a crime can be easily dismissed as false.
G. As new technology makes it possible for unskilled individuals to produce sophisticated fakes using only a few photographs, fake movies are likely to grow in popularity outside of the world of superstars. This will encourage the development of revenge porn.
H. In cybercrime, the use of false identities and imposter fraud is on the rise.
I. Issues with authenticity and credibility: It is harder to tell whether videos are authentic or not when there are profound fakes present.

Advantages of Deepfake:

A. GANs can be used to generate fictional medical images, which can be used to train illness detection algorithms for rare diseases and to assuage patient privacy concerns.
B. The drive for accessibility to increase equity can be sped up with Deepfake.
C. The discriminator gets better at identifying fake video clips as the generator gets better at creating them. As the discriminator gets better at spotting fake videos, the generator, on the other hand, gets better at creating them.
D. Artificial general intelligence (AGI), which is currently under research, will enable artificial intelligence to reason more effectively in the future.
E. Exhibits in galleries and museums can be animated by deepfake films.
F. In instructional videos, AI avatars can be created utilizing deep-fakes technology.
G. Startups like London-based Synthesia have been attracting more attention from the business sector as real-people video productions have become much more difficult to pull off due to lockdowns and health issues.
H. Along with being utilized for entertainment and education, deepfake technology may be used to create custom avatars for each user.
I. Uncomplicated identity protection For instance, in news coverage about the discrimination against LGBTQ people in Russia, interviewees' identities have been protected by AI-generated avatars.
J. Using high-resolution deep fakes face-swapping technology, Disney has improved their visual effects as deep fakes technology continues to evolve.

<u>Regulation of Deepfakes</u>

- Recently, countries like China are seen limiting the production of deepfakes, or artificial-intelligence-generated video, audio and pictures that imitate real people.

A. **Deepfakes (Deep Learning + Fake)** are synthetic media in which a person in an existing image or video is replaced with someone else's likeness.
B. Deepfakes leverage powerful techniques from machine learning (ML) and artificial intelligence (AI) to manipulate or generate **visual and audio content** with a **high potential to deceive**.

Uses:

- Many are entertaining and some are helpful.
- Voice-cloning deepfakes can restore people's voices when they lose them to disease.
- Deepfake videos can enliven galleries and museums.
- For the entertainment industry, technology can be used to improve the dubbing on foreign-language films, and more controversially, resurrect dead actors.

DEEPFAKE

A. It gets harder as the technology improves.
B. In 2018, US researchers discovered that deepfake faces don't blink normally.
C. Poor-quality deepfakes are easier to spot.
D. The lip synching might be bad, or the skin tone patchy. There can be flickering around the edges of transposed faces.

ISSUES WITH DEEPFAKES

Building mistrust:

1. Since they are compelling, deepfake videos can be used to **spread misinformation and propaganda**.
2. They seriously compromise the public's ability to distinguish between fact and fiction.

Wrongful depiction:

I. There has been a history of using deepfakes to depict someone in a compromising and embarrassing situation.
II. For instance, there is no dearth of deepfake pornographic material of celebrities. Such photos and videos do not only amount to an invasion of privacy of the people reportedly in those videos, but also to harassment.
III. As technology advances, making such videos will become much easier.

Financial fraud:

- Deepfakes have been used for financial fraud.
- In the recent example, scammers used AI-powered software to trick the CEO of a U.K. energy company over the phone into believing he was speaking with the head of the German parent company. As a result, the CEO transferred a large sum of money — €2,20,000 — to what he thought was a supplier.
- The audio of the deepfake effectively mimicked the voice of the CEO's boss, including his German accent.

THREATS TO NATIONAL SECURITY

Influencing elections:

Deepfakes can be used to influence elections.

A. Recently, Taiwan's cabinet approved amendments to election laws to punish the sharing of deepfake videos or images.
B. Taiwan is becoming increasingly concerned that China is spreading false information to influence public opinion and manipulate election outcomes, and this concern has led to these amendments.

This could also happen in India's elections too.

Espionage:

A. Deepfakes can also be used to carry out espionage activities.
B. Doctored videos can be used to blackmail government and defence officials into divulging state secrets.

Production of hateful material:

1. In India, deepfakes could be used to produce inflammatory material, such as videos purporting to show the armed forces or the police committing 'crimes' in areas with conflict.
2. These deepfakes could be used to radicalise populations, recruit terrorists, or incite violence.

LEGAL PROTECTION AVAILABLE IN INDIA

IPC & IT Act:

Currently, very few provisions under the **Indian Penal Code (IPC)** and the **Information Technology Act, 2000** can be potentially invoked to deal with the malicious use of deepfakes.

1. Section 500 of the IPC provides punishment for defamation.
2. Sections 67 and 67A of the Information Technology Act punish sexually explicit material in explicit form.

RPI:

- **The Representation of the People Act, 1951**, includes provisions prohibiting the creation or distribution of false or misleading information about candidates or political parties during an election period.

ECI GUIDELINES:

- The Election Commission of India has set rules that require registered political parties and candidates to get pre-approval for all political advertisements on electronic media, including TV and social media sites, to help ensure their accuracy and fairness.

CHALLENGES

Lack of regulatory framework for AI:

- There is often a lag between new technologies and the enactment of laws to address the issues and challenges they create.
- In India, the legal framework related to AI is insufficient to adequately address the various issues that have arisen due to AI algorithms.
- The lack of proper regulations creates avenues for individuals, firms and even non-state actors to misuse AI.

Policy vacuums on deepfakes:

- The legal ambiguity, coupled with a lack of accountability and oversight, is a potent mix for a disaster.
- Policy vacuums on deepfakes are a perfect archetype of this situation.

Challenging authenticity:

- ❖ As the technology matures further, deepfakes could enable individuals to deny the authenticity of genuine content, particularly if it shows them engaging in inappropriate or criminal behaviour, by claiming that it is a deepfake.

WAY AHEAD

A. The Union government should introduce separate legislation regulating the nefarious use of deepfakes and the broader subject of AI.
B. Legislation should not hamper innovation in AI, but it should recognise that deepfake technology may be used in the commission of criminal acts and should provide provisions to address the use of deepfakes in these cases.
C. The proposed Digital India Bill can also address this issue.
D. Tech firms are also working on detection systems that aim to flag up fakes whenever they appear.

A. As media consumers, we must be able to decipher, understand, translate, and use the information we encounter.
B. Meaningful regulations created in collaboration with the technology industry, civil society, and the government can aid in preventing the creation and spread of malicious deep fakes.
C. Deep fakes pose risks to the government, society, economy, culture, and local communities, which should be known by policymakers.
D. Prior to resolving the issues deep fakes present, media literacy needs to be improved.
E. The only method to deal with this problem is with technical solutions supported by artificial intelligence that can recognize and block deep fakes.
F. Blockchains can be used to digitally sign and validate a video's or document's authenticity because they are resistant to a variety of security issues.

- ➢ As **media consumers,** we must be able to **decipher, understand, translate,** and use the information we encounter.
- ➢ The best method to deal with this problem is with technical solutions supported by **artificial intelligence** that can **recognize** and **block deep fakes.**
- ➢ Prior to resolving the issues associated with **deep fakes, media literacy** has to be improved.
- ➢ There is also a need for **easy-to-use** and accessible technology solutions to detect **deep fakes, authenticate media,** and **amplify authoritative sources.**
- ➢ On the part of **society,** to **counter the menace of deep fakes,** there is a need to take the responsibility to be a **critical consumer** of media on the **Internet, think** and **pause before sharing on social media,** and be part of the solution.

RANSOMWARE

1. "The AIIMS cyber attack is a wake-up call for national security" published in the Indian Express on 1st November 2022.
2. "Are ransomware attacks increasing in India?" published in The Hindu on 1st November 2022.
3. The recent massive ransomware attack has crippled the e-hospital services of AIIMS, Delhi for seven days.

RANSOMWARE

- Ransomware is a type of malicious software, used by cyber criminals, to infect a computer system by blocking access to the stored data by encrypting the files. A ransom is then demanded from the owner in exchange for the decryption key.
- A Cybersecurity firm, in its third-quarter global report, has identified 25 major ransomware in circulation. According to Interpol's first-ever **Global Crime Trend report**, ransomware was the **second highest-ranking threat after money laundering**, at 66%. It is also expected to increase the most (72%).

1. New Virus, Ransomware becoming a global threat in day-to-day computer handling.
2. The phenomenon that users of computers and researchers in cyber security were witness to from, May 13 has raised many questions of vulnerability.

OPERATION OF THE RANSOMWARE

1. It is a type of malicious software designed to block access to a computer system until a sum of money is paid.
2. The intrusion was a phishing attack, persuading a user to open a mail sent by a motivated intruder, appears to be from a genuine and authorised source, and the result of a malware (WannaCrypt 2.0) assembled not at one place but in several centres across the globe.
3. The ransom demanded in each instance was $300 to be paid in Bit coin — a digital currency which renders the beneficiary anonymous and is difficult to locate.
4. One rough estimate is that the ransom-seekers will eventually net $1 billion, and that they have already received about $33,000.

ORIGIN OF RANSOM WARE

- The malware was possibly stolen from a stockpile of weapons which **the National Security Agency (NSA)** had built up over the years as a counter-offensive to cyber-attacks on the US and its allies by nations such as Russia, China and North Korea.
- Shadow Brokers (whose exact identity is yet to be unravelled) had started posting online certain tools they had stolen from the NSA 'armoury'.
- It revives memories of **Stuxnet,** a worm that both the US and Israel used against Iran's nuclear programme more than five years ago.
- While there is no corroboration to the charge levelled against the NSA, it is interesting that a few former intelligence officers have taken the stand that the tools used in the latest episode were indeed from **the NSA's 'Tailored Access Operations' unit.**

ANNOYING ASPECTS OF THE THREAT

- There are two aspects to the outrageous attack that are worrisome.
- The first is that the holes in the older version of Windows were known to Microsoft, but **it did not do much to patch them up,** except for customers who paid to remove the deficiencies.
- The other theory is that customers who were aware of the risk **did not bother to act** because of the costs involved and the problems related to adapting to upgrades.
- Either way, this was a lesson to be learnt by both software manufacturers and users.

Defend Against Ransomware

- **Back up your data**. The best way to avoid the threat of being locked out of your critical files is to ensure that you always have backup copies of them, preferably in the **cloud and on an external hard drive**.
- **Secure your backups**. Make sure your backup data is not accessible for modification or deletion from the systems where the data resides.

- Ransomware will look for data backups and encrypt or delete them so they cannot be recovered, so use backup systems that do not allow direct access to backup files.
- **Use security software and keep it up to date.** Make sure all your computers and devices are protected with comprehensive security software and keep all your **software up to date**.
- **Practice safe surfing.** Be careful where you click. Don't respond to emails and text messages from people you don't know, and only download applications from trusted sources.
- This is important since malware authors often use social engineering to try to get you to install dangerous files.
- **Only use secure networks**. Avoid using public Wi-Fi networks, since many of them are not secure, and cybercriminals can snoop on your internet usage.
- **Implement a security awareness program.** Provide regular security awareness training for every member of your organization so they can avoid phishing and other social engineering attacks. Conduct regular drills and tests to be sure that training is being observed.

SAFEGUARDS AVAILABLE IN INDIA AGAINST CYBER THREATS

1. **Information Technology Act, 2000 (Amended in 2008)**: It is the main law for dealing with cybercrime and digital commerce in India.
2. National Critical Information Infrastructure Protection Centre (NCIIPC) was created under Section 70A of IT Act 2000 to protect Cyberinfrastructure.
3. **CERT-In (Cyber Emergency Response Team, India)**: It is National Nodal Agency for Cyber Security and is Operational since 2004
4. **National Cyber Security Policy, 2013:** The policy provides the vision and strategic direction to protect the national cyberspace.
5. **Cyber Swachhta Kendra**: Cyber Swachhta Kendra helps users to analyse and keep their systems free of various viruses, bots/ malware, Trojans, etc.
6. **Indian Cyber Crime Coordination Centre (I4C)**: Launched in 2018, It is an apex coordination centre to deal with cybercrimes.
7. **Cyber Surakshit Bharat:** It was launched by the Ministry of Electronics and Information Technology (MEITy) in 2018 with the aim to spread awareness about cybercrime and building capacity for safety measures for Chief Information Security Officers (CISOs) and frontline IT staff across all government departments.

The Cyber Warrior Police Force: It was organised on the lines of the Central Armed Police Force in 2018

DARKSIDE RANSOMWARE ATTACK

- Recently, the Federal Bureau of Investigation(FBI) officially confirmed that **DarkSide was responsible for compromising Colonial Pipeline's networks.**

DarkSide Group

- DarkSide is an Eastern Europe-based c**ybercriminal hacking group** that targets victims using **ransomware and extortion**
- The group has claimed that it is **apolitical and is only concerned about making money** and has claimed that it also **donates some of its proceeds to charities.**
- The DarkSide group appeared to have a code of conduct that prohibits attacks against hospitals, hospices, schools, universities, non-profit organizations, and government agencies.

- Recently, the **Colonial Pipeline** (the operator of one of the largest fuel pipelines in the USA) announced that it had been hit with a **ransomware attack**, in which criminal groups lock up **computer systems and hold data hostage** until the victim pays a ransom.

- In response, the company protectively shut down its pipeline.
- The pipeline carries **2.5 million barrels a day - 45%** of the East Coast's supply of diesel, petrol and jet fuel.
- The company has reportedly paid a ransom amount of $5 million in Bitcoin to retrieve its files.

IMPACT ON OIL PRICES

1. Oil prices rose in response to the attack on Colonial Pipeline with the price of Brent **crude rising to $69 per barrel.**
2. The temporary shortage also led to an increase in pump prices in the US with the average national price of petrol rising to over $3.0 per gallon, the highest level since 2014.
3. The disruption led to a gas s**hortage across the east coast** with customers facing long lines to **purchase fuel and many pumps** running out of petrol and diesel as panic buying led to customers **purchasing larger quantities of fuel**.
4. Crude oil prices have risen despite a surge in Covid-19 infections in Asia due to **expectations of increasing crude oil demand from the US** and Europe leading to further upward pressure on auto fuel prices.

IMPACT ON INDIA:

India, the world's third-biggest oil importer and consumer

- Rising oil prices are posing fiscal challenges for India, where heavily-taxed retail fuel prices have touched record highs in some parts of the country.
- The increase in oil prices will increase the country's import bill, and further, disturb its current account deficit (excess of imports of goods and services over exports).

MEASURES NEED TO BE TAKEN

1. There is a need to move towards **fortifying approache**s to **prevent attacks** including employing a z**ero-trust security framework** in enterprise networks.
2. A zero-trust approach means anything is suspected whenever any activity is done on the network, and every user, including the CEO, will have to be verified time and again.
3. Other measures such as **Cloud Access Security Brokers (CPAB),** which act as intermediaries between users and cloud service providers, could "give teeth" to an **overall cybersecurity strategy.**
4. India's oil and gas PSUs were making efforts to beef up **security, and that organisations** managing **critical infrastructures** such as pipelines and refineries were required by the government to implement certain security measures.

1. Ransomware Attack
2. A ransomware attack is a cyberattack using malware that encrypts the victim's files and requires users to pay a ransom to decrypt the files.
3. It is often designed to spread across a network and target database and file servers, and can thus quickly paralyze an entire organization.
4. It is a growing threat, generating billions of dollars in payments to cybercriminals and inflicting significant damage and expenses for businesses and governmental organizations.

REGULATION OF CRYPTOCURRENCIES IN INDIA

- Recently, the PM chaired a meeting on cryptocurrency where the need for its regulation was discussed.
- Earlier, RBI cautioned investors about digital currency over its non-transparent advertising.
- A cryptocurrency is a virtual currency used for financial transactions. It uses blockchain technology for various transactions. Earlier, the RBI has issued a circular prohibiting use of these virtual currencies. Recently, The Supreme Court on Wednesday lifted the ban imposed by the Reserve Bank of India (RBI) on virtual currency trading, including cryptocurrencies.

VARIOUS CONCERNS RELATED TO CRYPTOCURRENCIES:

- **Privacy Concerns:** The privacy of users' data is at stake. There is concern regarding privacy of users data in using cryptocurrencies as all the transaction information is stored in distributed ledger (called blockchain), which is publicly visible. Thus Hacker can easily observe how the money flows.
- **High Volatility:** The price of Bitcoin suddenly rose to almost $20,000 and then dropped to $6,000. Due to such incidents, it is complicated for the investors to trust the ecosystem.
- **Destination for black money**: The fear among regulators and policymakers is that cryptocurrencies, being an alternative source of value to fiat currency, could be misused to launder black money or finance terrorist activities.
- **Cybersecurity Concerns:** Cryptocurrencies are prone to cybersecurity breaches and hacks. Various attacks are common, even companies and governments are not full proof to them. For example, the Swiss blockchain company, Trade.io, has reported that crypto tokens worth almost $8 million have been stolen from their cold wallet.
- **Dark activities:** The possibility that the new money will nurture illicit activities and markets like drug selling, weapons etc. through Darknet is always high using cryptocurrency anonymously. It also increases the risk of its use in various terrorist activities across the border.
- **Monetary control and economic behaviour:** It could dramatically change global monetary policymaking. People will exchange their national currencies for the new digital coin in order to buy and sell the many products that will be priced in it. This will further impact the profit of banks and will put stress on their balance sheet.
- **Inflation:** Governments and policymakers will have reduced ability to control inflation. Usually, when inflation picks up, central banks take steps to control it through various monetary rates. Cryptocurrency will be out of control of the central bank so liquidity control will be an issue.
- Cryptocurrency is, despite all its risks, perhaps the most exciting asset of the 21st century. A decentralized digital currency that works on the very interesting and likely here-to-stay blockchain technology. There are a thousand reasons to be excited about cryptocurrency, but also real reason to be conservative in your investment strategy.

INDIA AND CRYPTOCURRENCY

- **2009**: First cryptocurrency**, Bitcoin** launched in 2009 by **Satoshi Nakamoto**.
- **2018:** RBI banned banks and other regulated entities from supporting crypto transactions.
- **2019:** Inter-ministerial committee recommended banning all private cryptocurrencies.
- **2020:** SC struck down the ban on the trading of cryptocurrency as unconstitutional.
- **2021:** Cryptocurrency and Regulation of Official Digital Currency Bill, 2021 introduced.

1. Under this, a plan to ban private digital currencies favours RBI backed currency.
2. A 3-6 month exit period prior to banning the trading, mining and issuing of cryptos.

Finally, Cryptocurrencies, though unregulated, are not illegal in India.

RBI AND DIGITAL CURRENCY

- RBI exploring **DLT (Distributed Ledger Technology)** based Central Bank Digital Currency.
- Under DLT, details are recorded in multiple places at the same time.
- For ex: **Blockchain** is just one type of **distributed ledger.**
- **Central Bank Digital Currency (CBDC)**: It will be a legal tender.
- Can be converted/exchanged at par with similarly denominated cash.

FEATURES OF CRYPTOCURRENCY

- **Anonymous:** Cryptocurrencies make it possible to lend, sell, buy, or borrow without an identity, credit score, or even a bank.
- **Highly secure:** All records of its creation and when it's sent or received are stored in a sort of big digital book that anyone can access, keeping it honest. It can't (easily) be stolen or seized and can be used anywhere in the world.
- **Cheaper to transfer:** Some coins are used to transfer value (measured in a currency like dollars) cheaper and faster than using credit or conventional means. Meaning the cost to send someone crypto, which can be converted into regular currency, is cheaper than something like a check or wire transfer.
- **Illegal and highly volatile:** However crypto is NOT just used for illegal purposes. In fact, due chiefly to its price fluctuation and other reasons it has fallen out of favor on the black market.
- **No physical form:** Cryptocurrency does not exist in physical form (like paper money) and is typically not issued by a central authority. However, it can be and many governments are working to create a crypto coin version of its respective fiat currency.
- **Decentralised:** Cryptocurrencies typically use decentralized control as opposed to a central bank digital currency. When a cryptocurrency is minted or created prior to issuance or issued by a single issuer, it is considered centralized. When created with decentralized control, each cryptocurrency works through what is called **distributed ledger technology**, which is typically a blockchain, that serves as a public financial transaction database.
- **Blockchain technology used:** A blockchain is a database that stores encrypted blocks of data then chains them together to form a chronological single-source-of-truth for the data.

1. Digital assets are distributed instead of copied or transferred, creating an immutable record of an asset
2. The asset is decentralized, allowing full real-time access and transparency to the public
3. A transparent ledger of changes preserves integrity of the document, which creates trust in the asset.
4. Blockchain's inherent security measures and public ledger make it a prime technology for almost every single sector.

Some of the real-world applications of technology related to cryptocurrency

1. **Use in voting:** People can vote to the deserving leader while being anonymous to their identity.
2. **Use in funds distribution:** A huge fund is distributed to the leaders of the states but because of corrupt minds, the money vanishes and remains in pieces. Cryptocurrency will definitely help the country to get rid of it.

BENEFITS OF CRYPTOCURRENCY

1. **Inherent security:** Use of pseudonyms and ledger systems conceals the identities.

2. **Low transaction cost:** Very low fees and charges for transactions.
3. **Lack of interference from the banking system:** Outside ambit of banking systems.
4. **Lower Entry Barriers:** No entry barriers, unlike conventional banking systems.
5. **Universal recognition:** Lots of cryptocurrencies and acceptable in many nations.

CONCERNS/CHALLENGES

I. **Security risks:** Cyberattacks on wallets, exchange mechanism (Cryptojacking).
II. **Shield to Crime:** Used for Illicit Trading, Criminal Activities, & organised crimes.
III. **Threat to the Indian rupee:** If a large number of investors invest in digital coins rather than rupee-based savings like provident funds, the demand of the latter will fall.
IV. **Lack of Liquidity and Lower Acceptability:** Outside the traditional banking systems.
V. **Price Volatility:** Prone to price fluctuations & waste of computing power.
VI. **Lack of Consumer Protection:** No Dispute Settlement Mechanisms and control of Securities and Exchange Board of India (SEBI).

WAY FORWARD

1. Take a cue from developed countries, have safeguards, measures and regulatory structure.
2. Need to expedite passing of the Cryptocurrency regulation bill.

SOME POPULAR CRYPTOS

1. **Bitcoin:** Introduced in 2009 Created by "**Satoshi Nakamoto"** (Real name and identity unknown)
2. It is world's first successful cryptocurrency.
3. **DOGECOIN:** Introduced in 2013 by **Jackson Palmer and later Billy Markus.** Dogecoin is a digital currency like bitcoin or ethereum.
4. **Ethereum:** Launched in 2015, created by **Vitalik Buterin.**
5. **Litecoin:** Introduced in 2011 Created by Charlie Lee. Litecoin is unique from Bitcoin in that it can produce a greater number of coins and its transaction speed is faster.
6. **Stellar Lumen (XLM):** Introduced in 2015 Created by Jed McCaleb. Stellar is a decentralized computer network that operates using blockchain technology. On the Stellar network, you can trade its form of currency, which is called XLM.

WEB 3.0:A SOLUTION TO DATA PRIVACY AND DATA SECURITY

- Web 3.0, Web 2.0, Web 1.0, Platform, Decentralization, Block chain technology, IOT, Transparency.
- Web 3.0 is the potential next phase of the internet wherein the internet will be decentralised and run on block chain technology.

Web 3.0

1. Web3 (also known as Web 3.0 and sometimes stylized as web3) is an idea for a new iteration of the **World Wide Web based on block chains,** which incorporates concepts including decentralization and token-based economics.
2. The concept of Web3, also called Web 3.0, used to describe a potential next phase of the internet, created quite a **buzz in 2021.**

3. The model, a decentralised internet to be run on **block chain technology,** would be different from the versions in use, **Web 1.0 and Web 2.0. In web3,** users will have ownership stakes in platforms and applications unlike now where tech giants control the platforms.

WEB 3.0 VS WEB 2.0 VS WEB 1.0

1. **Web 3.0 is the potential next phase** of the internet wherein the internet will be decentralised and run on blockchain technology.
2. Of the earlier versions, Web 1.0 was mostly static where users would go to a website and read and interact with static information; the differentiating characteristic of **Web 2.0 compared to Web1.0** is that users can create content. They can interact and contribute in the form of comments, registering likes, sharing and uploading their photos or videos and perform other such activities.

some of the concerns with Web 2.0

1. In **Web 2.0,** most of the data in the **internet and the internet traffic** are owned or handled by very few **behemoth companies.** This has created issues related to **data privacy, data security and abuse** of such data. Web3 offers a solution to these problems.
2. There is a sense of disappointment that the original purpose of the internet has been distorted.

Web 3.0 benefits the Common man

- **Data Protection -** Massive data breaches that have proliferated during the Web2 era.
- Data protection must be central to the next wave of tech innovations.
- Web3 applications sometimes referred to DApps are built on decentralised peer-to-peer networks like Ethereum and IPFS.
- Instead of being run by some tech giants companies, these networks are built, operated, and maintained by users.
- It is possible to split up large files into smaller chunks.
- It can be individually encrypted and stored in other locations, making it nearly impossible to hack.
- **User Friendly -** Any change in personal data like your address or credit card number needs to be changed once on your end.
- Automatically all your sites will be updated. This will make the Web much more user-friendly.
- They aren't subject to the business hours of mainstream financial institutions.
- Web3 allows for low-cost, nearly instantaneous, borderless, peer-to-peer transfers of actual value.

1. **Innovations -** Centralisation helped billions of people get access to amazing technologies (mostly free to use), but it has stifled innovation.
2. Companies that own networks have unilateral power over who gets network access, how revenue is divided, what features are supported, etc.

3. That makes it harder for start-ups, creators and other groups to grow their internet presence.
4. Decentralising the web removes these hurdles for new start ups.

RECENT APPLICATIONS OF WEB3.0

1. The applications are much larger and wilder. It is growing beyond its financial origins such as cryptocurrency.
2. Web3 will power the new financial world order on metaverse.

❖ Metaverse is as a combination of virtual and augmented reality and video where people can live in a virtually programmed and developed world (like a pokemon game)

1. It is different from reality but is built by taking inspiration from the real environment around us.
2. It will unleash innovation in online gaming, tokenisation of assets in virtual spaces.
3. Some of the use cases of Web3 are Decentralised Autonomous Organisations (DAOs), Decentralised Finance (DeFi), Stablecoins and Central Bank Digital Currencies (CBDCs), private and digital infrastructure, and creator economy enablers like NFTs and blockchain-based games.

CHALLENGES

1. The classic challenge of decentralised networks is that they are public goods. Without a central entity to control decisions and capture profits, it is hard to incentivise their maintenance and development.
2. Crypto helps solve this problem through decentralised coordination and providing economic incentives for development.
3. A lot of work has to be done to lay the foundation for Web3 —meaning that users, developers, tech companies, and others would have to come in on agreements around how the Web3 protocols would work.
4. Only when this work gets going, and when financial incentives align behind it, will Web3 start to get real.

FEATURES OF WEB 3.0:

It does have a few defining features:

1. **Decentralization:** This is a core tenet of **Web 3.0. In Web 2.0,** computers use HTTP in the form of unique web addresses to find information, which is stored at a fixed location, generally on a single server. With Web 3.0, because information would be found based on its content, it could be stored in multiple locations simultaneously and hence be decentralized. This would break down the massive databases currently held by internet giants like Facebook (now Meta) and Google, and would prevent their undue enrichment by handing greater control to users. With Web 3.0, the data generated by disparate and increasingly powerful computing resources, including mobile phones, desktops, appliances, vehicles, and sensors, will be sold by users through decentralized data networks, ensuring that users retain ownership control.
2. **Trust less and permission less:** In addition to decentralization and being based upon open source software, Web 3.0 will also be trust less (i.e., the network will allow participants to interact directly without going through a trusted intermediary) and permission less (meaning that anyone can participate without authorization from a governing body).
3. **Artificial intelligence (AI) and machine learning:** In Web 3.0, computers will be able to understand information similarly to humans, through technologies based upon Semantic Web concepts and natural language processing. **Web 3.0** will also use machine learning,

which is a branch of **artificial intelligence (AI)** that uses data and algorithms to imitate how humans learn, gradually improving its accuracy. These capabilities will enable computers to produce faster and more relevant results in a host of areas like drug development and new materials, as opposed to merely targeted advertising that forms the bulk of current efforts.

4. **Connectivity and ubiquity:** With Web 3.0, information and content are more connected and ubiquitous, accessed by multiple applications and with an increasing number of everyday devices connected to the web—an example being the **Internet of Things.**

CONCLUSION:

1. Web3 will deliver "decentralized and fair internet where users control their own data".
2. The spirit of Web3 is Decentralized Autonomous Organization (DAO) which is that all the business rules and governing rules in any transaction are transparently available for anyone to see and software will be written conforming to these rules.
3. Crypto-currency and block chain are technologies that follow the DAO principle. With DAO, there is no need for a central authority to authenticate or validate.

5G SERVICES ROLLOUT IN INDIA

- The Prime Minister of India has recently launched **5G services in India** on the sidelines of the inaugural ceremony of India Mobile Congress 2022.

I. **Evolution**: **5G is the 5th generation mobile network** or wireless technology. It is a new global wireless standard after 1G, 2G, 3G, and 4G networks.

II. **Network**: 5G enables a new kind of network designed to connect virtually everyone and everything together including machines, objects, and devices.

III. **Objectives**: 5G will deliver higher multi-Gbps peak data speeds, ultra-low latency, more reliability, massive network capacity, increased availability, and a more uniform user experience to more users.

IV. **Higher performance and improved efficiency** to empower new user experiences and connect new industries.

BENEFITS OF THE 5G LAUNCH IN INDIA

1. **Affordability**: Telecom industry players like Reliance Industries Limited, Bharti Enterprises and Aditya Birla Group committed to a speedy roll-out of "affordable" 5G services in India.
2. **Superior experience**: Indian mobile phone users will experience ultra-high Internet speeds via 5G wireless technology and bring a new digital era in the country.
3. **Socio-economic transformation:** 5G technology will bring transformation in crucial areas including agriculture, health, education, Transport, logistics, smart cities, Industry 4.0 and financial inclusion etc.
4. **Global position**: 5G technology will bolster tech revolution domestically and propel India's position as an economic and tech powerhouse globally.
5. **Newer opportunities**: will provide new opportunities for start-ups to come up with innovative solutions to solve existing challenges, create jobs and contribute to India's economic resilience.
6. For example, demonstrations of 5G solutions, chipsets, networking equipment etc. development by Indian telecom start-ups, MSMEs and large manufacturers
7. **Self-reliance**: India was dependent on other countries for 2G, 3G and 4G technologies. However, India has set a global standard in telecom technology for the first time with 5G.

8. **Tech Developer, not consumer**: Henceforth, India will play an active role in the development and implementation of 5G related technology rather than being a mere consumer of technology.
9. **More Users:** As per the recent Ericsson report, 5G technology might contribute to 39 % of mobile subscriptions in India by 2027 i.e. about 500 million estimated subscriptions.
10. **Foundation/Link Technology**: 5G technology will serve as a link to several science & technology driven application useful in daily lives such as-

- Connected Ambulance (Emergency healthcare)
- Community Clinic (Mass healthcare / treatment)
- Remote Ultrasound Robot Demo (remote healthcare)
- Fixed Wireless Access (FWA) for Rural Broadband Connectivity.
- Indigenously developed 5G core for public networks
- High Security Routers
- AI based Cyber Threat Detection Platform
- Smart-Agri Programme using IoTs, HD Cameras and Drones

ISSUES WITH 5G IMPLEMENTATION:

1. **Technological Adoption:** Widespread rollout of 5G across India (especially rural areas) will need strong technological backup and capital adequacy on behalf of Indian telecommunication companies.
2. **Low Fiberization Footprint**: For an efficient 5G coverage, doubling of Fiber connectivity will be needed for pan-India networks as presently FOC connects only 30% of India's telecom towers.
3. **Hardware challenge**: Since India has banned some leading foreign telecom original equipment manufacturers (OEMs), deployment of 5G may face hurdles w.r.t. Indian hardware.
4. **Spectrum pricing**: 5G spectrum pricing in India is far costlier than the global average, raising valid concerns over affordability of services by customers eventually.

ROLE OF DIGITAL INDIA MISSION IN 5G LAUNCH

1. **Affordable Devices:** With *Atma Nirbhar Bharat* the cost of devices were reduced to a large extent. India is now at second position in the world for manufacturing of mobile and is also a large exporter of mobiles.
2. For example, from 2 mobile manufacturing units in 2014, India presently has 200 manufacturing units promoting competition and cost-effectiveness.

Digital Connectivity:

1. **Broadband Users**: From 6 cr in 2014, India now has 80 crore Broadband users.
2. **Optical Fibre Cable(OFC)**: Now, more than 1,70,000 Gram Panchayats (GPs) are connected with OFC from approx 100 GPs earlier in 2014.
3. **Internet users** in the rural areas of the country are growing at a faster rate than the urban area thereby bridging the digital divide.
4. **Cost of Data:** The cost of data has reduced from Rs. 300 per GB in 2014 to Rs. 10 per GB in 2022. Average Data used per person is 14 GB per month, and reduction in cost of data has brought considerable savings per month for citizens.
5. **Idea of Digital First:** There were apprehensions about adoption of the digital technology by the rural poor, however rural India is fast adopting the digital technologies and internet in their daily lives.

5G revolution and challenges

- Prime Minister Narendra Modi recently announced that 5G revolution deployment in India will commence sooner than expected.

5G TECHNOLOGY

1) 5G or fifth generation revolution is the latest upgrade in the long-term evolution (LTE) mobile broadband networks.
2) 5G enables a new kind of network that is designed to connect virtually everyone and everything together including machines, objects, and devices.
3) It's a unified platform which is much more capable than previous mobile services with more capacity, lower latency, faster data delivery rate and better utilisation of spectrum.

EVOLVED FROM 1G TO 5G

1) **1G:** Launched in the 1980s. Analog radio signals and supported only voice calls.
2) **2G:** Launched in the 1990s. Uses digital radio signals and supported both voice and data transmission with a Bandwidth (BW) of 64 Kbps.
3) **3G:** Launched in the 2000s. With a speed of 1 Mbps to 2 Mbps it has the ability to transmit telephone signal including digitized voice, video calls and conferencing.
4) **4G**: With a peak speed of 100 Mbps-1 Gbps it also enables 3D virtual reality.
5) **5G:** with a speed of more than 1Gbps, it is capable of connecting entire world without limits.

Salient features

- **Capability:** 5G will provide much faster mobile broadband service as compared to the previous versions and will provide support to previous services like mission critical communication and the massive Internet Of Things (IoT).
- **Upgraded LTE**: 5G is the latest upgrade in the long-term evolution (LTE) mobile broadband networks.
- **Speed:** With peak delivering rate of up to 20 Gbps and an average of 100Mbps, it will be much faster as compared to its predecessors. The speed increment is partly achieved partly by using higher-frequency radio waves than previous networks.
- **Capacity**: There will be up to 100 x increase in traffic capacity and network efficiency.
- **Spectrum usage**: Will provide better usage for every bit of spectrum, from low bands below 1 GHz to high bands.
- **Latency**: It's expected to have lower latency with better instantaneous, real-time access of the data. The 5G, like 4G LTE, also uses Orthogonal Frequency Division Multiplexing (OFDM) but the new 5G NR (New Radio) air interface will enhance OFDM and provide better flexibility in data delivery.

Applications of 5G technology

1. **High-Speed mobile network**: 5G will revolutionize the mobile experience with supercharged wireless network. Compared to conventional mobile transmission technologies, voice and high-speed data can be simultaneously transferred efficiently in 5G.
2. **Entertainment and multimedia**: 5G can provide 120 frames per second, high resolution and higher dynamic range video streaming without interruption. Audiovisual experience will be

rewritten after the implementation of the latest technologies powered by 5G wireless. Augmented Reality and virtual Reality services will be better experienced over 5G.

3. **Internet of Things**: IoT applications collects huge amount of data from millions of devices and sensors and thus requires an efficient network for data collection, processing, transmission, control and real-time analytics which 5G network is a better candidate.

Interesting facts about 5G

1. According to researchers, about 1.5 billion people will have access to 5G by 2024.
2. It may not seem like it at present, however, 5G will cover about 40% of the world.

The security risks introduced BY 5G

1. **Increased attack surface**: With millions and even billions more connected devices, 5G makes it possible for larger and more dangerous attacks. Current and future vulnerabilities of the existing internet infrastructure are only exacerbated. The risk of more sophisticated botnets, privacy violations, and faster data extraction can escalate with 5G.
2. **More IoT, more problems**: IoT devices are inherently insecure; security is often not built-in by design. Each insecure IoT device on an organization's networks represents another potential hole that an attacker can expose.
3. **Decreased network visibility**: With 5G, our networks will only expand and become more usable by mobile users and devices. This means much more network traffic to manage. But without a robust wide area network (WAN) security solution like Secure Access Service Edge (SASE) in place, companies may not be able to gain the network traffic visibility required to identify abnormalities or attacks.
4. **Increased supply chain and software vulnerabilities**: Currently and for the foreseeable future, 5G supply chains are limited. Vulnerabilities exist — particularly as devices are rushed to market — increasing the potential for faulty and insecure components. Compared to traditional mobile networks, 5G is also more reliant on software, which elevates the risk of exploitation of the network infrastructure.

Challenges in rolling out 5G

1. **Enabling critical infrastructures**: 5G will require a fundamental change to the core architecture of the communication system. The major flaw of data transfer using 5G is that it can't carry data over longer distances. Hence, even 5G technology needs to be augmented to enable infrastructure.
2. **Financial liability on consumers**: For transition from 4G to 5G technology, one has to upgrade to the latest cellular technology, thereby creating financial liability on consumers.
3. **Capital Inadequacy**: Lack of flow of cash and adequate capital with the suitable telecom companies (like Bharti Airtel and Vodafone Idea) is delaying the 5G spectrum allocation.

Way forward

- India should not miss the opportunity and should proactively work to deploy 5G technology. We should focus on strengthening our cyber infrastructure.
- 5G start-ups that enable this design and manufacturing capabilities should be promoted. This will spur leaps in the coverage, capacity and density of wireless networks.

Way Forward

1. 5G technology will bring harmony with the Prime Minister's vision to promote '*Atma Nirbhar Bharat*', *Jai Anusandhan* and ' *Sabka Saath, Sabka Vishwas'*.
2. It will pave the way for realization of a vision of bringing that technology to the common people which works for the people, works by connecting with the people.
3. 5G should be integrated in the policy domains like Digital India mission to ensure transformational potential on the lives of citizens way beyond simple provision of higher internet speeds. E.g. Telemedicine during COVID-19.
4. Promotion of digitalisation, indigenous technology (Make in India), industrial revolution 4.0 will certainly pave the way for Techade (technology decade) of India.

CONCLUSION

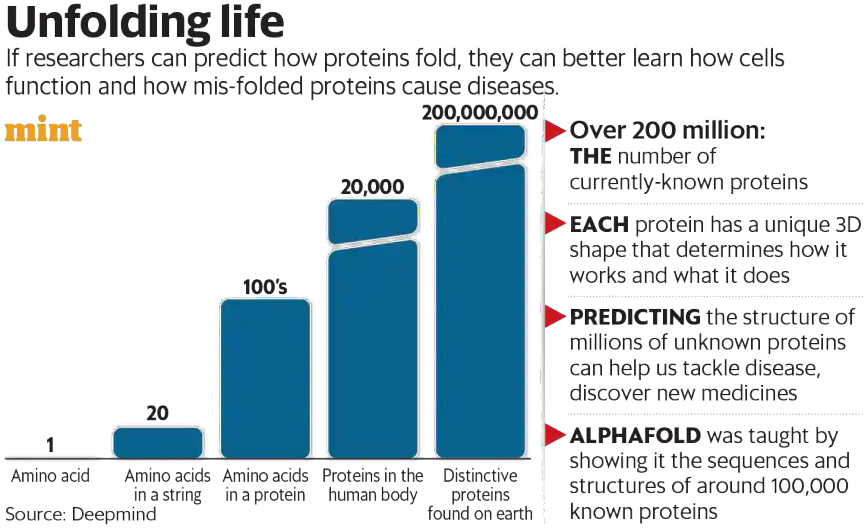
- The recent recommendation of the Telecom Regulatory Authority of India to the government to develop a national road map for India to implement 5G in the best possible manner should include cyber security concerns.

ALPHAFOLD & PROTEIN STRUCTURE

- Recently, DeepMind, a company based in London, announced that it had predicted the **three-dimensional structures** of more than **200 million proteins using AlphaFold.**
- AlphaFold is an **AI-based protein structure prediction tool**. It is based on a computer system called **deep neural network**.
- Inspired by the human brain, neural networks use a **large amount of input data** and provide the desired output exactly like how a human brain would.
- The real work is done by the **black box** between the input and the output layers, called the **hidden networks**.
- AlphaFold is fed with **protein sequences as input**. When protein sequences enter through one end, the predicted three-dimensional structures come out through the other.

WORKING MECHANISM:

1. It uses processes based on "training, learning, retraining and relearning."
2. The first step uses the available structures of 1,70,000 proteins in the Protein Data Bank (PDB) to train the computer model. Then, it uses the results of that training to learn the structural predictions of proteins not in the PDB.
3. Once that is done, it uses the high-accuracy predictions from the first step to retrain and relearn to gain higher accuracy of the earlier predictions.



implications

1. Knowing protein structure and function is essential to understanding human diseases.
2. Protein structures using x-ray crystallography, nuclear magnetic resonance spectroscopy, or cryogenic electron microscopy. These techniques are not just time-consuming, they often take years and are based mainly on trial-and-error methods.
3. AlphaFold makes the process of protein structuring easier. It is a watershed movement in science and structural biology in particular.
4. AlphaFold has already helped hundreds of scientists accelerate their discoveries in vaccine and drug development since the first public release of the database nearly a year back.

Significance for India

1. The Indian community of structural biology is strong and skilled. It needs to quickly take advantage of the AlphaFold database and learn how to **use the structures to design better vaccines and drugs.**
2. Understanding the **accurate structures of COVID-19 virus proteins** in days rather than years will accelerate vaccine and drug development against the virus.
3. India could facilitate joint collaborations with the prevalent hardware muscle and data science talent in the private sector and specialists in academic institutions to pave the way for data science innovations.

ALPHAFOLD: AI-BASED PROTEIN STRUCTURE PREDICTION TOOL

1. DeepMind, a company based in London and owned by Google, announced that it had predicted the three-dimensional structures of more than 200 million proteins using AlphaFold.
2. This is the entire protein universe known to scientists today.

ALPHAFOLD

1. AlphaFold is an AI-based protein structure prediction tool.
2. It is based on a computer system called deep neural network.
3. Inspired by the human brain, neural networks use a large amount of input data and provide the desired output exactly like how a human brain would.

4. The real work is done by the black box between the input and the output layers, called the hidden networks. AlphaFold is fed with protein sequences as input.
5. When protein sequences enter through one end, the predicted three-dimensional structures come out through the other.
6. It is like a magician pulling a rabbit out of a hat.

ALPHAFOLD WORK

1. It uses processes based on "training, learning, retraining and relearning."
2. The first step uses the available structures of 1,70,000 proteins in the **Protein Data Bank (PDB)** to train the computer model.
3. Then, it uses the results of that training to learn the structural predictions of proteins not in the PDB.
4. Once that is done, it uses the high-accuracy predictions from the first step to retrain and relearn to gain higher accuracy of the earlier predictions.
5. By using this method, AlphaFold has now predicted the structures of the entire 214 million unique protein sequences deposited in the **Universal Protein Resource (UniProt)**

IMPLICATIONS OF THIS DEVELOPMENT

1. Proteins are the business ends of biology, meaning proteins carry out all the functions inside a living cell.
2. Therefore, knowing protein structure and function is essential to understanding human diseases.
3. Scientists predict protein structures using x-ray crystallography, nuclear magnetic resonance spectroscopy, or cryogenic electron microscopy.
4. These techniques are not just time-consuming, they often take years and are based mainly on trial-and-error methods.
5. The development of AlphaFold changes all of that.
6. It is a watershed movement in science and structural biology in particular.

development mean for India

1. **Vaccine development:** Understanding the accurate structures of COVID-19 virus proteins in days rather than years will accelerate vaccine and drug development against the virus.
2. **Structural biology:** From the seminal contribution of G. N. Ramachandran in understanding protein structures to the present day, India is no stranger to the field and has produced some fine structural biologists.

Back2Basics: Proteins

1. Protein is found throughout the body—in muscle, bone, skin, hair, and virtually every other body part or tissue.
2. It makes up the enzymes that power many chemical reactions and the hemoglobin that carries oxygen in your blood.
3. At least 10,000 different proteins make you what you are and keep you that way.
4. Protein is made from twenty-plus basic building blocks called amino acids.
5. Because we don't store amino acids, our bodies make them in two different ways: either from scratch or by modifying others.
6. Nine amino acids—histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine—known as the essential amino acids, must come from food.

7. Chemically, amino acids are organic compounds made of carbon, hydrogen, nitrogen, oxygen or sulfur.
8. There are seven types of proteins: antibodies, contractile proteins, enzymes, hormonal proteins, structural proteins, storage proteins, and transport proteins.

Recently, DeepMind, a company based in London, announced that it had predicted the **three-dimensional** structures of more than 200 million **proteins using AlphaFold.**

ALPHAFOLD

1. AlphaFold is an AI based protein structure prediction tool.
2. It is based on a computer system called Deep NEURAL NETWORK
3. Neural networks use a large amount of input data and provide the desired output exactly like how a human brain would.
4. The real work is done by the black box between the input and the output layers, called the Hidden Networks.

- AlphaFold is fed with protein sequences as input.
- When protein sequences enter through one end, the predicted three-dimensional structures come out through the other.

▪ Mechanism:

1. **The first step** uses the available structures of 1,70,000 proteins in the **Protein Data Bank (PDB)** to train the computer model.
2. Then, it uses the results of that training to **learn the structural predictions of proteins not in the PDB.**
3. Then, it uses the **high-accuracy predictions** from the first step to **retrain and relearn** to gain higher accuracy of the earlier predictions.
4. By using this method, AlphaFold has now predicted the structures of the entire **214 million unique protein sequences** deposited in the **Universal Protein Resource (UniProt)** database.

Implication:

1. Knowing protein structure and function is essential to **understand human diseases.**
2. Proteins are generally structured using **x-ray crystallography, nuclear magnetic resonance spectroscopy,** or **cryogenic electron microscopy.**
3. These techniques are not just time-consuming, t**hey often take years** and are based mainly on **trial-and-error methods.**
4. AlphaFold makes the process of **protein structuring easier.**
5. It is a watershed movement in science and **structural biology** in particular.

AlphaFold has already helped hundreds of scientists accelerate their discoveries in VACCINE **and drug development** since the first public release of the database nearly a year back.

Available Substitutes:

1. AlphaFold is neither flawless nor the only AI-based protein structure prediction tool.
2. RoseTTaFold, developed by University of Washington in Seattle, U.S., is another tool.
3. Although less accurate than AlphaFold, it can predict the structure of protein complexes.

INDIA BENEFIT :-

- India needs to quickly take advantage of the AlphaFold database and learn how to use the structures to design better vaccines and drugs.

- Understanding the accurate structures of COVID-19 virus proteins in days rather than years will accelerate vaccine and drug development against the virus.
- India should also speed up implementation of PPP in the sciences.
- It should facilitate joint collaborations with the prevalent hardware muscle and data science talent in the private sector and specialists in academic institutions to pave the way for data science innovations.

HERMIT, THE PEGASUS-LIKE SPYWARE THAT TARGETED ANDROID, IOS DEVICES

1. The most recent sophisticated malware to make headlines is "Hermit," and it's thought to have targeted Android and iPhone devices in Italy and Kazakhstan.
2. The Lookout, a cybersecurity company based in San Francisco, was the first to discover Hermit's deployment.
3. The spyware was created by an Italian vendor named RCS Lab.
4. Then, last week, Google's Threat Analysis Group (TAG) published a thorough blog post outlining how they thought Hermit was used to target smartphones.

SPYWARE

- Spyware is generally understood to be malicious software intended to infiltrate your computer system, collect information about you, and send it to a third party against your will.
- Legitimate software that tracks your data for business purposes like advertising is also referred to as spyware.
- Malicious spyware is, however, specifically meant to make money off of stolen data.
- The performance of networks and devices is also impacted by spyware, which slows down normal user activity.

HERMIT -AFFECT

1. Hermit is spyware similar to NSO Group's Pegasus.
2. Once installed, it has the ability to make unauthorized calls, record audio on the device, and perform a variety of other unauthorized tasks.
3. The spyware is capable of stealing contacts, calendar events, bookmarks and searches from saved account emails.
4. Additionally, it has the ability to snap photographs of the device, steal data such as information about the kernel, model, manufacturer, OS, security patch, phone number, etc.
5. On a hijacked phone, it may also download and install APK files, which are the programme software files for Android.
6. The spyware can also read notifications, upload files from the device, and take screenshots of the display.
7. According to research by Lookout, an Android system's root or "privilege" access can be used to delete applications like Telegram and WhatsApp.
8. Researchers claim that spyware has the ability to secretly delete and reinstall Telegram. The reinstalled version, however, is probably a hacked one. The old app's data may likewise be stolen by it.
9. The user may be prompted to reinstall WhatsApp using the Play Store for WhatsApp.
10. Hermit can therefore manage and monitor data from all important applications once it has been installed on a phone.

HERMIT INSTALLED ON IOS AND ANDROID DEVICES

1. Licensing fees for sophisticated spyware like Hermit and Pegasus cost millions of dollars, and these are not straightforward operations.
2. It differs from typical malware that targets normal users. Furthermore, it appears that complicated operations were used in the instance of Hermit.
3. All efforts, according to Google's TAG team, began with a special URL given to the victim's phone.
4. The page installed the application on both Android and iOS when the user clicked.
5. When contacting an ISP was not an option, the spyware would pose as a messaging app.
6. The link would encourage users to download a version of either WhatsApp, Instagram, or Facebook while pretending to be a recovery page for a Facebook account, according to Google's screenshot example.
7. Back then, the computer was an Android. These messaging apps were definitely hacked in these versions.

circumvent the security precautions put in place by Apple and Google

I. Google stated that they thought the perpetrators pursuing the victims had to cooperate with the 'Internet Service Provider,' or ISP, of the target.
II. According to Google, the actors disable the target's mobile data connectivity by working with the target's ISP.
III. After the target's data connectivity was disconnected, the attacker would give them a malicious link through SMS demanding them to install a programme to restore it.
IV. The majority of applications pretend to be mobile carrier applications, in our opinion, because of this.
V. Lookout claims that some attacks in Kazakhstan were concealed as pages for popular phone manufacturers Oppo, Samsung, and Vivo.
VI. Additionally, their investigation reveals that Tykelab Srl, a provider of telecommunications solutions, collaborated with RCS Lab.
VII. Lookout believes that RCS Lab is likely using this as a "front company," and its blog post asserts that there are numerous connections between the two.
VIII. According to Google's investigation, the malware in Apple's case took advantage of the enterprise certificate that specific businesses grant to their apps.
IX. Bypassing the App Store, this certification enables businesses to publish their own internal programmes for direct distribution on iOS devices. These certifications, which Apple later withdrew, were obtained by the "Hermit spyware" programmes.
X. Because it was a member of the Apple Developer Enterprise Program, Google claimed that a business by the name of 3-1 Mobile SRL held the required certificate.
XI. They "do not believe the apps were ever available on the App Store," Google emphasised further.
XII. Once installed, these applications used a number of zero-day vulnerabilities as well as other known issues to increase access and conduct surveillance.
XIII. Apple has reportedly revoked the certifications for these infected apps, according to a recent 9to5Mac story.

PROTECT THEMSELVES

I. According to Lookout's investigation, "a national government organisation is probably behind the effort" in Kazakhstan.
II. Google added that it **had located and informed all Android victims in Kazakhstan and Italy.**
III. Additionally, it claimed that all Firebase projects used to command and control the campaign had been **disabled and that Google Play Protect had undergone adjustments.**

IV. Lookout claims to have o**bserved this being used in Syria.** Documents in Italy revealed that it had be**en abused during an anti-corruption operation.**

V. Mobile gadgets are the ideal targe**t for monitoring, in their opinion**. Users should continue **to adhere to fundamental guidelines even though not everyone will be targeted.**

VI. This includes keeping **your phones up to date frequently because each upd**ate contains a fix for **either known or unknown vulnerabilities.**

VII. Once more, people should refrain from clicking **on unexpected link**s, even if **they are curious about them.**

VIII. **I**t is also advised that u**sers review the apps** on their device on a regular basis to see if anything new has been installed.

IX. The use of **surveillance tools by the governme**nt is also strongly condemned in Google's blog post, w**hich notes that these tools are frequently** "used by governments for purposes antithetical to democratic values: targeting dissidents, journalists, human rights workers, and opposition party politicians."

1. Computer viruses

- Viruses are a sort of malware that are frequently introduced by victims into an application, programme, or system in the form of a piece of code.

2. Worm malware

I. Worms are a kind of malware that self-replicates, much like malware viruses do.

II. However, unlike viruses, worm malware may replicate itself without the assistance of a human and is not host-dependent, therefore it is not required to attach to a piece of software in order to harm it.

III. Software flaws can be the source of worm transmission.

IV. They may also be downloaded from portable media, sent as attachments via emails or direct conversations, or both. When these files are opened, they could connect to a malicious website or launch the computer worm automatically.

3. Trojan viruses

I. Trojans are a sort of malware that impersonates legitimate programmes, files, or software in order to trick users into downloading it and unwittingly handing over control of their devices.

II. A trojan can carry out its intended function once it has been installed, whether it be to hurt, interfere with, steal from, or cause another type of harm to your data or network.

III. Frequently, internet downloads, direct messages, and email attachments are used to propagate Trojan virus.

4. Ransomware

- As the name suggests, ransomware is a category of virus that demands payment in exchange for use. It seizes control of a victim's device or data, locks it up, and encrypts it.

5. Botnets or bots

- A piece of harmful coding is used by botnets, a sort of malware, to access machines. Botnets can sometimes be used to directly hack into devices, allowing thieves to even take remote control of them.

6. Adware and malware

- Adware is malware that includes advertising, as the name suggests. Adware, also referred to as

advertising-supported software, displays unwanted advertisements on your computer and may even display pop-up advertisements that monitor users' online activity.This is occasionally done for marketing objectives. Adware can go bad when it collects your data with the intention of selling it to third parties, using it for identity theft, or abusing your credit card.

7. Spyware

- Malware that sneaks onto devices without the owner's awareness is known as spyware. This is frequently done to monitor online activity, track login and password information, or gather private information that might be used fraudulently.

8. Rootkits

- Rootkits are a kind of malware that gives hackers remote access to their victims' devices, frequently without their knowledge. Rootkits can hijack or circumvent security software because they are made to be hidden, which increases the likelihood that they will stay on your computer for a long time and cause serious harm.

9. Fileless malware

- Malware classified as "fileless" leverages native or built-in software, programmes, and protocols on devices to install and carry out destructive actions. In other words, this kind of malware is fileless, as downloading any files is not required. Malware that doesn't use files is memory-based.

10. Malvertising

- Malvertising, a subset of malware that originates from advertisements on trustworthy websites, should not be confused with adware. However, adware is a form of malware that is pre-installed on a system. Both attacks wreak havoc through online advertising.

- 'Hermit' is the latest sophisticated spyware in the news, and it is believed to have targeted iPhones and Android devices in Italy and Kazakhstan.
- Hermit's deployment – the spyware has been developed by an **Italian vendor called RCS Lab** – was first reported by cyber security researchers at the Lookout, a San-Francisco-based cybersecurity firm.

Hermit

- **Hermit is a spyware** on the lines of Pegasus by NSO Group. Once installed on a device, it can record audio on the device, carry out unauthorised calls, and carry out many unauthorised activities.
- The spyware can steal stored account emails, contacts, browser bookmarks/searches, calendar events, etc.
- It can also take pictures on the device, steal device information such as details about applications, the kernel information, model, manufacturer, OS, security patch, phone number, etc.
- It can also download and install APK (the app software files on Android) on a compromised phone.
- The spyware can also upload files from the device, read notifications, and take pictures of the screen.
- Because it can gain access to the root or the 'privilege' access of an Android system, Lookout's research showed, it can uninstall apps like Telegram and WhatsApp.

- ❖ According to the researchers, the spyware can silently uninstall/reinstall Telegram.
- ❖ Except the reinstalled version is likely a compromised one. It can also steal data from the old app.
- ❖ For WhatsApp, it can prompt the user to reinstall WhatsApp via Play Store.
- ❖ So, once Hermit has been deployed to a phone, it can control and track data from all key applications.

HERMIT GET DEPLOYED ON ANDROID AND IOS DEVICES

I. Sophisticated spyware such as Hermit and Pegasus cost millions of dollars in licensing fees, and these are not simple operations.
II. It's not like common malware targeting regular users.
III. And in the case of Hermit, it appears the operations used were complex.
IV. According to Google's TAG team, all campaigns started with a unique link sent to the victim's phone.
V. When the user clicked, the page installed the application on both Android and iOS.

SPYWARE OTHER SIMILAR TYPES OF CYBER ATTACKS

- ➢ Malware is short for malicious software and it is a catch-all term for various malicious software, including viruses, adware, spyware, browser hijacking software, and fake security software.
- ➢ Ransomware, Spyware, Worms, viruses, and Trojans are all varieties of malware.

TYPES OF MALWARE

I. **Viruses** which are the most commonly-known form of malware and potentially the most destructive. They can do anything from erasing the data on your computer to hijacking your computer to attack other systems, send spam, or host and share illegal content.
II. **Worm** is a type of malware that spreads copies of itself from computer to computer which can replicate itself without any human interaction, and it does not need to attach itself to a software program in order to cause damage.
III. **Trojan** is a type of malware that is often disguised as legitimate software which can be employed by cyber-thieves and hackers trying to gain access to users' systems.
IV. **Spyware** collects your personal information and passes it on to interested third parties without your knowledge or consent. Spyware is also known for installing Trojan viruses.
V. **Ransomware** is malware that employs encryption to hold a victim's information at ransom.
VI. **Adware** displays pop-up advertisements when you are online.
VII. **Fake security software** poses as legitimate software to trick you into opening your system to further infection, providing personal information, or paying for unnecessary or even damaging "clean ups".
VIII. **Browser hijacking software** changes your browser settings (such as your home page and toolbars), displays pop-up ads and creates new desktop shortcuts. It can also relay your personal preferences to interested third parties.

FRONTIER DETHRONES FUGAKU AS THE WORLD'S FASTEST SUPERCOMPUTER

A. The supercomputer, built for the U.S. Department of Energy's Oak Ridge National Laboratory, has reached Linmark benchmark score of 1.1 exaflops.

B. In 2020, Fugaku, a supercomputer jointly developed by RIKEN and Fujitsu Ltd., topped the supercomputer benchmarking index. Two years later, the Japanese machine was dethroned by another built in the West.

FUGAKU SUPERCOMPUTER

- The world's most powerful supercomputer **Fugaku** is fully developed in Japan. This marks the end of a seven-years long development procedure for Fugaku, which started developing in 2014 in collaboration with Fujitsu.

Fugaku

A. The computer has 100 times the application performance of the K supercomputer and is developed to implement high-resolution, long-duration and large-scale simulations.
B. Fugaku has topped the Top500 list, a supercomputer benchmark index, for two consecutive years.
C. A portion of Fugaku's research is said to be dedicated to COVID-19 related projects.
D. It aims to make the device core of Japan's computing infrastructure.
E. It will help in building a long-lived and healthy society.

SUPERCOMPUTER

A. The supercomputer is a computer with a high-level computational capacity compared to a general-purpose computer.
B. The performance of a supercomputer is measured in floating-point operations per second (FLOPS) instead of million instructions per second (MIPS).
C. They are expensive and are employed for specialized applications that require immense amounts of mathematical calculations (number crunching).
1. For example, weather forecasting requires a supercomputer.
2. Other uses of supercomputers scientific simulations, (animated) graphics, fluid dynamic calculations, nuclear energy research, electronic design, and analysis of geological data (e.g. in petrochemical prospecting).
3. Japanese supercomputer Fugaku (442 petaflops) and IBM's Summit (148.8 petaflops) are the two most powerful supercomputers in the world.

SUPERCOMPUTER IN INDIA

- **Mihir**: Mihir (146th on the list), clubs with Pratyush to generate enough computing power to match PARAM-Siddhi.
- **PARAM-Siddh**i: It is the second Indian supercomputer to be entered in the top 100 on the Top500 list.
- The supercomputer was established earlier this year, under the National Supercomputer Mission (NSM) and is going to be installed in the Centre for Development of Advanced Computing's (C-DAC) unit.
- **Pratyush:** It is a supercomputer used for weather forecasting at the Indian Institute of Tropical Meteorology, ranked 78th on the November edition of the list.

APPLICATION OF SUPERCOMPUTING

1. Weather Forecasting
2. Scientific Research
3. Data Mining

Challenges of Supercomputing in India

1. Lack of Research & Development in India.
2. Lack of Funding.
3. Limited manufacturing of electronics used in Supercomputing missions.

NATIONAL SUPERCOMPUTING MISSION (NSM)

1. The mission would be implemented jointly by the Department of Science and Technology (DST) and Department of Electronics and Information Technology (DeitY) through two organizations the Centre for Development of Advanced Computing (C-DAC) and the Indian Institute of Science (IISc), Bangalore.
2. It was launched in 2015.
3. **Objective**- To make India one of the world leaders in Supercomputing and to enhance India's capability in solving grand challenge problems of national and global relevance.
4. To attain global competitiveness and ensure self-reliance in the strategic area of supercomputing technology.

C-DAC

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

The world's most powerful supercomputer Fugaku is now fully developed in Japan, and the machine is available for research use.

1) Fugaku is fully open and available for shared use, Japan's Research Organization for Information Science and Technology (RIST) has selected 74 projects that will use the supercomputer in FY2021.
   • Fugaku is a key national technology,
   • Objective is to achieve research results that will help build a long-lived and healthy society, disaster mitigation, and better energy use, with the ultimate goal to establish the government's vision of an ultra-smart Society 5.0.
   • Fugaku has topped the Top500 list, a supercomputer benchmark index, for two consecutive years.
   • The computer has 100 times the application performance of K supercomputer and is developed to implement high-resolution, long-duration and large-scale simulations.
   • A portion of Fugaku's research is said to be dedicated to COVID-19 related projects.
   • The initiative by the Japanese government aims to make a society where all people live safe and comfortable lives.

INTERNET OF THINGS (IOT)

- The Internet of Things (IoT) can become a game changer that India needs as this concept is set to disrupt almost every sector in India from smart cities and telecom to manufacturing and mobility.
- The rapid development in the IoT leads to the starting of the next digital revolution. However, the Internet of Things throws up many challenges like data safety and privacy.

- ❖ So India needs to push ahead with this concept to kick-start the radical development process with the proper regulatory framework in place to govern IoT.

INTERNET OF THINGS (IOT)

- ➢ Internet of Things is the inter-linking of digital devices, machines, people and other objects with each other through wireless networks.
- ➢ It enables anything and everything to connect and communicate with each other.
- ➢ It is the future internet. Because the first version of the INTERNET was about data created by the internet. The next version is about the data created by things.

WORK

1. Anything that can be connected, will be connected in IoT.
2. Any device that has on/off switch can be a part of the IoT.
3. Most often the connected devices will have an I.P address. With Internet Protocol Version 6 (IPv6), allocating IP addresses to billions of devices has never been so much easier.
4. Examples of things which can be connected to the internet include

- ➢ Connected wearables – Smart glasses, Smartwatches, fitness bands etc.
- ➢ Connected Homes – linking household appliances to the network.
- ➢ Connected cars – Vehicles that are connected to the internet.
- ➢ Connected cities – Connected traffic signals, Smart metres which analyse usage of water, gas, electricity etc, Smart bins which give signals when they need to be emptied etc.

Different networks shall be connected to each other to provide inter-connectivity between different things. For example,

1. BAN (Body Area Network): Wearables.
2. LAN (Local Area Network): Smart home.
3. WAN (Wide Area Network): Connected car.
4. VWAN (Very wide area network): Smart city.

INTERNET OF THINGS (IOT)

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- ➢ However, the Internet of Things throws up many challenges like data safety and privacy.
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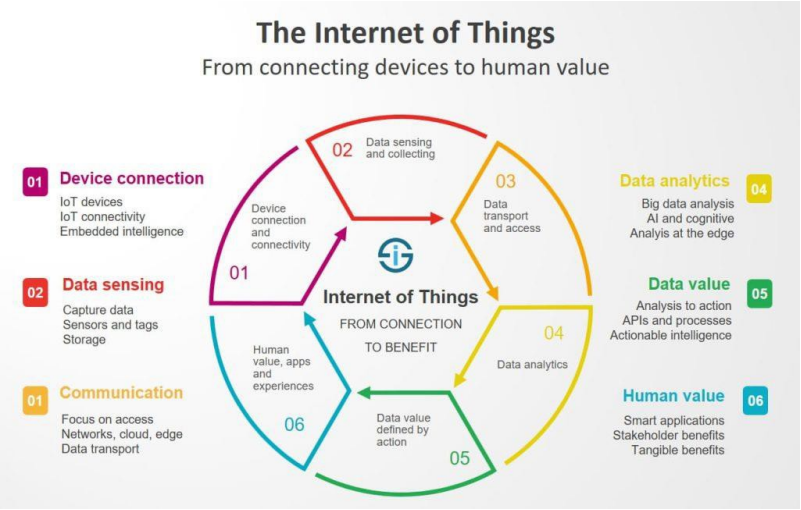

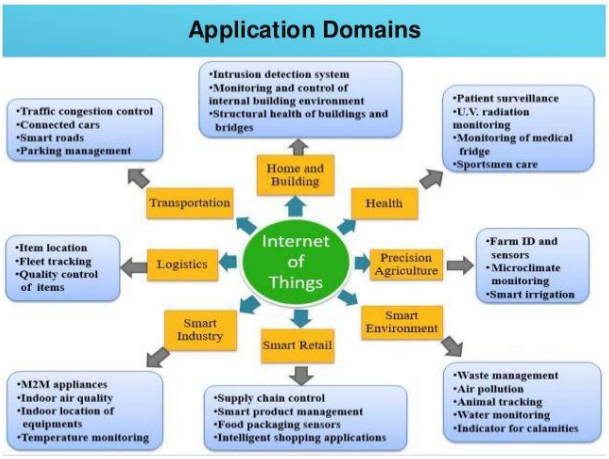

INTERNET OF THINGS

1. IoT is the network of devices, vehicles, and home appliances that contain electronics, software, actuators, and connectivity which allows these things to connect, interact and exchange data.
2. IoT involves extending Internet connectivity beyond standard devices, such as desktops, laptops, smartphones, and tablets to everyday objects.
3. These objects may be anything from cell phones, coffee makers, washing machines, headphones, lamps, wearable devices.
4. It can also be components of machines, for example, a jet engine of an airplane or the drill of an oil rig.
5. Embedded with technology, these devices can communicate and interact over the Internet, and they can be remotely monitored and controlled.
6. Thus, it is all about connecting devices over the internet and letting them 'talk' to us, applications, and each other.
7. However, the Internet of Things doesn't necessarily have to be connected to the internet; it can also be a network of things.

ADVANTAGES OF IOT

1. **Monitor Data:** It helps us know the precise quantity of supplies or the air quality in home, it can also provide more data that could not have previously been possible to collect easily. For instance, monitoring the expiration of products will improve safety.
2. **Ease of Access:** Right now, one can easily gain the required information in real-time, from almost any location. It only takes a smart device and an internet connection. Example using Google Maps to see our location, instead of asking a person in real life.
3. **Speedy Operation:** All this data pouring in enables us to complete multiple tasks with amazing speed. For example, IoT makes automation effortless. Smart industries automate repetitive tasks, thus allowing employees to invest their time and effort into more challenging things.
4. **Adapting to New Standards:** As IoT is an ever-changing topic, its changes are minimal compared to the other techs of the high-tech world. Without IoT, it would be complicated for us to keep track of all the latest things.
5. **Better Time Management:** IoT is a clever time-saving tool. We can look up the latest news on our phones during our daily commute, or check a blog about our favourite pastime,

purchase an item in an online shop, we can do almost all the things from the palm of our hands.

6. **Automation and Control:** Without human interference, the machines are communicating with each other providing faster and timely output.
7. **Saving Money:** Another main advantage of IoT is saving money. If the cost of the tagging and monitoring machines are less compared with the amount of money saved, this is the reason for the Internet of Things being very widely adopted.
8. Allowing the data to be communicated and shared between devices and then translating it into our required way, makes our systems efficient.

APPLICATIONS OF INTERNET OF THINGS

(1) Daily Lives

1. There can be several IoT examples in our day-to-day lives.
2. For instance, a person returning home after his office hours can call his coffee-maker to make the coffee ready when he reaches home.
3. IoT can be used to water the plants of the garden whenever the moisture level falls below a certain limit.
4. We can utilize IoT to convert a normal home into a smart home. It can be used in energy efficiency in homes and office places.

(2) Industry

1. IoT's effects may vary from industry to industry based on its utilization.
2. In the manufacturing sector, IoT can be utilized to enhance performance, minimize human-induced errors and consequently improve the overall quality of the manufactured products.
3. In the IT sector, utilization of IoT can result in improvement in services, development of more advanced software and digital services, etc.

(3) Agriculture

1. IoT can be utilized to collect data about rainfall, soil moisture, soil nutrients, pest infestation, etc.
2. It can assist in making informed decisions to increase agricultural production as well as reducing the risks of crop failures etc.
3. It can help make agriculture profitable with better price-discovery for farmers through smart techniques.

(4) Healthcare

1. Medical practitioners and doctors can use IoT to remotely monitor the patient's health.
2. Smart beds can detect when the patient is trying to get up, his abnormal activities, etc.
3. Specialized sensors for senior citizens can be developed with the help of IoT.
4. Wearable heart monitors can help monitor the heartbeats, blood pressure of patients, etc.
5. It can revolutionize telemedicine applications.

(5) Media

- Corporate media houses can utilize IoT to monitor consumer habits for the purpose of behavior targeting = display consumer-specific advertisements. They can utilize Big Data and Data Mining for this purpose.

(6) Transportation

1. IoT can be used in driverless cars and improve intra-vehicular communication to reduce accidents and traffic jams etc.
2. We can use it for electronic toll collections, smart parking, smart traffic management, etc.
3. IoT can be useful in logistics, fleet management, safety assistance, etc.

(7) Smart cities

1. IoT can be utilized in solid waste management systems to improve the cleanliness of the city.
2. Smart meters and power grids can improve energy efficiency and reduce transmission loss.
3. IoT can be used to track the air pollution levels in the cities and give a warning when it breaches the prescribed safety levels.
4. IoT can also be used to develop smart transportation systems to minimize congestion in the cities.

(8) Smart Retail

1. IoT provides an opportunity to retailers to connect with the customers to enhance the in-store experience. Interacting through Smartphones and using Beacon technology can help retailers serve their consumers better.
2. They can also track consumers' paths through a store and improve store layout and place premium products in high traffic areas.

(9) Energy Engagement

1. Power grids of the future will not only be smart enough but also highly reliable.
2. The basic idea behind the smart grids is to collect data in an automated fashion and analyze the behavior or electricity consumers and suppliers for improving efficiency as well as the economics of electricity use.
3. Smart Grids will also be able to detect sources of power outages more quickly and at individual household levels like a nearby solar panels, making possible distributed energy systems.

CASE WITH INDIA

1. IoT is the natural evolution of the internet and has many benefits including boosting global economies, improving public utilities, and increasing efficiencies.
2. Many of our global counterparts have already begun reaping the rewards of investing in IoT-based infrastructure.
3. The Indian government outlined a plan to leverage IoT as part of the Digital India mission.
4. The Indian IoT market is expected to reach $15 billion by 2020 and constitute 5% of the global market.
5. Investing in IoT will boost our economy on par with global leaders and it will also bring in investments, create jobs and improve Indian public infrastructure

MEASURES TAKEN BY THE GOVERNMENT TO PROMOTE IOT

1. The central government launched a plan to utilize IoT as part of the **Digital India mission**.
2. The government came up with the **National Digital Communications Policy 2018** to satisfy the modern realities of the telecom such as 5G technology, IoT, Machine to Machine (M2M) communication, etc.
3. The government also allowed 100% FDI in the telecom sector. This will help in the development and growth of the IoT.

4. Department of Electronics and Information Technology (DeITY) has published a draft policy for IoT. The target is to establish an IoT market of USD 15 billion by 2020 and having a share of 5-6% in the global IoT industry.

CHALLENGES WITH THE IOT

1. **Data Breach:** Having access to data is excellent. Unfortunately, our personal data is more exposed.
2. **Dependence on Technology:** IoT is mainly dependent on the internet connection. When there is none, it can't be used.
3. **Complexity in Operation:** IoT may seem to be managing tasks with ease, a lot of complex operations are done behind it. If by mistake the software makes a wrong calculation, this will affect the rest of the process.
4. **Our Safety:** As all the household appliances, industrial machinery, public sector services and many other devices all are connected to the Internet, a lot of information is available on it. This information is prone to attack by hackers. It would be very disastrous if private and confidential information is accessed by unauthorized intruders.
5. **Inter Compatibility:** As devices from various manufacturers will be interconnected to each other, the issue of compatibility in tagging and monitoring increases. This disadvantage can be overcome if manufacturers make a common standard, but there is still a possibility that the technical problems may still persist.
6. **Lesser Employment of Menial Staff:** The uneducated workers and helpers may lose their jobs as an effect of automation of daily activities. This can lead to unemployment in the society.
7. **Technology Takes Control of Life:** Our lives are increasingly controlled by technology and will be dependent on it. The younger generation is already addicted to technology for every little work to be done.

IoT impacting the digital transformation of education

1. **Tracking movement:** Integrated systems of IoT, which automatically transmit information about the child boarding the bus, the bus reaching the school, and the child entering the school premises, can be available to both parents and teachers via an app and automated messages.
2. **Attendance system:** Teachers and faculty members need not waste time on roll call. Instead, the student's identity card automatically communicates with the sensors in the classroom and marks attendance.
3. **Automatic sharing:** Taking notes and marking critical points is an integral part of a student's class activity. But, with IoT, all the contents on the black/whiteboard is automatically converted into a portable document and shared over email.
4. **Session capture:** An IoT environment automatically captures a classroom session (audio and video) and puts it on a shareable drive. This can be accessed by those students who missed the class. This way learning becomes both inclusive and accessible.
5. **Ensuring security:** With **COVID-19** still doing the rounds, an **IoT-**based system integrated with **CCTVs** can scan the campus and spot people who are not wearing masks. The coordinates can be sent as an SMS and an email to the administrative authority for further action.
6. **Read and translate:** IoT can also be used to quickly scan editable text from books, papers, and other documents directly into a phone, tablet or computer and translate into more than 40 languages.

APPLICATIONS OF THE INTERNET OF THINGS

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STATUS OF IOT IN INDIA

1. Many countries have already begun reaping the rewards of investing in IoT based infrastructure.
2. Indian IoT market is expected to reach $15 billion by 2020 and accounts for 5% of the global market.
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CHALLENGES OR CONCERNS WITH THE IOT

Job losses

- The IoT application in industries can cause loss of skilled and semi-skilled jobs in manufacturing as well as service sectors.
- There can be considerable unemployment issues with automation in the automobile manufacturing units.

SAFETY –PRIVACY ISSUES :-

1. Internet of Things (IoT) involves Data Mining, use of big data etc. which causes concern over the safety and privacy of citizens.
2. Sharing and selling of personal data without consent by IT and internet companies has become a major issue.
3. There are also concerns over the potential for increased government surveillance and the consequent encroachment of civil rights to suppress dissent or marginalise communities.
4. Furthermore, ransomware attacks and hacking of bank accounts are also causing a big safety issue.
5. These issues may further increase due to the faster growth of IoT.

SOLUTIONS

1. We need to skill our labour force to address the challenges arising due to IoT.
2. Skill India mission can provide the platform for their skill development.
3. At the same time, there is a need to create new job opportunities in other sectors to absorb the extra labour force.

On Safety & Privacy issues

1. We need to have the Data Privacy Legislation and policy frameworks to address these issues. The draft personal data protection bill 2018 as recommended by BN Srikrishna Committee may help in this regard and hence should be enacted as soon as possible.
2. Many regulations across the world need IoT companies to collect user consent before collecting the said data. India also needs to implement such regulations.
3. Also, there is a need to improve the firewalls, develop software to address the issues caused by the growth of IoT.
4. We need to promote awareness and best practices among the users in order to minimise the associated risks pertaining to IoT.
5. Moreover, we need to improve the cyber policing by employing and skilling the professionals to deal with these issues. Dedicated cyber specialist personnel can be created in our policing system for this purpose.

Updates

Narrowband (NB)-IoT technology

- The Internet of things (IoT) has brought enormous benefits to rural villages and agriculture in India. However, there are hurdles in connectivity and infrastructure. Satellite-based networks can reduce the connectivity gap in remote areas but can be costly due to the equipment needed by both consumers and producers. Narrowband (NB)-IoT technology may help reduce the gap between remote areas and the benefits of Internet connectivity. As its name implies, NB-IoT utilizes a single, narrowband frequency (200 kilohertz), that reduces transmission rates yet enables several users to concurrently connect over an extensive area. The technology is low-cost for users and works on nearly any mobile phone.

WAY FORWARD

1. **IoT** makes life easier at the cost of privacy and hence **Data Protection Bill** can do a lot well in ensuring the privacy of an individual.
2. Policy-makers, regulators, device manufacturers, supporting industries, and service providers will all have to join hands in creating a safer space online.
3. In India, the NDCP (National Digital Communications Policy) brought alignment from critical stakeholders to advance India's infrastructure and security around digital communications.
4. The draft IoT policy seeks to establish committees to govern and drive IoT-specific initiatives. It is not yet clear how much access to personal data these committees get and how their actions will be monitored.
5. The Justice Srikrishna Committee had recommended some provisions for personal data protection including a consumer's right to information, consent, and right to request companies to erase their data if preferred.

NET NEUTRALITY IN INDIA

1. Directives on Net Neutrality incorporating the principles of non-discriminatory treatment of content were issued by Department of Telecommunications (DoT) in July 2018.
2. Subsequently, DoT amended the Unified License for Telecom Service Providers (TSPs) and Unified License (Virtual Network Operators) and Unified Access Service License Agreement to incorporate the principles of non-discriminatory treatment of content in Sept. 2018 and issued an amendment in Internet Service Provider license for Regulatory Framework on "Net Neutrality" in May 2019.
3. DoT sent a reference to Telecom Regulatory Authority of India (TRAI) on 31.07.2018 seeking TRAI's recommendations on 'Traffic Management Practices (TMPs) and Multi-Stakeholder

Body for Net Neutrality'. TRAI provided its recommendation on the subject on 22.09.2020. The recommendations of TRAI are under examination.

4. Technical audit of Internet Service Providers which includes technical information about the network, upstream and downstream bandwidth, tariff plans etc., is being done annually.
5. This information was given by the Minister of State for Communications, Shri Devusinh Chauhan in a written reply to a question in Rajya Sabha today.

- In December 2015, social media giant, Facebook launched 'Free Basics' (earlier known as internet.org) while Indian telecom giant Airtel launched 'Airtel Zero'.
- Both 'Free Basics' and 'Airtel Zero' let users access certain apps and websites for free (they were just charged for the data used). However, both the companies decided to charge or subsidize other companies that wanted to be a part of the 'Free Basics' or 'Airtel Zero' program.
- Facebook and Airtel's arguments were that they were trying to make the internet more accessible to people, especially the ones that could not afford high data charges.
- In 2016, TRAI banned both the projects as it went against the very principles of net neutrality since the companies could inevitably favor some content over the others.

NET NEUTRALITY

1. The Oxford dictionary defines net neutrality as 'the principle that Internet service providers should enable access to all content and applications regardless of the source, and without favoring or blocking particular products or websites.
2. This means when a customer pays an internet service provider or ISP for a data plan, he/she should be able to access all content online – news, social media, videos, games etc – at the same broadband speed which he had opted for.

ZERO-RATING PLATFORM

1. Zero-rating platforms (ZRP) offer free access to a limited number of sites through select telecom providers.
2. Those who wanted unrestricted access to the entire internet would still have to pay, but the poor would have access to a few useful sites offered by them.
3. Facebook's Free Basics is an example.
4. The TRAI last year ruled to end the Free Basics in India.

ZRP necessary to increase access

1. India has been closing the "internet gap" at a rapid rate well before Free Basics. Over 70%t of Indians have mobile phones, and the numbers are rising faster in India than anywhere else in the world.
2. Funds collected by government from telecoms companies under its Universal Service Obligation Fund (USOF) and TRAI's move to raise more through its licence fee for ISP can be used to subsidise Internet access for the poor. It can include all government sites, essential health information and so on and it can truly achieve free basics.

ZRPs detrimental

1. It essentially creates a **two-tier system** with a fast and a slow lane.
2. The free content will be on the slow lane where the download speed will be low.
3. Those with resources to promote their content will be on the paid fast lane with high download speed.

4. This effectively **erodes the concept of level playing field**, as new comers will no longer be able to compete with the already established tech giants.
5. This is also detrimental from the consumer point of view as their **usage pattern will be controlled** by the telecom companies.

SELF-REGULATION A SOLUTION

1. All telecom operators openly support the idea of net neutrality.
2. Therefore they argue that internet services should be under a self-regulatory mechanism for adhering to core principles of neutrality.
3. But there is a risk of some operators indulging in discriminatory practices such as blocking of particular content or tweaking speeds for access to particular services.
4. Most consumers in India, being first time users, would not even realise that their network has been gamed to favour a particular content provider.
5. So an intervention is needed in favour of net neutrality.

AK BHARGAVA COMMITTEE

- Committee recommended for adherence of the core principles of Net Neutrality, it also suggested few exceptions in the interests of national security and businesses.

HIGHLIGHTS OF REPORT

1. Legitimate traffic management practices may be allowed but should be tested against the core principles of Net Neutrality. Further, Improper (Paid or otherwise) Prioritization may not be permitted.
2. India specific Net Neutrality approach should be formulated by taking into account ***international best practices*** that serve specific needs of the country.
3. The primary goals of public policy in the context of Net Neutrality should be directed towards achievement of ***developmental aims of the country*** by facilitating Affordable Broadband, Quality Broadband and Universal Broadband for its citizens.

- ***User rights on the Internet*** need to be ensured so that Telecom or Internet Service Providers do not restrict the ability of the user to send, receive, display, use, post any legal content, application or service on the Internet, or restrict any kind of lawful Internet activity or use.
- Over-the-top (OTT) application services should be actively encouraged and any impediments in their expansion and growth should be removed.
- In order to deal with the complexities of the new digital world, a **think-tank** with best talent may also be set up.

VIRTUAL PRIVATE NETWORKS (VPNS)

Recently, India's cyber security watchdog **CERT-In** issued new rules regarding virtual private networks (VPNs).

VPN

- **A VPN is a service** that **protects users online by preventing their IP address** from being tracked by websites, law enforcement agencies, cybercriminals and others.
- **Corporate employees are the most frequent VPN users**, mainly for securely accessing company networks.

DATA/ STATISTICS

- India has over 270 million VPN users, about 20% of the country's population.
- They use it to access company networks securely, remain anonymous, access geo-restricted content, stay safe on public Wi-Fi networks, and get around internet curbs, among other things.

new rules

- **Storing Data**: preserving a wide range of data on their customers, including their contact numbers, email IDs and IP addresses, for five years.
- It also **mandates VPN providers** to record and keep their customers' logs for **180 days.**
- **Reporting an incident**: Companies are also required to report cyber security incidents to CERT-In within six hours of becoming aware of them.
- **Application**: they would apply **only to individual VPN customers** and not to enterprise or corporate VPNs.
- They will be also applicable to **data centres, virtual private server (VPS) providers, cloud service providers, virtual asset service providers, virtual asset exchange providers, custodian wallet providers** and Government organisations.
- **Penalty**: Failure to follow the rules will attract penalties for VPN providers. If they all refuse to comply, VPN services will effectively become illegal in India.
- **KYC verification process**: Users apart from potentially having their privacy data exposed to the government will also face a stringent know-your-customer verification process when signing up for a VPN service, and will have to **state their reasons** for using it.

Implications of the new rules

- **VPN companies will be forced to switch to storage servers**: which will inflate their costs and eliminate their core function of user privacy.
- **Privacy concerns**: the rules have triggered privacy concerns, and many top VPN providers have threatened to leave the country if forced to comply.
- **Top VPN providers NordVPN and Netherlands-based Surfshark** have refused to comply with the government order so far, with Nord suggesting it might leave the country.
- **Damaging the IT sector's growth**: taking such radical action that highly impacts the privacy of millions of people in India will most likely be counterproductive and strongly damage the IT sector's growth in the country.
- **Breach of account**: It has raised the concern that collecting excessive amounts of data within Indian jurisdiction without robust protection mechanisms could lead to even more breaches.

VIRTUAL SERVER -ITS USES

Meaning: A virtual server is a **simulated server environment built** on an actual physical server.

a. It recreates the **functionality** of a dedicated physical server.
b. The virtual **twin functions** like a physical server that runs software.
c. It **uses resources** of the physical server.
d. **Multiple virtual servers can run** on a single physical server.

Uses

1. It helps **reallocate resources** for changing workloads.

2. Converting one physical server into multiple virtual servers allows organisations to **use processing power and resources more efficiently** by running multiple operating systems and applications on one partitioned server.
3. Running multiple operating systems and applications on a single physical machine **reduces the cost as it consumes less space, hardware**.
4. Virtual servers are also said to **offer higher security than a physical server** infrastructure as the operating system and applications are enclosed in a virtual machine.

Virtual servers are also **useful in testing and debugging applications** in different operating systems and versions without having to manually install and run them in several physical machines.

GLOBAL SCENARIO

a. Currently, a handful of governments **either regulate or outright ban VPNs**.
b. These include **China, Belarus, Iraq, North Korea, Oman, Russia, and the UAE**.
c. In China though **not all VPNs are officially banned** only government-approved VPNs are officially permitted to function.
d. Other countries have **internet censorship laws,** which make using a VPN risky.

Way forward/ Government's stand

I. **Not a breach of privacy**: CERT-In says that the right to informational privacy of individuals is not affected by these rules since the agency does not envisage seeking of information on a continuing basis and expects to do so only in case of cybersecurity incidents.
II. **Contractual obligation**: the obligation of reporting cyber security incidents to CERT-In overrides any contractual obligation of not disclosing any details with the customer.
III. **Corporate VPNs will remain unaffected**: The CERT-In mandate could render VPN services illegal in India if providers don't comply with it, but corporate VPNs will remain unaffected.
IV. **VPNs are also used by journalists, activists and whistleblowers** for their work.
V. **Tracking criminals**: the move would make it easier for the law enforcement agencies to track criminals who use VPNs to hide their internet footprint.

Indian Computer Emergency Response Team (CERT-In)

- **Operational:** CERT-In has been operational since January 2004.
- The **constituency** of CERT-In is the Indian Cyber Community.
- CERT-In is the **national nodal agency** for responding to computer security incidents as and when they occur.
- **Power:** CERT-In is empowered under **Section 70B of the Information Technology Act** to collect, analyse and disseminate information on cyber security incidents.
- It has been designated to serve as the national agency to perform the **following functions** in the area of cyber security:

a) Collection, analysis and dissemination of information on cyber incidents.
b) Forecast and alerts of cyber security incidents
c) Emergency measures for handling cyber security incidents
d) Coordination of cyber incident response activities.
e) Issue guidelines, advisories, vulnerability notes and whitepapers relating to information security practices, procedures, prevention, response and reporting of cyber incidents.

Such other functions relating to cyber security as may be prescribed.

ENERGY

CHUTKA NUCLEAR POWER PLANT

- The **Chutka Nuclear Power Plant** is a proposed nuclear power plant to be built on a 1,200 acres (490 ha) area, near Chutka Village of Mandla district of Madhya Pradesh. The site is near Kanha National Park, one of the tiger reserves of India and the largest national park of Madhya Pradesh state in India.The project will have an installed capacity of 1400 Megawatt.

RUSSIA'S ADVANCED FUEL OPTION FOR KKNPP

- Recently, the **Russian state-owned** NUCLEAR ENERGY corporation **Rosatom** has offered a more **Advanced Fuel Option** to India's **largest nuclear power station** at Kudankulam, Tamil Nadu.
- It will allow its **reactors to run for an extended two-year cycle** without stopping to load fresh fuel.

RUSSIA OFFER TO INDIA

Update to KKNPP Reactors:

a) Rosatom's nuclear fuel division, **TVEL Fuel Company,** is the current supplier of **TVS – 2 M fuel for the two VVER 1,000 MWe reactors,** generating power in the **Kudankulam Nuclear Power Project (KKNPP)**. This fuel has an 18-month fuel cycle, meaning that the reactor **has to be stopped for fresh fuel loading every one-and-a-half years.**

b) TVEL has now offered the more modern **Advanced Technology Fuel (ATF),** whose **fuel cycle is 24 months.**

Benefits of the Update:

- It will ensure **more efficiency, additional power generation** due to prolonged operation of the reactor and **sizable savings of the foreign exchange** needed to buy fresh fuel assemblies from Russia.

NUCLEAR ENERGY

- Nuclear energy comes from splitting atoms in a reactor to heat water into steam, turn a turbine and generate electricity.
- Inside nuclear power plants, nuclear reactors and their equipment contain and control the chain reactions, most commonly fueled by Uranium-235, to produce heat through fission.

Emissions from Nuclear Power Generation:

- Nuclear power is **zero-emission**. It has **no GHG** or air pollutants.

Land Usage:

- According to US government data, a 1,000-megawatt nuclear plant requires 360 times less land than a similar-capacity wind farm and 75 times less land than solar plants.

SIGNIFICANCE FOR INDIA:

Availability of Thorium:

- India is the leader of the new resource of nuclear fuel called Thorium, which is considered to be the nuclear fuel of the future.
- With the availability of Thorium, India has the potential to be the first nation to realise the dream of a fossil fuel-free nation.

Cuts Import Bills:

- Nuclear energy will also **relieve the nation of about $100 billion annually** which we spend on importing petroleum and coal.

Stable and Reliable Source:

1) The **greenest sources of power** are definitelySOLAR AND WIND
2) But solar and wind power, despite all their advantages, **are not stable** and are **dependent excessively on weather** and sunshine conditions.
3) Nuclear power, on the other hand, provides a relatively clean, high-density source of reliable energy with an international presence.

INDIA'S INITIATIVES REGARDING NUCLEAR ENERGY

- India has consciously proceeded to explore the possibility of tapping nuclear energy for the purpose of power generation.
- In this direction a 3-STAGE NPP was formulated by **Homi Bhabha in the 1950s.**
- **The Atomic Energy Act, 1962** was framed and implemented with the set objectives of using two naturally occurring elements URANIUM and **Thorium** as nuclear fuel in Indian Nuclear Power Reactors.
- In December, 2021, the Government of India informed PARLIAMENT about building ten indigenousPHWR to be set up in fleet mode and had granted **"in principle approval"** for 28 additional reactors, including 24 to be imported from France, the U.S. and Russia.
- In December, 2021, the Centre has given in-principle (first step) approval for setting up of 6NPR-JAITAPUR-MAHARASTRA

- The Jaitpur Project is a key component of the strategic partnership between India and France.
  - Jaitapur would be the world's most powerful nuclear power plant. There would be six state-of-the-art Evolutionary Power Reactors (EPRs) with an installed capacity of 9.6 GW that will produce low carbon electricity.
  - The six nuclear power reactors, which will have a capacity of 1,650 MW each, will be set up with technical cooperation from France.

NUCLEAR POWER PLANTS

Presently, India has **22 operating nuclear power reactors,** with an installed capacity of 6780 MegaWatt electric (MWe). Some major power plants are:

1) Tarapur Atomic Power Station (TAPS), in Maharashtra
2) Rajasthan Atomic Power Station (RAPS), in Rajasthan
3) Madras Atomic Power Station (MAPS), in Tamil Nadu
4) Kaiga Generating Station (KGS), in Karnataka
5) Kudankulam Nuclear Power Station (KKNPS), in Tamil Nadu
6) Narora Atomic Power Station (NAPS), in Uttar Pradesh
7) Kakrapar Atomic Power Station (KAPS), in Gujarat

Among these, 18 reactors are PHWR and 4 are Light Water Reactors (LWRs).

NUCLEAR POWER PLANTS IN INDIA

- Nuclear energy is an important component of the country's energy mix and is being pursued along with other sources of energy in an optimal manner. **It is a clean, environment-friendly baseload source of power available 24X7.** It also has huge potential which can ensure the long-term energy security of the country in a sustainable manner.
- **Nuclear Power is the fifth-largest source of generating electricity in India** after coal, gas, wind power, and hydroelectricity.
- **As of 2021, there are 22 reactors** with an installed capacity of 6780 MWe operating above 80% plant load factor in the country. Among these **eighteen reactors are Pressurised Heavy Water Reactors (PHWRs)** and **four are Light Water Reactors (LWRs).**
- The nuclear energy program in India was launched around the time of independence under the leadership of **Homi J. Bhabha**.
- **Asia's first nuclear reactor is the Apsara Research Reactor situated in Mumbai.** The domestic uranium reserve in India is small and the country is dependent on uranium imports from other countries to provide fuel to its nuclear power industry. Since the 1990s, Russia has been a major supplier of nuclear fuel to India.

NUCLEAR POWER PLANTS IN INDIA – OPERATIONAL

Name of Nuclear Power Station	Location	Operator
Kakrapar Atomic Power Station – 1993	Gujarat	NPCIL
(Kalpakkam) Madras Atomic Power Station – 1984	Tamil Nadu	NPCIL
Narora Atomic Power Station- 1991	Uttar Pradesh	NPCIL
Kaiga Nuclear Power Plant -2000	Karnataka	NPCIL
Rajasthan Atomic Power Station – 1973	Rajasthan	NPCIL
Tarapur Atomic Power Station – 1969	Maharashtra	NPCIL
Kudankulam Nuclear Power Plant – 2013	Tamil Nadu	NPCIL

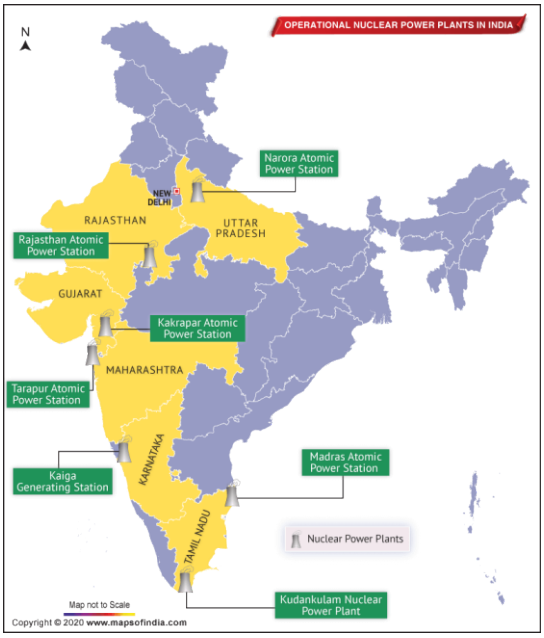
NUCLEAR POWER PLANTS IN INDIA – UNDER CONSTRUCTION

Name of Nuclear Power Station	Location	Operator
Madras (Kalpakkam)	Tamil Nadu	BHAVINI
Rajasthan Unit 7 and 8	Rajasthan	NPCIL
Kakrapar Unit 3 and 4	Gujarat	NPCIL
Kudankulam Unit 3 and 4	Tamil Nadu	NPCIL

NUCLEAR POWER PLANTS IN INDIA – PLANNED (FUTURE PROJECTS)

Name of Nuclear Power Station	Location
Tarapur	Maharashtra

Madras	Tamil Nadu
Kaiga	Karnataka
Chutka	Madhya Pradesh
Gorakhpur	Haryana
Bhimpur	Madhya Pradesh
Mahi Banswara	Rajasthan
Haripur	West Bengal
Mithi Virdi (Viradi)	Gujarat
Kovvada	Andhra Pradesh
Jaitapur	Maharashtra



Nuclear Power plants in Operation	Nuclear Power Plants under Construction	Planned Nuclear Power Plants
▪ Rawatbhata (Rajasthan) ▪ Tarapur (Maharashtra) ▪ Kudankulam (Tamil Nadu) ▪ Kakrapar (Gujarat) ▪ Kalpakkam (Tamil Nadu) ▪ Narora (Uttar Pradesh) ▪ Kaiga (Karnataka)	▪ Kakrapar 3&4 (Gujarat) ▪ Rawatbhata (Rajasthan) ▪ Kudankulam 3&4 (Tamil Nadu) ▪ Kalpakkam PFBR (Tamil Nadu)	▪ Jaitapur (Maharashtra) ▪ Kovvada (Andhra Pradesh) ▪ Mithi Virdi (Gujarat) ▪ Haripur (West Bengal) ▪ Gorakhpur (Haryana) ▪ Bhimpur (Madhya Pradesh) ▪ Mahi Banswara (Rajasthan) ▪ Kaiga (Karnataka) ▪ Chutka (Madhya Pradesh) ▪ Tarapur (Maharashtra)

KALPAKKAM:

1. Located 80 km south of Chennai on the Coromandel Coast
2. Known for MAPS and IGCAR
3. India's first fully indigenously constructed nuclear power station
4. Has two indigenously built CANDU type PHWRs called MAPS-1 and MAPS-2

KAIGA:

1. Nuclear power station located in the Uttar Kannada district in Karnataka
2. Has **four units** with one still under construction
3. All of the four are small-sized CANDU plants of 220 MW.

KAKRAPARA:

1. Located near Surat on the bank of the Tapi in Gujarat
2. It consists of **two** 220 MW PHWRs
3. There is also a plant for producing heavy water in the area
4. In January 2003 the CANDU Owners Group (COG) distinguished KAPS-1 as the worldwide best PHWR of its class.

RAWATBHATA:

1. Located on the bank of the Chambal River about 65 km from Kota, just 3 km from the Rana Pratap Sagar
2. RAPS is India's first pressurized water reactor of the CANDU type
3. Installed capacity of 6 reactors – 1190 MW.

TARAPUR:

1. Located in Maharashtra to the north of Mumbai
2. First nuclear reactor of India
3. With a total capacity of 1400 MW Tarapur is the largest nuclear power station in the country
4. First reactors were BWR which were the first of their kind in Asia.

NARORA:

1. Located in the Bulandshahar district of Uttar Pradesh on the bank of the Ganga
2. Its twin reactors are Indianised version of the Canadian CANDU type which operate on natural uranium as fuel and heavy water as the moderator cum primary coolant.

KUDANKULAM:

1. Located in the Tirunelveli district of TN
2. Under construction with the Russian assistance
3. Two 1000 MW reactors of the VVER- 1000 model are being constructed
4. Both are water-cooled water-moderated power reactors
5. When completed they will become the largest nuclear power generation complex of India

CHHAVAMITHI VIRDI:

A proposed new nuclear site to be located in Gujarat near Alang Port

It will be established with the help of the USA.

KOVVADA:

1. Proposed 2000 MW nuclear plant in Ranasthalam Mandal in the Srikakulam district of AP
2. It will be established with assistance from the USA
3. The Ministry of Environment and Forest has refused to give it the environmental clearance.

HARIPUR:

1. A coastal village of East Medinipur district of West Bengal
2. It will be established with the Russian assistance
3. Proposed Capacity – 10,000 MW
4. People are protesting against the reactor.

JAITAPUR:

1. Located in Maharashtra
2. It is proposed to construct 6 European Pressurized Reactors designed and developed by Areva of France
3. Each reactor will be of 1650 MW totaling 9900 MW
4. Controversial as it comes under the Zone- V (earthquake)

HYBRID ELECTRIC VEHICLE

In recent months, various automakers have launched hybrid electric vehicles in India.

HYBRID ELECTRIC VEHICLE (HEV)

- A HEV uses an internal combustion engine (ICE) (a petrol/diesel engine) and one or more electric motors to run.
- It is powered by the **electric motor** alone, which uses energy stored in batteries, by the ICE, or both.

Components:

- a low-voltage auxiliary battery,
- a traction battery pack to store electricity for the electric motor,
- an electric generator,
- an AC/DC converter,
- a power electronics controller,
- a thermal system to maintain working temperature,
- a conventional ICE,
- a fuel tank, a fuel filler,
- a transmission and an exhaust system.

Working:

1. HEV powertrains are designed to power cars in a **series, parallel or series-parallel (power split)** methods.
2. A **series HEV** uses only the electric motor to drive the wheels, while the ICE powers the generator, which in turn recharges the battery.
3. A **parallel HEV**, based on the driving condition, uses the best power source to power the vehicle. It will alternate between the electric motor and the ICE to keep the car moving.
4. A **series-parallel HEV** offers a combination of both models and allows split power, wherein power is routed from the ICE alone or from the battery to the electric motor to drive the vehicle.
5. In all three designs, the battery is charged through **regenerative braking technology**.

DIFFERENT TYPES OF HEVS

Micro HEV:

- These do not offer electric torque assistance as they lack an electric motor, but they have an **idle stop-start system** and energy management functions.

Mild HEV:

- A mild HEV cannot drive using only the electric motor

- Uses the **battery** at traffic lights or in stop-and-go traffic **to support the ICE**.
- Employ regenerative braking and some level of power assist to the ICE

Full HEV:

- A full HEV will have a **larger battery** and a more powerful electric motor compared with a mild HEV.
- As a result, a full HEV can power the vehicle for **longer distances** using just electric mode.
- Full HEVs offer **better fuel economy** compared with the other two types of HEVs but they also **cost more** than them.

Plug-in hybrid electric vehicles (PHEVs)

- These are just like full HEVs, but they can be charged using a **wall outlet**, as they have an onboard charger and a charging port.
- PHEVs **generally use the electric motor** until the battery is almost drained, and then automatically switch to the ICE.
- PHEVs accounted for about **23% of 1.95 million global EV** shipments in the first quarter of 2022.

Strong-hybrid electric vehicles (SHEVs):

- SHEVs use RBS for **self-charging** the HEVs.
- As per a study by iCAT, a government testing agency, SHEVs can run 40% of the distance and 60% of the time as an EV with the petrol engine shut off.

Regenerative Braking System (RBS)

Based on the type of RBS, the **energy recovery** happens in multiple ways.

1. A **kinetic system** can recover the energy lost during braking and then use this energy to recharge the high-voltage battery of the vehicle.
2. An **electric system** generates electricity through a motor during sudden braking.
3. A **hydraulic system** uses pressurised tanks to store the vehicle's kinetic energy and can offer a high energy recovery rate which is ideal for heavy vehicles.

Advantages in Automotive Applications:

A. Better braking efficiency in stop-and-go traffic which enhances fuel economy;
B. Aids in **reducing carbon emissions**;
C. the **extended range** of batteries; and
D. Helps in energy optimisation resulting in **minimum energy wastage**.

- While RBS are already available in most EVs, the technology is also used in **electric railways**.
- In recent months, **automakers have launched hybrid electric vehicles in India**, offering car buyers more choices in the nascent electric vehicle market.
- These new hybrid electric vehicles from different automakers, are relying on hybrid technology and its advantages over conventional internal combustion engine (ICE)-powered vehicles to change car buyers' minds.

HYBRID ELECTRIC VEHICLE

A. A hybrid electric vehicle (HEV) uses an ICE (a petrol/diesel engine) and one or more electric motors to run.

B. It is powered by the electric motor alone, which uses energy stored in batteries, by the ICE, or both.
C. The powertrain of the HEV is more complex than a regular ICE-powered car as it has EV components and a conventional ICE.
D. That means a typical HEV will have a low-voltage auxiliary battery, a traction battery pack to store electricity for the electric motor, an electric generator, an AC/DC converter, a power electronics controller, a thermal system to maintain working temperature, an ICE, a fuel tank, fuel filler, a transmission and an exhaust system.

HEV powertrains work

A. HEV powertrains are designed to power cars in a series, parallel or series-parallel (power split) methods.
B. A series HEV uses only the electric motor to drive the wheels, while the ICE powers the generator, which in turn recharges the battery.
C. A parallel HEV, based on the driving condition, uses the best power source to power the vehicle. It will alternate between the electric motor and the ICE to keep the car moving.
D. A series-parallel HEV offers a combination of both models and allows to split power, wherein power is routed from the ICE alone or from the battery to the electric motor to drive the vehicle.
E. Moreover, in all three designs, the battery is charged through regenerative braking technology.

Regenerative braking

- Regenerative braking recovers some of the kinetic energy that would otherwise turn into heat and instead converts it into electricity.
- Regenerative braking is a way of taking the wasted energy from the process of slowing down a car and using it to recharge the car's batteries. On a normal car, braking simply wastes energy – but with regenerative braking, some of the energy is able to be reused.

REGENERATIVE BRAKING WORK

A. A regenerative braking system (RBS) used in automotive applications has several advantages like **better braking efficiency in stop-and-go traffic** which enhances **fuel economy** and also helps in reducing carbon emissions.
B. Besides**, RBS also helps in energy optimisation resulting in minimum energy wastage**.
C. The **efficiency of HEVs and EVs** will in large part be **determined by their ability to recover as much energy as possible while braking**, with a higher degree of energy recovery lowering fuel consumption.
D. The adoption of regenerative braking technology in the auto industry is increasing on account of the operating efficiency of vehicles through reduced fuel consumption and the extended range of batteries.
E. The technology is also used in electric railways.
F. Rail transit can be described as frequent acceleration and braking of trains across many stations.
G. This increases the potential for braking energy recovery using energy storage systems, which can recuperate and reuse braking energy from metro cars, further enhancing energy efficiency.

DIFFERENT TYPES OF HEVS

The HEVs can be categorised into micro, mild and full hybrid vehicles, based on the degree of hybridisation.

A. **A full HEV** will have a larger battery and a more powerful electric motor compared with a mild HEV. As a result, a full HEV can power the vehicle for longer distances using just electric mode,
B. **A mild HEV** cannot drive using only the electric motor and uses the battery at traffic lights or in stop-and-go traffic to support the ICE.
C. **Micro hybrids** do not offer electric torque assistance as they lack an electric motor, but they have an idle stop-start system and energy management functions.
D. There are **plug-in hybrid electric vehicles (PHEVs)** that are just **like full HEVs**, but they can be charged using a wall outlet, as they have an onboard charger and a charging port.
E. PHEVs generally use the electric motor until the battery is almost drained, and then automatically switch to the ICE.

MAIN ADVANTAGES OF USING HYBRID TECHNOLOGY

A. Most vehicles with hybrid technology offer better fuel efficiency, more power, and minimum emissions.
B. The design of hybrid vehicles for reduced engine size and car weight as compared to ICE vehicles, translates into increased mileage to favour the demand for these vehicles.
C. Moreover, with the increase in total power and torque, HEVs can deliver instant torque and provide high torque even at low speeds

Main Advantages

A. **Fuel Efficiency:** Most vehicles with hybrid technology offer better fuel efficiency, more power, and minimum emissions.
B. **Increased Mileage:** The design of hybrid vehicles for reduced engine size and car weight as compared to ICE vehicles, translates into increased mileage to favour the demand for these vehicles.
C. **Instant Torque:** With the increase in total power and torque, HEVs can deliver instant torque and provide high torque even at low speeds.

Auto Industry Transition:

1. The automotive industry is transitioning, with an increasing focus on hybrid and battery electric vehicles (BEVs or EVs).
2. The rise in fossil fuel prices, increase in the adoption of clean mobility solutions, and stringent government norms for emission control are driving the growth of the EV market.

CHALLENGES FOR HYBRID TECHNOLOGY

HIGHER COST:

A. In a price-sensitive market like India, one of the major challenges for HEVs is the high vehicle cost.
B. Battery increases the cost of the vehicle, making it pricier than vehicles powered only by an ICE.
C. The RBS also adds to the higher cost of an HEV.

- **Lack of Infrastructure:** India's road to a fully-electric ecosystem still has a few hurdles - inadequate infrastructure, lack of high performing EVs .
- **Robust Manufacturing Ecosystem:** The absence of a robust manufacturing ecosystem for the materials associated with the EV revolution, coupled with the concentration of the supply chain in certain regions.

CONCLUSION

A. SHEVs will play a critical role not only in reducing fossil fuel consumption, carbon emissions and pollution but also in creating a **local EV parts manufacturing ecosystem**.
B. HEVs protect the huge existing investments and jobs related to ICE parts manufacturing thus ensuring a **faster and disruption-free technology transition**.
C. SHEV adoption will also accelerate BEV (Battery EV) adoption as these technologies have common electric powertrain parts that will help in aggregation of demand at parts level for local manufacturing, thereby **helping in reducing cost** for SHEVs and BEVs to create a viable ecosystem for electrified vehicles.

ENRICHED URANIUM STOCKPILE BY IRAN

Recently, Iran's atomic agency said that **its stockpile of 20% enriched uranium** has reached over 210 kilograms.

- In April 2021, the IAEA said Iran had begun the process of enriching uranium to 60% fissile purity at an above-ground nuclear plant at Natanz.
- Under the **historic 2015 nuclear deal** between Iran and the World Powers, **Iran was not meant to enrich uranium above 3.67%**. Enriched uranium above 90% can be used for nuclear weapons.

URANIUM ENRICHMENT:

A. Natural uranium consists of two different isotopes - **nearly 99% U-238** and only around **0.7% of U-235.**

B. **U-235 is a fissile material** that can sustain a chain reaction in a nuclear reactor.
C. **Enrichment process increases the proportion of U-235** through the process of isotope separation (U-238 is separated from U-235).
D. For **nuclear weapons**, enrichment is required upto **90% or more** which is known as weapons-grade uranium.
E. **Low-enriched uranium, which typically has a 3-5% concentration of U-235**, can be used to produce fuel for commercial nuclear power plants.

IRAN AND ENRICHED URANIUM

- Iran's atomic agency said that its stockpile of 20% enriched uranium has reached over 210 kilograms.
- It is the latest defiant move ahead of upcoming nuclear talks with the West.

URANIUM AS A FUEL

- Nuclear fuel is **mined** from naturally occurring uranium ore deposits and then **isolated through chemical reactions and separation processes.**
- Natural uranium consists of two different isotopes:

1. nearly 99% U-238 and
2. only around 0.72% of U-235.

- U-238 is not fissile, thus the concentration of U-235 must be increased before it can be effectively used as a nuclear fuel.
- **U-235** being a **fissile material** sustains a chain reaction in a nuclear reactor.

- ❖ Uranium enrichment is a process that creates an effective nuclear fuel out of mined uranium by increasing the percentage of uranium-235.
- ❖ Enrichment process basically increases the proportion of U-235 through the process of **isotope separation** (U-238 is separated from U-235).

For nuclear Weapons

- ❖ Highly Enriched Uranium or weapons-grade uranium
- ❖ For which enrichment is required up to 90% or more.

For Nuclear Reactor

A. Low Enriched Uranium or reactor-grade uranium
B. Enrichment is required upto 3-4% only.

JOINT COMPREHENSIVE PLAN OF ACTION (JCPOA)

A. Also known as the **Iran Nuclear Deal.**
B. The JCPOA was the result of prolonged negotiations from 2013 and 2015 between Iran and the P5+1
C. China, France, Germany, Russia, the United Kingdom, the United States and the EU.
D. The deal promises Iran economic incentives in exchange for limits on its nuclear programme, and is meant to prevent Tehran from developing a nuclear bomb.
E. Iran committed to drastically reduce its stockpiles of weapon grade Uranium, including centrifuges, enriched uranium, and heavy water.
F. Iran was not meant to enrich uranium above 3.67% which was meant to fulfill its energy requirement.
G. The **International Atomic Energy Agency (IAEA)** was instrumental in enforcing the agreement by monitoring Iran and conducting inspections.
H. The U.S. unilaterally pulled out of the nuclear deal in 2018 but Britain, France, Germany,China and Russia have tried to preserve the accord

IRAN'S MAXIMUM RESISTANCE

- ➢ Tensions rose after the U.S. pushed **unilateral sanctions**, widening its scope to cover nearly all Iranian banks connected to the global financial system.
- ➢ Earlier Iran's response was muted as the **E-3 (France, Germany, the U.K.)** and the EU promised to find ways to mitigate the U.S. decision.
- ➢ The E-3's in 2019 created **Instrument in Support of Trade Exchanges (INSTEX)**, to facilitate trade with Iran.
- ➢ However, the anticipated economic relief failed to materialize, thus pushing Iran's strategic patience.
- ➢ Tehran thus shifted to a strategy of 'maximum resistance'.
- ➢ Thereafter, Iran has been steadily breaking its commitments to pressurise the remaining signatories to find a way to provide sanctions relief.
- ➢ Iran has produced 25 kg 60% enriched uranium.
- ➢ A level that only countries with nuclear weapons have the physical capabilities to produce.

INDIA-IRAN RELATIONS

Regional Connectivity:

- ❖ Removing sanctions will rekindle India's interest in the Chabahar and Bandar Abbas ports.

- ❖ India’s interest in the International North-South Transit Corridor (INSTC), which runs through Iran,
- ❖ will improve connectivity with five Central Asian republics will also get a boost.

Indian Ocean Security:

- ➢ This would assist India in neutralising China's footprint in Pakistan's Gwadar port.
- ➢ Also, will help counter China’s alleged String of Pearls Policy.

Energy Security:

A. Due to the US’ Countering America’s Adversaries Through Sanctions Act (CAATSA), India has to bring down oil imports to zero.
B. Re-establishment of links between the US and Iran will help India to procure cheap Iranian oil and aid in energy security.

Way Forward

- ❖ After months of delays, the European Union, Iran and the U.S. will go for indirect talks to resuscitate the deal.

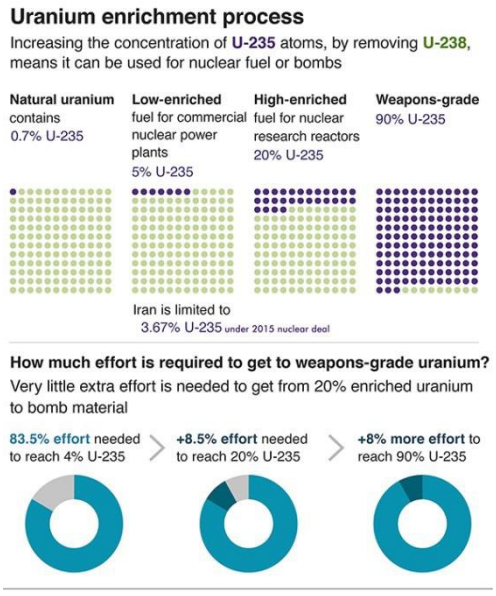
Continuous Dialogue:

- ❖ All countries part of the 2015 deal should engage constructively and resolve all issues peacefully and through dialogue.

Peaceful Globe:

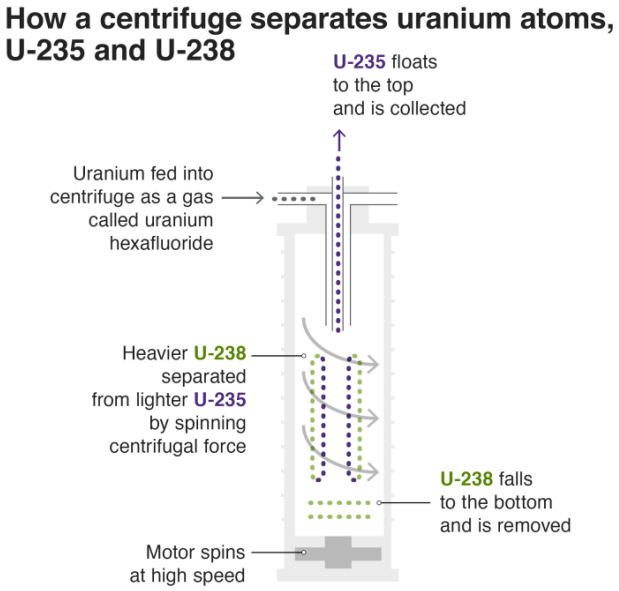
- ❖ Both the USA and Iran must act with strategic restraint as any crisis in West Asia will not only affect the region as a whole
- ❖ but will have a detrimental impact on global affairs as well.
- ❖ In the words of General Omar Bradley,
- ❖ Ours is a world of nuclear giants and ethical infants.
- ❖ We know more about war than about peace, more about killing than living.
- ❖ We have grasped the mystery of the atom and rejected the sermon on the mount.

Highly enriched uranium has a purity of 20% or more and is used in research reactors.



ASSOCIATED CONCERNS:

- ✓ The tricky process of enrichment becomes far easier and requires fewer centrifuges as it moves into the higher purities.
- ✓ In other words, getting to 90% purity is much easier starting from 20%, and easier still starting from 60%.



2015 NUCLEAR DEAL:

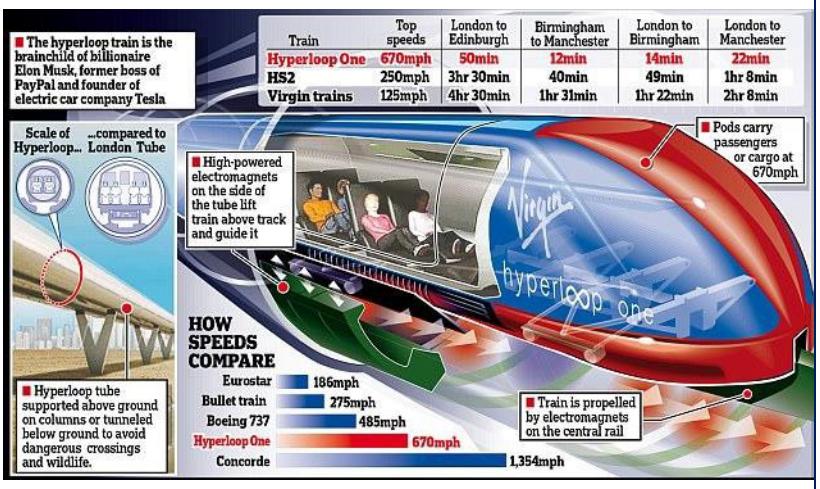
1. In 2015, **Iran with the P5+1 group of world powers** - the USA, UK, France, China, Russia, and Germany agreed on a long-term deal on its nuclear programme.

2. The deal was named as JCPOA and in common parlance as Iran Nuclear Deal.
3. Under the deal, **Iran agreed to curb its nuclear activity** in return for the lifting of sanctions and access to global trade.
4. The agreement **allowed Iran to accumulate small amounts of uranium** for research but it **banned the enrichment of uranium**, which is used to make reactor fuel and nuclear weapons.
5. Iran was also **required to redesign a heavy-water reactor being built,** whose spent fuel would contain plutonium suitable for a bomb and to allow international inspections.
6. **In May 2018, the USA abandoned the deal** criticising it as flawed and reinstated and tightened its sanctions.

- ❖ Since sanctions were tightened, **Iran has been steadily breaking some of its commitments** to pressure the remaining signatories to find a way to provide sanctions relief.
- ❖ After months of delays, the EU **Iran and the US** have recently announced that **indirect talks to resuscitate the deal would resume on 29th November 2021 in Vienna.**

HYPER-LOOP TECHNOLOGY

- The Railways is also in the news for its plans on **hyper loop trains, hydrogen fuel-cell trains and lighter aluminium coaches** — the most futuristic being **hyper loop.**



HYPER-LOOP TECHNOLOGY

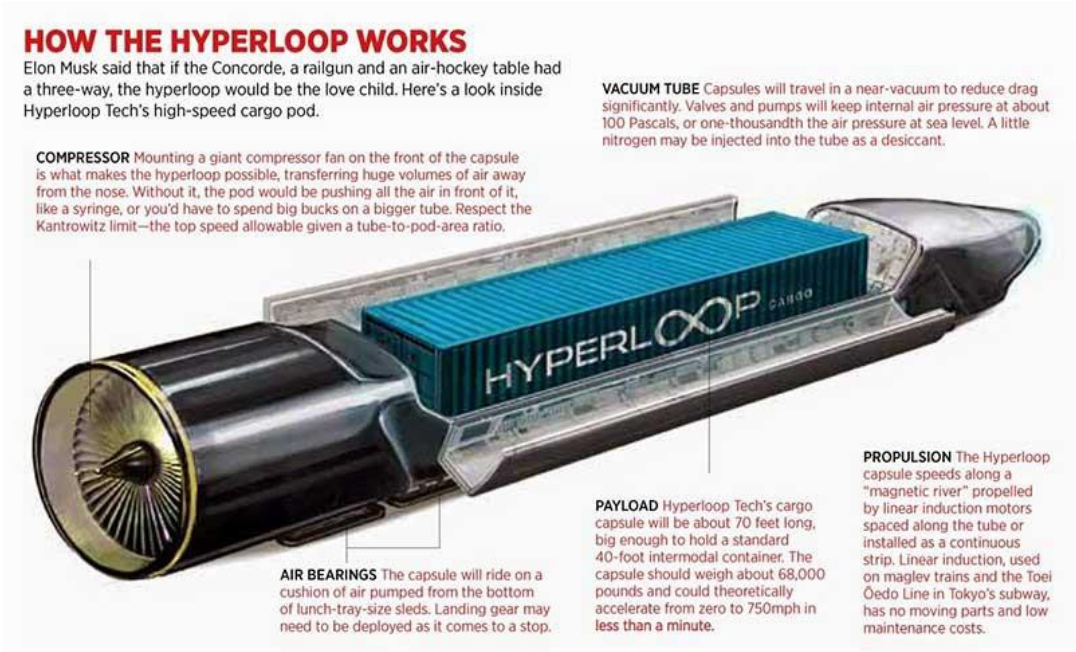
- Hyper loop is an ultra-high-speed ground transportation system for passenger and cargo proposed as a concept by Elon Musk, CEO of Tesla and SpaceX, in a white paper back in 2013.
- The system consists of sealed and partially evacuated tubes, connecting mobility hubs in large metropolitan areas, and pressurized vehicles, usually called pods, which can move at very high speeds, thanks to contactless levitation and propulsion systems as well as to the low aerodynamic drag.

ADVANTAGES OF HYPER LOOP TECHNOLOGY:

1. **Climate-Neutral:** With fully-electric and efficient operations, the system aims at being **climate-neutral over the course of its life cycle.**
2. **City Centre to City Centre:** By connecting mobility hubs in large metropolitan areas the **door-to-door travel time is considerably reduced.**
3. **Ultra-High Speeds:** Contactless levitation and propulsions systems as well as the **low pressure environment allow the pod to travel efficiently at ultra-high speeds.**
4. **Cost estimates of hyperloop** vary from $20-40 million per km; the lower figure is comparable with that for **high speed rail (HSR).**
5. The running costs are lower than that of **HSR, feasible due to lower energy input.** But maintenance issues have not been assessed.

HYPERLOOP WORKS

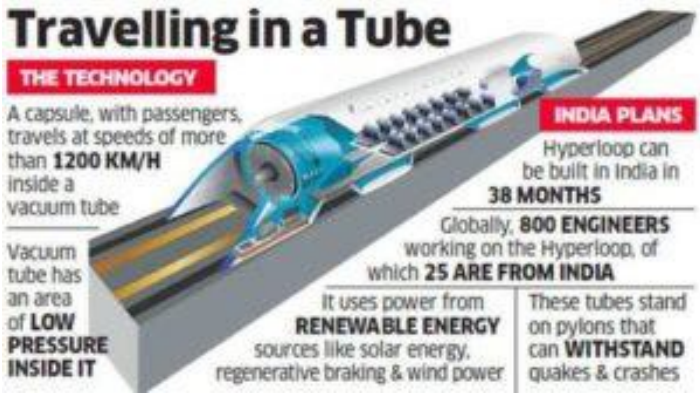
1. **Hyperloop Technology** consists of a long vacuum tube, and it has a compartment like a capsule. Those compartments are called pods. These pods run at high speed inside the vacuum tube. These tubes are called loops.
2. It mainly uses two types of technology- **Magnetic levitation and Air pressure.** Because of this, there is very less friction between the pods and the tube. Due to this, its speed is so fast that it leaves the maglev train too far behind.
3. Because in this **technology transportation** takes place in the loop itself, which means when passengers want to travel, they will travel through this loop. Hence this is named **hyperloop technology.**



1. In India, the Maharashtra government has deemed Hyperloop a public infrastructure project and approved the Virgin Hyperloop-DP World Consortium as the original project proponent for the Mumbai-Pune Hyperloop project.
2. Also, NITI Ayog cleared six new proposals for the public transportation system of India.
3. These technologies include metrino, stadler buses, hyper loop, pod taxis, hybrid buses and freight railroad.

HYPERLOOP TECHNOLOGY

1. Hyperloop is a new mode of **ultra-fast mass transportation solution** that transports people and cargo through a pod in a vacuum environment.
2. **Working-** Hyperloop works through the concept of shooting pods or compartments of passengers through an airtight tube that is in a partial vacuum.
3. The propulsion is done through **magnetic levitation**, with the air capsules or pods gliding or levitating over the tracks.



1. A maglev train system uses **two sets of magnets** — one for attracting and moving the train forward along the track, and another for repelling and pushing the train off the track.
2. **Advantages-** High speed, noiseless system, time and fuel saving**.**

3. **Challenges-** The magnetic levitation systems have been hard to build and maintain due to the cost of maintaining a vacuum.

NEED FOR NEW PUBLIC TRANSPORTATION:

1. Present levels of **urban mobility are already generating many problems** such as; high levels of congestion, environmental pollution, traffic fatalities.
2. Present infrastructure for transportation is focused on mobility of vehicle rather than that of people.
3. Nearly, **30 and 60% of a metropolitan area may be devoted to transportation**, an outcome of the over-reliance on some forms of urban transportation.
4. The scheme would provide a holistic solution for urban transportation problems ranging from parking policy, congestion pricing to transit-oriented development.

CONCERNS RELATED TO HYPER-LOOP TECHNOLOGY

Despite the ambitious progress that's already been made, we are still in the early **stage of hyperloop development with certain concerns needing attention :**

1. **High speeds:** The first hyperloop passenger test reached a top speed of 107 mph in 6.25 seconds. We still don't know the effect that extreme acceleration within an enclosed chamber will have on the **human body.** Astronauts train their bodies to handle extreme acceleration, and PBS wondered if the hyperloop experience will be **"two minutes of puke city."**
2. **Collisions within the vacuum tubes:** Hyperloop system designs have multiple pods traveling at very **high speeds within a single tube**. Because the pods are within the braking threshold of one another, there's the **risk of a very dangerous collision.**
3. **Hyperloop pod damage:** Obviously, humans need air to live, and the tunnels do not have breathable air. Engineers need to address the safety of a situation when the pod becomes compromised.
4. **Tunnel decompression:** Because the tunnel is a near-vacuum, a break in the structure would cause it to implode. For example, look at what happens if the air pressure of a railroad tank car vacuum is compromised. The damage is nearly instantaneous.
5. **These safety concerns** just scratch the surface. Engineers will have to plan for all sorts of contingencies like **heat expansion, earthquakes, or human error.**
6. **The nature of regulatory mechanism is unclear in India.**
7. **One problem that the builders will be facing is the land acquisition,** which has been a major problem for any project implemented in the past as well.

COMPANIES WORKING ON HYPERLOOP:

1. **Virgin Hyperloop (formerly Hyperloop One)** is one of the best-funded hyperloop projects, giving it the most resources for R&D. It's also leading the pack in patents, and in 2020, it completed the first-ever hyperloop passenger test.
2. **Hyperloop TT has a test track in France.** It plans to build a hyperloop between **Abu Dhabi and Dubai**, with the **track becoming operational by 2023**. In the **U.S., the company is planning** to have an **operational hyperloop by 2028,** connecting **Chicago, Cleveland, and Pittsburgh.** This route could potentially unify the region's labor market while reinvigorating regional manufacturing because of the **ability to quickly transport goods.**
3. **In 2020, a consortium of European and Canadian hyperloop companies** became another big player in the industry. Collectively working on the issue of international standardization, this joint technical committee will look at **regulation, interoperability, and safety**. The group

includes **Hardt Hyperloop (Netherlands), Hyper Poland, TransPod (Canada), and Zeleros Hyperloop (Spain).**

WAY FORWARD:

1. **NITI Aayog expert committee members** have found that there are two ways of doing it:
2. **One is, allowing foreign companies** to show demonstrations. Another way is, in parallel, do serious **R&D** in this particular area, and **NITI Aayog studies** show that we have a capacity to do **R&D** and come up with our **own designs.**
3. But since it is going to take time, in parallel, if the **foreign companies** are coming who want to set up a demonstration line in say Maharashtra or Karnataka, we should permit them.
4. India should also constitute a **Safety and regulatory mechanisms** because safety is a major issue in **hyperloop technology.**

NITI AAYOG EXPERT COMMITTEE ON HYPERLOOP TECHNOLOGY

1. **In 2020, Government think-tank NITI Aayog** has formed a high-level panel to explore the technological and commercial viability of the **Virgin Hyperloop technology** for ultrahigh speed travel in India.
2. It explore **technological, commercial, financial (viability) feasibility and (assess) safety standards and regulations to procure new technology.**

NUCLEAR FUSION ENERGY

- Recently, the **Scientists in the United Kingdom** said they have achieved a new milestone in producing **nuclear fusion energy,** or imitating the way energy is produced in the Sun.
- Energy by **nuclear fusion is one of mankind's long standing quests as it promises to be low carbon,** safer than how nuclear energy is now produced and, with an efficiency that can technically exceed a 100%.
- One **kilogram(kg)** of fusion fuel contains about 10 million times as much energy as a kg of coal, oil or gas.

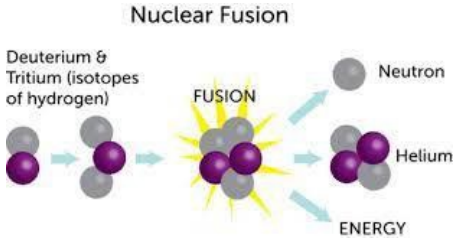
LOCATION OF EXPERIMENT

1. The **JET (Joint European Torus facility)** site is the largest operational one of its kind in the world.
2. The energy was produced in a machine called a **tokamak**, a doughnut-shaped apparatus.
3. A tokamak is a machine that confines a plasma using magnetic fields in a donut shape that scientists call a torus.
4. **Deuterium and tritium,** which are isotopes of hydrogen, were heated to temperatures 10 times hotter than the centre of the sun to create plasma.
5. This was held in place **using superconductor electromagnets** as it spins around, fuses and releases tremendous energy as heat.
6. The record and scientific data from these crucial experiments **are a major boost for ITER,** the larger and more advanced version of the JET.

NUCLEAR FUSION

1. Nuclear fusion is defined as the **combining of several small nuclei into one large nucleus** with the subsequent release of huge amounts of energy.
2. It is the **opposite reaction of fission**, where heavy isotopes are split apart.
3. Harnessing fusion, **the process that powers the Sun**, could provide a limitless, clean energy source.

4. In the sun, the extreme pressure produced by its immense gravity creates the conditions for fusion to happen.
5. Fusion reactions **take place in a state of matter called plasma**. Plasma is a hot, charged gas made of positive ions and free-moving electrons that has unique properties distinct from solids, liquids and gases.
6. At high temperatures, electrons are ripped from atom's nuclei and become a plasma or an ionised state of matter. Plasma is also known as the **fourth state of matter.**



ADVANTAGES OF NUCLEAR FUSION

1. **Abundant energy:** Fusing atoms together in a controlled way releases nearly four million times more energy than a chemical reaction such as the burning of coal, oil or gas and four times as much as nuclear fission reactions (at equal mass).
2. Fusion has the potential to provide the kind of baseload energy needed to provide electricity to the cities and the industries.
3. **Sustainability:** Fusion fuels are widely available and nearly inexhaustible. Deuterium can be distilled from all forms of water, while tritium will be produced during the fusion reaction as fusion neutrons interact with lithium.
4. **No CO_2**: Fusion doesn't emit harmful toxins like carbon dioxide or other greenhouse gases into the atmosphere. Its major by-product is helium: an inert, non-toxic gas.
5. **No long-lived radioactive waste:** Nuclear fusion reactors produce no high activity, long-lived nuclear waste.
6. **Limited risk of proliferation**: Fusion doesn't employ fissile materials like uranium and plutonium (Radioactive tritium is neither a fissile nor a fissionable material).
7. **No risk of meltdown**: It is difficult enough to reach and maintain the precise conditions necessary for fusion—if any disturbance occurs, the plasma cools within seconds and the reaction stops.

International Initiatives on Nuclear Fusion Energy

1. ITER-ASSEMBLY - It aims to build the world's largest tokamak to prove the feasibility of fusion as a large-scale and carbon-free source of energy. The ITER members include China, the European Union, India, Japan, South Korea, Russia and the United States.
2. CHINA ARTIFICIAL SUN :The Experimental Advanced Superconducting Tokamak (EAST) device designed by China replicates the nuclear fusion process carried out by the sun.

BREAKTHROUGH IN NUCLEAR FUSION ENERGY

- Researchers at the Lawrence Livermore National Laboratory in California for the first time produced more energy in a fusion reaction than was used to ignite it, something called net energy gain.

NUCLEAR FUSION

1. Nuclear fusion reactions power the sun and other stars.

2. Nuclear fusion reaction happens when two light nuclei (hydrogen) merge to form a single heavier nucleus (helium), releasing enormous amounts of energy and heat.
3. To combine two identical elements is actually very hard because they have the same positive charge and naturally repel each other.
4. A lot of energy is needed to overcome this resistance.
5. In the Sun, this happens due to extremely high temperatures of around 10 million degrees Celsius, and significant pressure of more than 100 billion times that of the Earth's atmosphere.

DIFFERENCES BETWEEN NUCLEAR FISSION AND FUSION

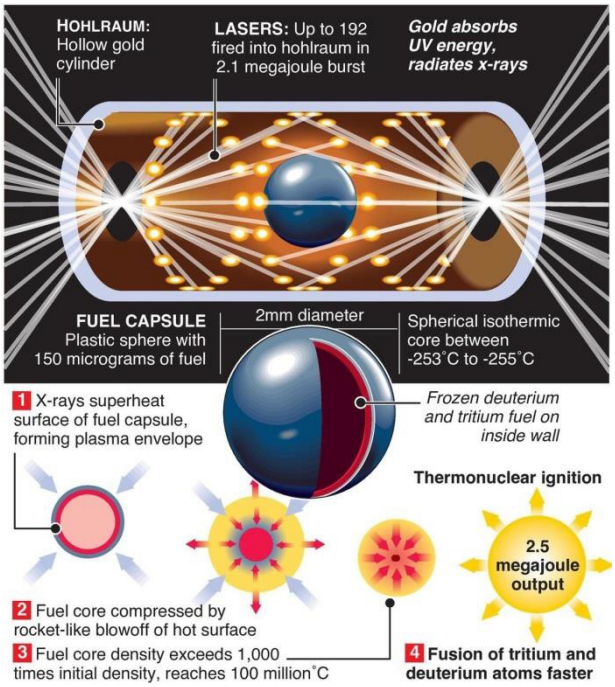
1. Fusion is the joining of atomic nuclei and fission is the splitting of atomic nuclei.
2. Fusion produces far more energy than that created by fission.
3. Fusion, unlike fission, does not create harmful radioactive by-products that need to be stored for thousands of years.

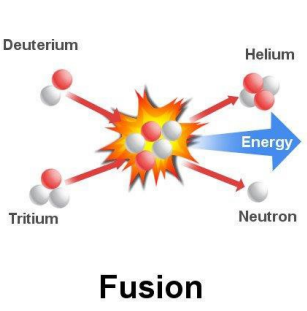
FUSION ENERGY SO SIGNIFICANT

1. **Less radioactive** - The waste produced by nuclear fusion is less radioactive and decays much more quickly.
2. **No need for fossil fuels** - Nuclear fusion doesn't need fossil fuels like oil or gas.
3. **No GHGs** - It also doesn't generate greenhouse gases (GHGs).
4. **Targeting net zero** - Widescale use of nuclear fusion could help countries meet their targets to produce net zero emissions by 2050.
5. **Availability** - Since most fusion experiments use hydrogen, which can be extracted cheaply from seawater and lithium, nuclear fusion offers the possibility of “basically unlimited” fuel.
6. **Self-limiting process** - Fusion is a self-limiting process in which the machine switches itself off if the reaction cannot be controlled.
7. Because of its significance, it has been described as the "**holy grail**" of energy production.

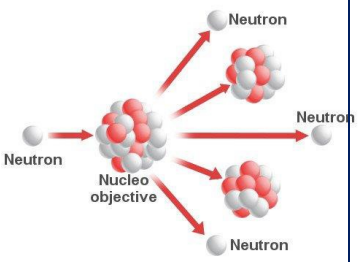
SCIENTISTS TRYING TO PRODUCE FUSION ENERGY

1. **Magnetic confinement -** Magnetic confinement uses a reactor called tokamak, in which a hydrogen plasma is heated to high temperature and the nuclei are guided by strong magnetic fields.
2. **International Thermonuclear Experimental Reactor (ITER)** is a famous example of an experiment trying to achieve fusion using magnetic confinement.
3. **Inertial confinement** - In the Livermore lab, a 192-beam laser fire pulses at a small capsule filled with deuterium-tritium atoms inside a cylinder called a hohlraum.
4. The latter heats up and releases X-rays, which heat the nuclei to millions of degrees centigrade and compress them to billions of Earth-atmospheres.
5. It is called inertial confinement because the nuclei’s inertia creates a short window between implosion and explosion in which the strong nuclear force dominates, fusing the nuclei.
6. It is relatively easier to attain break-even energy levels through inertial fusion compared to magnetic fusion.





Fusion



Fission

EXPERIMENT ACHIEVED

1. **Gain** - The ratio of the output energy to the input delivered to the container is the gain.
2. A gain of 1 is called '**scientific breakeven'** – an important milestone in the development of fusion energy.
3. **Lawson criterion** - In August 2022, the facility reported it had produced a burning plasma that met the Lawson criterion.
4. According to Lawson criterion, the heat generated was sufficient to potentially trigger other fusion reactions as well as offset heat loss during the reaction.
5. Now, the facility has reportedly achieved a burning plasma that meets the Lawson criterion as well as a gain greater than 1.

issues

1. **Effectiveness** - Some of the input energy is devoted to compressing the capsule instead of raising the temperature.
2. This fraction will increase as the amount of fuel increases, creating another barrier to high gain.
3. **Gain** - Future research will need to focus on reaching the next major milestone – a target gain of G > 100, which is required to run a power plant efficiently.
4. **Rate of firing** - The rate at which any reactor fires its lasers at the hydrogen capsules needs to be orders of magnitude faster.
5. **Conversion to usable form** - Even if the inertial fusion process is more efficient, the produced energy still needs to be converted into usable electricity.
6. **Cost** - The cost to run and maintain an inertial fusion reactor needs to decrease dramatically.
7. **Commercial viability** - It is still not obvious whether inertial fusion can be commercially competitive.
8. Fusion is still far from reality.

International Thermonuclear Experimental Reactor (ITER)

1. ITER is the world's largest experimental fusion reactor facility in **France**.

2. It is a large-scale scientific experiment intended to prove the viability of fusion as an energy source.
3. It includes the contributions of 35 countries, including **India,** China, South Korea, Japan, Russia and the United States.
4. ITER will not produce electricity, but it will resolve critical scientific and technical issues in order to take fusion to the point where industrial applications can be designed.

NUCLEAR FUSION TECHNOLOGY

1. Fusion reactions, Deuterium and Tritium, ITER, EAST-CHINA, ITER-India, Department of Atomic Energy.
2. Scientists in the United Kingdom have achieved a new milestone in producing nuclear fusion energy, or imitating the way energy is produced in the Sun.
3. Energy by nuclear fusion is one of mankind's long standing quests as it promises to be low carbon, safer than how nuclear energy is now produced and, with an efficiency that can technically exceed a 100%.

NUCLEAR FUSION TECHNOLOGY

1. In a Nuclear fusion process, **two lighter atomic nuclei combine to form a heavier nucleus**, while releasing energy. Devices designed to harness this energy are known as **fusion reactors.**
2. Nuclear Fusion reactions **power the Sun and other stars.** The process releases energy because the total mass of the resulting **single nucleus is less than the mass of the two original nuclei.** The leftover mass becomes energy.
3. The main fuels used in nuclear fusion are **deuterium and tritium,** both heavy isotopes of hydrogen. Deuterium constitutes a **tiny fraction of natural hydrogen, only 0,0153%,** and can be extracted inexpensively from seawater. **Tritium can be made from lithium, which is also abundant in nature.**

ADVANTAGES OF NUCLEAR FUSION TECHNOLOGY:

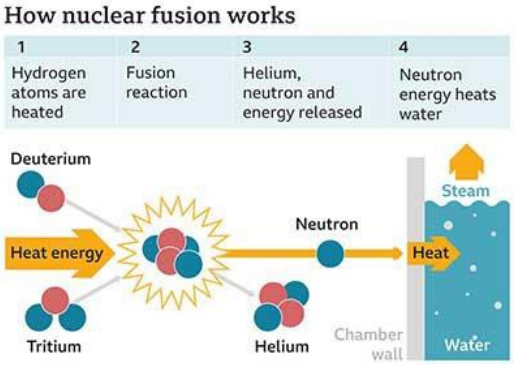
1. **Less nuclear waste :** The fusion reactors will **not produce high-level nuclear wastes like their fission counterparts,** so that disposal will be less of a problem. In addition, the wastes will not be of weapons-grade nuclear materials as is the case in fission reactors.
2. **Carbon neutral :** There **are no CO2 or other harmful atmospheric emissions** from the fusion process, which means that fusion **does not contribute to greenhouse gas emissions or global warming.**
3. The **2018 book Comprehensive Energy Systems notes:** "Nuclear fusion energy is a good choice as the **baseload energy in the future** with many advantages, such as **inexhaustibility of resources, inherent safety, no long-lived radioactive wastes, and almost no CO2 emissions."**
4. The potential advantages of nuclear fusion energy are manifold, as it represents a **long-term, sustainable, economic and safe energy source for electricity generation.**
5. Fuel is **inexpensive and abundant in nature.** The amount of deuterium present in one litre of water can in theory produce as much energy as the combustion of 300 litres of oil. This means that there is enough **deuterium in the oceans to meet human energy needs for millions of years.**

NUCLEAR FUSION TECHNOLOGY

- In nuclear fusion, you get energy when **two atoms join together to form one.** Fusion reactors use two different types of hydrogen isotopes for fuel—deuterium and tritium.

Deuterium is basic hydrogen and can be easily distilled from water. Tritium is a slightly radioactive isotope of hydrogen consisting of one proton and two neutrons.

- **One atom of deuterium and one atom of tritium combine to form a helium-4 atom and a neutron.** Most of the energy released is in the form of the **high-energy neutron.**



POTENTIAL OF NUCLEAR FUSION TECHNOLOGY

1. Nuclear fusion energy is also a **potential candidate for space travel**, especially for high-energy requirements. For the purpose of the transport of astronauts and cargo to Mars and beyond, an innovative concept with a **direct utilization of fusion energy via laser ignited (D,T) capsules for propulsion** has been suggested by the scientists of the Lawrence Livermore National Laboratory.
2. Nuclear fusion powers the **sun and all of the stars of the universe.** Harnessing fusion energy on earth would provide a **practically unlimited amount of renewable energy to supply the needs of the growing world population.**

INTERNATIONAL INITIATIVE ON NUCLEAR FUSION:

- International Thermonuclear Experimental Reactor : ITER ("The Way" in Latin) is one of the most ambitious energy projects in the world today.
- In southern France, 35 nations are collaborating to build the world's largest tokamak, a magnetic fusion device that has been designed to prove the feasibility of fusion as a large-scale and carbon-free source of energy based on the same principle that powers our Sun and stars. ITER will be the first fusion device to produce net energy.
- EAST-CHINA: The Experimental Advanced Superconducting Tokamak (EAST), internal designation HT-7U, is an experimental superconducting tokamak magnetic fusion energy reactor in Hefei, China.
- China broke the record by keeping the Experimental Advanced Superconducting Tokamak (EAST) by achieving plasma temperature at 120 million Celsius for 101 seconds and 160 million Celsius for 20 seconds, a major step toward the test run of the fusion reactor.
- It is designed to replicate the nuclear fusion process that occurs naturally in the sun and stars to provide almost infinite clean energy through controlled nuclear fusion, which is often dubbed the "artificial sun."
- ITER-India is a special project under Institute for Plasma Research. It is governed by the Empowered Board, which is chaired by the Secretary, Department of Atomic Energy (DAE). India became a full seventh partner of ITER in December 2005.
- ITER-India, Institute for Plasma Research (IPR), located in Gandhinagar, western India, is the Indian Domestic Agency to design, build and deliver the Indian in-kind contribution to ITER.

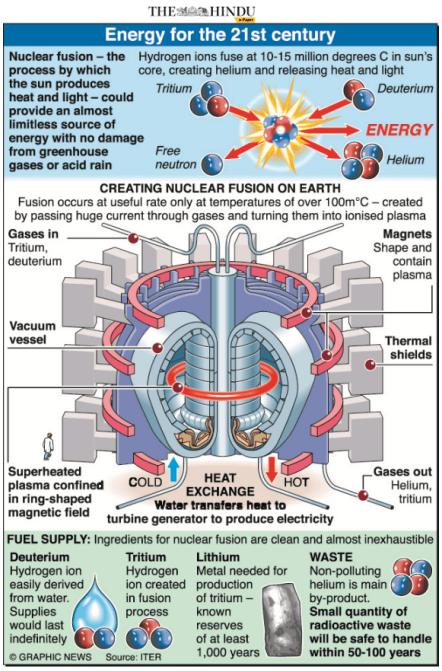
NUCLEAR FUSION ON EARTH IS DIFFERENT FROM SUN

1. Nuclear fusion is the same process that powers the sun. Deep in the sun's core, **hydrogen atoms are smashed together to form helium**, and helium atoms are also smashed together, **releasing tremendous amounts of energy.**
2. It's basically **gravity powered**—the sun is so massive that **gravity is strong enough to trigger fusion.** About **333,000 times the mass of earth.**
3. And it's huge, **about 1.3 million earths could fit inside the sun.** The **amount of energy it produces is frankly inconceivable at 384.6 yottawatts (3.846×1026 W), or 9.192×1010 megatons of TNT—per second.**

- A fusion reactor **fuses hydrogen atoms into helium atoms,** but on a **much, much smaller scale.** That fusion produces heat, which is used to produce steam to turn a turbine, producing electricity.
- But it's very **difficult to start a sustained fusion reaction on earth.** We **don't have the tremendous amounts of mass and gravity to work** with, so scientists use other methods to heat hydrogen up to tremendous temperatures, **over 100 million degrees Celsius.** That's about **10 times as hot as the sun.**
- Of course, **no material** we know of could **withstand such high temperatures, so fusion reactors use magnetic fields to contain the super-heated hydrogen**. Right now, it takes far more **energy to start fusion than you get out of the reactor.**

WAY FORWARD:

- The future of **nuclear fusion is uncertain.** Fusion research began to make substantial progress in the last decade. This has culminated in recent breakthroughs **in magnetic confinement technology, and work on laser and particle beam implosion is also progressing.**
- Although such developments are **encouraging and the potential is great,** much work remains to be done and significant contributions from fusion are certainly very far in the future.
  From an environmental standpoint, many people hope **nuclear fusion will be the long-term clean energy solution.** However, it may not be totally free of as yet **undefined environmental concerns.**



- Nuclear fusion is defined as the process of combining several small nuclei into one large nucleus with the subsequent release of huge amounts of energy.
- A specific case of fusion is the process by which **hydrogen atoms combine to produce helium**, and release immense energy in light and radiation.
- The **most efficient fusion reaction** in the laboratory setting is between two hydrogen isotopes, deuterium (D) and tritium (T).
- Deuterium, also called heavy hydrogen, has a neutron and a proton in its nucleus. Tritium has two neutrons and one proton. The D-T fusion reaction produces the highest energy gain at the 'lowest' temperatures.
- Nuclear fusion is possible only at extremely high temperatures and high pressure to push the hydrogen nuclei closer to fuse with each other. Hence, it is also called as 'Thermonuclear reaction or fusion'.

NUCLEAR FUSION WILL OCCUR IN STARS

1. In a nuclear fusion reaction, lighter atoms of hydrogen fuse to produce slightly heavier atoms like helium. Ordinarily, these atoms cannot fuse. The like charges of the electron clouds surrounding the atoms would repulse and keep them at bay from coming too close.
2. In the core of the stars, the temperature is around 15 million Kelvins. All the electrons are ripped away at these temperatures, forming what is known as plasma, often referred as the fourth state of matter. Plasma is hot, charged gas made of positive ions and free-moving electrons.
3. In the sizzling heat at the core of the Sun with the intense pressure and dense core, the plasma of hydrogen fuse with each other to form helium. This will spew colossal energy in the form of light and heat.

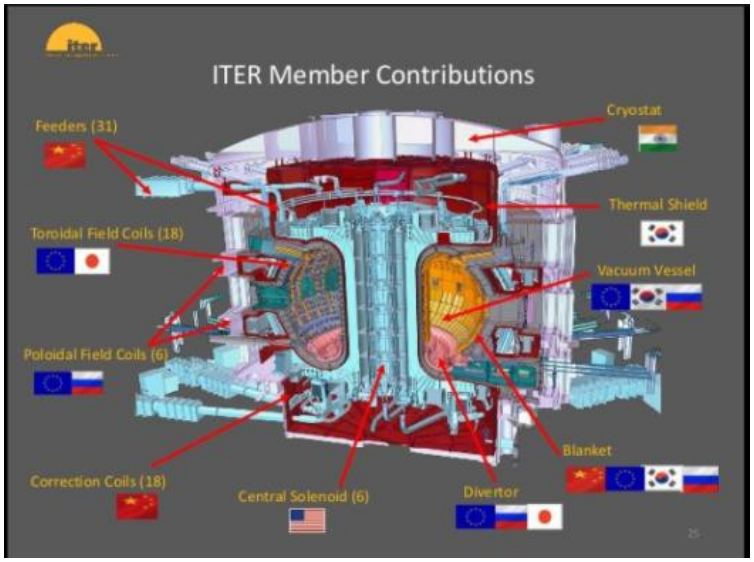
THE ESSENTIAL CONDITION TO ACHIEVE NUCLEAR FUSION IN THE LABORATORY

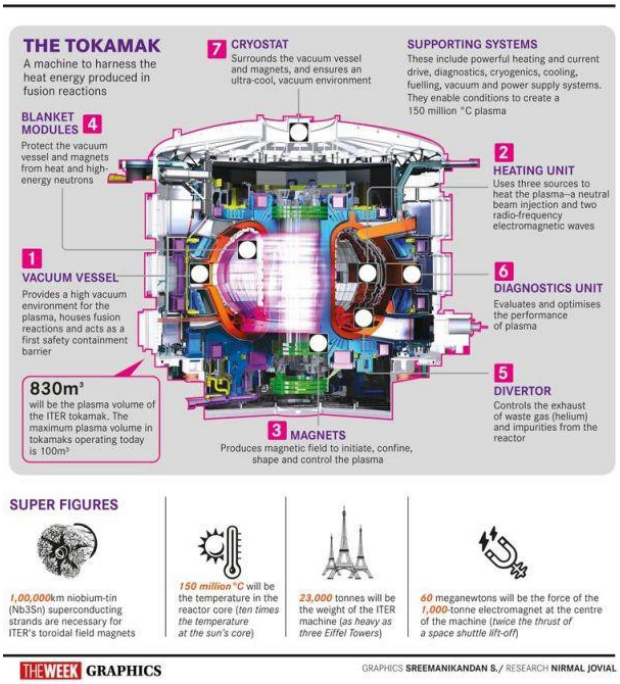
- Hence, three essential conditions are required to achieve nuclear fusion in a laboratory. These are **a)** Extreme high temperature, **b)** Sufficient plasma particle density, **c)** Sufficient confinement time (to hold the plasma, without expanding and containing within a defined volume). These conditions are very difficult to establish and sustain in a controlled manner and pose a big engineering challenge.

TOKAMAKS

- Scientists first thought about producing energy from controlled nuclear fusion in 1940s. Both the USSR and the US stepped up their fusion research in 1950s.
- Soon, the Soviets came up with a viable design to kindle and sustain nuclear fusion— the **Tokamak**.
- The thermonuclear fusion process is established in fusion reactors such as the Tokamaks. Although alternative designs such as **z-pinch and stellarator** have been designed and tested, tokamaks are still considered the best for achieving fusion.
- 'Tokamak' is an acronym for Russia term which translates into 'toroidal chamber with magnetic coils'.
- The Soviet scientists theorised that if one can create a magnetic field in the shape of a torus (doughnut shape) then the scorching plasma could be contained.
- The scalding of the walls of the container from the intense heat of plasma could be prevented.
- famous nuclear fusion projects around the world

International Thermonuclear Experimental Reactor (ITER)





1. The ITER fusion reaction is based on the isotopes of hydrogen (deuterium and tritium). ITER will be the world's largest tokamak.
2. Thirty-five countries, including India, Russia, the United States, the United Kingdom, China, European Union, are collaborating to jointly build the largest Tokamak as part of the INTERNATIONAL THERMO NUCLEAR EXPERIMENTAL REACTOR Scientists, engineers and technicians from all the 35 participating countries are working on the site and getting hands-on operational experience and training.
3. After years of ups and downs since March 2020, the machine assembly is underway in southern France. With the installation of the Cryostat, a device to cool the reactor, covering the assembly is slated to be completed by 2025.
4. The first plasma is expected to be produced at the end of 2025 or early 2026. After testing and troubleshooting, energy production might commence in 2035.
5. The plant is expected to generate 500 MW power and consume 50 MW for its operation, resulting in a net 450 MW power generation.

China's Experimental Advanced Superconducting Tokamak (EAST) or Artificial Sun

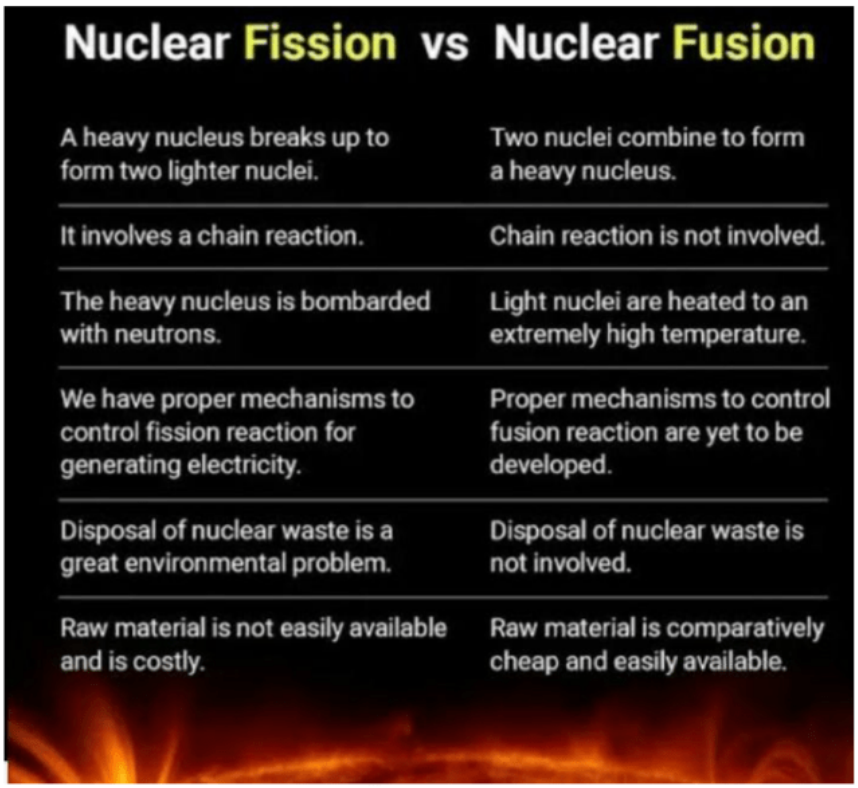
The purpose of the EAST is to replicate the process of nuclear fusion, which is the same reaction that powers the sun. Hence, called the artificial sun. EAST is part of ITER. Recently, China's EAST sustained the plasma at 70 million degrees Celsius for 1,056 seconds in January 2022.

progress in India with respect to Nuclear Fusion technology

- Way back in 1955, in the first 'Atoms for Peace' meeting in Geneva, Homi J. Bhabha saw a future in energy coming from thermonuclear fusion.
- The Institute for Plasma Research (IPR) in Gandhinagar and the Hot Plasma Project at Saha Institute of Nuclear Physics (SINP), Kolkata, took the lead in nuclear fusion research in India. The IPR owns **two operational tokamaks** – **ADITYA** and **Steady-State Tokamak (SST)-1**.

- **ADITYA Tokamak**: It is the first indigenously designed and built tokamak of the country. It was commissioned in 1989.
- **SST-1**: It is under design and fabrication at the IPR. The objectives are **a)** Studying the physics of the plasma processes in tokamak under steady-state conditions, **b)** Learning technologies related to the steady-state operation of the tokamak.

Nuclear Fusion different from Nuclear Fission



The advantages of nuclear fusion compared to fission include,

- **Do not pose danger like nuclear fission reactors**: Unlike fission reactors, fusion reactors like the tokamaks do not pose the dangers of a radioactive leak. The by-products of fusion reaction is helium which is not radioactive.
- **Provides more energy**: Fusion reactors produce four times more energy than nuclear fission reactions.

ADVANTAGES OF NUCLEAR FUSION

1. **Abundant energy**: Gram for gram, thermonuclear power **produces four million times more energy than burning coal**. A kilogram of fusion fuel contains about 10 million times as much energy as a kilogram of coal, oil or gas e.g., if four grams of hydrogen can be fused into helium, it can light a 60-watt light bulb for over 100 years.
2. **Sustainability**: Fusion fuels are widely available and nearly inexhaustible e.g., deuterium can be distilled from all forms of water.
3. **Non-pollutant**: Nuclear fusion does not emit harmful toxins like CO2 or other greenhouse gases. The **only waste product** from nuclear fusion **is the harmless helium** which is an inert and non-toxic gas.
4. **No risk of meltdown**: Any disturbance/malfunction will lead to the cool down of plasma within seconds and the reaction stops.

CHALLENGES ASSOCIATED WITH THERMONUCLEAR FUSION

- **First**, although there are many experimental tokamaks worldwide **none has demonstrated net energy production more than the input**. This is because lot of energy is consumed in creating high temperatures.
- **Second**, one of the critical challenges in the Tokamak is the **sudden appearance of plasma instabilities**.
- **Third**, triggering fusion reactions requires temperatures of 100 million degrees Celsius, and pressures of 100 billion Earth atmospheres.
- **Fourth**, currently, the nuclear fusion process is triggered by the nuclear fission process. However, this process is very destructive, as the fission explosion also releases lethal radiation that may last for millennia.
- Scientists are working hard to overcome the engineering challenges in creating and maintaining a stable nuclear fusion process. If scientists are able to overcome these challenges, nuclear fusion could meet humanity's energy needs for millions of years. Harnessing energy from controlled nuclear fusion reactions could play a vital role in mitigating climate change. The recent achievements provide an encouraging way forward in this regard.

LITHIUM-ION BATTERIES

- Indian researchers have discovered a **new anode material**, which could be helpful in ensuring the life and fast charging of lithium-ion batteries (LIBs).

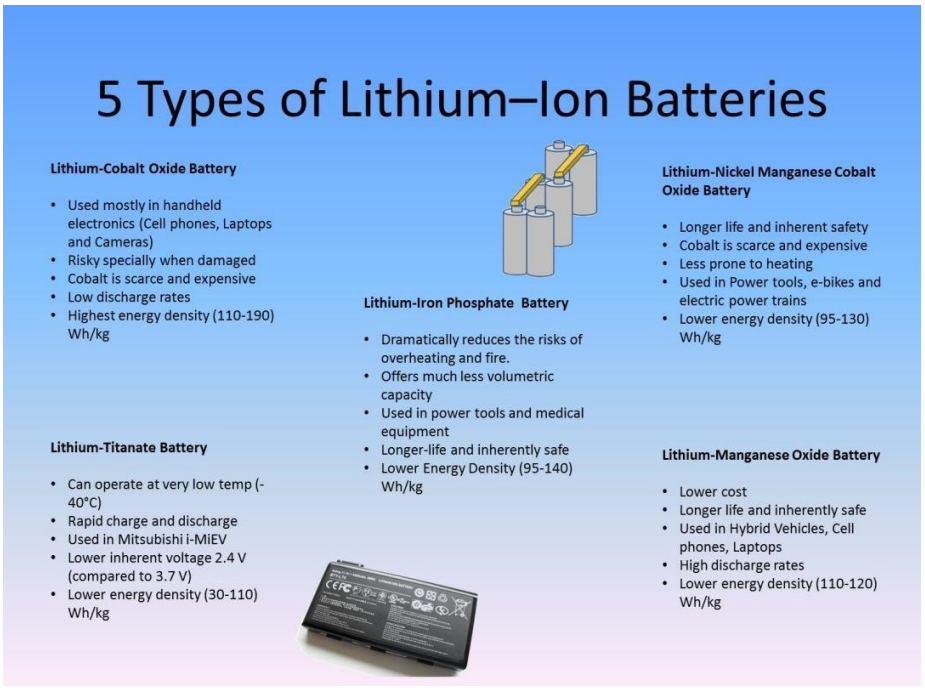
About the new study

1. The study is carried out by researchers from the Indian Institute of Technology (IIT) Gandhinagar in collaboration with the Japan Advanced Institute of Science and Technology (JAIST).
2. The new two-dimensional (2D) anode material is developed using Nano sheets derived from titanium diboride (TiB_2), which resemble a stack of sandwiches, where metal molecules exist between layers of boron.
3. This innovation has potential for translation from lab to real-life application.

- ### Working

1. LIBs have the anode material as the negative electrode, which is attached to the cathode material in the Li-ion battery cell.
2. The anode materials in a lithium-ion cell act as the host, enabling lithium-ion intercalation/de-intercalation during the battery's charge or discharge cycle.

Comparison



1. **LIBs with Graphite anode** are extremely energy dense, and can power an electric vehicle for hundreds of kilometres on a single charge. However, it has its challenges on the safety front as they are prone to fire hazards.
2. **Lithium Titanate anodes** are safer and more preferred alternatives and they also facilitate fast charging. But, they have a lower energy density, so they would need more frequent recharging.
3. **Li-Ion batteries enabled by nanosheets based anode material** have an edge as they offer ultra-fast charging time, long life cycle (10,000 cycles at high charge currents), and nanosheets used to prepare the anode have a high density of pores.

Table: Advantages and Disadvantages of Lithium-ion Batteries

Advantages	Disadvantages
• Lightweight battery	• Risky sourcing of lithium
• Lithium-ion batteries have impressive high energy density (one of the best energy-to-weight ratios).	• A major downside is the pace of lithium extraction that is unable to meet the growing demand for lithium supplies.
• High adaptability to several applications	• Expensive than other batteries
• As there is no memory effect, there is no need to fully drain the battery before recharging.	• Temperature-sensitive battery with quick degradation to heat exposure or at high temperatures.
• The battery can withstand a greater number of charge/discharge cycles.	• Flammable liquid electrolyte or damaged separator may lead to explosion or fire risk.
• Low self-discharge rate	• Highly fragile with a risk of perforation
• Easy maintenance	• Difficult transportation
• Slow loss of charge when not in use.	• Needs protection circuitry to maintain safe charging limits.
• If used correctly, lithium-ion batteries have a long lifespan.	• Improper disposal/recycling may lead to environmental contamination.

Source: Blackridge Research & Consulting

- India, through a newly-floated state-owned company **Khanij Bidesh India Ltd,** has inked a pact with **an Argentine firm** to jointly **prospect lithium in Argentina,** a country that has the **one of the largest reserves** of Lithium in the world.

1. Khanij Bidesh India Ltd was incorporated in August 2019 by three state-owned companies, NALCO, Hindustan Copper and Mineral Exploration Ltd, with a specific mandate to acquire strategic mineral assets such as lithium and cobalt abroad.

2. It is also learnt to be exploring options in Chile and Bolivia, two other top lithium-producing countries.

- Lithium is a crucial building block of the LITHIAM ION RECHAGABLE BATTERIES that power ELECTRIC VEHICLES (EVs), **laptops** and **mobile phones.**

1. Currently, India is heavily dependent on import of these cells and the move to ink sourcing pacts for lithium is also seen as a move to reduce its dependency on China which is a key source of both the raw material and cells.
2. India is seen as a late mover as it attempts to enter the lithium value chain, coming at a time when Electric Vehicles are predicted to be a sector ripe for disruption.

3. 2021 is likely to be a turning point for battery technology, with several potential improvements to the Li-ion technology, and alternatives to this tried-and-tested formulation, under advanced stages of commercialisation.

LI-ION BATTERIES:

1. A lithium-ion battery or Li-ion battery is a type of **rechargeable battery.**
2. Li-ion batteries use an **intercalated** (Intercalation is the reversible inclusion or insertion of a molecule into materials with layered structures) lithium compound as one electrode material, compared to the metallic lithium used in a non-rechargeable lithium battery.
3. The battery consists of electrolyte, which allows for **ionic movement,** and the two electrodes are the constituent components of a lithium-ion battery cell.
4. Lithium ions move from the **negative electrode** to the **positive electrode during discharge and back when charging.**

Lithium-ion Battery Applications:
Electronic gadgets, Tele-communication, Aerospace, Industrial applications.

1. Lithium-ion battery technology has made it the favourite power source for electric and hybrid electric vehicles.

Disadvantages of Li-ion Batteries:

1. Long charging times.
2. Safety issues as instances of batteries catching fires have been there.
3. Expensive to manufacture.
4. While the Li-ion batteries are seen as sufficiently efficient for applications such as phones and laptops, in case of EVs, these cells still lack the range that would make them a viable alternative to internal combustion engines.

<u>Potential Alternatives to Li-ion technology:</u>

- Graphene Batteries:
  Graphene batteries may be an important alternative to lithium-ion batteries, with the latter having limitations due to the frequency with which lithium requires charging. Graphene is a newly stabilized and isolated material.
- **Fluoride Batteries:**

- Fluoride Batteries have the potential to last eight times longer than lithium batteries.

<u>Sand Battery:</u>
This alternative type of lithium-ion battery **uses silicon to achieve three times better performance** than current graphite Li-ion batteries. The battery is still lithium-ion like the one found in a smartphone, but it uses silicon instead of graphite in the anodes.

Ammonia-powered Batteries:

1. Ammonia-powered batteries may not be coming any time soon, but the chemical commonly known as a household cleaner is still an alternative to lithium in the way it can power fuel cells in vehicles and other equipment.
2. If scientists can figure out a way to produce ammonia without creating the greenhouse gas emissions that result right now, they can ship it anywhere in the world to be converted into hydrogen to power those fuel cells.

Lithium-Sulfur Batteries:

- Researchers in Australia say they have developed the world's most powerful rechargeable battery using lithium-sulfur, said to perform four times better than the strongest batteries currently available.

Vertically Aligned Carbon Nanotube Electrode:

- These are good candidates for lithium-ion battery electrodes which require high rate capability and capacity.

Solid-state Batteries:

- It uses alternatives to **aqueous electrolyte solutions,** an innovation that could lower the risk of fires, sharply increase energy density and potentially take only 10 minutes to charge an EV, cutting the recharging time by two-thirds.
- These cells can extend the driving distance of a compact electric vehicle while maintaining legroom - a quantum leap in battery tech.

CHALLENGES OF LITHIUM ION BATTERIES

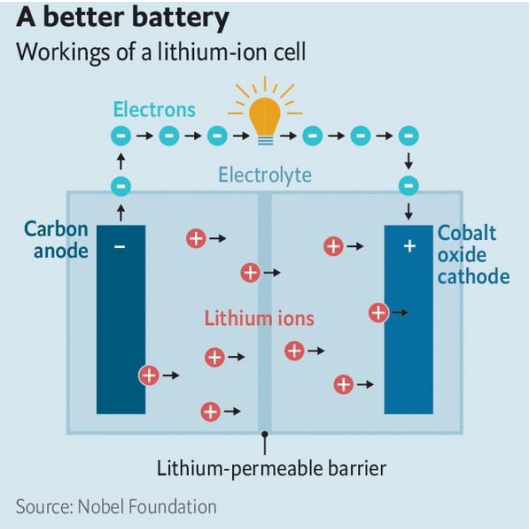
Safety and sustainability continue to pose impediments in the growth envisaged in Lithium Ion Batteries (LIBs) usage.

Lithium ion batteries

- Every Li-ion battery consists of three active components - anode, cathode and electrolyte.
- The anode and cathode is where the lithium is stored while the electrolyte carries positively charged Li-ions from the anode to the cathode and vice versa through the separator.
- The movement of the Li-ions creates free electrons in the anode, which creates a charge at the positive current collector.

Features

1. Small size
2. Light weight
3. High energy density
4. Ability to recharge
5. Longer lifespan compared to a lead acid battery
6. More efficiency
7. Greater driving range
8. Affordable



impediments in the growth of Li-ion batteries

By 2025, the global demand for LIBs is likely to cross about $100 billion with the automobile sector leading as the fastest growing consumer.

1. Fires- In India, reports of fatality and material loss due to fire from LIBs are on the rise.
2. Sustainability- There are concerns around sustainability and lifecycle management of LIBs.

OVERCOME THE CHALLENGES

- ✓ **Safety -** Both range and fast charging aspects require thorough understanding from the metal chemistries to the overall LIB system level.
- ✓ The quality of raw materials and components must be ensured for high fidelity manufacturing practices.
- ✓ Electric vehicle designs need highly efficient thermal management systems and fault-detection mechanisms to avoid thermal runaways.
- ✓ EVs need an accelerated go-to-market approach to cater to the sustainability goals driven by organisations and nations across the world.
- ❖ **Environmental sustainability**- As the long-term sustainability of depending on primary mineral sources (mines) is in question, recycling is key.
- ❖ Most recycling processes practise partial recovery wherein only high-margin metals are recovered from waste and the rest is discarded.
- ❖ The current recycling rate is around 5-9%.

The Battery Waste Management Rules 2022 was notified by the government to accelerate the development of infrastructure for waste collection and improve recycling rates.

1. The Extended Producer Responsibility increases the accountability battery manufacturers need to assume towards collection, refurbishment/recycle of batteries.
2. The need of the hour is to accelerate the development of circular economy solutions that recycle all the metals and facilitate a cradle-to-cradle (infinite loop) approach.
3. A strong collaboration among technologists, policy-makers and governments is required to help manage the EV revolution.

CHALLENGES OF LITHIUM-ION BATTERIES

Sustainability And Lifecycle Management Of Lib, Accelerated Go-To-Market Approach, Development Of Circular Economy Solutions, Cradle-To-Cradle Approach, Battery Waste Management Rules 2022

Various impediments to the growth of LIB:

Safety issues with LIB:

- In India, reports of fatality and material loss due to fire from LIBs are on the rise due to defects in battery cells as well as in battery designs.

Concerns around sustainability and lifecycle management of LIBs:

1. The challenge of the ever increasing demand for metals required for the batteries and the mines as the only primary mineral source.
2. Environmentally sustainable solutions to deal with the mountains of garbage created by end-of-life batteries.

Challenge of Partial recovery of metals from recycling processes:

1. Most recycling processes practise partial recovery wherein **only high-margin metals are recovered** from waste discarding the rest resulting in a loss of economic opportunity for the nations which continue to rely on high-cost imports.
2. It also provides little economic incentive for other recyclers to recover low-margin metals from the discarded waste.

Li ion batteries (LIB):

- Lithium-ion batteries use aqueous electrolyte solutions, where ions transfer to and fro between the anode (negative electrode generally made of graphite) and cathode (positive electrode made of lithium), triggering the recharge and discharge of electrons.

Features of LIB:

- Small size of the batteries
- light weight
- affordability
- the ability to sustain multiple charge cycles
- high energy density

Issues with Lithium-ion batteries

A. One major issue is that lithium metal is extremely reactive.
B. These have long charging times and weak energy density.
C. The main form of lithium corrosion are dendrites, which are branched lithium structures that grow out from the electrode and can potentially pierce through the separator and on to the other end, short-circuiting the cell.
D. In current lithium-ion batteries, in which the electrolyte is a flammable liquid, dendrite formation can trigger a fire.
E. While lithium-ion batteries are seen as sufficiently efficient for phones and laptops, they still lack the range that would make EVs a viable alternative to the internal combustion engine.

SAFETY OF THE LIB

A. Designing vehicles that are lightweight in design offering maximum range and performance.
B. Both range and fast charging aspects require **thorough understanding of metal chemistries** as well as the overall LIB system level.
C. Metal compositions offer high performance and affordability since, cheaper metals and components (including battery management systems) ensure viability in a hugely competitive market.
D. The quality of raw materials and components necessitates the need for **high fidelity manufacturing practices.**
E. EV designs, deployed worldwide, need highly **efficient thermal management systems** and **fault-detection mechanisms** on account of the extreme temperature sensitivity of LIBs to avoid thermal runaways similar to the incidents that have been witnessed recently.

ensure sustainability and lifecycle management of LIBs

1. According to predictions, the volume of the end-of-life LIBs is likely to increase from 7,05,000 tonnes in 2025 to about 9 million tonnes by 2040.
2. As the long-term sustainability of depending on primary mineral sources (mines) is in question, recycling is key.
3. Unlike traditional practices, design of EVs is integrated with that of the battery and its components.
4. The customisations on the battery end get more complex with new features like swappable battery options and connectivity requirements as in the case of autonomous cars.
5. EVs therefore need an **accelerated go-to-market approach** to cater to the sustainability goals driven by organisations and nations across the world.

Government Measures to mitigate the environmental, social and financial impacts of LIB waste:

a) The government has notified the **Battery Waste Management Rules 2022** to manage a wide range of batteries that include LIBs.
b) The mechanism of "**Extended Producer Responsibility" (EPR)** increases the accountability battery manufacturers need to assume towards collection, refurbishment/recycling of batteries.
c) This move is expected to accelerate the development of infrastructure for waste collection and improve recycling rates from the mere 5-9 per cent, as it stands today.

need of the hour

a) A **mandated minimum percentage of recycled material** in all products will open doors for new technologies to be adopted.
b) Thus, the need of the hour is to accelerate the **development of circular economy solutions** that recycle all the metals and facilitate a **cradle-to-cradle (infinite loop) approach.**
c) The ultimate goal is to meet sustainability goals and deploy technologies/best practices that reduce dependency on primary ores and unless that is done, partial recovery of metals or export of black powder (crushed battery waste) for recovery will continue.
d) A strong collaboration among technologists, policy-makers and governments is required to help manage the **'EV revolution'and bridge the huge gap between technology readiness that addresses both sustainability and safety issues in LIBs.**

GREEN HYDROGEN MISSION

- The National Hydrogen Mission was launched on August 15, 2021, with a view to cutting down carbon emissions and increasing the use of renewable sources of energy.
- The Ministry of New and Renewable Energy (MNRE) will formulate the scheme guidelines for implementation.

Key features

a) **Power capacity:** The mission seeks to promote the development of green hydrogen production capacity of at least 5 MMT per annum with an associated renewable energy capacity addition of about 125 GW in the country by 2030.
b) **Job creation:** It envisages an investment of over ₹8 lakh crore and creation of over 6 lakh jobs by 2030.
c) **Reducing energy import bill:** It will also result in a cumulative reduction in fossil fuel imports of over ₹1 lakh crore and abatement of nearly 50 MMT of annual greenhouse gas emissions by 2030.
d) **Export promotion:** The mission will facilitate demand creation, production, utilisation and export of green hydrogen.
e) **Incentivization:** Under the Strategic Interventions for Green Hydrogen Transition Programme (SIGHT), two distinct financial incentive mechanisms targeting domestic manufacturing of electrolysers and production of green hydrogen will be provided under the mission.
f) **Green Hydrogen Hubs:** Regions capable of supporting large-scale production and/or utilisation of hydrogen will be identified and developed as Green Hydrogen Hubs.

Hydrogen Energy: A Backgrounder

a) Hydrogen is an important source of energy since it has **zero carbon content** and is a **non-polluting source of energy** in contrast to hydrocarbons that have net carbon content in the range of 75–85 per cent.
b) Hydrogen energy is **expected to reduce carbon emissions** that are set to jump by 1.5 billion tons in 2021.
c) It has the **highest energy content by weight** and **lowest energy content by volume**.
d) As per **International Renewable Energy Agency (IRENA)**, Hydrogen shall make up **6 per cent of total energy consumption by 2050**.
e) Hydrogen energy is currently at a nascent stage of development, but has considerable potential for aiding the process of energy transition from hydrocarbons to renewable.

Why hydrogen

- **Better properties:** At standard temperature and pressure, hydrogen is a nontoxic, nonmetallic, odourless, tasteless, colourless, and highly combustible diatomic gas.
- **Clean fuel:** Hydrogen fuel is a zero-emission fuel when burned with oxygen. It can be used in fuel cells or internal combustion engines. It is also used as a fuel for spacecraft propulsion.
- **Ample sources:** Hydrogen can be sourced from natural gas, nuclear power, biomass, and renewable power like solar and wind.
- **Phasing out carbon:** India remains committed to environmental and climate causes with a massive thrust on deploying renewable energy and energy efficiency measures.
- **Diversification of our energy basket:** This would be the key lever enabling this transition. That's why the emergence of hydrogen at the centre stage is a welcome development.

Hydrogen can be produced

Commercially viable Hydrogen can be produced from –

- ❖ Hydrocarbons including natural gas, oil and coal through processes like steam methane reforming, partial oxidation and coal gasification
- ❖ Renewables like water, sunlight and wind through electrolysis and photolysis and other thermo-chemical processes.

GREEN HYDROGEN PRODUCED

a) For source material, green hydrogen today is typically generated from water through a process known as electrolysis, which uses an electric current to split water into its component molecules of hydrogen and oxygen.
b) This is done using a device called an **electrolyzer**, which utilizes a cathode and an anode (positively and negatively charged electrodes).
c) This process produces only oxygen – or steam – as a by-product.
d) As for energy supply, to qualify as "green hydrogen," the source of electricity used for electrolysis must derive from renewable power, such as wind or solar energy.
e) Currently the production of green hydrogen is two or three times more expensive than blue hydrogen.

GREEN HYDROGEN BE USED

Hydrogen can be used in broadly two ways. It can be burnt to produce heat or fed into a fuel cell to make electricity.

a) **Fuel-cell Mobility:** Hydrogen electric cars and trucks
b) **Container ships** powered by liquid ammonia made from hydrogen
c) **"Green steel" refineries** burning hydrogen as a heat source rather than coal
d) **Hydrogen-powered electricity turbines** that can generate electricity at times of peak demand to help firm the electricity grid

Challenges in producing Green Hydrogen

India's transition towards a green hydrogen economy (GHE) can only happen once certain key issues are addressed.

a) **Supply-Chain Issues:** GHE hinges upon the creation of a supply chain, starting from the manufacture of electrolysers to the production of green hydrogen, using electricity from a renewable energy source.
b) **Technology:** Green hydrogen needs electrolysers to be built on a scale larger than we've yet seen.
c) **Storage:** Either very high pressures or very high temperatures are required, both with their own technical difficulties.
d) **Explosion Hazard:** It is hazardous because of its low ignition energy and high combustion energy.
e) **Risk to use:** Automotive fuels are highly inflammable, but a vehicle laden with hydrogen is likely to be more vulnerable in case of a major accident.
f) **High Cost of Production:** To become competitive, the price per kilogram of green hydrogen has to reduce to a benchmark of $2/kg. At these prices, green hydrogen can compete with natural gas.
g) **Energy intensivity:** Creating green hydrogen needs a huge amount of electricity, which means an enormous increase in the amount of wind and solar power to meet global targets.
h) **Lack of proper infrastructure**, only 500 Hydrogen stations exist globally. Only countable manufacturers are involved as market players in this technology.

i) **Others:** Low user acceptance and social awareness. Developing after-sales service for hydrogen technology.

Policy and Economic Challenges

- **Economic sustainability:** One of the biggest challenges faced by the industry for using hydrogen commercially is the economic sustainability of extracting green or blue hydrogen.
- **Technological challenges:** The technology used in production and use of hydrogen like Carbon Capture and Storage (CCS) and hydrogen fuel cell technology are at nascent stage.
- **Cost Factor:** These technologies are expensive which in turn increases the cost of production of hydrogen and will require a lot of investment which in turn add fiscal pressure on government.
- **Higher Maintenance costs:** Maintenance costs for fuel cells post-completion of a plant can be costly.
- **Need for legal and administrative adherence:** Certification mechanisms, recommendations, and regulations for different components of the system.

Way forward

a) Hydrogen energy is at a nascent stage of development but has significant potential for realizing the energy transition in India.
b) The new policy is a futuristic vision that can help the country not only cut down its carbon emissions but also diversify its energy basket and reduce external reliance.
c) India's transition can be a testament to the world on the achievement of energy security, without compromising the goal of sustainable development.
d) The GoI must strongly pursue the objective of creating a GHE to make India a global manufacturing hub and place itself at the top of the green hydrogen export market.

NATIONAL GREEN HYDROGEN MISSION

THE UNION CABINET HAS APPROVED THE NATIONAL GREEN HYDROGEN MISSION.

GREEN HYDROGEN

- Green Hydrogen is a type of hydrogen produced by splitting water through electrolysis, using electrolyser powered entirely by renewable power sources.

Advantages –

a) Green hydrogen could replace fossil fuels and fossil fuel-based feedstocks, and decarbonize a range of sectors such as petroleum refining, fertiliser production, steel production, chemicals, transport, etc.
b) Renewable energy that cannot be stored or used by the grid can be channeled to produce hydrogen.

Disadvantages –

- Green hydrogen is not commercially viable at present.
- The current cost in India is around Rs 350-400 per kg; it is likely to become viable only at a production cost of under Rs 100/ kg.
- This is what the National Hydrogen Energy Mission aims for.

NATIONAL GREEN HYDROGEN MISSION

- The National Green Hydrogen Mission was first announced by the Prime Minister in his Independence Day speech in 2021.
- The initial outlay includes

a) ₹17,490 crore for the Strategic Interventions for Green Hydrogen Transition Programme (SIGHT);
b) ₹1,466 crore for pilot projects;
c) ₹400 crore for research and development; and
d) ₹388 crore for other mission components.

Objectives - The mission has a stated aim of making India a global hub for the production of green hydrogen.

The mission is also aimed at

1. Creation of export opportunities for green hydrogen and its derivatives;
2. Decarbonisation of the energy sector and use in mobility applications in a bid to lower the dependence on fossil fuels;
3. Development of indigenous manufacturing capacities;

The government plans to bring down the costs of renewable power generation and of electrolysers used to produce green hydrogen through,

1. Implicit subsidy support and
2. Government-backed R&D push.

IMPLEMENTATION:-

1. The Ministry of New and Renewable Energy is to formulate the scheme guidelines for implementation of the respective components.
2. This scheme will promote the development of green hydrogen production capacity of 5 million metric tonnes (MMT) p.a. with an associated renewable energy capacity addition of 125 GW by 2030.
3. A major part of this is a proposed SIGHT
4. Under the SIGHT, there will be two financial incentive mechanisms that target domestic manufacturing of electrolysers and the production of green hydrogen.
5. These mechanisms will be promoted to achieve a reduction in fossil fuel imports and abatement of annual greenhouse gas emissions by 2030.

The draft Mission will be a major push for hydrogen in the auto sector - R&D for fuel cell development and pilot projects for fuel cell vehicles.

vehicles that run on hydrogen be called

1. Hydrogen is an energy carrier, not a source of energy.
2. Hydrogen fuel must be transformed into electricity using a **fuel cell stack** before it can be used to power a car or truck.
3. A fuel cell converts chemical energy into electrical energy using oxidising agents through an **oxidation-reduction reaction**.
4. Fuel cell-based vehicles most commonly combine hydrogen and oxygen to produce electricity to power the electric motor on board.
5. Since fuel cell vehicles use electricity to run, they are considered electric vehicles (EVs).

HYDROGEN FUEL CELL CARS WORK

- Inside each fuel cell, hydrogen is drawn from an onboard pressurised tank and made to react with a catalyst, usually made from platinum.
- As hydrogen passes through the catalyst, it is stripped of its electrons, which must move along an external circuit, producing electrical current.
- This current is used by the electric motor to power the vehicle, with the only byproduct being water vapour.
- **Significance** - Hydrogen fuel cell cars have near-zero carbon footprint.
- Hydrogen is about 2-3 times as efficient as burning petrol, because an electric chemical reaction is much more efficient than combustion.
- The Toyota Mirai and the Honda Clarity cars are powered by fuel cells.

INDIA

1. India's electricity grid is mainly coal-based and will continue to be so, thus negating collateral benefits from a major EV push - as coal will have to be burnt to generate the electricity that will power these vehicles.
2. Hydrogen vehicles can be especially effective in long-haul trucking and other hard-to-electrify sectors such as shipping and long-haul air travel.
3. Using heavy batteries in these applications would be counterproductive, especially for countries such as **coal-fired India**.
4. Given that much of the generation capacity addition over last 10 years has been by way of renewable energy sources such as solar and wind, this can be diverted for green hydrogen production during non-peak hours.
5. Besides auto, there is a concerted attempt to leverage green hydrogen in sectors such as petroleum refining and steel.
6. **Steel sector, a stakeholder** - In the proposed Mission, the steel sector has been made a stakeholder.
7. It will set up pilot plants partly government-funded to explore how green hydrogen can be used in Direct Reduced Iron (DRI) production by partly replacing natural gas with hydrogen in these gas-based DRI plants.
8. Based on the success of the pilot projects, the gas-based DRI units are to be encouraged for large-scale adoption of the process.

Hydrogen as a fuel

a) Hydrogen is the most common element in nature.
b) It exists only in combination with other elements, and has to be extracted from naturally occurring compounds like water.
c) Hydrogen's potential as a clean fuel source has a history of 150 years.
d) But, it was only after the oil price shocks of the 1970s that the possibility of hydrogen replacing fossil fuels came to be considered seriously.
e) Three carmakers (Honda, Toyota, and Hyundai) having since moved to commercialise the technology, albeit on a limited scale.

Type of hydrogen	Sources and processes by which hydrogen is derived
Grey hydrogen	Hydrogen produced from fossil fuels. Constitutes the bulk of the hydrogen generated today.
Blue hydrogen	Hydrogen generated from fossil fuels with carbon capture and storage options

Green hydrogen	Hydrogen generated using electrolysers powered by renewable sources

Hydrogen Fuel Cell

- Recently, Germany launched the **world's first fleet of fully hydrogen-powered trains, these are emissions-free trains** that can reach speeds of 140 kilometres per hour and can run about 1,000 km before the tank runs dry.

KEY POINTS OF HYDROGEN FUEL CELL

- Hydrogen fuel cells are a clean, reliable, quiet, and efficient source of high-quality electric power.
- They use hydrogen as a fuel to drive an electrochemical process that produces electricity, with water and heat as the only by-products.
- Hydrogen is one of the most abundant elements on earth for a cleaner alternative fuel option.

a) Green hydrogen is produced by electrolysis of water using renewable energy (like Solar, Wind) and has a lower carbon footprint.
b) Electricity splits water into hydrogen and oxygen.
c) By Products: Water, Water Vapor.
d) Brown hydrogen is produced using coal where the emissions are released into the air.
e) Grey hydrogen is produced from natural gas where the associated emissions are released into the air.
f) **Blue hydrogen** is produced from natural gas, where the **emissions are captured** using carbon capture and storage.

Significance:

1. Best Zero Emission Solutions: It is one of the best Zero Emission solutions. It is completely environment friendly with no tailpipe emissions other than water.
2. Tailpipe emissions: Emission of something such as gas or radiation into the atmosphere.
3. Quiet operation: The fact that the fuel cells make little noise means that they can be used in challenging contexts, such as in hospital buildings.
4. Easier scaling: Operation times of fuel cells are longer than those of batteries, with fuel cells, only the amount of fuel needs to be doubled to double the operation time, while batteries require the capacity of the components to be doubled to achieve the same.

Issues:

1. **High Cost:** Green hydrogen makes up **only 0.03% of global hydrogen production** and it is up to five times more expensive than 'grey' hydrogen produced from natural gas or worse, 'brown' hydrogen produced from coal.
2. **Hydrogen Storage:** Storage and transportation of hydrogen is more complex than that required for fossil fuels. This implies additional costs to consider for hydrogen fuel cells as a source of energy.
3. **Hydrogen Extraction:** Despite being the most abundant element in the Universe, hydrogen does not exist on its own so needs to be extracted from water via electrolysis or separated from **carbon fossil fuels.**

- Both of these processes require a significant amount of energy to achieve. This energy can be more than that gained from the hydrogen itself as well as being expensive.
- In addition, this extraction typically requires the use of fossil fuels, which in the absence of carbon capture and storage (CCS) **undermines the green credentials of hydrogen.**

INDIAN SCENARIO:

- **Initiatives Taken:** The Union Budget for 2021-22 has announced a NHM that will draw up a road map for using hydrogen as an energy source.

Other Initiatives for Renewable Energy:

A. JNNSM
B. ISA
C. PM-KUSUM
D. NATIONAL WIND-SOLAR HYBRID POLICY
E. ROOFTOP SOLAR SCHEME

- There is a potential for India **to save more than 24 million tonnes of CO2 emissions every year** and 2,400 million litres of diesel fuel (and associated costs) if the **trains are switched to hydrogen.**
- India currently has around 13,500 trains running every day, around 5,000 (37%) of these are diesel locomotives and the rest is fully electrified.

WAY FORWARD

- **Emission Friendly Alternatives:** Another alternative that many hydrogen councils across the world are pushing for is '**blue' hydrogen**, which is **grey hydrogen coupled with additional installations for carbon capture and storage** incorporated into the production facility.
- This way, up to 90% of the CO2 emitted during hydrogen production can be captured for reuse or storage and prevented from escaping into the atmosphere.

GREEN HYDROGEN: FUEL OF THE FUTURE

- Recently, the Indian Minister of Petroleum and Natural Gas advocated at the **World Economic Forum (WEF)** in Davos, Switzerland that **India will emerge as the leader of green hydrogen**.
- **Background:** This came almost a month after Oil India Limited (OIL) commissioned India's first 99.99% pure green hydrogen plant in **eastern Assam's Jorhat**.
- **Minister's stand:** It will be done by taking advantage of the current energy crisis across the globe.

Green Hydrogen

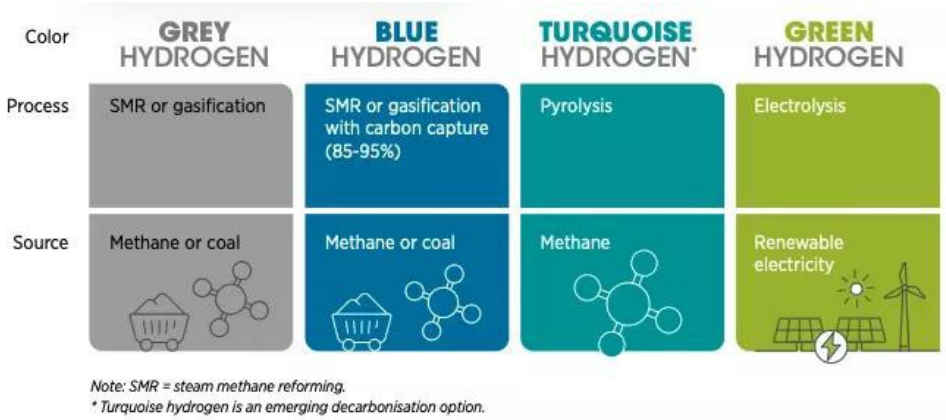
A. It is a colourless, odourless, tasteless, non-toxic and highly combustible gaseous substance.
B. Hydrogen is the lightest, simplest and most abundant member of the family of chemical elements in the universe.
C. **Future hydrogen:** The colour — green — prefixed to it makes hydrogen the "fuel of the future".
D. The 'green' depends on how the electricity is generated to obtain the hydrogen, which does not emit greenhouse gas when burned.
E. **Production:** Green hydrogen is **produced through electrolysis** using renewable sources of energy such as solar, wind or hydel power.
F. **India's Green Hydrogen production:** India has just begun to generate green hydrogen with the objective of raising non-fossil energy capacity to 500 gigawatts by 2030.

G. Recently, India's first 99.99% pure green hydrogen pilot plant was set up in eastern **Assam's Duliajan**, at the petroleum exploration major's Jorhat pump station.

1. It was in keeping with the goal of making the country ready for the pilot-scale production of hydrogen and its use in various applications
2. Research and development efforts are ongoing for a reduction in the cost of production, storage and the transportation of hydrogen.
3. Powered by a 500 KW solar plant, the green hydrogen unit has an installed capacity to produce 10 kg of hydrogen per day and scale it up to 30 kg per day.
4. A specialised blender has also been installed for blending green hydrogen produced from the unit with the natural gas supplied by the Assam Gas Corporation Limited and supplying the blended gas to the Jorhat area for domestic and industrial use.
5. OIL has engaged experts from the Indian Institute of Technology-Guwahati to assess the impact of the blended gas on the existing facility.

Other types of Hydrogen: Hydrogen can be 'grey' and 'blue' too.

- **Grey hydrogen** is generated through fossil fuels such as coal and gas and currently accounts for 95% of the total production in South Asia.
- **Blue hydrogen**, too, is produced using electricity generated by burning fossil fuels but with technologies to prevent the carbon released in the process from entering the atmosphere.



Advantages of Green Hydrogen as a fuel

1. **Stored for a long period:** The intermittent nature of renewable energy, especially wind, leads to grid instability. Green hydrogen can be stored for long periods of time. The stored hydrogen can be used to produce electricity using fuel cells.
2. **Grid stability:** In a fuel cell, a device that converts the energy of a chemical into electricity, hydrogen gas reacts with oxygen to produce electricity and water vapour. Hydrogen, thus, can act as an energy storage device and contribute to grid stability.
3. **Monetary benefits:** Experts say the oxygen, produced as a by-product (8 kg of oxygen is produced per 1 kg of hydrogen), can also be monetised by using it for industrial and medical applications or for enriching the environment.
4. **Flexible carrier:** Hydrogen is a flexible energy carrier and can be used for many energy applications like the integration of renewables and transportation.
5. **Fewer emissions:** It is produced using RE and electrolysis to split water and is distinct from grey hydrogen, which is produced from methane and releases greenhouse gases.

6. **The byproduct is also environmentally friendly:** Energy can be extracted from hydrogen through combustion or through fuel cells, which emit only water as a by-product.
7. **Global dominance increasing:** Several countries in Europe and North America are experimenting with mixing green hydrogen with PNG. For instance, in the UK, power utilities are blending hydrogen into pipelines to fuel power plants, industrial applications and to serve homes. The mixing is around 15-20% in some networks. Besides, there are various pilot projects on hydrogen blending with PNG being tested in countries like the Netherlands, Germany, France, Australia, South Korea and Japan.

DISADVANTAGES

1. **Increased leakage risks:** According to a study by the US Energy Department's National Renewable Energy Laboratory (NREL) in 2013, "How it (hydrogen) affects the pipelines it travels in and appliances that use it.
2. On the pipeline front, hydrogen embrittlement can weaken metal or polyethylene pipes and increase leakage risks, particularly in high-pressure pipes".
3. **Brittle:** Hydrogen embrittlement is a situation when the metal (pipeline) becomes brittle due to the diffusion of hydrogen into the material. The extent of embrittlement depends on the amount of hydrogen and the material's microstructure.

INDIA PURSUING GREEN HYDROGEN

Under the **Paris Agreement** of 2015, India is committed to reducing its greenhouse gas emissions by 33-35% from the 2005 levels.

- It is a legally binding international treaty on climate change with the goal of limiting global warming to below 2°C compared to pre-industrial levels.

1. At the **2021 Conference of Parties in Glasgow**, India reiterated its commitment to move from a fossil and import-dependent economy to a **net-zero economy by 2070**.
2. India's average **annual energy import bill** is more than $100 billion.
3. The increased consumption of fossil fuel has made the country a **high carbon dioxide (CO2) emitter**, accounting for nearly 7% of the global CO2 burden.
4. In order to become **energy independent by 204**7, the government stressed the need to introduce green hydrogen as an alternative fuel that can make India the global hub and a major exporter of hydrogen.
5. It will benefit **India's transportation sector** (which contributes 1/3 of India's greenhouse-gas emissions), iron and steel and chemical sectors.
6. Hydrogen energy can provide **impetus to India's aim to decarbonise by 2050** and attain 175 GW of renewable energy capacity by 2022.
7. The energy in 2.2 pounds (1 kilogram) of hydrogen gas contains about the same as the energy in 1 gallon (6.2 pounds, 2.8 kilograms) of gasoline.

NATIONAL HYDROGEN MISSION

I. The Union Budget for 2021-22 has announced a National Hydrogen Energy Mission (NHM) that will draw up a road map for using hydrogen as an energy source. The initiative has the potential of transforming transportation.
II. It was launched on August 15, 2021, with a view to cutting down carbon emissions and increasing the use of renewable sources of energy.
III. NHM initiative will **capitalise on** one of the most abundant elements on earth (Hydrogen) for a cleaner alternative fuel option.

IV. It will have a **specific strategy for the short term** (4 years) and broad strokes principles for the long term (10 years and beyond).
V. **Aim:** It aims to develop India into a global hub for manufacturing hydrogen and fuel cell technologies across the value chain.
VI. Toward this end, a framework to support manufacturing through suitable incentives and facilitation aligned with 'Make in India' and 'Atmanirbhar Bharat' will be developed.
VII. **Help in achieving climate targets:** The Mission and the green hydrogen sector will give us a quantum jump in meeting our climate targets.
VIII. The target is to make India a green hydrogen hub, and this will also lead to a clean energy transition.

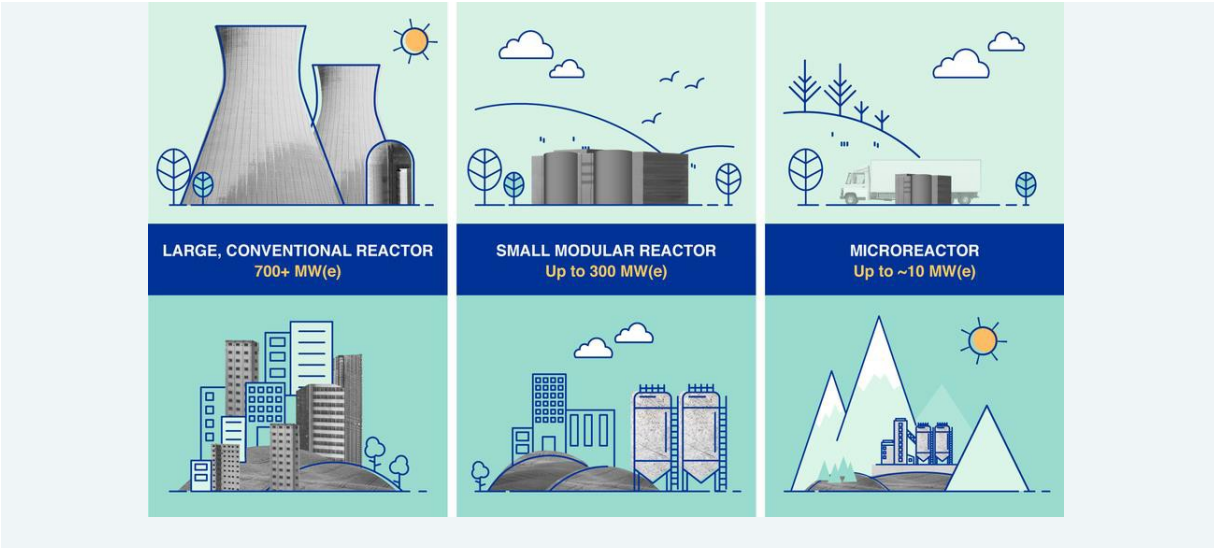
High dependence on import of energy: India is not energy independent. It spends over Rs 12 lakh crore on importing energy.

Way Ahead

- Renewable developers see green hydrogen as **an emerging market** and some have targeted the transport sector, although electric vehicles have begun to catch the imagination of consumers today.
- Policymakers need to take a **holistic approach to plan and analyse** the best model suited to adopt green hydrogen as a primary fuel.

SMALL MODULAR REACTORS

Union Minister of State of the Ministry of Science & Technology recently said, India is taking steps for development of Small Modular Reactors (SMR), with up to 300 MW capacity to fulfill its commitment to Clean Energy transition.



SMALL MODULAR REACTORS (SMRS)

I. SMRs are **advanced nuclear reactors** that have a **power capacity of up to 300 MW(e)** per unit, which is about one-third of the generating capacity of traditional nuclear power reactors. SMRs, which can produce a large amount of low-carbon electricity, are:
II. **Small** – physically a fraction of the size of a conventional nuclear power reactor.
III. **Modular** – making it possible for systems and components to be factory-assembled and transported as a unit to a location for installation.
IV. **Reactors** – harnessing nuclear fission to generate heat to produce energy.

V. **Advantages of SMRs**

VI. SMR, with up to 300 MW capacity by nature are **flexible in design and require smaller footprint.** Given their smaller footprint, SMRs can be sited on locations not suitable for larger nuclear power plants.

VII. Being mobile and agile technology, **SMR can be factory-built unlike the conventional nuclear reactors** that are built on–site. Thus, SMRs offers significant savings in cost and construction time.

VIII. SMR is a **promising technology in industrial de-carbonization** especially where there is a requirement of reliable and continuous supply of power. It is said that SMR is **simpler and safer as compared to large nuclear plants.**

Union Minister Dr Jitendra Singh says, India taking steps for development of Small Modular Reactors (SMR), with up to 300 MW capacity to fulfill its commitment to Clean Energy transition

- The Minister calls upon the private sector and Start-ups to explore development of this critical technology within India

SMRs offers significant savings in cost and construction time and is a promising technology in industrial de-carbonization, besides being mobile and agile: Dr Jitendra Singh

I. Union Minister of State (Independent Charge) Science & Technology; Minister of State (Independent Charge) Earth Sciences; MoS PMO, Personnel, Public Grievances, Pensions, Atomic Energy and Space, Dr Jitendra Singh today said, India is taking steps for development of Small Modular Reactors (SMR), with up to 300 MW capacity to fulfill its commitment to Clean Energy transition.

II. In his address to a Workshop on Small Modular Reactors (SMR) organized by NITI Aayog and Department of Atomic Energy, Dr Jitendra Singh said, the participation of private sector and Start-ups needs to be explored in development of this critical technology within India. He emphasized that technology sharing and availability of funding are the two crucial links for ensuring commercial availability of SMR technology.

III. Dr Jitendra Singh said, the exploration of new clean energy options is in tune with Prime Minister Modi's roadmap for clean energy transition through bold climate commitments which are reflected in our updated Nationally Determined Contributions (NDCs).

IV. Dr Jitendra Singh pointed out that as we have already taken steps for clean energy transition with penetration of non-fossil based energy resources and achieving net-zero by 2070, nuclear in terms of base load power can play a big role in the de-carbonization strategy. It is in this context that the role of nuclear energy will be critical for clean energy transition of not just India but for the entire world, the Minister added.

V. Small Modular Reactors (SMR), with up to 300 MW capacity by nature are flexible in design and require smaller footprint. Being mobile and agile technology, SMR can be factory-built unlike the conventional nuclear reactors that are built on–site. Thus, SMRs offers significant savings in cost and construction time. SMR is a promising technology in industrial de-carbonization especially where there is a requirement of reliable and continuous supply of power. It is said that SMR is simpler and safer as compared to large nuclear plants.

VI. Dr Jitendra Singh said, an impressive number of measures have been taken to promote renewable energy in the country and India today stands at number four in the RE installed capacity across the world, after China, Europe and United States. He added that these measures also conform to the Prime Minister's Aatmanirbhar Bharat goal, where India contributes significant value to global value chain.

VII. It must be noted that India, comprising 17% of the world population has seen its primary energy growing at rate of 4% during the last decade, almost double the global growth rate of 1.3%. However, by historical standards, our share in global emissions is less than 5%.

FLEX FUEL VEHICLES

- Recently, the Government has advised the Automobile Manufacturers in India, to start manufacturing Flex Fuel Vehicles (FFV) and Flex Fuel Strong Hybrid Electric Vehicles (FFV-SHEV) complying with BS-6 in a time bound manner.

FFV and FFV-SHEV:

I. **Flex-fuel vehicles (FFV):** They have engines that can run on flexible fuel — a combination of petrol and ethanol, which can include up to 100 % ETHANOL

II. **Flex Fuel Strong Hybrid Electric Vehicles (FFV-SHEV):** When FFV is integrated along with strong **hybrid electric technology,** it is referred as FFV-SHEVs.

III. **Strong hybrid** is another term for full hybrid vehicles, which have the capability to run solely on **either electric or petrol modes.**

IV. In contrast, **mild hybrids** cannot run purely on one of these modes and use the secondary mode merely as a supplement to the main mode of propulsion.

V. In order to accelerate the introduction of FFVs, thePLI SCHEME has included automobile and auto components of flex fuel engines.

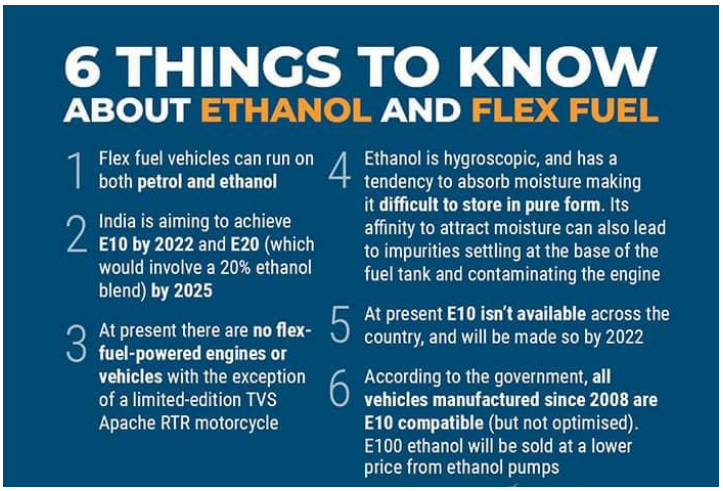
SIGNIFICANCE OF THE MOVE:

1. Easing Pressure on Import Bill: The policy is expected to reduce the demand for petroleum products.
2. India presently imports more than 80% of its petroleum requirement, and this also represents one of the biggest outflows of money from the country.
3. Benefiting Farmers: The wide uptake of ethanol or methanol as a fuel is intended to create an additional revenue stream for farmers.
4. This will provide direct benefits to farmers and help in doubling the farmer's income.
5. Boost to Atma Nirbhar Bharat: It is in line with Prime Minister's vision ofATMA NIRBHAR BHARAT and government's policy on promoting ethanol as a transport fuel.
6. Reducing Greenhouse Gas & Tackling Climate Change: This move will drastically reduce greenhouse gas emissions from vehicles on a well-to-wheel basis.
7. Thereby, helping India to comply with its commitment made at COP-26 to reduce the total projected carbon emissions by one billion tonnes by 2030.

Related Government Initiatives:

1. NATIONAL BIO FUEL POLICY-2018
2. E-100 PROJECT
3. PM-JIVAN YOJANA

4. GOBARDHAN SCHEME
5. RUCO



BS-VI Fuel Norms:

1. The Bharat Stage (BS) are **emission standards instituted by the Government of India** to regulate the output of air pollutants from motor vehicles.
2. India **directly shifted from BS-IV to BS-VI norms**. The switch to BS-VI vehicles was to happen in 2022 but looking at the poor air condition, the move was advanced by four years.
3. In BS-VI fuel, the volume of PM2.5 ranges from 20 to 40 micrograms per cubic metre whereas in BS-IV fuel it is up to 120 micrograms per cubic metre.
4. BS-VI fuel **will bring down sulphur content by 5 times** from the current BS-IV levels. It has 10 ppm of sulphur as against 50 ppm in BS-IV.
5. Sulphur in the fuel contributes to fine particulate matter emissions. High sulphur content in the fuel also leads to corrosion and wear of the automobile engine.
6. With BS-VI fuel, for every one kilometre, **a car will emit 80% less particulate matter** and nearly 70% less nitrogen oxide.
7. AIR POLLUTANTS in BS-VI fuel are much less as compared to BS-IV fuel.
8. BS-VI norms also **seek to reduce the level of certain harmful hydrocarbons** in the emissions that are produced due to incomplete combustion of fuel.

FLEX FUEL

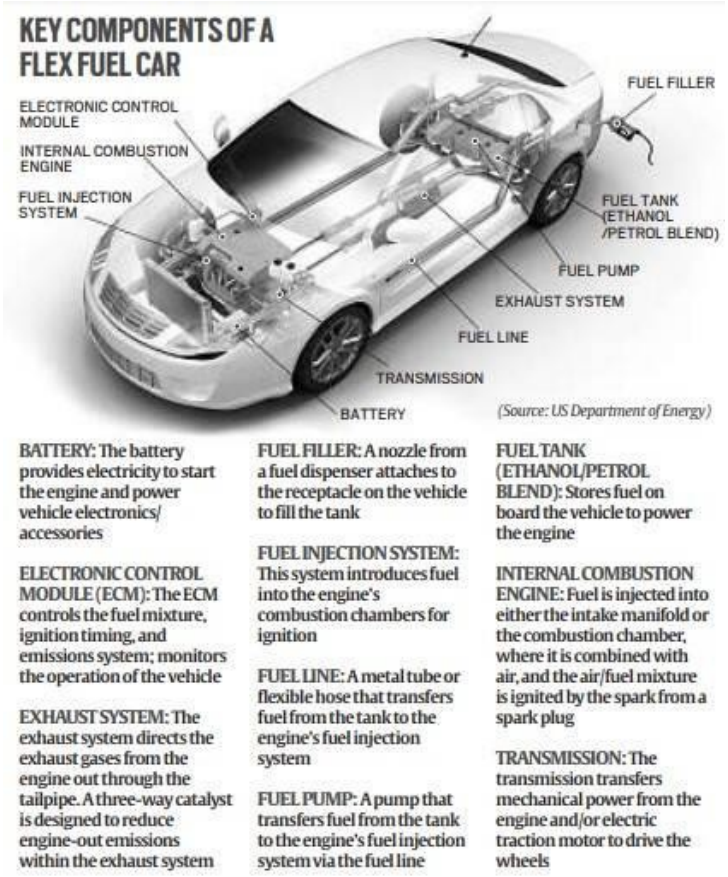
India's first 'flex fuel' developed car is set to launch soon.

FLEX FUEL VEHICLE

It is a Toyota sedan that can run on one or multiple fuel types.

Pilot Project:

1. The pilot has been initiated as part of a **government-led push to carmakers** for adopting alternative fuels and the sedan.
2. It will be equipped with flex fuel tech.
3. Aim will be to replicate the commercial deployment of this particular technology in other markets such as Brazil, Canada and the US.



FLEX FUEL TECHNOLOGY

- A flex fuel, or flexible fuel, vehicle has an internal combustion engine (ICE), but unlike a regular petrol or diesel vehicle, this can run on **more than one type of fuel**, or even a mixture of fuels.
- The most common versions use a blend of **petrol and ethanol or methanol**, but these engines are also equipped to run on 100 percent petrol or ethanol as well.
- This is made possible by equipping the engine with a **fuel mix sensor** and an engine control module (ECM) programming that senses and automatically adjusts for any ratio of designated fuels.

- **Benefit:**

1. The use of ethanol blending **sharply lowers harmful pollutants** such as carbon monoxide, sulphur, and carbon and nitrogen oxides.
2. The blending will help **cutback on oil imports** for fueling vehicles.
3. Countries such as Brazil have the **ability to be flexible** on the degree of the mix depending on the crude prices, varying it when energy prices surge. The precondition being that the vehicular fleet has been equipped to adjust to this fuel mix of varying degrees.

- **Problems:**

1. A flex fuel car typically takes a **small hit on fuel efficiency** when using ethanol for motive power, ranging from between 4 percent and 8 percent.
2. Crops such as sugarcane are usually **very water-intensive**.

3. A NITI Aayog report suggested that in 2019-20, of the total ethanol produced in the country, over 90 percent came from sugarcane alone.

Government Initiatives

1. Currently, around 9.5 percent ethanol blending with petrol has been achieved in fuel dispensed in pumps in most metros and it is likely that the **targeted 10 percent** ethanol blending will be achieved by **November 2022**.
2. The government announced its **2025 target of 20 percent** blending of ethanol in petrol envisaged in its National Biofuel Policy 2018.

FLEX-FUEL VEHICLES

- Key phrases: FFVs, Ethanol, Hybrid engine, E10, E20, E100, Flex Fuel Strong Hybrid Electric Vehicles (FFSHEV)
- FFVs are capable of running on 100 per cent petrol or 100 per cent bioethanol or a combination of both.

FLEX-FUEL VEHICLES (FFVS) :

1. The **flex-fuel engine**-based vehicles use a blend of the gasoline and ethanol. FFVs will allow vehicles to use all the blends and also run on unblended fuel.
2. **Flex fuel vehicles (FFV)** are capable of running on 100 per cent petrol or 100 per cent bio-ethanol or a combination of both.
3. Ethanol is a by-product of sugarcane but can also be made from grains. In short, ethanol is a **renewable fuel** made from various plant materials collectively known as **biomass.**
4. Given the size of the country's sugarcane and grain production, India can meet most of its ethanol requirements indigenously.
5. In a good flex-fuel vehicle, up to 83 per cent ethanol can be mixed with petrol, which is a global standard.
6. **Bio-ethanol** contains less energy per litre than petrol but the calorific value (energy contained in the fuel) of bio-ethanol will become on par with petrol with use of advanced technology.
7. The government has also advised carmakers to start making **Flex Fuel Strong Hybrid Electric Vehicles (FFSHEV).** Such a vehicle, though yet to be made widely available in world markets, essentially houses an electric motor which powers the vehicle alongside the traditional petrol engine.

different from existing vehicles

1. Since an FFV is capable of running on either petrol or ethanol, it will be the first of its kind 100 per cent dual fuel vehicle to be running on Indian roads.
2. To be sure, a litre of petrol sold in India has an average of 8 percent ethanol content even though oil marketing companies have clearance to do even 10 percent (E10) blending.
3. All vehicles manufactured in India are tuned for E10. All existing vehicles on Indian roads will not be able to run on higher ethanol content beyond 10 percent.

Government of India pushing for FFVs

1. Last year (FY21), India's oil import bill stood at $62.7 billion which was matched in just the first seven months (April-October) of this year. To make matters worse, the rupee is at its

weakest level in last three financial years. The government is desperate to bring down the oil import bill by creating fuel substitutes like **ethanol, hydrogen and electricity**.

2. Even a push till the E20 level can result in savings of $4 billion per annum, as per estimates. This is possible only if flex-fuel vehicles are made available in the market. Also, FFVs will also help the government meet its commitments when it comes to **reducing emission.**

Advantages of Flex-Fuel Vehicles:

1. **Environmental impact:** Ethanol burns cleaner than gasoline and therefore is responsible for fewer toxic fumes, which is highly advantageous from an anti-pollution point of view. The fact that ethanol does not contribute significantly to greenhouse gasses, makes it a popular alternative among the environmentally conscious.
2. Alternative fuel ethanol is Rs 60-62 per litre while petrol costs more than Rs 100 per litre in many parts of the country, so by using ethanol, Indians will save Rs 30-35 per litre. Since India has surplus produce of corn, sugar and wheat, the **mandatory blending of ethanol programme** will help farmers in realising higher incomes.
3. **Alternative to oil:** Many flex fuel vehicles make use of ethanol, which originates from corn and sugar cane, a viable alternative to purchasing foreign oil.
4. For India, FFVs will present a different advantage as they will allow vehicles to use different blends of ethanol mixed petrol available in different parts of the country.
5. **For the overall Indian economy**, higher usage of ethanol as an automobile fuel will help save import costs as the country meets more than 80 per cent of its crude oil requirements through imports.
6. **Tax benefit.:** Another significant advantage of driving a flex fuel vehicle is the flex fuel tax credit which replaced the clean-fuel burning deduction. This tax credit substantially reduces and may even eliminate a taxpayer's tax obligation

Disadvantages of Flex-Fuel Vehicles:

1. **Sole use:** The use of ethanol can be considered a disadvantage as well because any crops that are made available for fuel production cannot be used for any other use. This could lead to higher prices for products like animal feed that could otherwise be derived from them. Corn, in particular, is a labour-intensive crop to cultivate and is prone to drought, bad weather conditions and disease
2. **Engine damage:** Ethanol can also unfortunately cause corrosion and damage to the engine, mainly because it absorbs dirt easily
3. **Expense:** Ethanol is also not as economical as gasoline; in that it does not provide the same level of fuel efficiency. Suppliers of ethanol may not be as numerous as those who supply gasoline, so flex fuel stations may be fewer and farther between than is presently the case with gasoline stations. In fact, there are currently only a few stations nationwide that supply ethanol.

Way Forward:

- Although the advantages and disadvantages of flex fuel vehicles will be debated for some time to come, one of the most popular fuels for these vehicles, ethanol, is finding favour with many in power positions. More ethanol refining plants are requesting permission to develop additional facilities. Ethanol has moved out of the research phase and may very well be the first alternative fuel to be implemented nationally, which can only count in favour for the continuing popularity of flex fuel vehicles.

ADDITIONAL TOPICS

SUPER COMPUTERS- PARAM ANANTA

- Recently, PARAM ANANTA, a state-of the art Supercomputer at IIT Gandhinagar was dedicated to the nation under National Supercomputing Mission (NSM).

DETAILS

- **PARAM ANANTA** system is **based on Direct Contact Liquid Cooling technology** to obtain a high power usage effectiveness and thereby reducing the operational cost.
- Multiple applications from various scientific domains such as **Weather and Climate, Bioinformatics, Computational Chemistry, Molecular Dynamics, Material Sciences, Computational Fluid Dynamics etc**. have been installed on the system for the benefit of researchers. This high end computing system will be a great value addition for the research community.

BRIEF HISTORY OF SUPERCOMPUTERS IN INDIA

- Supercomputing in India **began in 1980** when the Indian government set up an indigenous development programme as there were several issues to procure supercomputers from abroad.
- The **National Aerospace Laboratories started the project "Flosolver MK1",** a parallel processing system operating in December 1986. Following this, multiple projects were commissioned from different organisations, including C-DAC, C-DOT, NAL, BARC, and ANURAG.
- C-DOT created "CHIPPS", the C-DOT High-Performance Parallel Processing System, and BARC created the Anupam series of supercomputers. ANURAG created the PACE series of supercomputers.
- Although the C-DAC mission released the "PARAM" series of the supercomputer, it was only in 2015 that the **launch of the National Super Computing Mission boosted the Indian supercomputers**. NSM announced a seven-year programme worth Rs 4,500 crore to install 73 indigenous supercomputers by 2022.

PARAM SERIES

1) PARAM is a series of supercomputers designed and assembled by the Centre for Development of Advanced Computing (C-DAC) in Pune. (Started in 1987 1987).
2) PARAM means "supreme" in the Sanskrit language, whilst also creating an acronym for "PARAllel Machine".
3) The **fastest machine in the series is the PARAM Siddhi AI** which ranks 89th in world with an Rpeak of 5.267 petaflops.
1) PARAM 8000: The first machine built from scratch unveiled in 1991.
2) PARAM 8600
3) PARAM 9000
4) PARAM 10000
5) PARAM Padma: The **first Indian supercomputer to enter the Top500 list of supercomputers in the world**, it ranked 171 in June 2003.
6) PARAM Yuva
7) Param Yuva II
8) PARAM ISHAN
9) PARAM Brahma

10) PARAM Siddhi-AI- ranked 63 among the most powerful supercomputers in the world.

Supercomputers under the National Supercomputing Mission:

- PARAM Shivay
- PARAM Sanganak
- PARAM Pravega
- PARAM PORUL

A. A supercomputer is a computer with a high level of performance as compared to a general-purpose computer because its architectural and operational model depends on the parallel and grid processing.
B. Primary motive to design of supercomputer was to be used in large scale organizations where need more computing power.
C. Supercomputer has a power to execute many processes simultaneously on thousand of processors, because these types of processors can execute billions and trillion of instructions per seconds, so its computing performance matrix is FLOPS (that is floating-point operations per second).
D. The performance of a supercomputer is commonly measured in floating-point operations per second (FLOPS) instead of million instructions per second (MIPS). Supercomputers were started in 1960s.

The first supercomputer was designed by Seymour Cray in 1960 in Control Data Corporation (CDC)

PETAFLOP

1) A petaflop is the ability of a computer to do one quadrillion floating point operations per second (FLOPS).
2) Floating-point numbers have decimal points in them. The number 2.0 is a floating-point number because it has a decimal in it. The number 2 (without a decimal point) is a binary integer.
3) Specific to floating-point numbers, a floating-point operation is any mathematical operation (such as +, -, *, /) or assignment that involves floating-point numbers (as opposed to binary integer operations).

PETASCALE

1) Petascale computing refers to computing systems capable of calculating at least 1015 floating point operations per second (1 petaFLOPS).
2) Petascale computing allowed faster processing of traditional supercomputer applications. The first system to reach this milestone was the IBM Roadrunner in 2008.

CATEGORIES OF SUPERCOMPUTERS

The supercomputer has to divide into three categories such as Vector processing machines, tightly connected cluster computer and in finally commodity computer.

- **Vector processing machines:** This machine was invented in 1980 to 1990s. In which arrange the all processor in the array form, and its CPU is capable to execute all huge mathematically operations in a few time.
- **Tightly connected cluster computer:** In these types of system, connect all groups of computers and assigned the task to all group equally so the reason of this clustering enhanced the speed of computer. There are four types of cluster like as Director-based clusters, Two-node clusters, Multi-node clusters, and massively parallel clusters.

- **Commodity Cluster**: In this system, high-bandwidth low-latency local area networks were interconnected by the Commodity computer.

APPLICATIONS

- Supercomputers have a wide variety of applications such as weather forecasting, aerospace engineering, automobile crash and safety modeling, quantum physics, physical simulations, molecular modeling, oil and gas exploration, defense applications and many more.
- Other applications include virtual reality, computational chemistry, finance, transportation, etc.

There are many application areas where to use of supercomputer such as

Biology Areas

- Mostly, supercomputer used to diagnose for various diseases, and provide the assistance for producing good result in strokes, brain injuries and other blood flow issues in your body

Military and Defense Missions

- Supercomputing help to provide virtual testing for nuclear explosion and weapon ballistics
- Climate Patterns
- Supercomputer application is able to study and understand climate patterns.

Airlines Industry

- With the help of supercomputer, designed the flight simulators for newbie pilots and this simulator help to training for new pilots.

Weather Forecasting

- To gather the information related to weather forecasting, supercomputer run in the NOAA's system, means National Oceanic and Atmospheric Administration. NOAA system is able to execute all types of simple and logically instructions.

Scientific Research areas

- In the weather and science research areas depend on the supercomputer because for analyzing data from the exploring solar system, satellites that rounding earth, and other area such as nuclear research.

Advance database (Data Mining)

- Some large scale companies need the supercomputer for extracting useful information from data storage house or in the cloud system. Such as insurance companies.

Financial Market Place

- Supercomputer plays vital role in the real financial success in the emerging online currency world such as bit coin and stock market

Simulated Environment in Automobile

- Supercomputer provides the help to people for buying vehicle because before purchasing the vehicle customer can test through simulation environment that is created by supercomputer.

Smog Control System

- ❖ Scientists use supercomputers in own laboratory for predicting the fog and other pollution level on the particular areas, and then take final step to prevent them.

INDIA'S NATIONAL SUPERCOMPUTING MISSION

Launch

- ➢ The National Supercomputing Mission was **launched in 2015 for over a period of seven years.**
- ➢ Development and Implementation
- ✓ The Mission is being jointly steered by the Department of Science and Technology (DST) and the Ministry of Electronics and Information Technology (MeitY).
- ✓ It is being implemented by the Centre for Development of Advanced Computing (C-DAC), Pune, and the Indian Institute of Science (IISc),

Objectives

1) To make India one of the world leaders in Supercomputing and to enhance India's capability in solving grand challenge problems of national and global relevance
2) To empower our scientists and researchers with state-of-the-art supercomputing facilities and enable them to carry out cutting-edge research in their respective domains
3) To minimize redundancies and duplication of efforts, and optimize investments in supercomputing
4) To attain global competitiveness and ensure self-reliance in the strategic area of supercomputing technology

Supercomputers in India

- ➢ India's fastest supercomputer Param Parvega sports a supercomputing capacity of 3.3 petaflops.
- ➢ Some other supercomputers of India are: Param Siddhi, Cray XC40-based Pratyush, Mihir, Param Shivay etc.
- ➢ By 2022, the government aims to install 73 indigenous supercomputers across the country.

DIFFERENCE BETWEEN A RAMJET AND SCRAMJET

- ❖ The key benefits of scramjet and ramjet engines are that they don't have rotating or moving parts, which enables the vehicle to travel at higher speeds with greater efficiency. The following are **Differences between a Ramjet and Scramjet**:

RAMJET	SCRAMJET
Ramjets don't have any moving parts, unlike turbojets.	The leading enabling technology for this initiative is the scramjet engine.
Ramjet engines known as scramjets (supersonic-combustion ramjets) maintain supersonic airflow throughout the machine.	It might be impossible to maintain a supersonic flight without it.
Ramjet-powered vehicles require rocket-assisted take-off to push them to a speed where they can begin to create thrust.	Scramjet technology is complex since there are few ground-based testing options.

It is a type of airbreathing jet engine that generates thrust by using the engine's forward motion.

It is a ramjet airbreathing jet engine version in which combustion occurs in supersonic airflow.

Using shock cones, a ramjet slows the air to subsonic speeds before combustion.

A scramjet relies on high vehicle speed to forcefully compress entering air before combustion.

NATIONAL ANTI-DOPING BILL

Recently, Parliament passed the National Anti-Doping Bill.

- **Meaning:** The term "doping" refers to the **use of prohibited medications**, drugs, or treatments by athletes with the intention of improving athletic performance.
- **Regulation**: In 1967 the International Olympic Committee (IOC) banned doping, and in 1999 the IOC led the initiative to form the **World Anti-Doping Agency (WADA)**.

1. **WADA forms the backbone of anti-doping laws** and testing worldwide, and assists in setting the standard for other agencies and sports.
2. **WADA's main activities include** education of the health risks of doping, scientific research of doping practices, development of anti-doping capabilities, and development of testing methods for doping detection.

Criteria that constitutes doping:

1. It enhances performance
2. It presents a risk to the athlete's health
3. It is contrary to the spirit of the sport

Issues associated with doping:

- ✓ Athletes would often **suffer adverse health effects** and even **premature death** that seemed to be associated with the doping practices.
- ✓ **Stunted growth** and disruption of **puberty in children**.
- ✓ Steroid use can be associated with **depression, and in some cases, suicide**.

National Anti Doping Agency (NADA)

1. It is under the Ministry of Youth Affairs & Sports.
2. It was set up as a registered society under the Societies Registration Act of 1860 in 2005 with a mandate for Dope free sports in India.
3. The primary objectives are to implement anti-doping rules as per WADA code, regulate dope control programmes, to promote education and research and create awareness about doping and its ill effects.
4. NADA includes scientists and representatives from the Indian Olympic Association (IOA).

Recent activities by NADA:

- ✓ NADA has developed an anti-doping **education and awareness generation toolkit** with the use of technology.
- ✓ **Awareness generation** right down the school level about what comprises doping and related aspects.

MAJOR PROVISIONS OF THE BILL

STATUTORY AUTHORITY

- The Bill is intended to provide a statutory framework for the operation of the **National Anti-Doping Agency**, the **National Dope Testing Laboratory** and other **dope testing laboratories** and for creation of a **National Board for Anti-Doping in Sports** to strengthen anti-doping activities in sport.
- **Statutory framework** in the form of **legislation for prohibition** of doping in sports and enforcing anti-doping activities in the country.

Investigation

- The bill provides for planning, implementing, and monitoring anti-doping activities as well as **investigating anti-doping rule violations**.

Prohibition

- The legislation **prohibits athletes, athlete support personnel**, and other persons from engaging in doping in sports.

Punishment

- The violation of anti-doping rules may result in disqualification of results including forfeiture of medals, points, and prizes, ineligibility to participate in a competition or event for a prescribed period, and financial sanctions.

The proposed Bill intends to accomplish:

- **Building institutional capabilities** in anti-doping and enabling hosting of major sports events;
- **Protecting rights** of all sportspersons;
- Ensuring **time-bound justice** to athletes;
- **Enhancing cooperation** among agencies in fighting doping in sports;
- Reinforcing India's commitment to **international obligations** for clean sports;
- **Independent mechanism** for anti-doping adjudication;
- Providing **legal sanctity** to National Anti Doping Agency (NADA) & National Dope Testing Laboratory (NDTL);
- Establishing **more Dope Testing Labs**;
- **Creating job opportunities** both, directly & indirectly; and
- **Creating opportunities** for academic research, science and manufacturing relating to Anti-Doping.
- **Establishing standards** for the manufacturing of nutritional supplements for sports in India.

Facts/ Data

- National Sports University worth 900 crore rupees is in Manipur.
- India bagged seven medals in the Tokyo Olympics which is the highest in the Indian Olympic history.

SIGNIFICANCE OF THE BILL

Club of select countries

1. India will now join the League of Nations like the **US, China, France, Australia, Japan, S Korea** to have a law and dope test laboratory.
2. **Around 30 countries** have their own **Anti-Doping Law**.

Increase the testing capacity

1. India could carry out **only about 6,000 tests a year** at present and the proposed legislation would help increase the testing capacity significantly.
2. For holding any major international championship, the number of tests required **could be as high as 10,000 a month**.

Testing facility

- The Bill will also pave the way for **establishing more Dope Testing Laboratories** in the country.
- Samples from **16 countries were tested in laboratories** located in India.

Focus on the field of sports medicine

- All competitions should be brought under NADA and sought more focus on the field of sports medicine and science to help players recover from injuries.

Awareness, education and research

- The passing of the Bill will help to increase awareness, education and research facilities related to anti-doping within the country.

Way Forward

- **Strong message to the world**: The making of this Law will send a strong message to the world that India is very serious about sports, sportspersons and tackling doping.
- **Highest standards of integrity**: The new Law will ensure highest standards of integrity while participating and preparing for sports competitions, domestically and internationally.
- **UNESCO convention**: It also seeks to give effect to the United Nations Educational, Scientific and Cultural Organisation International Convention against doping in sports and compliance with such other obligations and commitments.
- **Sports infrastructure**: the government will leave no stone unturned in the promotion of sports and enhancing facilities for the sportspersons and creating sports infrastructure.
- **North-east India:** Government has worked on **Act East policy** as athletes from the northeast have made an **immense contribution** to a sports arena in India.

CRYPTOJACKING

1) Cryptojacking **attacks on computer systems have gone up by 30%** to 66.7 million in the first half of 2022 compared to the first half of last year, according to a report by SonicWall, a US-based cybersecurity firm.
2) While volume increases were widespread, **some business sectors were hit harder** than others, such as the **finance industry**, which saw a rise of 269%

CRYPTOJACKING

- Cryptojacking is a cyber attack wherein a computing device is hijacked and controlled by the attacker, and its resources are used to illicitly mine cryptocurrency.
- In most cases, the malicious programme is installed when the user clicks on an unsafe link, or visits an infected website — and unknowingly provides access to their Internet-connected device.

CRYPTOJACKING

- Coin mining is a legitimate, competitive process used to release new crypto coins into circulation or to verify new transactions.
- It involves solving complex computational problems to generate blocks of verified transactions that get added to the blockchain.
- The reward for the first miner who successfully manages to update the crypto ledger through this route is crypto coins.
- But the race to crack this 64-digit hexadecimal number code needs considerable computing power involving state-of-the-art hardware, and electrical power to keep the systems involved up and running.
- Cryptojackers co-opt devices, servers, and cloud infrastructure, and use their resources for mining. The use of stolen or cryptojacked resources slashes the cost involved in mining.

cryptojacking incidents gone up

1. According to the SonicWall's Cyber Threat Report, the crackdown on ransomware attacks is forcing cybercriminals to look for alternative methods.
2. Cryptojacking involves lower risk, and promises potentially higher payday.
3. Cryptojacking is an appealing alternative for cybercriminal gangs as it has a lower potential of being detected by the victim; unsuspecting users across the world see their devices get unaccountably slower, but it's hard to tie it to criminal activity, much less point to the source.
4. Unlike ransomware, which announces its presence and relies heavily on communication with victims, cryptojacking can succeed without the victim ever being aware of it.

concern

1. Cryptojacking is hard to detect and the victims of these attacks mostly remain unaware that their systems have been compromised.
2. Some telltale signs are the device slowing down, heating up, or the battery getting drained faster than usual.
3. Apart from individuals, businesses too are on the target list of cryptojackers.
4. The primary impact of cryptojacking is performance-related, though it can also increase costs for the individuals and businesses affected because coin mining uses high levels of electricity and computing power.

KALA AZAR (BLACK DEATH)

- According to reports, eleven districts of Bengal have reported at least 65 cases of black fever or kala azar in the last couple of weeks

KALA-AZAR

1. It is a slow progressing indigenous disease caused by a protozoan parasite of genus Leishmania.
2. Kala azar or leishmaniases is one of the most dangerous neglected tropical diseases (NTDs) which is endemic in 76 countries, with approximately 200 million people at risk of infection

Forms:

- There are 3 main forms of leishmaniasis – visceral (also known as kala-azar, which is and the most serious form of the disease), cutaneous (the most common where skin is affected), and mucocutaneous

Transmission:

1. **Leishmania parasites are transmitted** through the **bites of infected female** phlebotomine sandflies, which feed on blood to produce eggs.
2. Some 70 animal species, including humans, have been found as natural reservoir hosts of Leishmania parasites.

Impacts:

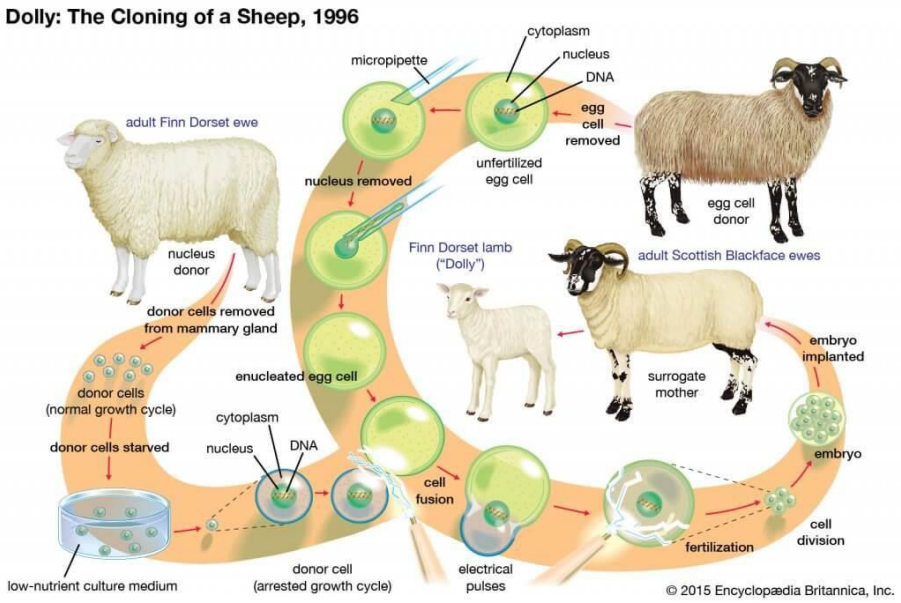
1. The disease affects some of the poorest people and is associated with malnutrition, population displacement, poor housing, a weak immune system and lack of financial resources.
2. Leishmaniasis is also linked to environmental changes such as deforestation, building of dams, irrigation schemes and urbanization.

PREVENTION AND CONTROL:

1. **Prevention and control of leishmaniasis** requires a combination of intervention strategies.
2. It is a treatable and curable disease, "which requires an immunocompetent system because medicines will not get rid of the parasite from the body, thus the risk of relapse if immunosuppression occurs".
3. Effective disease surveillance is important to promptly monitor and act during epidemics and situations with high case fatality rates under treatment.

CLONING, GMO, THREE PARENT BABY

- Cloning is a technique scientists **use to make exact genetic copies of living things.** Genes, cells, tissues, and even whole animals can all be cloned.
- The **copied material**, which has the same genetic makeup as the original, is referred to as a **clone.**
- **Production of cells or organisms originally derived from a single original cell or organism by the asexual method under laboratory conditions**.
- **Dolly was the first mammal successfully cloned**. The first clones were **frogs**.
- Scientists at **India's National dairy research institute Karnal Haryana produced the first cloned buffalo** in 2009; however, the **buffalo died a few days later.**



TYPES OF CLONING

There are three different types of cloning:

A. Gene cloning, which creates copies of genes or segments of DNA.
B. Reproductive cloning, which creates copies of whole animals.
C. In this we actually reproduce not organ but entire being(donor) from where we got genetic information.
D. Egg cell is placed into the uterus after few divisions in it. The cell is allowed to develop into foetus that is genetically identical to the donor of the original nucleus.
E. Therapeutic cloning, which creates embryonic stem cells. Researchers hope to use these cells to grow healthy tissue to replace injured or diseased tissues in the human body.
F. In therapeutic cloning, the aim is to clone cells that make particular organs or types of tissue.
G. Egg is placed in a Petri dish to develop into embryonic stem cells which have shown potential for treating several ailments.
H. It is also called somatic cell nuclear transfer or research cloning.
I. In this technique, the resultant embryo is allowed to grow for 14 days.
J. Its stem cells would then develop into human tissue or a complete human organ for transplant.

Use of therapeutic cloning:

1) Overcomes the problem of **immune rejection** which is a major concern in tissue transplantation
2) Cell which are removed can give rise to all cells in the body except embryo i.e. it can **treat diseases** by replacing damaged cells
3) Help in studying **stem cells and future medical importance of it to treat against common diseases** affecting today such as diabetes and Parkinson's disease.
4) Understanding the process of **cancer formation**
5) Help in **plastic, reconstructive and cosmetic surgery.**

HUMAN CLONING

Positive	Negative
1) Can solve the issue of infertility	➢ Tamper with genetics in human beings,

2) Can help save a life in case of kidney failure 3) May be possible to reproduce sudden trait in humans via cloning	raises the probability of deliberate reproduction of undesirable traits. ➢ May violate social norms ➢ Endangers and exploits women: Put them on high risk of ovarian cancer, infertility.

Methods:

- **Natural:** This happens naturally when one embryo spontaneously divides into two or more embryos, thus creating identical twins or, sometimes, triplets or even more
- **Artificial:** An existing embryo is mechanically divided into two or more embryos that are then allowed to develop naturally
- **Artificial and Donor:** Through the use of somatic cell of Donor.

SIGNIFICANCE

1) An embryo made by cloning can be turned into a stem cell factory. Stem cells are an early form of cells that can grow into many different types of cells and tissues. Scientists can turn them into nerve cells to fix a damaged spinal cord or insulin-making cells to treat diabetes.
2) The cloning of animals has been used in a number of different applications. Animals have been cloned to have gene mutations that help scientists study diseases that develop in the animals.
3) Livestock like cows and pigs have been cloned to produce more milk or meat.Example India is doing this project on Indigenous breeds
4) Cloning might one day bring back extinct species like the woolly mammoth or giant panda.
5) It overcomes the problem of immune rejection which is major concern during organ transplantation
6) It can help in understanding process of ageing

ISSUES

1) Many researchers think it is worthwhile to explore the use of embryonic stem cells as a path for treating human diseases. However, some experts are concerned about the striking similarities between stem cells and cancer cells. Both cell types have the ability to proliferate indefinitely and some studies show that after 60 cycles of cell division, stem cells can accumulate mutations that could lead to cancer. Therefore, the relationship between stem cells and cancer cells needs to be more clearly understood if stem cells are to be used to treat human disease.
2) Researchers have observed some adverse health effects in sheep and other mammals that have been cloned. These include an increase in birth size and a variety of defects in vital organs, such as the liver, brain and heart.
3) Another potential problem centers on the relative age of the cloned cell's chromosomes. As cells go through their normal rounds of division, the tips of the chromosomes, called telomeres, shrink. Over time, the telomeres become so short that the cell can no longer divide and, consequently, the cell dies. This is part of the natural aging process that seems to happen in all cell types. As a consequence, clones created from a cell taken from an adult might have chromosomes that are already shorter than normal, which may condemn the clones' cells to a shorter life span. Indeed, Dolly, who was cloned from the cell of a 6-year-old sheep, had chromosomes that were shorter than those of other sheep her age. Dolly died when she was six years old, about half the average sheep's 12-year lifespan.

4) Reproductive cloning would present the potential of creating a human that is genetically identical to another person who has previously existed or who still exists. This may conflict with long-standing religious and societal values about human dignity, possibly infringing upon principles of individual freedom, identity and autonomy. However, some argue that reproductive cloning could help sterile couples fulfill their dream of parenthood. Others see human cloning as a way to avoid passing on a deleterious gene that runs in the family without having to undergo embryo screening or embryo selection.
5) Therapeutic cloning, while offering the potential for treating humans suffering from disease or injury, would require the destruction of human embryos in the test tube. Consequently, opponents argue that using this technique to collect embryonic stem cells is wrong, regardless of whether such cells are used to benefit sick or injured people.

India does not have specific laws regarding cloning but has guidelines prohibiting whole human cloning or reproductive cloning. India allows therapeutic cloning and the use of embryonic stem cells for research purposes

RESTRICTION FRAGMENT LENGTH POLYMORPHISM (RFLP)

1) Restriction Fragment Length Polymorphism is a technique that uses Restriction enzymes to identify variations in the homologous DNA sequences.
2) The DNA isolated from an individual organism has a unique sequence and even the members within a species differ in some parts of their sequence.
3) The restriction sites would also vary and hence if DNA from a given individual was subjected to digestion with a restriction enzyme the fragments generated would vary when compared with another individual's DNA similarly digested.
4) A major application of this technique is DNA Fingerprinting.
5) Individuals except identical twins vary in their RFLP pattern as indicated schematically in the agarose gel electrophoresis.
6) Hence the term DNA fingerprint is used and this is the basis of a major technique used in forensic science to identify and relate individuals.

POLYMERASE CHAIN REACTION

1) The polymerase chain reaction or PCR as it is commonly known was invented by Kerry Mullis in 1985.
2) It results in the selective amplification of a specific region of a DNA molecule and so can also be used to generate a DNA fragment for cloning.
3) The basic principle underlying this technique is that when a double-stranded DNA molecule is heated to a high temperature, the two DNA strands separate giving rise to single-stranded molecules which can be made to hybridise with small oligonucleotide primers (single-stranded) by bringing down the temperature.
4) If to this an enzyme called DNA polymerase and nucleotide triphosphates are added, much like what happens during replication, i.e primer extension occurs.
5) This procedure is repeated several times ultimately results in amplification of the DNA stretch between the two primers (one on each strand of the DNA).
6) A single PCR amplification cycle involves three basic steps of denaturation, annealing, and extension.
7) In the denaturing step, the target DNA is heated to a high temperature, above 80 C which results in DNA strand separation.
8) PCR-based diagnosis is faster, safer, and more specific – because it does not use live pathogens; instead, DNA from the infected tissue is isolated and the PCR technique is carried out using primers having specific complementary sequences to the pathogen DNA.

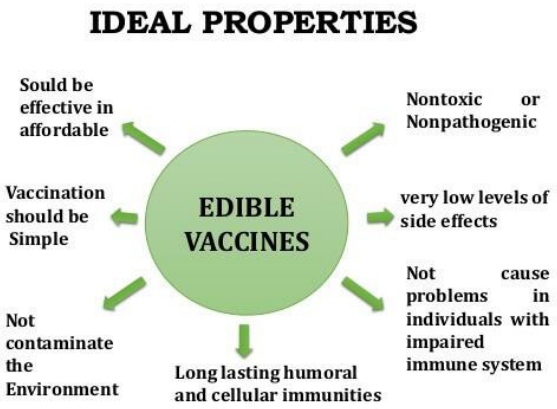
9) It is interesting that archaeologists are using combinations of PCR and fingerprinting analysis to relate and establish ancient Egyptian dynasties from samples obtained from mummies.

MOLECULAR FARMING

1) Molecular farming is a new technology that uses plants to produce large quantities of pharmaceutical substances such as vaccines and antibodies. It relies on the same method used to produce genetically modified (GM) crops – the artificial introduction of genes into plants.
2) A number of vaccines, antibodies, and other therapeutic substances made in plants such as tobacco, maize, potato, and carrot are already commercially available or in advanced clinical trials. Producing pharmaceuticals in plants is easy and efficient compared to conventional production methods.
3) Typically, animal or microbial cell cultures are used to produce vaccines but costs associated with maintenance, safety; storage and transport are 80% higher compared to plant-derived vaccines.

EDIBLE VACCINES

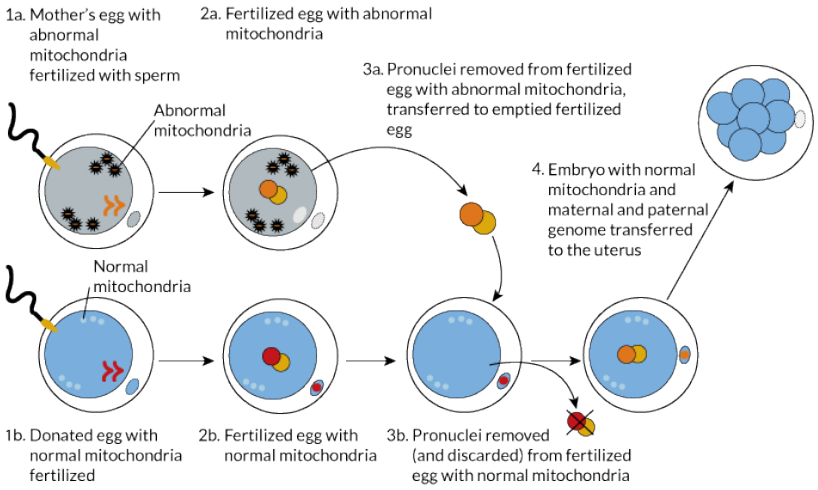
- A genetically manipulated food containing organisms or related antigens that may provide active immunity against infection.
- Edible vaccines against many microorganisms are being developed, with the goal of using them to vaccinate children in nonindustrialized countries where there are obstacles to the use of the traditional injectable vaccine.
- **Examples of Edible vaccines: Transgenic Potatoes for Diarrhoea:**
- They were tested and found to be effective, however raw potatoes are non-edible and cooking destroys protein antigens.



Advantages of Edible vaccines	**Disadvantages of edible vaccines**
1) They are cheap therefore they can be mass-produced. 2) They are stable at room temperatures. 3) Need to process and purify do not occur 4) Most importantly they trigger immunity at the mucosal surface. For e.g.: Those that line the mouth.	1) Will the antigen be able to survive the hostile condition of the stomach and even if they will then be trigger immune system in the right way. 2) Continued vaccine production might not be guaranteed due to changes in plants 3) Glycosylation in patterns in plants differ from humans and could affect the functionality of vaccine.

THREE PARENT BABY / MITOCHONDRIAL GENE THERAPY

1) A team of Greek and Spanish doctors has produced a baby (in Greece) using **genetic material from two women and a man.**
2) The **procedure replaces a small amount of faulty DNA in a mother's egg with healthy DNA from a second woman, so that the baby would inherit genes from two mothers and one father.** The idea is to prevent certain genetic diseases being passed on to children.
3) The technique used is called as **'Maternal Spindle transfer'** in which **maternal DNA is put into the egg of a donor woman**, which is then fertilized using the father's sperm.
4) The procedure was developed to **help existing IVF treatments in which mothers have mitochondrial diseases.**
5) The technique is considered controversial by some doctors.
6) **Mitochondrial diseases are long-term, genetic, often inherited disorders** that occur when mitochondria fail to produce enough energy for the body to function properly.
7) **In Vitro Fertilization (IVF)** is a medical procedure in which **mature egg cells are removed from a woman, fertilized with male sperm outside the body, and inserted into the uterus** of the same or another woman for normal gestation.
8) **Britain became the first country to allow for a three-parent baby** and in 2017 the first 3 parent baby was born.



Risks:

- Several people argue that this leads to **designer babies**
- Experts have warned that three-parent babies could be at greater risk of cancer and premature ageing, and would need to be monitored all their lives.
- Since this is uncharted territory and the children born from this technology would have heritable genetic changes, there are also significant unknown risks to future generations.
- There are numerous serious risks associated with this technology. These include most notably the possibility that developmentally disabled or deceased babies will be produced.
- Aberrations could also lead to developmental defects in babies or also manifest in later life as increased rates of ageing of cancer.

LAUNCH VEHICLE MARK 3 (LVM3 OR GSLV MARK 3

The Indian Space Research Organisation's (ISRO) **heaviest rocket** Launch Vehicle Mark 3 (LVM3 **or GSLV Mark 3**) took off from the Satish Dhawan Space Centre, Sriharikota, and successfully **orbited 36 satellites of U.K.-based OneWeb.**

- ISRO would place another 36 satellites in the next M3 mission.
- This mission is being undertaken as part of the commercial arrangement between **NSIL** and m/s Network Access Associates Limited (m/s **OneWeb Ltd**), a U.K. based company.

LVM3:

1) LVM3-M2 is the dedicated commercial satellite mission of **NewSpace India Limited** (NSIL), a Central Public Sector Enterprise (CPSE) under the Department of Space, Government of India.
2) The **43.5 metre** LVM3 weighing around 644 tonnes carried 36 satellites weighing 5,796 kg or about 5.7 tonne.
3) With this launch, LVM3 has made its entry into the **global commercial launch service market**.
4) The LVM3 was conceived primarily for launching **geo-stationary satellites** with a payload capacity of 4T, which can be used for launching 6T payloads for LEO.
5) The mission is very critical to meet the customer's expectations to launch 36 satellites in 9 phases with precision. The mission was designed in such a way that C25 stage was to handle this operation using in-house built inertial navigation systems.

ONEWEB:

- OneWeb is a joint venture between **India's Bharti Enterprises** and the **U.K**. government.
- This is OneWeb's **14th launch**, bringing the constellation to 462 satellites.
- This launch represents more than **70%** of its planned 648 Low Earth Orbit (**LEO**) satellite fleet that will deliver **high-speed, low-latency** connectivity worldwide.
- With only four more launches to go, OneWeb remains on track to activate **global coverage in 2023.**

Significance:

- The launch with ISRO and NSIL opens up the space sector in India with the possibility of billions of dollars flowing into the country.
- This partnership with NSIL and ISRO demonstrates OneWeb's commitment to provide connectivity across the length and breadth of India by 2023.
- It will bring secured solutions not only to enterprises but also to towns, villages, municipalities and schools, including the hardest-to-reach areas across the country.

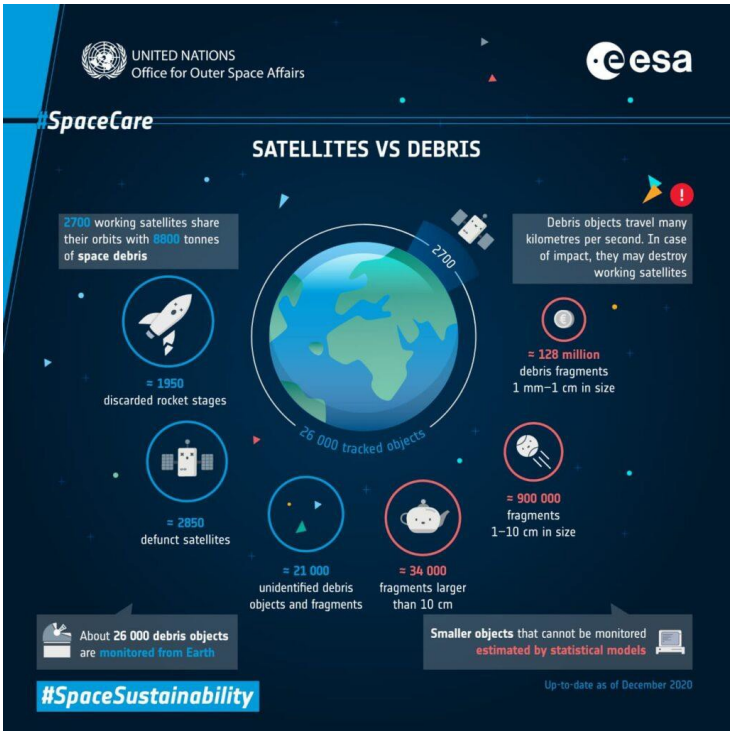
ADOPTING SUSTAINABLE SPACE TECHNOLOGY

- World Space Week this year is themed around 'Space and Sustainability'. Among other things, the 2022 theme seeks to specifically inspire focus on the challenges the world faces to keep space safe and sustainable**.**

MEAN BY SPACE

- Space is an almost perfect vacuum, nearly void of matter and with extremely low pressure. In space, sound doesn't carry because there aren't molecules close enough together to transmit sound between them. Not quite empty, bits of gas, dust and other matter floats around "emptier" areas of the universe, while more crowded regions can host planets, stars and galaxies.
- From our Earth-bound perspective, outer space is most often thought to begin about 62 miles (100 kilometers) above sea level at what is known as the Kármán line. This is an imaginary boundary at an altitude where there is no appreciable air to breathe or scatter

light. Passing this altitude, blue starts to give way to black because oxygen molecules are not in enough abundance to make the sky blue.



Space sustainability

- Space sustainability is ensuring that all humanity can continue to use outer space for peaceful purposes and socioeconomic benefit now and in the long term. This will require international cooperation, discussion, and agreements designed to ensure that outer space is safe, secure, and peaceful.

necessitate the sustainable space technology debate

A. **Mounting challenge of Space debris:** Challenges are endless in both quantitative and qualitative terms, i.e., they are several and severe, ranging from satellite crowding and collision risk to space debris in the Low Earth Orbit (LEO).
B. **Ever increasing satellites:** The sense of urgency around space sustainability is already skyrocketing—more than 80 countries currently contribute to the over 6,800 active satellites in orbit, of which many are used for both civilian and military purposes, as well as over 30,000 pieces of orbital debris.
C. **Militarization of space:** Given the development of new and emerging space technologies, the rapid militarisation and securitisation of space, and the growing distrust amongst nations in the domain, space activity is only set to increase and acquire a more national security-oriented focus.
D. **Large scale Development of ASAT:** This is already visible in several countries around the world. There has been a recent uptick in the development and testing of destructive anti-satellite (ASAT) weapons, with 26 tests in the past two decades conducted by the four countries that have access to these weapons (US, Russia, China, and India).
E. **Massive investment into military space capability:** France, which is currently leading the European Council, has also invested several billion euros into military space capabilities, and regularly emphasises the security importance of space for other EU countries.

F. **Increasing Defence space commands:** Australia set up its Defence Space Command in early 2022 to increase its strategic potential in space, and South Korea deployed a spy satellite to better monitor North Korea in June 2022, giving its military space plan a huge push.
G. However, none of these countries have a sustainability provision in their defence space operations or programmes.
H. **Dichotomy in Security and sustainability:** Sustainability and security are two sides of the same coin, but as a result of this inherent dichotomy, they are often juxtaposed against each other.
I. **Keeping Security is the priority:** The contrast between highly motivated and funded national security efforts and the relatively non-prioritised international engagements around space sustainability is an example of a larger trend of indifference towards sustainable development in favour of higher military spending.
J. **SDG on backburner:** To substantiate this point, funding for the Sustainable Development Goals (SDGs) was adversely affected due to COVID-19 in 2021, and this reportedly dramatically pushed back progress on the SDGs, but the global military expenditure has consistently been on an upward incline and crossed the US$2 trillion mark for the first time in the same year.
K. **Securitization of space:** The trade-off between security and sustainability can jeopardise sustainable development within a plethora of issue domains, thus, increasing the likelihood of exhausting limited resources. This in turn could exacerbate the risk of conflict due to the resulting scarce resources, ultimately creating a vicious cycle of securitisation and conflict.
L. **Rat race in Space :** As a case in point, the incumbent space race has always been marked by competing security and commercial interests, which has resulted in a constant escalation of global government spending on space programmes to its record value of US$98 billion in 2021. Space sustainability, on the other hand, has only seen activity recently, and primarily in an international and voluntary set-up.

REGULATIONS ARE NEEDED FOR SUSTAINABLE SPACE

- **Prioritising peaceful use of space:** A Working Group on the Long-term Sustainability of Outer Space Activities was set up by the Committee on the Peaceful Uses of Outer Space (COPUOS) in 2010, which has 95 UN member states taking part in it. The Group adopted a set of guidelines by consensus in 2019, although it failed to make these guidelines or any other regulations legally binding. It agreed to work over it for 5 years from 2022 onwards, but since the Group uses a consensus-based approach to reach agreements, it is difficult to expect more stringent or extensive regulatory frameworks to emerge from it.
- **Consensus is difficult but necessary:** Consensus-based approaches in multilateral forums, especially related to arms or other security objectives, often contrast with individual national security interests of its member states and have been criticised for their slow or ineffective progress.
- **Convention on Certain Conventional Weapons:** Another example of this is the Convention on Certain Conventional Weapons' (CCW) Group of Government Experts (GGE) meetings on lethal autonomous weapons systems (LAWS), which have only produced a set of 11 non-binding guiding principles since deliberations around LAWS began in 2014.
- **Space sustainable ratings should be developed:** The World Economic Forum, for instance, introduced a new standard called the Space Sustainability Rating (SSR), in 2022, which aims to recognise, reward, and encourage space actors to design and implement sustainable and responsible space missions. It remains to be seen whether countries will respond favourably to tools like the SSR, which are based on a positive reinforcement model, to be more space sustainability-conscious.

Conclusion

- space sustainability is only at the cusp of becoming actionable.
- When space experts, intergovernmental organisations, or countries themselves conclude that sustainability should be a part of their space mandate, and when they devise possible methods to help achieve this, they cannot do so in a vacuum.
- Space sustainability should not become the political football like climate change.