



INSIGHTSIAS

SIMPLIFYING IAS EXAM PREPARATION

INSTA PT 2022 EXCLUSIVE

SCIENCE AND TECHNOLOGY

JANUARY 2021 – FEBRUARY 2022

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Space Technology

(Indian Space Programmes)

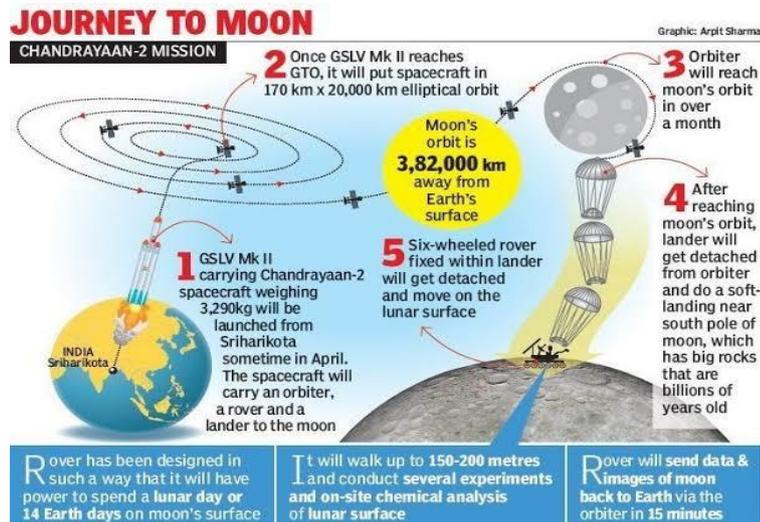
1. Chandrayaan-3

Indian Space Research Organisation (ISRO) is set to launch Chandrayaan-3 in August 2022.

What we know about Chandrayaan 3 so far?

Chandrayaan-3 is the **successor to the Chandrayaan-2 mission** and it will likely attempt another **soft-landing** on the lunar surface.

- It will be a mission repeat of Chandrayaan-2 but **will only include a lander and rover** similar to that of Chandrayaan-2. It will **not have an orbiter**.



What is Chandrayaan-2?

- The Mission brought together an **Orbiter, Lander and Rover** with the goal of exploring **the south pole of the Moon**.
- It aimed **at studying not just one area of the Moon but all the areas combining the exosphere**, the surface as well as the sub-surface of the moon in a single mission.

Why are we interested in studying the moon?

- The Moon is the **closest cosmic body** at which space discovery can be attempted and documented.
- It is also a promising test bed to **demonstrate technologies required for deep-space missions**.
- The Moon provides **the best linkage to Earth's early history**.
- It offers an **undisturbed historical record** of the inner Solar system environment.

Why was the Lunar South Pole targeted for exploration?

The **Lunar South pole** is especially interesting because the lunar surface **area that remains in shadow is much larger than that at the North Pole**.

- There could be a **possibility of presence of water in permanently shadowed areas** around it.
- In addition, **the South Pole region has craters that are cold traps and contain a fossil record** of the early Solar System.

What happened to Chandrayaan-2?

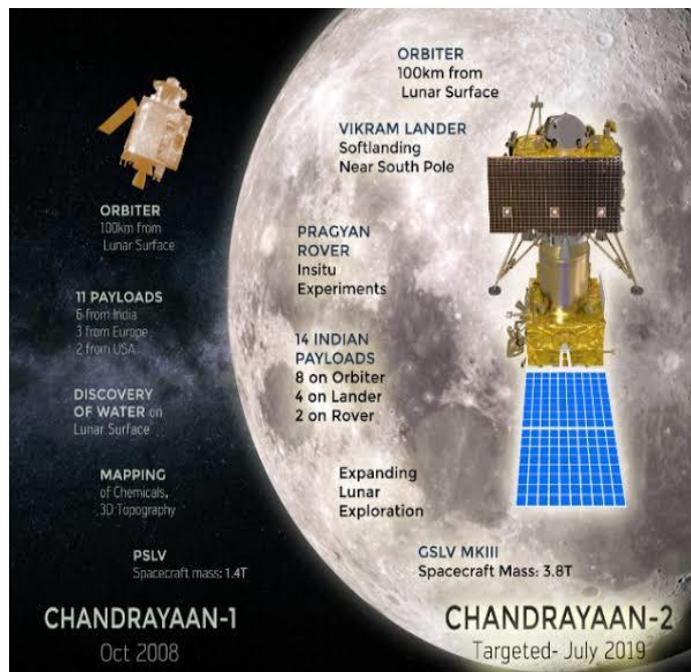
- The **Chandrayaan-2 mission, which was lost** after it hard- landed **on the dark side of the Moon in 2019, remains active in the form of its orbiter** hovering over the Moon.
- Scientists used **the Solar X-ray Monitor (XSM)** onboard Chandrayaan-2 in September 2019 to study the Sun.
- The lander and rover malfunctioned in the final moments and crash-landed, getting destroyed in the process.
- The primary objective of Chandrayaan 2 was **to demonstrate the ability to soft-land on the lunar surface** and operate a robotic rover on the surface.

However, the Orbiter and other instruments of Chandrayaan-2 mission have over the years, gathered a wealth of new information that has added to our knowledge about the Moon and its environment.

What is the information gathered?

Presence of water molecules on moon.

- **Presence of Minor elements:** Chromium, manganese and Sodium have been detected for the first time through remote sensing. The finding can lay the path for understanding magmatic evolution on the Moon and deeper insights into the nebular conditions as well as planetary differentiation.
- **Information about solar flares:** A large number of microflares outside the active region have been observed for the first time, and according to ISRO, this “has great implications on the understanding of the mechanism behind heating of the solar corona”, which has been an open problem for many decades.
- **Exploration of the permanently shadowed regions as well as craters and boulders underneath the regolith,** the loose deposit comprising the top surface extending up to 3-4m in depth. This is expected to help scientists to zero in on future landing and drilling sites, including for human missions.



2. Gaganyaan Mission

The **Indian Space Research Organisation (ISRO)** recently conducted a successful qualification test of its **High Thrust VIKAS Engine** at the **ISRO Propulsion Complex (IPRC)** in Tamil Nadu's Mahendragiri.

- The **Vikas engine** will power the ambitious Gaganyaan mission into space.

About the Vikas engine:

- It is a family of liquid fuelled rocket engines.
- It is used in the **Polar Satellite Launch Vehicle (PSLV)** and the **Geosynchronous Satellite Launch Vehicle (GSLV)** series of expendable launch vehicles for space launch use.

About Gaganyaan:

- Formal announcement of the Gaganyaan programme was made by Prime Minister Narendra Modi during his Independence Day address on August 15, 2018.
- The initial target was to launch the human spaceflight before the 75th anniversary of India's independence on August 15, 2022.

With this launch, **India will become the fourth nation in the world to launch a Human Spaceflight Mission after the USA, Russia and China.**

Objectives:

The objective of the Gaganyaan programme is to demonstrate the capability to send humans to low earth orbit on board an Indian launch vehicle and bring them back to earth safely.

Preparation and launch:

1. Four Indian astronaut-candidates have already undergone generic space flight training in Russia as part of the Gaganyaan programme.
2. ISRO's heavy-lift launcher [GSLV Mk III](#) has been identified for the mission.

3. [ISRO's new SSLV programme](#)

ISRO's indigenous new launch rockets, called the **Small Satellite Launch Vehicle (SSLV)**.

What is SSLV?

The SSLV is intended to **cater to a market for the launch of small satellites into low earth orbits.**

- It can carry satellites weighing up to 500 kg to a low earth orbit.
- The SSLV is **the smallest vehicle at 110-ton mass at ISRO.**
- It will take only 72 hours to integrate. Only six people will be required to do the job.
- The cost will be only around Rs 30 crore.
- It is best suited for launching multiple microsattellites at a time and supports multiple orbital drop-offs.

Need for?

Launch of **small satellites into low earth orbits** has become significant in recent years.

- About 15 to 20 SSLVs would be required every year to meet the national demand alone.

What is PSLV?

The launch of small satellites has until now been dependent on 'piggy-back' rides with big satellite launches on **ISRO's work-horse – the Polar Satellite Launch Vehicle** which has had over 50 successful launches so far.

- PSLV can launch satellites weighing in the range of 1000 kg. But, it takes **70 days to integrate this launch vehicle.**
- It is the third generation launch vehicle of India. It is **the first Indian launch vehicle to be equipped with liquid stages.**

What is a GSLV Rocket?

1. The GSLV expands to a geosynchronous satellite launch vehicle.
2. The GSLV Mark III is a three-stage heavy lift launch vehicle developed by ISRO.
3. As its name suggests, it can launch satellites that will travel in orbits that are synchronous with the Earth's orbit.
4. These satellites can weigh up to 2,500 kg and are first launched into transfer orbits that have a distance from Earth of 170 km at closest approach and about 35,975 km at furthest approach which is close to the height of the geosynchronous orbit.

Difference between PSLV and GSLV:

- India has two operational launchers- Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV).
- PSLV was developed to launch low-Earth Orbit satellites into polar and sun synchronous orbits. It has since proved its versatility by launching geosynchronous, lunar and interplanetary spacecraft successfully.
- On the other hand, GSLV was developed to launch the heavier INSAT class of geosynchronous satellites into orbit. In its third and final stage, GSLV uses the indigenously developed cryogenic upper stage.

Different orbits:

1. Geostationary orbit (GEO)
2. Low Earth orbit (LEO)
3. Medium Earth orbit (MEO)

4. Polar orbit and Sun-synchronous orbit (SSO)
5. Transfer orbits and geostationary transfer orbit (GTO)
6. Lagrange points (L-points)

Geosynchronous vs Sun-synchronous:

1. When satellites are about 36,000 km from the Earth’s surface, they enter what is called **the high Earth orbit**. Here, it orbits in sync with the Earth’s rotation, creating the impression that the satellite is stationary over a single longitude. Such a satellite is said to be **geosynchronous**.
2. Just as the geosynchronous satellites have a sweet spot over the equator that allows them to stay over one spot on Earth, polar-orbiting satellites have a sweet spot that allows them to stay in one place. This orbit is a **Sun-synchronous orbit**, which means that whenever and wherever the satellite crosses the equator, the local solar time on the ground is always the same.



4. EOS-04 launch

Isro has successfully launched earth observation satellite **EOS-04**, two other satellites (**INSPIRESat-1 and INS-2TD**) onboard PSLV recently.

- It was launched from **the first launch pad at the country’s only spaceport in Sriharikota - Satish Dhawan Space Centre, Andhra Pradesh.**

Significance:

- This is **ISRO's first launch in 2022.**
- It was **the first mission since the failure of the GSLV F10 mission in August 2021.**
- This was **the first mission of the space agency under the chairmanship of S Somanath.**

Orbit:

The three satellites were injected successfully into a **sun-synchronous polar orbit of 529 km.**

About EOS-04:

EOS-04 is **a radar imaging satellite** capable of providing high-quality images under all weather conditions.

- It can be used to capture images for agriculture, forestry, flood mapping, soil moisture and hydrology.
- The satellite has a mission life of 10 years.

Advantages of radar imaging over optical instruments:

Radar imaging is unaffected by weather, cloud or fog, or the lack of sunlight. It can produce high-quality images in all conditions and at all times.

INS-2DT:

INS-2DT is a **technology demonstrator satellite**, which has a thermal imaging camera and can help in the assessment of land and water surface temperatures apart from mapping vegetation.

InspireSat-1 satellite:

This satellite will use two instruments to study ionosphere dynamics and the Sun’s coronal heating process.

PSLV C52/ EOS-04



EOS-04 is a Radar Imaging Satellite designed to provide high quality images under all weather conditions for applications such as Agriculture, Forestry and Plantations, Flood Mapping, Soil Moisture & Hydrology. Collecting earth observation data in C-Band, it complements/supplements the data from Resourcesat, Cartosat series and RISAT-2B series.



INS-2TD is a technology demonstrator satellite from ISRO, which is a precursor to the India-Bhutan joint satellite (INS-2B). Having a thermal imaging camera as its payload, the satellite benefits the assessment of: land surface temperature; water surface temperature of wetlands/lakes; delineation of vegetation (crops and forest); and thermal inertia (day/night).



INSPIRESat-1 is a student satellite developed by Indian Institute of Space Science & Technology (IIST), in association with University of Colorado, USA. Other contributors are NTU, Singapore and NCU, Taiwan. Two scientific payloads improve the understanding of ionosphere dynamics and sun’s coronal heating processes.

SALIENT FEATURES

Satellite	Mass (kg)	Power (W)	Mission life
EOS-04	1710	2280	10 years
INS-2TD	17.5	42	6 months
INSPIRESat-1	8.1	30	1 year

5. Aditya-L1 Support Cell

Aditya-L1 Support Cell is a community service centre that has been set up to bring all data on board India’s first dedicated solar space mission to a single web-based interface.

- It is a **joint effort of Indian Space Research Organisation and Aryabhata Research Institute of Observational Sciences.**
- It will allow every interested individual to perform scientific analysis of the data.

About Aditya- L1 mission:

What is it? It is **India’s first solar mission.**

It will be launched using **the Polar Satellite Launch Vehicle (PSLV) in XL configuration.**

The space-based observatory will have **seven payloads (instruments)** on board to study the Sun’s corona, solar emissions, solar winds and flares, and Coronal Mass Ejections (CMEs), and will carry out round-the-clock imaging of the Sun.

Objectives:

- Study the sun’s outer most layers, the corona and the chromospheres.
- Collect data about coronal mass ejection, which will also yield information for space weather prediction.

Significance of the mission:

The data from Aditya mission will be immensely helpful in discriminating between different **models for the origin of solar storms and also for constraining how the storms evolve** and what path they take through the interplanetary space from the Sun to the Earth.

Position of the satellite:

In order to get the best science from the sun, continuous viewing of the sun is preferred without any occultation/ eclipses and hence, Aditya- L1 satellite will be placed in **the halo orbit around the Lagrangian point 1 (L1) of the sun-earth system**.

What are Lagrangian points and halo orbit?

Lagrangian points are the locations in space where the combined gravitational pull of two large masses roughly balance each other. Any small mass placed at that location will remain at constant distances relative to the large masses.

There are five such points in Sun-Earth system and they are denoted as L1, L2, L3, L4 and L5.

A halo orbit is a periodic three-dimensional orbit near the L1, L2 or L3.

Why do we study the sun and the solar wind?

The sun is **the only star we can study up close**. By studying this star we live with, we learn more about stars throughout the universe.

The sun is **a source of light and heat for life on Earth**. The more we know about it, the more we can understand how life on Earth developed.

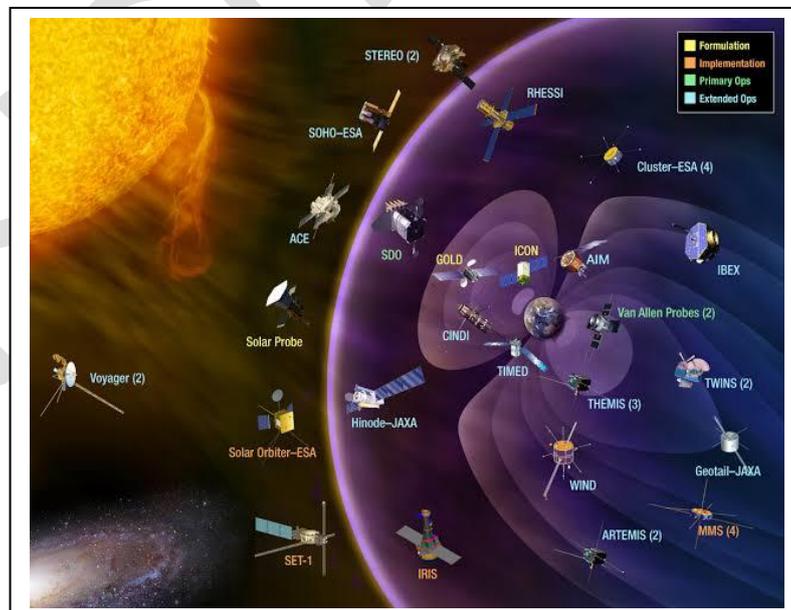
It is **the source of the solar wind**; a flow of ionized gases from the sun that streams past Earth at speeds of more than 500 km per second (a million miles per hour).

Disturbances in the solar wind shake Earth's magnetic field and pump energy into the radiation belts, part of a set of changes in near-Earth space known as space weather.

Effects On satellites: Space weather can change the orbits of satellites, shorten their lifetimes, or interfere with onboard electronics. The more we learn about what causes space weather – and how to predict it – the more we can protect the satellites we depend on.

Safety and preparedness:

The solar wind dominates the space environment. As we send spacecraft and astronauts further and further from home, we must understand this space environment just as early seafarers needed to understand the ocean.

**6. Bhuvan**

The Department of Space (DoS), under which ISRO comes, has signed an MoU with geospatial technology company CE Info Systems Pvt Ltd.

- The collaboration will enable them to jointly identify and build a holistic geospatial portal utilising earth observation datasets, '**NavIC**', **Web Services and APIs (application programming interface) available in MapmyIndia**.
- The geospatial portals will be called '**Bhuvan**', '**VEDAS**' and '**MOSDAC**'.

Key facts:

Bhuvan is the national geo-portal developed and hosted by ISRO comprising geospatial data, services, and tools for analysis.

VEDAS (Visualisation of Earth observation Data and Archival System) is an online geoprocessing platform that uses optical, microwave, thermal, and hyperspectral EO data covering applications particularly meant for academia, research and problem solving.

MOSDAC (Meteorological and Oceanographic Satellite Data Archival Centre) is a data repository for all the meteorological missions of ISRO and deals with weather-related information, oceanography, and tropical water cycles.

What is NAVIC?

Navigation with Indian Constellation (NavIC) is an independent regional navigation satellite system designed to provide position information in the Indian region and 1500 km around the Indian mainland.

NavIC will provide two types of services:

1. Standard Positioning Service (SPS) which is provided to all the users.
2. Restricted Service (RS), which is an encrypted service provided only to the authorised users.

Its applications include:

1. Terrestrial, Aerial and Marine Navigation.
2. Disaster Management.
3. Vehicle tracking and fleet management.
4. Integration with mobile phones.
5. Precise Timing.
6. Mapping and Geodetic data capture.
7. Terrestrial navigation aid for hikers and travellers.
8. Visual and voice navigation for drivers.

How many satellites does NAVIC consist of?

It is powered by eight IRNSS satellites, of which one provides messaging services.

Three of these will be geostationary over the Indian Ocean, i.e., they will appear to be stationary in the sky over the region, and four will be geosynchronous – appearing at the same point in the sky at the same time every day.

- This configuration ensures each satellite is being tracked by at least one of fourteen ground stations at any given point of time, with a high chance of most of them being visible from any point in India.

7. AstroSat

AstroSat's Ultraviolet Imaging Telescope spots rare ultraviolet-bright stars in a massive intriguing cosmic dinosaur in the Milky Way.

Significance of the discovery:

Such UV-bright stars are speculated to be the reason for the ultraviolet radiation coming from old stellar systems such as elliptical galaxies which are devoid of young blue stars. Hence, it is all the more important to observe more such stars to understand their properties.



About AstroSat:

- AstroSat is **India's first multi-wavelength space telescope**, which has five telescopes seeing through different wavelengths simultaneously — visible, near UV, far UV, soft X-ray and hard X-ray.
- Onboard the AstroSat is a 38-cm wide **UltraViolet Imaging Telescope (UVIT)**, which is capable of imaging in far and near-ultraviolet bands over a wide field of view.
- AstroSat was launched on 28 September 2015 by ISRO into a near-Earth equatorial orbit.
- It is a **multi-institute collaborative project**, involving IUCAA, ISRO, Tata Institute of Fundamental Research (Mumbai), Indian Institute of Astrophysics (Bengaluru), and Physical Research Laboratory (Ahmedabad), among others.

**(NASA Missions)****8. Parker Solar Probe**

For the first time in history, we can see **the planet Venus in Color**, thanks to NASA Parker Solar Probe.

- **The Wide-field Imager for Parker Solar Probe (WISPR)** by the American space agency has managed to take pictures of the surface of Venus revealing stunning continents, plains, plateaus and even a layer of Oxygen.

First spacecraft to fly through the outer atmosphere of the Sun:

Recently, the Parker Solar Probe, became the first spacecraft to fly through **the outer atmosphere of the Sun- 'Corona'**.

- The spacecraft flew through Corona and sampled magnetic fields and particles there.

Significance:

The achievement would help scientists discover critical information about the sun and its influence on our solar system.

About the mission:

Launched in 2018, Parker Solar Probe will travel through the sun's atmosphere, closer to the surface than any spacecraft before it, facing brutal heat and radiation conditions — and ultimately providing humanity with the closest-ever observations of a star.

The NASA probe recently made an extremely close encounter with the Sun. Additionally, the Parker Solar Probe also broke the record for **the closest satellite to survive a near pass of the Sun.**

Journey:

- In order to unlock the mysteries of the sun's atmosphere, Parker Solar Probe will use Venus' gravity during seven flybys over nearly seven years to gradually bring its orbit closer to the sun.
- The spacecraft will fly through the sun's atmosphere as close as 3.9 million miles to our star's surface, well within the orbit of Mercury and more than seven times closer than any spacecraft has come before.

The Parker Solar Probe has become the first spacecraft to fly through **the outer atmosphere of the Sun- 'Corona'**. The spacecraft flew through Corona and sampled magnetic fields and particles there.

Parker Solar Probe has three detailed science objectives:

1. Trace the flow of energy that heats and accelerates the solar corona and solar wind.
2. Determine the structure and dynamics of the plasma and magnetic fields at the sources of the solar wind.
3. Explore mechanisms that accelerate and transport energetic particles.

Why study corona?

- The **corona is hotter than the surface of the sun.**
- The corona gives rise to the solar wind, a continuous flow of charged particles that permeates the solar system.
- Unpredictable solar winds cause disturbances in our planet's magnetic field and can play havoc with communications technology on Earth.
- Nasa hopes the findings will enable scientists to forecast changes in Earth's space environment.

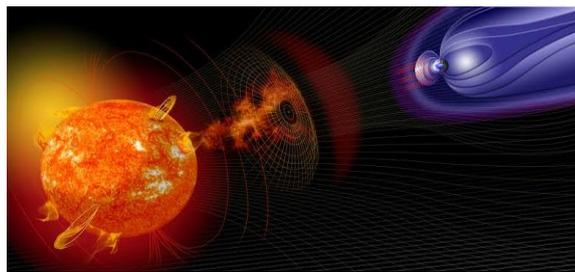
9. HelioSwarm and MUSE

NASA has selected **two science missions - the Multi-slit Solar Explorer (MUSE) and HelioSwarm -** to help improve our understanding of the dynamics of **the Sun, the Sun-Earth connection, and the constantly changing space environment.**

- These missions will provide deeper insights into our universe and offer critical information to help protect astronauts, satellites, and communications signals such as GPS.

About MUSE:

- The MUSE mission will help scientists understand the forces driving the heating of **the Sun's corona** and the eruptions in that outermost region that are at the foundation of space weather.
- The mission will offer deeper insight into the physics of the solar atmosphere by using a powerful instrument known as a **multi-slit spectrometer** to observe the Sun's extreme ultraviolet radiation and obtain the highest resolution images ever captured of the solar transition region and the corona.

**HelioSwarm:**

The HelioSwarm mission is a **constellation or "swarm" of nine spacecraft that will capture the first multiscale in-space measurements of fluctuations in the magnetic field and motions of the solar wind** known as **solar wind turbulence.**

- The Sun's outermost atmospheric layer, **the heliosphere**, encompasses an enormous region of the solar system.
- Solar winds spread through the heliosphere, and their interactions with planetary magnetospheres and disruptions such as coronal mass ejections affect their turbulence.

10. NASA's Perseverance rover

Nasa's **Perseverance 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:**

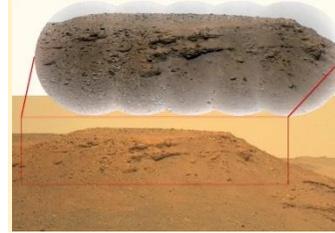
1. Collected the first rock cores from another planet.
2. Served as a base station for Ingenuity helicopter.
3. Extracted oxygen from thin Martian air.
4. It broke a record for the most distance driven by a rover on Mars in a single day by travelling almost 320 meters on February 14.
5. Tested the first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

About **Perseverance Rover**:

NASA's **Perseverance rover** is exploring the **Jezero Crater on Mars** and attempting to collect its first rock samples.

- It was launched in 2020 aboard a United Launch Alliance Atlas V.

The first scientific analysis of images taken by **NASA's Perseverance rover** has now confirmed that **Mars' Jezero crater** — which today is a dry, wind-eroded depression — was once a quiet lake, fed steadily by a small river some 3.7 billion years ago.



Why is this mission significant?

1. It carried a unique instrument, **MOXIE or Mars Oxygen ISRU 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).
2. It carried **Ingenuity**, the first ever helicopter to fly on Mars.
3. 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.

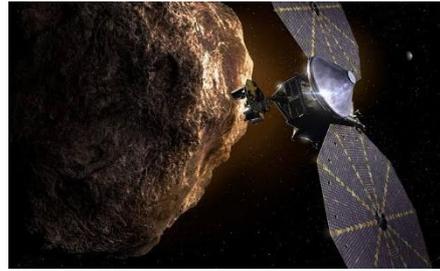
What is the reason for the near-term interest in Mars?

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

11. NASA's Lucy mission

Eurybates is one of a handful of asteroids that Lucy will visit over the next 12 years.

- Recently, astronomers at Las Vegas were observing a star which appeared to briefly blink out because the asteroid Eurybates had passed in front of it.
- As Eurybates eclipsed the star, a phenomenon scientists call an **"occultation,"** a 40-mile- (64-kilometer-) wide shadow the size of the asteroid passed over the region.
- This **information will be used by Lucy researchers to supplement data gathered by the Lucy spacecraft's** close flyby of Eurybates in 2027.



Why Occultations?

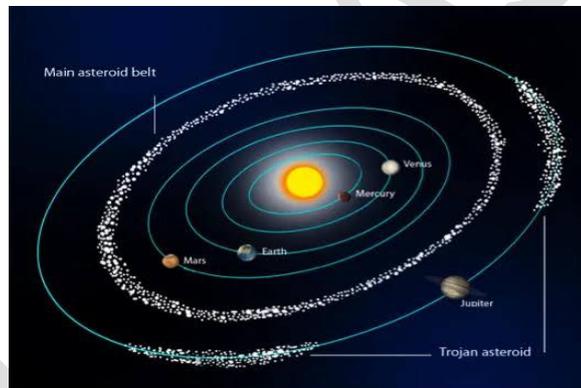
An **occultation** is any event where one celestial object passes in front of another, blocking the latter object from an observer's view. The best-known example is a solar eclipse, which occurs when the Moon passes between the Sun and Earth, blocking the Sun from our view.

About 'Lucy' Mission:

- This is **NASA's first mission to explore the Jupiter Trojan asteroids.**
- It is a **solar-powered mission.**

Aim of the mission:

The mission is designed to understand the composition of the diverse asteroids that are a part of **the Trojan asteroid swarms**, to determine the mass and densities of the materials and to look for and study the satellites and rings that may orbit the Trojan asteroids.



What are Trojan Asteroids? Why are they called so?

These asteroids are believed to be the remnants of the early solar system, and studying them will help scientists understand its origins and evolution, and why it looks the way it does.

- The Trojan asteroids are believed to be formed from the same material that led to the formation of planets nearly 4 billion years ago when the solar system was formed.

12. OSIRIS-REx and asteroid Benu

OSIRIS-REx is bringing back an asteroid sample. It will arrive home in 2023, ejecting a capsule full of samples that may help eager scientists decipher the origin of Earth's water and life.

- The debris NASA's asteroid-touching spacecraft collected could help us learn about the origins of our solar system.

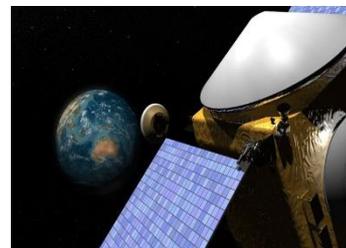
Background:

On October 20th, 2021, **NASA's OSIRIS-REx spacecraft** briefly touched **asteroid Benu**, from where it is meant to collect samples of dust and pebbles and deliver them back to Earth in 2023.

What is the OSIRIS-REx mission?

OSIRIS-REx stands for Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer.

- This is **NASA's first mission meant to return a sample from the ancient asteroid.**
- Launched in 2016, it reached its target in 2018 and will return a sample to Earth in 2023.

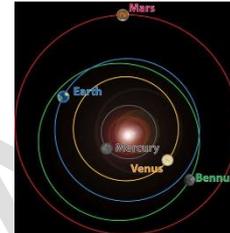


Asteroid Benu:

The asteroid was discovered by a team from the NASA-funded **Lincoln Near-Earth Asteroid Research team in 1999**.

Scientists believe that it was **formed in the first 10 million years of the solar system's formation**, implying that it is **roughly 4.5 billion years old**.

- Because of Benu's age, it is **likely to contain material that contains molecules that were present when life first formed on Earth**, where life forms are based on carbon atom chains.
- Because of its **high carbon content**, the asteroid **reflects about four per cent of the light that hits it**, which is very low when compared with a planet like Venus, which reflects about 65 per cent of the light that hits it. **Earth reflects about 30 per cent**.
- It classified as a **Near Earth Object (NEO)**, might strike the Earth in the next century, between the years 2175 and 2199.

**Site for sample collection:**

NASA has selected a site located in a crater high in Benu's northern hemisphere designated "Nightingale".

Why are scientists studying asteroids?

- To look for information about the formation and history of planets and the sun since asteroids were formed at the same time as other objects in the solar system.
- To look for asteroids that might be potentially hazardous.

13. Artemis Program

- **Artemis– Acceleration, Reconnection, Turbulence and Electrodynamics of Moon's Interaction with the Sun.**
- It is **NASA's mission to the Moon**.
- **Objective:** To measure what happens when the Sun's radiation hits our rocky moon, where there is no magnetic field to protect it.
- Artemis was **the twin sister of Apollo and goddess of the Moon in Greek mythology**.

Significance of the mission:

With the Artemis program, NASA will **land the first woman and next man on the Moon by 2024**.

Scientific objectives:

1. Find and use water and other critical resources needed for long-term exploration.
2. Investigate the Moon's mysteries and learn more about our home planet and the universe.
3. Learn how to live and operate on the surface of another celestial body where astronauts are just three days from home.
4. Prove the technologies we need before sending astronauts on missions to Mars, which can take up to three years roundtrip.

14. Laser Communications Relay Demonstration (LCRD)

NASA has launched its new **Laser Communications Relay Demonstration (LCRD)**.

- It is the agency's **first-ever laser communications system**.
- The LCRD will help the agency test optical communication in space.

About LCRD:

LCRD is a technology demonstration that will pave the way for future optical communications missions.

- The LCRD payload is hosted onboard **the US Department of Defense's Space Test Program Satellite 6 (STPSat-6)**.
- It will be in a **geosynchronous orbit**, over 35,000km above Earth.

Advantages of optical communications systems:

Optical communications systems are smaller in size, weight, and require less power compared with radio instruments.

- A smaller size means more room for science instruments.
- Less weight means a less expensive launch.
- Less power means less drain on the spacecraft's batteries.
- With optical communications supplementing radio, missions will have unparalleled communications capabilities.

Laser VS radio:**Laser communications and radio waves use different wavelengths of light.**

- Laser uses infrared light and has a shorter wavelength than radio waves. This will help the transmission of more data in a short time.

15. NASA's DART mission

Just two weeks after its launch, NASA's **Double Asteroid Redirection Test (DART) spacecraft** has opened its "eye" and returned its first images from space — a major operational milestone for the spacecraft and DART team.

- DART will reach its target on September, 2022.

About DART Mission:

- The main aim of the mission is to test the newly developed technology that would allow a spacecraft to crash into an asteroid and change its course.
- It also carries about 10 kg of xenon which will be used to demonstrate the agency's new thrusters called **NASA Evolutionary Xenon Thruster–Commercial (NEXT-C) in space**.
- The spacecraft carries a high-resolution imager called **Didymos Reconnaissance and Asteroid Camera for Optical Navigation (DRACO)**. Images from DRACO will be sent to Earth in real-time and will help study the impact site and surface of Dimorphos.
- DART will also carry a small satellite or CubeSat named **LICIACube (Light Italian CubeSat for Imaging of Asteroids)**. LICIACube is expected to capture images of the impact and the impact crater formed as a result of the collision. It can also capture images of any dust cloud formed during the impact.



Which asteroid will be deflected?

The target of the spacecraft is a small moonlet called **Dimorphos** (Greek for "two forms"). Dimorphos orbits a larger asteroid named Didymos (Greek for "twin").

DART at Scale



16. NASA's VIPER Mission

NASA has chosen a landing site for the Volatiles Investigating Polar Exploration Rover (VIPER).

- The site is on the western edge of **Nobile crater**, near the lunar south pole. The crater was named after Italian polar explorer **Umberto Nobile**.

Background:

NASA, in July 2021, announced that it will launch its **Volatiles Investigating Polar Exploration Rover, or VIPER**, in 2023.

- NASA is undertaking the mission to understand if it is possible for human life to sustain there, by using locally available resources.

About the mission:

- VIPER is a mobile robot.
- It is **the first resource mapping mission on any other celestial body**.
- NASA's Commercial Lunar Payload Services (CLPS) will be providing the launch vehicle and lander for what's going to be a 100-day mission.

Objectives of the mission:

1. To explore the Moon's South Pole region.
2. Help create lunar resource maps.
3. Evaluate the concentration of water as well as other potential resources on its surface.

Significance of the mission:

VIPER's findings will inform "future landing sites under the Artemis program by helping to determine locations where water and other resources can be harvested" to sustain humans over extended stays.

17. NASA's Cassini spacecraft

NASA's Cassini spacecraft has made the following discoveries in **the moons of Saturn** by flying through their plumes:

1. Titan has **methane** in its atmosphere.

VIPER rover to search for ice-water on moon
 NASA's new VIPER rover is set to search a lunar crater for ice – which could provide drinking water, air and rocket fuel needed for future manned missions to the moon

Project cost: \$660m

VIPER
 Volatiles Investigating Polar Exploration Rover

Nov 2023: VIPER hitchhikes ride on static lander bound for moon. Mission will last 100 days

Landing site:
 Near **Nobile Crater** at South Pole. Area in almost permanent shadow with temperatures as low as **-223°C**

1m-long drill will test for subsurface water-ice

Rover is similar size to golf buggy

Areas where NASA believes water-ice may be found

VIPER will follow pre-planned route of **16-24km**, but route could change depending on what it finds

2022: Artemis program to return astronauts to moon begins with unmanned test of Orion space capsule
2024: First astronaut landing since 1972 expected by third mission

Sources: BBC, New York Times, NASA
 Pictures: NASA
 © GRAPHIC NEWS

2. Enceladus has a **liquid ocean** with erupting plumes of gas and water.

Researchers have concluded that there may be unknown **methane-producing processes** on Enceladus that await discovery.

Methane-producing organisms on Earth:

- Most of the methane on Earth has a **biological origin**. Microorganisms called **methanogens** are capable of generating methane as a **metabolic byproduct**. They do not require oxygen to live and are widely distributed in nature.
- **Methanogens** are found in swamps, dead organic matter, and even in the human gut. They are known to survive in high temperatures and simulation studies have shown that they can live in Martian conditions.

How else can methane be produced on Enceladus?

1. Methane could be formed by **the chemical breakdown of organic matter present in Enceladus' core**.
2. **Hydrothermal processes** could help the formation of carbon dioxide and methane.

About Cassini Mission:

- Launched in 1997.
- The mission is a cooperation between NASA, the European Space Agency and the Italian Space Agency.
- This was **the first landing ever accomplished in the outer Solar System**.
- Cassini is **the fourth space probe to visit Saturn and the first to enter orbit**.
- Its design **includes a Saturn orbiter and a lander for the moon Titan. The lander, called Huygens**, landed on Titan in 2005.

Objectives of the mission:

1. Determine the three-dimensional structure and dynamic behavior of the rings of Saturn.
2. Determine the composition of the satellite surfaces and the geological history of each object.
3. Measure the three-dimensional structure and dynamic behavior of the magnetosphere.
4. Study the dynamic behavior of Saturn's atmosphere at cloud level.
5. Study the time variability of Titan's clouds and hazes.
6. Characterize Titan's surface on a regional scale.

18. Landsat 9

Landsat 9 was recently launched by NASA.

About Landsat 9:

- It is an **Earth monitoring satellite**.
- It is a joint mission of NASA and the US Geological Survey (USGS).
- Together with Landsat 8, it will collect images of Earth's surface. It takes 8 days to capture the whole Earth.
- It is the most technologically advanced satellite of its generation. It can see more colour shades with greater depths than the previous satellites, helping scientists capture more details about our ever-changing planet.
- The instruments aboard Landsat 9 are **the Operational Land Imager 2 (OLI-2) and the Thermal Infrared Sensor 2 (TIRS-2)**. They will measure different wavelengths of light reflected off the Earth's surface.

About the Landsat series:

The first Landsat satellite was launched in 1972 and since then, Landsat satellites have collected images of our planet and helped understand how land usage has changed over the decades.

Significance and applications of Landsat missions:

Landsat images have been used to study the health of forests, coral reefs, monitor water quality and melting glaciers.

How will the satellite help monitor climate change?

1. If a forest is affected by drought, it will be seen in Landsat images and can help the researchers decode the areas at risk.
2. Similarly during a wildfire, the Landsat images will capture the plumes of smoke and help study the extent of a burning.
3. The satellite images can also help recovery experts plan sites for replanting.
4. Landsat images can also help identify water bodies affected by potentially harmful algal blooms.

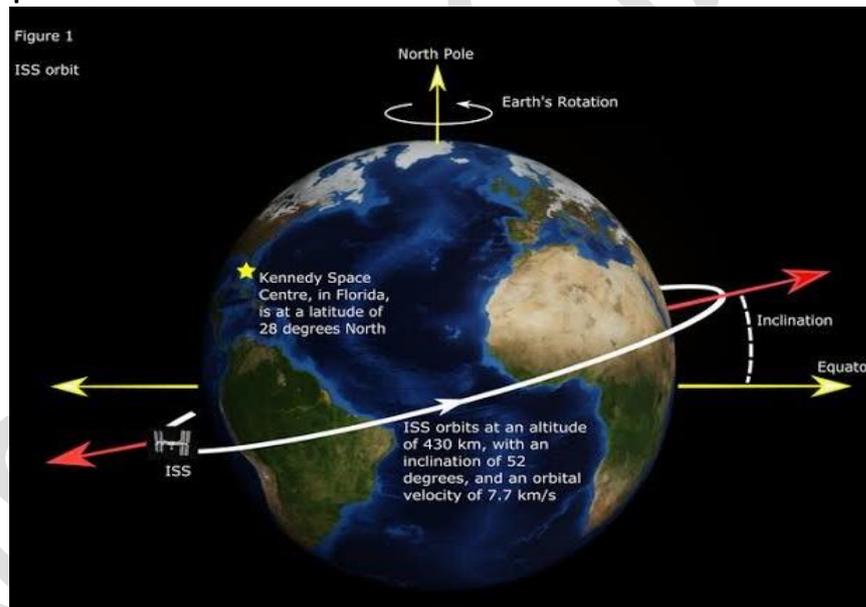
19. Why is NASA sending water bears, baby squid to the International Space Station?

Nasa has sent glow-in-the-dark baby squids and about 5,000 tardigrades, also called water bears, to the International Space Station.

- They were part of the 22nd SpaceX cargo resupply mission.

Objectives of these new experiments:

1. To help scientists design improved protective measures for astronauts going on long-duration space travel.
2. To understand how beneficial microbes interact with animals, potentially leading to breakthroughs in improving human health on Earth.



Why send microbes?

Microbes play a crucial role in the normal development of animal tissues and in maintaining human health, and the research will allow scientists to have a better understanding of how beneficial microbes interact with animals when there is a lack of gravity.

- In the human body, microorganisms contribute to a variety of functions, including digestion, developing the immune system and detoxifying harmful chemicals. A disruption in our relationship with these microbes can lead to disease.

What is the International Space Station?

- A space station is essentially a large spacecraft that remains in low-earth orbit for extended periods of time.
- The ISS has been in space since 1998.

Russia's space agency is planning to launch its own orbital station in 2025.

Background:

Russia is considering withdrawing from the International Space Station programme to go it alone.

- Russia lost its monopoly for manned flights to the ISS in 2020 after the first successful mission of U.S. company Space X.

- **It is a result of cooperation between the five participating space agencies that run it:** NASA (United States), Roscosmos (Russia), JAXA (Japan), ESA (Europe), and CSA (Canada).
- The ISS **circles the Earth in roughly 93 minutes, completing 15.5 orbits per day.**
- ISS is a modular space station (habitable artificial satellite) in low Earth orbit.
- The ISS serves as a **microgravity and space environment research laboratory** in which scientific experiments are conducted in astrobiology, astronomy, meteorology, physics, and other fields.

20. Crew-2 mission

Four astronauts were launched to **the International Space Station (ISS)** from Florida as part of a collaboration between NASA and SpaceX under **the Commercial Crew Program.**

- The mission is called **Crew-2** and is **the second crew rotation of the SpaceX Crew Dragon and the first with international partners.**

What will Crew-2 do at the ISS?

- Members of the mission conduct microgravity studies, investigate food physiology meant to study the effects of dietary improvements on immune function and the gut microbiome and how those improvements can help crews adapt to spaceflight.
- Their central focus during this time will be to continue a series of **Tissue Chips** in Space studies.
- **Tissue Chips** are small models of human organs that contain multiple cell types that behave similarly to the human body. According to NASA, these chips can potentially speed up the process of identifying safe and effective drugs and vaccines.

What is the Commercial Crew Program?

- The main objective of this program is to make access to space easier in terms of its cost, so that cargo and crew can be easily transported to and from the ISS, enabling greater scientific research.
- Through this program, NASA plans to lower its costs by sharing them with commercial partners such as Boeing and SpaceX, and also give the companies incentive to design and build the Commercial Orbital Transportation Services (COTS).

Background:

Boeing and SpaceX were selected by NASA in September 2014 to develop transportation systems meant to transfer crew from the US to the ISS.

21. Hubble Space Telescope

- The Hubble Space Telescope is a large telescope in space. NASA launched Hubble in 1990.
- It was built by the United States space agency NASA, with contributions from the European Space Agency.
- **Hubble is the only telescope designed to be serviced in space by astronauts.**
- Expanding the frontiers of the visible Universe, the Hubble Space Telescope looks deep into space with cameras that can see across the entire optical spectrum from infrared to ultraviolet.
- The **Hubble Space Telescope makes one orbit around Earth every 95 minutes.**

Achievements:

- It has helped in discovering the moons around Pluto.
- Evidence regarding the existence of black holes has emerged based on the observations through Hubble.
- The birth of stars through turbulent clouds of gas and dust have also been observed.
- The hubble telescope made observations of six galaxies merging together.

- On February 11, 2021, the Hubble made observations of small concentrations of black holes.

22. Nasa's InSight lander

Nasa's InSight lander has recorded over 500 quakes on Mars since its touch down on the Red Planet in November 2018.

- These findings support the idea that the planet is seismically active.

About InSight Mission:

- InSight is part of **NASA's Discovery Program**.
- It will be **the first mission to peer deep beneath the Martian surface**, studying the planet's interior by measuring its heat output and listening for marsquakes, which are seismic events similar to earthquakes on Earth.
- It will **use the seismic waves generated by marsquakes to develop a map of the planet's deep interior**.

Significance of the mission:

- The findings of Mars' formation will help better understand how other rocky planets, including Earth, were and are created.
- InSight would delve deep beneath the surface of Mars, detecting the fingerprints of the processes of terrestrial planet formation, as well as measuring the planet's "vital signs": Its "pulse" (seismology), "temperature" (heat flow probe), and "reflexes" (precision tracking).

InSight seeks to answer one of science's most fundamental questions: **How did the terrestrial planets form?**

(Chinese Mission)

23. China's artificial moon

China has built an **artificial moon research facility that is capable of lowering the gravity level using magnetism**.

- The research facility is scheduled to officially launch later this year.
- This research facility is also said to be **the first of its kind in the world**.

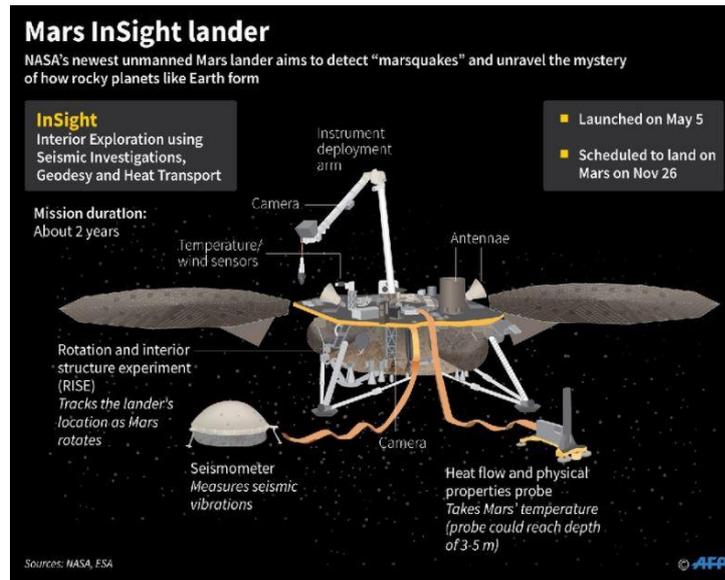
Objective of the project:

The idea is to make gravity "disappear" by using powerful magnetic fields inside a 60cm vacuum chamber.

About the mini moon:

- The mini-moon is about two feet in diameter and the artificial surface has been made with rocks and dust.
- The facility is located in the eastern city of Xuzhou, in Jiangsu province.

Uses, applications and benefits of this facility:



- China plans to use this research facility **to test out instruments and technology in a low-gravity environment** similar to that of the moon, and see whether its experiments can be successful on the lunar surface.
- The research facility is also expected **to help in determining the possibility of human settlement on the moon.**

Magnetic levitation:

- The idea to develop artificial moon facility has its roots in the Russian-born physicist **Andre Geim's** experiments to levitate a frog with a magnet.
- **Magnetic levitation** is certainly not the same as antigravity, but there is a variety of situations where mimicking microgravity by magnetic fields could be invaluable to expect the unexpected in space research.

The principle behind this:

Atoms are made up of atomic nuclei and tiny electrons that orbit them in little loops of current; these moving currents, in turn, induce tiny magnetic fields.

- Usually, the randomly oriented magnetic fields of all the atoms in an object, whether they belong to a drop of water or a frog, cancel out, and no material-wide magnetism manifests.
- Apply an external magnetic field to those atoms, however, and everything changes: The electrons will modify their motion, producing their own magnetic field to oppose the applied field.
- If the external magnet is strong enough, the magnetic force of repulsion between it and the field of the atoms will grow powerful enough to overcome gravity and levitate the object — whether it's an advanced piece of lunar tech or a confused amphibian — into the air.

24. [China's Space Station](#)

As **China gears up to become the only country to have an exclusive and probably the only space station by 2024 or latest by 2030**, its neighbor, India too has plans to follow suit in a few years.

- Recently, the Union Minister for Space Jitendra Singh announced in Parliament that India's first space station would be set up by 2030.

Background:

Even though the retirement of the ISS is currently scheduled for 2024, NASA and the international partners have indicated that the ISS's operational life could be extended to 2030.

About [China's Space Station](#):

- The new multi-module **Tiangong station** is set to be operational for at least 10 years.
- The space station will **operate in low-Earth orbit** at an altitude of 340-450 km above Earth's surface.

Significance of the space station:

1. The low orbit space station would be the country's eye from the sky, providing round the clock bird's-eye view for its astronauts on the rest of the world.
2. It shall aid China's aim to become a major space power by 2030.

Concerns:

China's space station will be equipped with a **robotic-arm** over which the US has raised concerns for its possible military applications.

- The Concern is that this technology "could be used in a future system for grappling other satellites".

Indian Space Station:

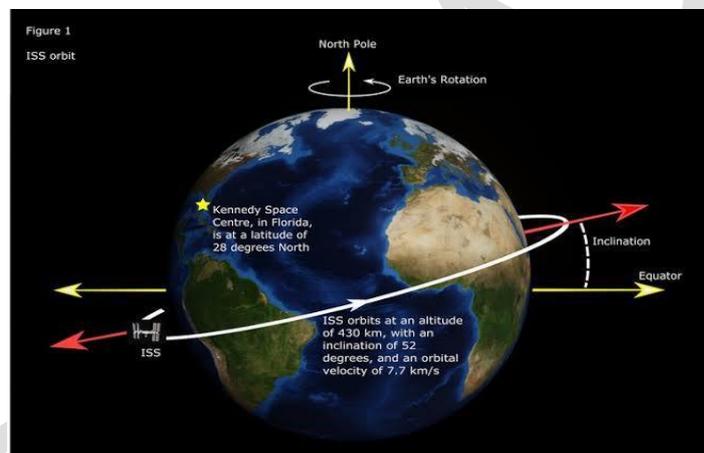
- The Indian space station will be much smaller (mass of 20 tonnes) than the International Space Station and will be used for carrying out **microgravity** experiments (not for space tourism).
- Preliminary plan for the space station is to accommodate astronauts for up to 20 days in space, and the project will be an extension of **the Gaganyaan mission**.
- It will orbit Earth at an altitude of around 400km.
- ISRO is working on a space docking experiment (Spadex), a technology that is crucial for making the space station functional.

Other space stations:

- The only space station currently in orbit is **the International Space Station (ISS)**. The ISS is backed by the United States, Russia, Europe, Japan and Canada.
- So far, **China has sent two previous space stations into orbit- the Tiangong-1 and Tiangong-2 were trial stations**.
- India is planning to launch its own space station by 2030.

Significance:

- Space stations are essential for collecting meaningful scientific data, especially for biological experiments.
- Provide platforms for greater number and length of scientific studies than available on other space vehicles.
- Each crew member stays aboard the station for weeks or months, but rarely more than a year.
- Space stations are used to study the effects of long-term space flight on the human body.



China has complained to the UN detailing two alleged space incidents involving its **Tiangong Space Station** and two **Starlink satellites** from Elon Musk-founded aerospace firm, SpaceX. China complained that satellites launched by SpaceX nearly struck the Tiangong Space Station.

Why did China approach the UN?

Both the U.S. and China are parties to **the Outer Space Treaty**, which is formally known as the **'Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies'**.

- The multilateral treaty, adopted by the UN General Assembly, provides the basic framework on international space law.

Key provisions and their relevance in this case:

- According to **article VI of the treaty**, nations will be responsible for national space activities whether carried out by governmental or non-governmental entities. That means the U.S. can be held responsible for the activities of SpaceX.
- **Article VII** states that nations will be liable for damage caused by their space objects, such as satellites.
- **Article V of the treaty** requires parties to immediately inform other parties or the UN Secretary-General of any phenomenon they discover in outer space, "which could constitute a danger to the life or health of astronauts".

How does the UN help with space issues?

The **United Nations Office for Outer Space Affairs** was created to service **the ad hoc Committee on the Peaceful Uses of Outer Space**.

- The committee was established in 1958 shortly after the launch of **the first artificial satellite, Sputnik-1**.
- It has been serving as a focal point for international cooperation in the peaceful exploration and use of outer space.

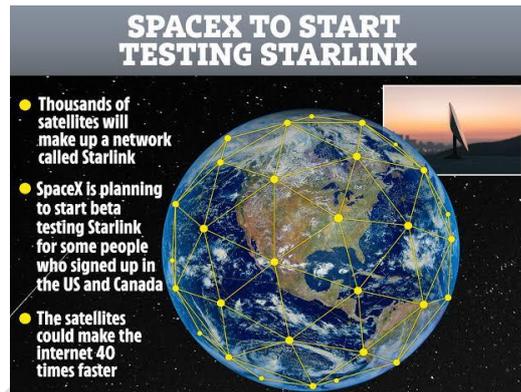
The Outer Space Treaty:

It came into force on October 10, 1967.

The principles embodied in the treaty has facilitated the orderly conduct of activities in outer space.

What's the concern now?

- Space-related conflicts have occurred in the past and will most likely continue to happen in the future as well, considering the growing number of activities in the space, involving different parties.
- The International Space Station and China's space station, Tiangong, which is under construction, operate in the LEO, where much of **the space debris** can be found.
- Besides, there are about 30,000 satellites and other pieces of debris in Earth's orbit that can reach speeds of nearly 29,000 km/h, raising the possibility of international incidents in the outer space."



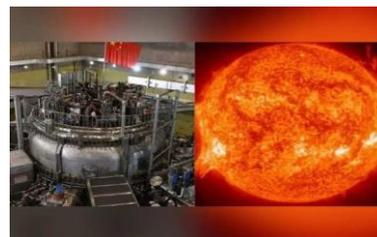
SpaceX's internet satellite network:

It operates at 550km above the Earth's surface in LEO, which is increasingly getting crowded. The firm has deployed about 1,900 Starlink satellites.

25. China conducts nuclear fusion experiment for 'artificial sun'

Top scientists from China have claimed to have successfully created a **'fake Sun'**. The artificial Sun created by China is about **ten times hotter than the real Sun, around which our planet revolves**.

- It is called the **Experimental Advanced Superconducting Tokamak (EAST)**, also known as **'Artificial Sun' experiment**.
- In June, it set a **new record**, where it achieved a plasma temperature of 216 million Fahrenheit (120 million C) for 101 seconds.



How was the experiment carried out and what were the results?

- Experts focused their giant array of almost 200 laser beams onto a tiny spot to create a mega blast of energy – eight times more than they had ever done in the past.
- Although the energy only lasted for a very short time – just 100 trillionths of a second – the scientists were able to create more energy than they are using.
- In this experiment, scientists used two isotopes of hydrogen, giving rise to helium.

Why is this significant?

It is believed that **the temperature at the core of the Sun** is **15 million C**, which also means that the temperature produced by (EAST) is **nearly seven times that of the Sun**.

- It is a significant step in the country's quest to unlock clean and limitless energy, with minimal waste products.

What is EAST?

The artificial Sun experiment is being developed through a reactor, with the help of nuclear fusion.

- The mission mimics **the energy generation process of the sun.**
- The reactor consists of an advanced **nuclear fusion** experimental research device located in Hefei, China.
- It is **one of three major domestic tokamaks** that are presently being operated across the country.
- The EAST project is part of **the International Thermonuclear Experimental Reactor (ITER)** facility, which will become **the world's largest nuclear fusion reactor when it becomes operational in 2035.**

The ITER project includes the contributions of several countries, including India, South Korea, Japan, Russia and the United States.

How does the 'artificial sun' EAST work?

It replicates the nuclear fusion process carried out by the sun and stars.

- For nuclear fusion to occur, tremendous **heat and pressure are applied on hydrogen atoms** so that they fuse together.
- **The nuclei of deuterium and tritium — both found in hydrogen — are made to fuse together to create a helium nucleus, a neutron along with a whole lot of energy.**
- Here, fuel is heated to temperatures of over 150 million degrees C so that **it forms a hot plasma "soup" of subatomic particles.**
- With the help of a **strong magnetic field**, the plasma is kept away from the walls of the reactor to ensure it does not cool down and lose its potential to generate large amounts of energy. The plasma is confined for long durations for fusion to take place.

Why is fusion better than fission?

While fission is an easier process to carry out, it **generates far more nuclear waste.**

- Unlike fission, **fusion also does not emit greenhouse gases** and is considered a safer process with lower risk of accidents.
- Once mastered, **nuclear fusion could potentially provide unlimited clean energy and very low costs.**

Which other countries have achieved this feat?

China is not the only country that has achieved high plasma temperatures. In 2020, **South Korea's KSTAR reactor** set a new record by maintaining a plasma temperature of over 100 million degrees Celsius for 20 seconds.

26.Chang'e-5 probe

Early-stage findings of Chang'e-5 probe, which use geological mapping to link 'exotic' fragments in the collected samples to features near the landing site, were recently presented by China.

Background:

Chinese spacecraft carrying rocks and soil from the moon had begun its journey back to Earth in December 2020, putting China on course to become **the first country to successfully retrieve lunar samples since the 1970s.**

What Next?

A successful landing in Inner Mongolia made China only **the third country to have retrieved lunar samples after the United States and the Soviet Union.**

The **objective of the mission** was to bring back lunar rocks, the first attempt by any nation to retrieve samples from the moon in four decades.

About Chang'e-5 probe:

It is an **unmanned spacecraft** by China. The probe is named after the mythical Chinese **moon goddess**.

The rocket **comprises four parts**: an orbiter, a returner, an ascender and a lander.

The Chang'e-5 mission is expected to realize four "firsts" in China's space history:

1. The first time for a probe to take off from the surface of the Moon.
2. The first time to automatically sample the lunar surface.
3. The first time to conduct unmanned rendezvous and docking in lunar orbit.
4. The first time to return to Earth with lunar soil samples in escape velocity.

(Joint Venture Missions)**27. NASA-ISRO NISAR Mission**

The NISAR mission is scheduled for launch in 2023.

- ISRO has already delivered the S-band SAR payload to NASA for NISAR [NASA-ISRO SAR] mission.

About NISAR:

- It is optimised for studying hazards and global environmental change and can help manage natural resources better and provide information to scientists to better understand the effects and pace of climate change.
- It will scan the globe every 12 days over the course of its three-year mission of imaging the Earth's land, ice sheets and sea ice to give an "unprecedented" view of the planet.
- It will detect movements of the planet's surface as small as 0.4 inches over areas about half the size of a tennis court.
- NASA will provide one of the radars for the satellite, a high-rate communication subsystem for science data, GPS receivers and a payload data subsystem.
- ISRO will provide the spacecraft bus, the second type of radar (called the S-band radar), the launch vehicle and associated launch services.
- NISAR will be equipped with the largest reflector antenna ever launched by NASA and its primary goals include tracking subtle changes in the Earth's surface, spotting warning signs of imminent volcanic eruptions, helping to monitor groundwater supplies and tracking the rate at which ice sheets are melting.

Synthetic aperture radar:

The name **NISAR is short for NASA-ISRO-SAR**. SAR here refers to **the synthetic aperture radar** that NASA will use to measure changes in the surface of the Earth.

- Essentially, SAR refers to a technique for producing high-resolution images. Because of the precision, the radar can penetrate clouds and darkness, which means that it can collect data day and night in any weather.

28. James Webb Space Telescope

- James Webb, the world's premier space science observatory that was launched recently will succeed the Hubble Space Telescope, NASA's flagship telescope that has been in service for more than three decades now.

About JSWT:

JWST is a joint venture between the US (Nasa), European (Esa) and Canadian space agencies (CSA).

- It is an orbiting infrared observatory that will complement and extend the discoveries of the **Hubble Space Telescope**, with longer wavelength coverage and greatly improved sensitivity.
- Webb was formerly known as the "Next Generation Space Telescope" (NGST) and it was renamed in 2002 after a former NASA administrator, James Webb.
- It will be a large infrared telescope with an approximately 6.5 meter primary mirror.

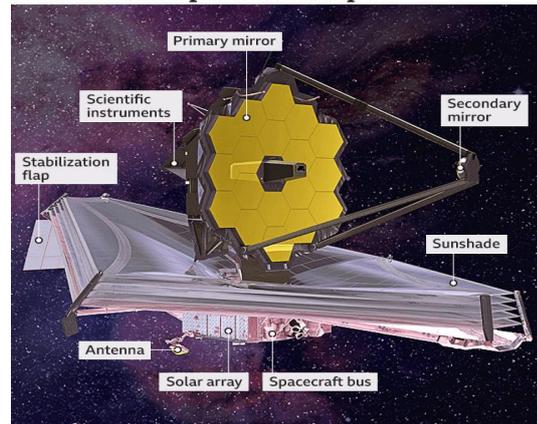
Objectives and functions of the telescope:

- It will look deeper into the cosmos - and thus further back in time - than is possible with Hubble.
- It will do this with a much bigger mirror (6.5m in diameter versus 2.4m) and instruments that are tuned to the infrared.
- Scientists hope this set-up can detect the light from the very first population of stars in the Universe to switch on more than 13.5 billion years ago.

Orbit:

- [The Hubble Space Telescope](#) orbits around the Earth at an altitude of ~570 km above it.
- Webb will not actually orbit the Earth, instead it will sit at the **Earth-Sun L2 Lagrange point**, 1.5 million km away.
- At the **L2 point Webb's solar shield** will block the light from the Sun, Earth, and Moon which will help Webb stay cool, which is very important for an infrared telescope.

James Webb Space Telescope



Source: Nasa

BBC

James Webb Telescope Vs Hubble Space Telescope

<p>Location of operation</p> <p>JWST: 1.5 million km away from Earth</p> <p>HST: 570 km away from Earth</p>	<p>Primary mirror</p> <p>JWST: 6.5 meter</p> <p>HST: 2.4 meter</p>
<p>No of mirror segments</p> <p>JWST: 18 segments</p> <p>HST: 1 segment</p>	<p>Mission objective</p> <p>JWST: Look back 13.5 bn years and watch the birth of new galaxies</p> <p>HST: Look back 12.5 bn years and peer into young galaxies</p>
<p>Service conditions</p> <p>JWST: Not serviceable</p> <p>HST: Can be repaired</p>	
<p>Wavelengths</p> <p>JWST: Explore near-infrared and mid-infrared light</p> <p>HST: Explores into ultraviolet, visible, parts of near-infrared light</p>	

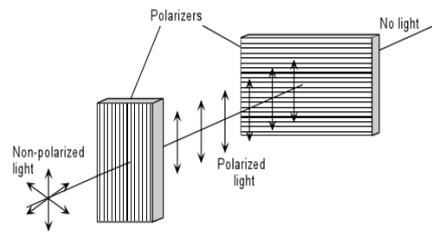
29. Polar-Areas Stellar-Imaging in Polarisation High-Accuracy Experiment (PASIPHAЕ)

[Polar-Areas Stellar-Imaging in Polarisation High-Accuracy Experiment \(PASIPHAЕ\)](#) is an international collaborative sky surveying project.

- Scientists aim to study the polarisation in the light coming from millions of stars.

Background:

Polarization is a property of light that represents the direction that the light wave oscillates.

**How will the survey be carried out?**

1. The survey will use two high-tech optical **polarimeters** to observe the northern and southern skies, simultaneously.
2. It will **focus on capturing starlight polarisation of very faint stars** that are so far away that polarisation signals from there have not been systematically studied.
3. The distances to these stars will be obtained from measurements of [the GAIA satellite](#).
4. By combining these data, astronomers will perform **a maiden magnetic field tomography mapping** of the interstellar medium of very large areas of the sky using a novel polarimeter instrument known as **WALOP (Wide Area Linear Optical Polarimeter)**.

Significance of the project:

The theory is that a small fraction of CMB radiation emitted during the universe's rapid inflationary phase should have its fingerprints on a specific kind of polarisation, known technically as **B-mode signals**. These B-modes are theorised to have arisen as a result of powerful [gravitational waves](#) seen during inflation.

However, these signals have been difficult to isolate because of the enormous amounts of **polarised radiation in our own Milky Way**, caused by large dust clouds that fill the galaxy.

- In essence, PASIPHAE endeavours to ascertain the effect of these obstacles, so we can, ultimately, learn how things played out in the early universe.

(Other Missions)**30. [European Space Agency's EnVision mission to Venus](#)**

European Space Agency (ESA) has selected [EnVision](#) as its **next orbiter that will visit Venus sometime in the 2030s**.

What is EnVision?

1. EnVision is an ESA led mission with contributions from **NASA**.
2. It will be launched on an Ariane 6 rocket, the spacecraft will take about 15 months to reach Venus and will take 16 more months to achieve orbit circularisation.
3. **Objectives:** To **study the planet's atmosphere and surface**, monitor trace gases in the atmosphere and analyse its surface composition. A radar provided by NASA will help to image and map the surface.

Why are scientists interested in studying Venus?

Earth and Venus have evolved so differently from each other even though they are roughly of the same size and composition. Venus is the hottest planet in the solar system because of the heat that is trapped by its thick cloud cover.

With such missions, scientists seek to address the following questions:

1. What history did Venus experience to arrive at this state and does this foretell Earth's fate should it, too, undergo a catastrophic greenhouse effect?
2. Is Venus still geologically active?
3. Could it have once hosted an ocean and even sustained life?
4. What lessons can be learned about the evolution of terrestrial planets in general, as we discover more Earth-like exoplanets?

31. Inspiration4: SpaceX's first all-civilian space mission

Musk's [SpaceX](#) recently announced that 'Inspiration4', its first all-civilian, non-governmental spaceflight, is on track for launch on September 15.

- The [Crew Dragon spacecraft](#) is set to be launched from NASA's Kennedy Space Centre in Florida in the US.
- It will take a group of four private citizens into space for three days.



What is Inspiration4?

The mission involves circling the Earth for three days, and then splashing down into the Atlantic Ocean.

- Inspiration4 will orbit the Earth at 575km, higher than [the International Space Station](#) (408km) and [the Hubble space telescope](#) (547km).
- This will be the farthest distance travelled by a crewed mission since 2009, when astronauts last went to repair the Hubble.
- The Dragon module that the group will be using has also been modified for the mission.

Why is the journey significant?

- According to the reports, the journey will present an opportunity for collecting large amounts of health data that will aid in planning future crewed space missions.
- This will also help in assessing behavioural and cognitive changes over the journey.

Along with the recent space journeys by billionaires Jeff Bezos and Richard Branson, Inspiration4 is seen as part of an effort to open up space travel to non-professionals.

32. New Shepard rocket system

Amazon CEO Jeff Bezos back on earth after 10-min flight to space on [Blue Origin's New Shepard spacecraft](#).

Significance of the mission:

The astronauts experienced three to four minutes of zero-g and travelled above the Kármán Line, the internationally-recognised boundary of space.

What is New Shepard, the rocket system?

- It is a rocket system meant to take tourists to space successfully.
- The system is built by Blue Origin.
- New Shepard has been named after astronaut Alan Shepard, the first American to go to space.
- It offers flights to space over 100 km above the Earth and accommodation for payloads.
- The system is a fully reusable, vertical takeoff and vertical landing space vehicle.

Scientific objectives of the mission:

It is a rocket system that has been designed to take astronauts and research payloads past the Karman line – the internationally recognised boundary of space.

- The idea is to provide easier and more cost-effective access to space meant for purposes such as academic research, corporate technology development and entrepreneurial ventures among others.

33. Stardust 1.0

Stardust 1.0 was launched recently from Loring Commerce Centre in Maine, US.

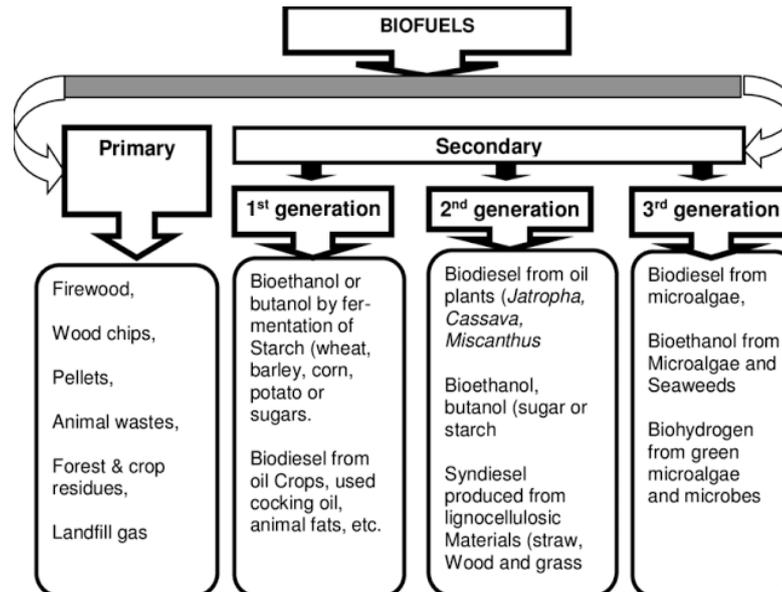
- It has become the **first commercial space launch powered by biofuel**, which is non-toxic for the environment as opposed to traditionally used rocket fuels.
- Stardust 1.0 is a launch vehicle suited for student and budget payloads.

What are Biofuels?

Any hydrocarbon fuel that is produced from an organic matter (living or once living material) in a short period of time (days, weeks, or even months) is considered a biofuel.

Biofuels may be solid, liquid or gaseous in nature.

1. Solid: Wood, dried plant material, and manure.
2. Liquid: Bioethanol and Biodiesel.
3. Gaseous: Biogas.

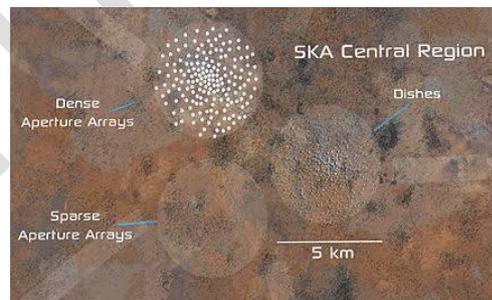


34. Square Kilometre Array

The **Square Kilometre Array Observatory (SKAO) Council** held its maiden meeting and approved the establishment of the **world's largest radio telescope**.

About SKAO:

- SKAO is a new intergovernmental organisation dedicated to radio astronomy and is headquartered in the UK.
- At the moment, organisations from ten countries are a part of the SKAO.
- These include Australia, Canada, China, India, Italy, New Zealand, South Africa, Sweden, the Netherlands and the UK.



What are radio telescopes?

- Unlike optical telescopes, radio telescopes can detect invisible gas and, therefore, they can reveal areas of space that may be obscured by cosmic dust.

About SKA Telescope:

- The telescope is proposed to be the largest radio telescope in the world.
- It will be located in Africa and Australia whose operation, maintenance and construction will be overseen by SKAO.

(Space related Concepts)

35. What is dark energy and dark matter?

Astronomical observations suggest that a **significant part of the universe is made up of dark matter which interacts with the rest of the universe only through the gravitational pull.**

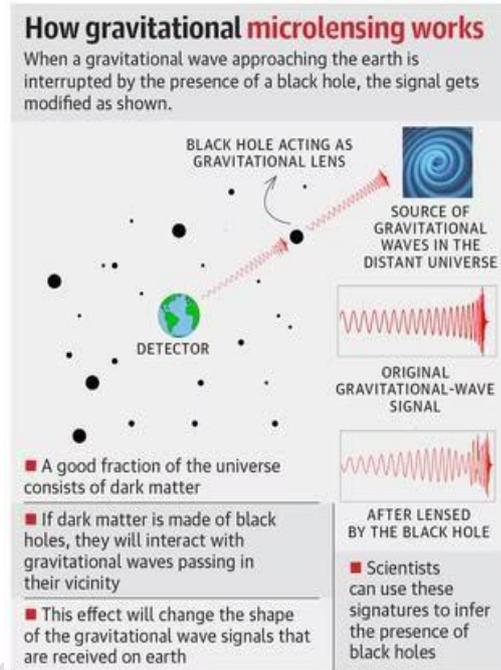
- Many large lab experiments have tried to detect elementary particles that could be candidates for dark matter. However, such dark matter particles have not been detected until now.

Assessing dark matter:

The researchers use the non-observation of the lensing signatures to assess what fraction of the dark matter could be made of black holes. **Gravitational lensing is useful to cosmologists because it is directly sensitive to the amount and distribution of dark matter.**

What is gravitational lensing? How does it work?

- **Gravitational lensing is an effect of Einstein’s theory of general relativity** – simply put, mass bends light.
- The gravitational field of a massive object will extend far into space, and cause light rays passing close to that object (and thus through its gravitational field) to be bent and refocused somewhere else.
- The **more massive the object, the stronger its gravitational field** and hence the greater the bending of light rays – just like using denser materials to make optical lenses results in a greater amount of refraction.



What is Dark Energy?

More is unknown than is known. We know how much dark energy there is because we know how it affects the universe’s expansion. Other than that, it is a complete mystery. But it is an important mystery. It makes up about 68% of the universe.

Dark Energy is a hypothetical form of energy that exerts a negative, repulsive pressure, behaving like the opposite of gravity.

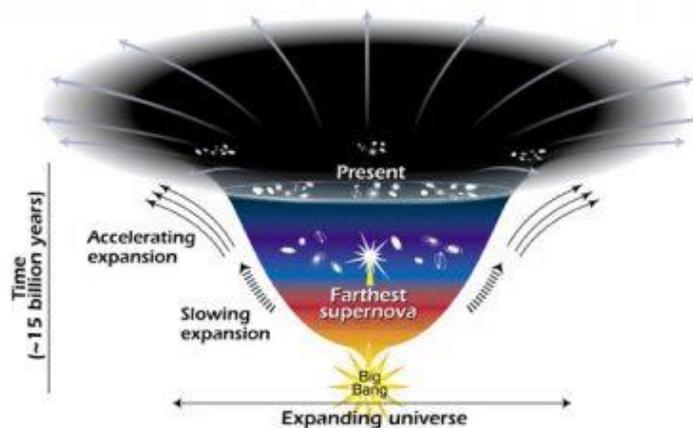
- It is causing the rate of expansion of our universe to accelerate over time, rather than to slow down. That’s contrary to what one might expect from a universe that began in a Big Bang.

How is dark energy different from dark matter?

Everything we see – the planets, moons, massive galaxies – makes up less than 5% of the universe. **About 27% is dark matter and 68% is dark energy.**

While **dark matter attracts and holds galaxies together, dark energy repels and causes the expansion of our universe.**

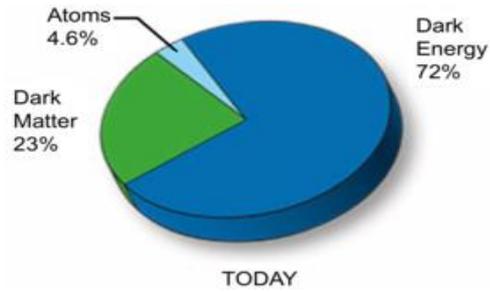
- The existence of dark matter was suggested as early as the 1920s, while dark energy wasn’t discovered until 1998.



This diagram reveals changes in the rate of expansion since the universe’s birth 15 billion years ago. The more shallow the curve, the faster the rate of expansion. The curve changes noticeably about 7.5 billion years ago, when objects in the universe began flying apart at a faster rate. Astronomers theorize that the faster expansion rate is due to a mysterious, dark force that is pushing galaxies apart.

XENON1T experiment:

- It is **the world’s most sensitive dark matter experiment** and was operated deep underground at the INFN Laboratori Nazionali del Gran Sasso in Italy.
- It uses the dual-phase (liquid/gas) xenon technique and is located underground at the Laboratory Nazionali del Gran Sasso of INFN, Italy.



The theory of general relativity:

The leading theory, however, considers dark energy a property of space. Albert Einstein was the first to understand that space was not simply empty. He also understood that more space could continue to come into existence. In his theory of general relativity, Einstein included a cosmological constant to account for the stationary universe scientists thought existed.

- After **Hubble** announced the expanding universe, Einstein called his constant his "biggest blunder."
- But Einstein's blunder may be the best fit for dark energy. Predicting that empty space can have its own energy, the constant indicates that as more space emerges, more energy would be added to the universe, increasing its expansion.

36. Jio Platforms to provide satellite broadband services

Jio has formed a joint-venture with Luxembourg-based SES to deliver satellite broadband services across India.

How?

The joint venture will use **multi-orbit space networks** that is a combination of **GEO (geostationary equatorial orbit) and MEO (medium earth orbit) satellite constellations** capable of delivering multi-gigabit links and capacity to enterprises, mobile backhaul and retail customers across the length and breadth of India and neighbouring regions.

How is this different from what Starlink or OneWeb offer?

SES primarily has satellites in the GEO and the MEO, while those of Elon Musk-led **Starlink** and Bharti Group’s **OneWeb** are in **low earth orbit (LEO)**.

- While **GEO satellites are positioned at an altitude of 36,000 km**, MEO and LEO are lower at altitudes of **5,000-20,000km and 500-1,200 km**, respectively.
- **The altitude of the satellite is directly proportional to the area of earth that it covers.** Therefore, the higher a satellite is positioned, the larger an area it covers.

OneWeb's LEO internet programme:

OneWeb is a Low Earth Orbit (LEO) satellite communications operator. Using LEO satellites OneWeb seeks to offer connectivity across **the UK, Alaska, Northern Europe, Greenland, the Arctic Seas and Canada**. The company expects the service to be switched on before the end of the year. It calls this programme the **‘Five to 50’ service** of offering internet connectivity to **all regions north of 50 degrees latitude**.

Differences between GEO, MEO and LEO satellites:

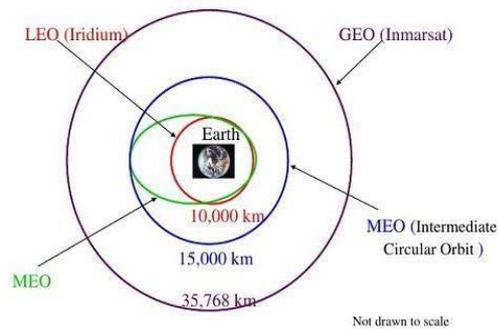
Coverage: GEO satellites provide a larger coverage and therefore only three satellites can cover the whole earth.

- Hundreds of LEO satellites are needed to provide coverage to a larger area.

Cost: LEO satellites are smaller and are cheaper to launch than GEOs or MEOs.

- But, LEO based satellites have risks, for example the recent Starlink incident. SpaceX's satellites fell out of orbit as a result of the solar flare.

Orbits of Different Satellites



What are the benefits of LEO satellites based internet?

1. LEO satellites are positioned around 500km-2000km from earth, compared to stationary orbit satellites which are approximately 36,000km away.
2. As LEO satellites orbit closer to the earth, they are able to provide stronger signals and faster speeds than traditional fixed-satellite systems.
3. Because signals travel faster through space than through fibre-optic cables, they also have the potential to rival if not exceed existing ground-based networks.

Challenges:

LEO satellites travel at a speed of 27,000 kph and complete a full circuit of the planet in 90-120 minutes. As a result, **individual satellites can only make direct contact with a land transmitter for a short period of time** thus requiring massive LEO satellite fleets and consequently, a significant capital investment.

Criticisms of LEO satellites:

- **The balance of power has shifted from countries to companies since most of these are private companies run projects.** As a result, there are questions related to who regulates these companies, especially given the myriad of nations that contribute to individual projects.
- **Complicated regulatory framework:** Stakeholders in these companies are from various countries. Thus it becomes challenging to receive requisite licences to operate in each country.
- **Satellites can sometimes be seen in the night skies** which creates difficulties for astronomers as the satellites reflect sunlight to earth, leaving streaks across images.
- Satellites travelling at a lower orbit can also interrupt the frequency of those orbiting above them.
- Those objects, colloquially referred to as **'space junk,'** have the potential to damage spacecraft or collide with other satellites.

Potential:

LEO satellite broadband is preferable in areas that cannot be reached by fibre and spectrum services. The target market will therefore be rural populations and military units operating away from urban areas.

37.Space debris

Space debris poses a global threat to the continued use of space-based technologies that support critical functions like communication, transport, weather and climate monitoring, remote sensing.

- Predicting collision probability from these space objects is crucial from the national security perspective as well as for the protection of public and private space assets of Indian origin.

Amount of space debris in space:

The real amount of space debris is said to be between 500,000 and one million pieces as current sensor technology cannot detect smaller objects. They all travel at speeds of up to 17,500 mph (28,162 kmph) fast enough for a relatively small piece of orbital debris to damage a satellite or a spacecraft.

Technologies that can tackle the problem in future are:

- Moving an object out of the way by altering its orbit is one method of diverting a potential crash, but the sheer amount of debris requires constant observation and prediction – by any means necessary.
- **Nasa's Space Debris Sensor orbits the Earth on the International Space Station.** The sensor was attached to the outside of the space station's European Columbus module in December 2017. It will detect millimetre-sized pieces of debris for at least two years, providing information on whatever hits it such as size, density, velocity, orbit and will determine whether the impacting object is from space or a man-made piece of space debris.
- **REMOVEdebris**, satellite contain two cubesats that will release simulated space debris so that it can then demonstrate several ways of retrieving them.
- **Deorbit mission:** There are two emerging technologies being developed under what's known as the e.Deorbit mission to grasp the wayward space junk, or to catch it.
- **Other technologies include** moving objects with a powerful laser beam. It is important to start doing that soon, current scientific estimates predict that without active debris removal, certain orbits will become unusable over the coming decades.

Netra:

To safeguard its space assets from space debris, **Isro had set up a dedicated Space Situational Awareness (SSA) Control Centre named "Netra"** in Bengaluru last December.

- Netra's key objective is to monitor, track and protect the national space assets and function as a hub of all SSA activities.
- Only the US, Russia and Europe have similar facilities in place to track space objects and share collision warnings.

India's Anti-Satellite (ASAT) missile:

Mission Shakti is a joint programme of the Defence Research and Development Organisation (DRDO) and the Indian Space Research Organisation (ISRO).

- As part of the mission, **an anti-satellite (A-SAT) weapon** was launched and targeted an Indian satellite which had been decommissioned. Mission Shakti was carried out from DRDO's testing range in Odisha's Balasore.

Significance:

India is only the 4th country to acquire such a specialised and modern capability, and Entire effort is indigenous. Till now, only the US, Russia and China had the capability to hit a live target in space.

38. Dwarf Planet

- According to the definition adopted by the International Astronomical Union (IAU) in 2006, a dwarf planet is, "a celestial body orbiting a star that is massive enough to be rounded by its own gravity but has not cleared its neighboring region of planetesimals and is not a satellite.
- In essence, the term is meant to designate any planetary-mass object that is neither a planet nor a natural satellite that fits two basic criteria.
 - For one, **it must be in direct orbit of the sun** and not be a moon around another body.
 - Second, **it must be massive enough for it to have become spherical in shape under its own gravity.** And, unlike a planet, **it must have not cleared the neighborhood around its orbit.**

The five best-known dwarf planets are Ceres, Pluto, Makemake, Haumea, and Eris.

Defence Technology

1. IAC Vikrant:

INS Vikrant (IAC-1) is the first aircraft carrier built in India and the first Vikrant-class aircraft carrier built by Cochin Shipyard (CSL) in Kochi, Kerala for the Indian Navy.



- It has been designed by the Indian Navy's Directorate of Naval Design (DND), and is being built at Cochin Shipyard Limited (CSL), a public sector shipyard under the Ministry of Shipping.
- The IAC-1, the biggest warship made indigenously, has an overall length of 263 m and a breadth of 63 m.
- It is capable of carrying 30 assorted aircraft including combat jets and helicopters.

2. Pralay Missile

- DRDO recently successfully conducted maiden flight test of a new indigenously developed surface-to-surface missile 'Pralay'.
- Pralay' is India's first conventional quasi-ballistic missile. A quasi-ballistic missile has a low trajectory, and while it is largely ballistic, it can maneuver in flight.
- The missile has been developed in a way that it is able to defeat the interceptor missiles and also has the ability to change its path after covering a certain range mid-air.
- It is powered with a solid propellant rocket motor and many new technologies.
- **Range:** The missile has a range of 150-500 kilometre and can be launched from a mobile launcher.
- Pralay will be the longest-range surface-to-surface missile in the inventory of the Army.

3. Agni 5

India successfully tests nuclear-capable Agni-V ballistic missile.

- **The Agni-V Intercontinental-range Ballistic Missile (ICBM)** has been developed by the Defence Research & Development Organisation (DRDO) and Bharat Dynamics Limited.
- It weighs close to 50,000 kilograms. The missile is 1.75 meters tall with a diameter of two metres.
- The 1,500-kilogram warhead will be placed on top of the three-stage rocket boosters powered by solid fuel.
- The missile can range the whole of Asia, Europe and parts of Africa. Once inducted, Agni-V will be maintained by the Strategic Forces command.
- India has already conducted seven trials of the missile, which has a range of over 5,000 kilometres.



1. Agni-P (Prime) missile

- It is new-generation nuclear-capable ballistic missile.
- It was successfully test-fired by the Defence Research and Development Organisation (DRDO).
- Agni-P is a new-generation advanced variant of Agni class of missiles. **It is a canisterised missile with range capability between 1,000 and 2,000 km.**



- **Canisterisation** of missiles reduces the time required to launch the missile while improving its storage and mobility.

The longest of the Agni series, **Agni-V, an Inter-Continental Ballistic Missile (ICBM)** with a range of more than 5,000 km, has already been tested several times and validated for induction.

2. Python-5

- DRDO conducts maiden trial of Python-5 Air to Air Missile.
- Python is a family of air-to-air missiles (AAMs) built by the Israeli weapons manufacturer Rafael Advanced Defense Systems.
- Python 5 can engage enemy aircraft from very short ranges and near beyond visual range.



3. LCA-Mk2

- Light Combat Aircraft-Tejas Mark 2, the second-generation fighter prototypes are underway in association with the DRDO's Aeronautical Development Agency (ADA).
- The first flight is expected to be ready by 2023.
- The Mk2 is 1,350 mm longer featuring canards and can carry a payload of 6,500 kg.

THE NEW TEJAS

The long-awaited indigenous fighter Tejas Mk II, which will be manufactured by HAL, will go into production by 2025-2026

17.5 ton
Tejas Mark II will be the same weight as the Mirage, Jaguar and Grippen

ALSO IN THE WORKS
Advanced medium combat aircraft (AMCA) given a go-ahead by IAF late last year

25-ton fighter will be powered by two engines capable of super-cruise speeds

Will have advanced tech to ensure minimum radar signatures

ADDITIONS THE NEW GEN

- Heavier stand-off weapon capacity
- State-of-the-art AESA radar
- Indigenously developed air-to-air missile Astra (with a range of 70km)

WHEN: Set to go into production after the Tejas LCA order of 123 aircraft to replace the IAF's ageing MiG-21s is completed

4. Ghost Army:

Ghost Army was the first mobile tactical deception unit of the US Army deployed during World War II.

- The US President recently signed into law a bill titled, "Ghost Army Congressional Gold Medal Act", to recognise the Ghost Army.

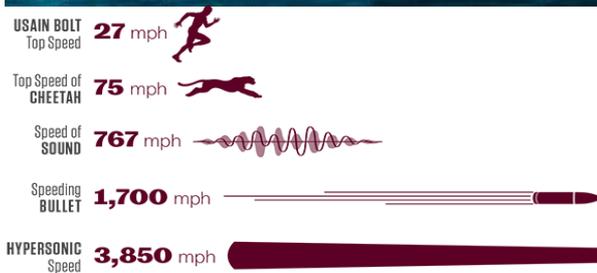


5. Hypersonic weapons

US has said that China's pursuit of hypersonic weapons "increases tensions in the region".

What are hypersonic speeds?

- **Hypersonic speeds** are 5 or more times the speed of sound.



Concerns and implications for India and the world:

- The weapon could, in theory, fly over the South Pole. That would pose a big challenge for the US military because its missile defence systems are focused on the northern polar route.
- India is especially concerned with the latest developments considering relations with China in the recent past. Such capabilities highlight the threat for our space assets along with the surface assets.

Technology used:

The exact details on technology used by China in this particular test are not known through media sources. But most of the hypersonic vehicles primarily use [the scramjet technology](#).

What is scramjet technology?

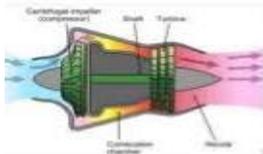
Scramjets are a category of **engines designed to handle airflows of speeds in multiples of the speed of sound.**

- In an air-breathing scramjet engine, air from the atmosphere is rammed into the engine’s combustion chamber at a supersonic speed of more than Mach two.
- In the chamber, the air mixes with the fuel to ignite a supersonic combustion but the cruiser’s flight will be at a hypersonic speed of Mach six to seven. So it is called **supersonic combustion ramjet or Scramjet.**

TYPES OF ATMOSPHERIC JET ENGINES

TURBOJET

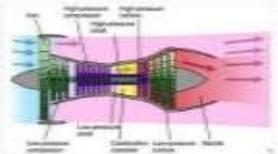
Turbojets are the oldest and most general purpose jet engines, finding use in a large variety of applications. They are most efficient at supersonic velocities, and are capable of speeds around Mach 3. They were also found on the Concorde and the Tupolev Tu-144.



4/15/2017

TURBOFAN

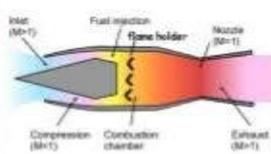
A turbofan is essentially a turbojet but with a large ducted fan that provides additional thrust by moving large amount of low velocity air around the main engine. This type of engine is more efficient than turbojets at subsonic speeds. Ex. Boeing 747.



VAISHAV PATHAK, MECHANICAL, STECH 4TH YEAR

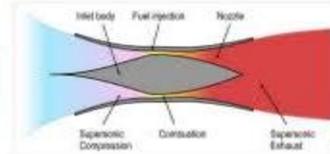
RAMJET

A ramjet is nothing more than a turbojet with all of the rotating parts removed. Ramjets are primarily used with missiles, due to their simple, small, and high-velocity design.



SCRAMJET

A scramjet is identical to a ramjet, but with one difference: combustion occurs with the air moving at supersonic velocities. As a result, scramjets are estimated not to work well below Mach 5, but could possibly reach speeds of Mach 24 (18000 mph).



Cryogenic Engines	Scram jet Engines
No air intake is required in this engine	Air intake is required to operate this engine
Fuel needs to be stored at very low temperature	Fuel storage does not require low temp like cryogenic
It runs efficiently when low temperature fuel transforms and mixes correctly and ignites.	It runs efficiently at supersonic speed that forcefully compress air before combustion
India is the sixth nation apart from the US, Russia, France, Japan and China to possess cryogenic engine technology.	India is the fourth country apart from US, Russia and ESA to demonstrate the flight testing of a Scramjet Engine.
Its cost of payload is independent of oxidizer	Since oxidizer saves the cost, It can carry more payload

Technologies / New Discoveries

1. Quantum communication

In a major step forward towards **satellite-based quantum communication**, scientists from Ahmedabad-based Space Applications Centre and Physical Research Laboratory successfully demonstrated **quantum entanglement**.

- Using real-time **Quantum Key Distribution (QKD)**, they conducted hack-proof communication between two places separated by 300 meters.

Significance:

Quantum communication is one of the safest ways of connecting two places with high levels of code and quantum cryptography that cannot be decrypted or broken by an external entity.

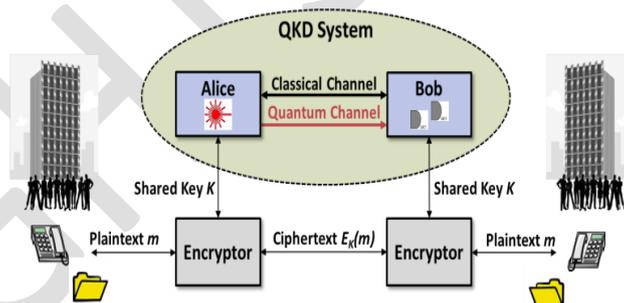
- If a hacker tries to crack the message in quantum communication, it changes its form in such a manner that would alert the sender and would cause the message to be altered or deleted.

- Quantum Technology is based on the principles of Quantum mechanics developed in the early 20th century to describe nature at the scale of atoms and elementary particles.
- Quantum technology is manifested through applications in **secure communication, disaster management** through better prediction, computing, simulation, chemistry, **healthcare**, cryptography, imaging among others.
- Scientists have expanded quantum theory to **understand biological phenomena such as smell, consciousness, enzyme catalysis, photosynthesis**, avian navigation like that of the Robin, origin of life and effects on coronavirus.

What you need to know about this technology?

Typical encryption relies on traditional mathematics and while for now it is more or less adequate and safe from hacking, **the development of quantum computing threatens that.**

- Quantum computing** refers to a new era of faster and more powerful computers, and the theory goes that they would be able to break current levels of encryption.
- QKD works by **using photons** — the particles which transmit light — to transfer data.
- QKD allows two distant users, who do not share a long secret key initially, to produce a common, random string of secret bits, called a **secret key**.
- Using the one-time pad encryption this key is proven to be secure to encrypt and decrypt a message, which can then be transmitted over a standard communication channel.



Significance of this technology:

- The encryption is **“unbreakable”** and that’s mainly because of the way data is carried via the photon. **A photon cannot be perfectly copied and any attempt to measure it will disturb it.** This means that a person trying to intercept the data will leave a trace.
- The **implications could be huge for cybersecurity**, making businesses safer, but also making it more difficult for governments to hack into communication.

2. Quantum Key Distribution

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 for a distance of over 100 kilometres.

Why is this significant?

- With this success, the country has demonstrated **indigenous technology of secure key transfer for bootstrapping military-grade communication security key hierarchy**.
- This technology will enable **security agencies to plan a suitable quantum communication network** with indigenous technology backbone.

What is Quantum Key Distribution?

QKD provides for secure communication using various components of quantum mechanics.

- 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.

What makes QKD unbreakable?

The security of QKD stems from the ability to detect any intrusion on the QKD transmission. Because of the unique and fragile properties of photons, any third party (or eavesdropper) who tries to read or copy the photons in any way will change the photons' state.

- The change will be detected by the endpoints, alerting them that the key has been tampered with and must be discarded.
- A new key is then transmitted. Moreover, since the keys generated are truly random, they are protected from future hacking attempts.

3. Quantum entanglement

Scientists have identified **the first "quantum entangled" animal in history-frozen tardigrade**, in a recent study.

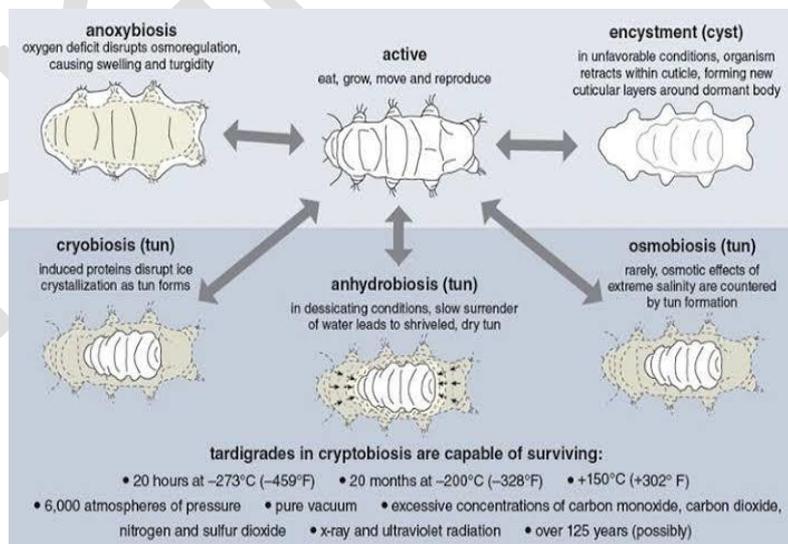
- **Frozen tardigrade** are microscopic multicellular organisms known to tolerate extreme physiochemical conditions through a latent state of life known as **cryptobiosis**.



Cryptobiosis:

Also known as anabiosis, it is a metabolic state of life entered by an organism in response to adverse environmental conditions such as desiccation, freezing, and oxygen deficiency.

- In the cryptobiotic state, all measurable metabolic processes stop, preventing reproduction, development, and repair.
- When environmental conditions return to being hospitable, the organism will return to its metabolic state of life as it was prior to the cryptobiosis.



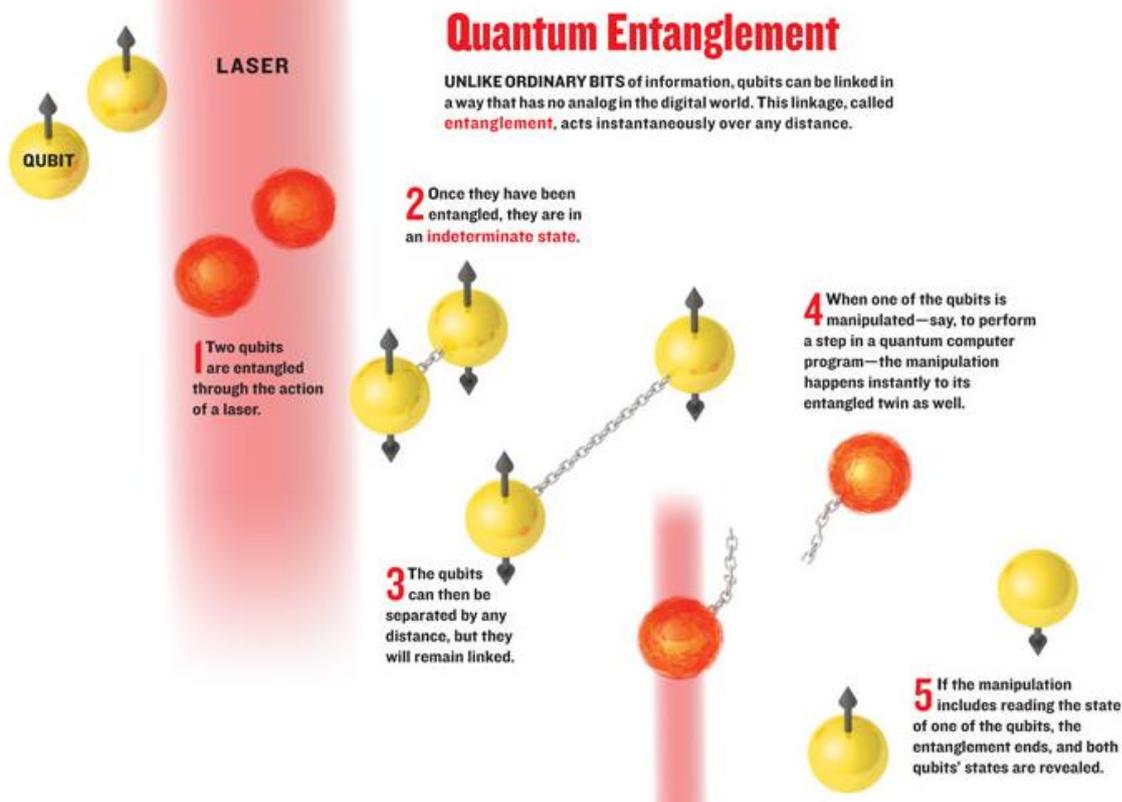
Quantum Entanglement:

It is the physical phenomenon that **occurs when a pair or group of particles is generated and they interact in such a way that the quantum state of each particle of the pair or group cannot be described independently of the state of the others.**

- In this quantum mechanical phenomenon, the quantum states of two or more objects have to be described with reference to each other, even though the individual objects may be spatially separated.
- This leads to correlations between observable physical properties of the systems.
- **Albert Einstein** dismissed this idea as a 'spooky action'.

Significance:

Quantum entanglement is one of the peculiarities of quantum mechanics, which makes phenomena such as quantum teleportation and super-dense coding possible.



4. Neutrino project

Tamil Nadu has made clear to the Supreme Court that it does not want **the Indian Neutrino Observatory (INO)** to be set up in a sensitive ecological zone in the Western Ghats at great cost to wildlife, biodiversity, and by ignoring the local opposition and public agitations to the project.

Why is it being opposed?

- The project in question falls exactly on the hill slopes of this part of the Western Ghats, which align within it a significant tiger corridor, namely **the Mathikettan-Periyar tiger corridor**.
- This corridor links **the Periyar Tiger Reserve** along the Kerala and Tamil Nadu borders and **the Mathikettan Shola National Park**.
- The proposed project area also ecologically links to the eastern habitats, where **Srivilliputhur Meghamalai Tiger Reserve** is located. It hosts tigers from this region and helps in genetic dispersal.
- The area is a significant watershed and catchment zone for **the rivers Sambhal and Kottakudi**.

About the project:

The India-based Neutrino Observatory (INO) Project is a multi-institutional effort aimed at building a **world-class underground laboratory** with a rock cover of approximately 1200 m for

non-accelerator based high energy and nuclear physics research in India. The initial goal of INO is to study neutrinos.

It is a mega-science project jointly funded by the Department of Atomic Energy (DAE) and the Department of Science and Technology (DST).

The project proposal includes:

- Construction of an underground laboratory and associated surface facilities at **Pottipuram in Bodi West hills of Theni District of Tamil Nadu.**
- Construction of an **Iron Calorimeter (ICAL) detector for studying neutrinos.**
- Setting up of **National Centre for High Energy Physics at Madurai**, for the operation and maintenance of the underground laboratory, human resource development and detector R&D along with its applications.

About Neutrino Observatory

Charnockite rock
Lab cavern
2km tunnel
Entrance portal

A SCHEMATIC VIEW OF THE PROPOSED INDIA-BASED NEUTRINO OBSERVATORY UNDERGROUND LAB

Where	Why	Neutrino	Highlights
At Pottipuram village in Theni district, on the Tamil Nadu-Kerala border	The initial goal of India-based Neutrino Observatory (INO) is to study neutrinos	Neutrinos are the smallest particles that form the universe	Two underground laboratory caverns with a rock cover of over 1000 metres; access tunnel of 2 km length

Where else	Underground	Underwater
	SNO, Canada; Kamioka, Japan; Gran Sasso, Italy	Amundsen - Scott South Pole Station, Antarctica; Antares - under Mediterranean sea off the coast of Toulon, France

SOURCE: INO WEBSITE

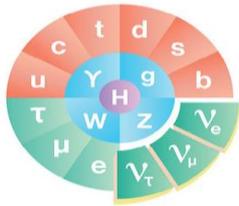
What are neutrinos?

Neutrinos, first proposed by Swiss scientist Wolfgang Pauli in 1930, are **the second most widely occurring particle in the universe**, only second to photons, the particle which makes up light. In fact, neutrinos are so abundant among us that every second, there are more than 100 trillion of them passing right through each of us — we never even notice them.

Neutrinos occur in three different types, or flavours. These are separated in terms of different masses. From experiments so far, we know that **neutrinos have a tiny mass**, but the ordering of the neutrino mass states is not known and is one of the key questions that remain unanswered till today. This is a major challenge INO will set to resolve, thus completing our picture of the neutrino.

Sources:

Neutrinos are created by various **radioactive decays; during a supernova, by cosmic rays striking atoms etc.**



FUNDAMENTAL

Neutrinos are fundamental particles, which means that—like quarks and photons and electrons—they cannot be broken down into any smaller bits.



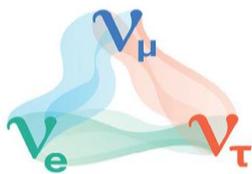
ABUNDANT

Of all particles with mass, neutrinos are the most abundant in nature. They're also some of the least interactive. Roughly a thousand trillion of them pass harmlessly through your body every second.



ELUSIVE

Neutrinos are difficult but not impossible to catch. Scientists have developed many different types of particle detectors to study them.



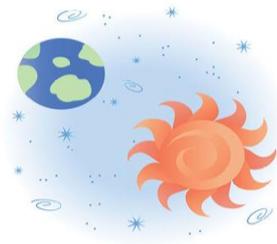
OSCILLATING

Neutrinos come in three types, called flavors. There are electron neutrinos, muon neutrinos and tau neutrinos. One of the strangest aspects of neutrinos is that they don't pick just one flavor and stick to it. They oscillate between all three.



LIGHTWEIGHT

Neutrinos weigh almost nothing, and they travel close to the speed of light. Neutrino masses are so small that so far no experiment has succeeded in measuring them. The masses of other fundamental particles come from the Higgs field, but neutrinos might get their masses another way.



DIVERSE

Neutrinos are created in many processes in nature. They are produced in the nuclear reactions in the sun, particle decays in the Earth, and the explosions of stars. They are also produced by particle accelerators and in nuclear power plants.



MYSTERIOUS

Neutrinos are mysterious. Experiments seem to hint at the possible existence of a fourth type of neutrino: a sterile neutrino, which would interact even more rarely than the others.



VERY MYSTERIOUS

Scientists also wonder if neutrinos are their own antiparticles. If they are, they could have played a role in the early universe, right after the big bang, when matter came to outnumber antimatter just enough to allow us to exist.

Features of neutrinos:

1. Neutrinos **interact very weakly with everything else** – trillions of them pass through every human being every second without anyone noticing.
2. A **neutrino's spin always points in the opposite direction of its motion.**
3. It is now generally believed that the phenomenon of neutrino oscillations requires **neutrinos to have tiny masses.**

Why detect them?

Neutrinos hold the key to several important and fundamental questions on the origin of the Universe and the energy production in stars. Another important possible application of neutrinos is in the area of neutrino tomograph of the earth, that is detailed investigation of the structure of

the Earth from core on wards. This is possible with neutrinos since they are the only particles which can probe the deep interiors of the Earth.

Why should the laboratory be situated underground?

Neutrinos are notoriously difficult to detect in a laboratory because of their extremely weak interaction with matter.

- The background from cosmic rays (which interact much more readily than neutrinos) and natural radioactivity will make it almost impossible to detect them on the surface of the Earth. This is the reason most neutrino observatories are located deep inside the Earth's surface.
- The overburden provided by the Earth matter is transparent to neutrinos whereas most background from cosmic rays is substantially reduced depending on the depth at which the detector is located.

5. Nuclear Fusion Technology

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**.

What's the new record now?

A team at the **Joint European Torus (JET) facility** near Oxford in central England generated 59 megajoules of sustained energy during an experiment in December, more than doubling a 1997 record.

- **A kg of fusion fuel contains about 10 million times as much energy as a kg of coal, oil or gas.**

The experiment:

The energy was produced in a machine called a **tokamak**, a doughnut-shaped apparatus, and **the JET site is the largest operational one of its kind in the world**.

- **Deuterium and tritium**, which are **isotopes of hydrogen**, are heated to temperatures 10 times hotter than the centre of the sun to create plasma.
- This is held in place using superconductor electromagnets as it spins around, fuses and releases tremendous energy as heat.

Why is this achievement so significant?

- 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%.

What is **International Thermonuclear Experimental Reactor (ITER)**?

ITER is a **fusion research mega-project** supported by seven members – China, the European Union, India, Japan, South Korea, Russia and the USA – **based in the south of France**, to further demonstrate the scientific and technological feasibility of fusion energy.

What will ITER do?

- Produce 500 MW of fusion power.
- Demonstrate the integrated operation of technologies for a fusion power plant.
- Achieve a deuterium-tritium plasma in which the reaction is sustained through internal heating.
- Test tritium breeding.
- Demonstrate the safety characteristics of a fusion device.

What is Fusion?

Fusion is the energy source of the Sun and stars. In the tremendous heat and gravity at the core of these stellar bodies, hydrogen nuclei collide, fuse into heavier helium atoms and release tremendous amounts of energy in the process.

How is it different from fission?

- Nuclear fusion is considered by some scientists to be a potential energy of the future, particularly because **it produces little waste and no greenhouse gases.**
- It differs from fission, a technique currently used in nuclear power plants, where the bonds of heavy atomic nuclei are broken to release energy.
- In the fusion process, two light atomic nuclei are "married" to create a heavy one. **This is the process that is at work in stars, including our Sun.**

Three conditions must be fulfilled to achieve fusion in a laboratory:

1. Very high temperature (on the order of 150,000,000° Celsius).
2. Sufficient plasma particle density (to increase the likelihood that collisions do occur).
3. Sufficient confinement time (to hold the plasma, which has a propensity to expand, within a defined volume).

All current nuclear reactors are based on the fission process, in which the nucleus of a heavier atom is split into those of lighter elements in a controlled manner. This process is accompanied with the release of large amounts of energy. Fusion is the opposite process, in which nuclei of relatively lighter atoms, typically those of hydrogen, are fused to make the nucleus of a heavier atom.

Much more energy is released in the fusion process than in fission. The fusion of atoms of two heavier isotopes of hydrogen — deuterium and tritium — for example, to form a helium nucleus produces four times as much energy as is released during the fission of a uranium atom, the kind of which we see in our nuclear reactors.

6. Cryptocurrency and Blockchain Technology

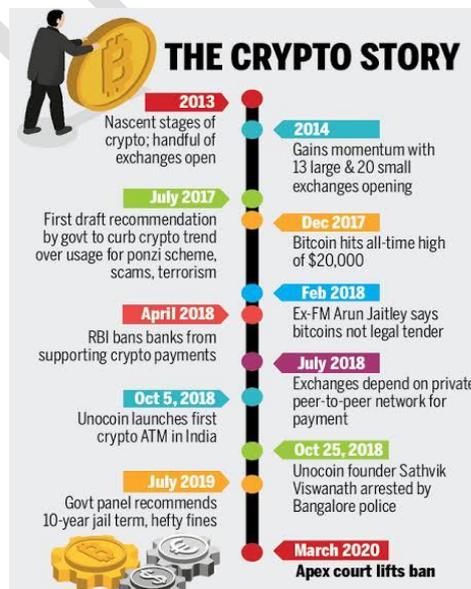
Latest developments:

- In Union Budget 2022, finance minister Nirmala Sitharaman proposed **30 per cent tax on earnings from cryptocurrencies and non-fungible tokens (NFTs).**
- She also said that **losses from their sale could not be offset against other income,** delivering another disincentive to trading and investment in digital assets.
- The government also introduced **1 per cent tax deducted at source (TDS) on digital assets.**

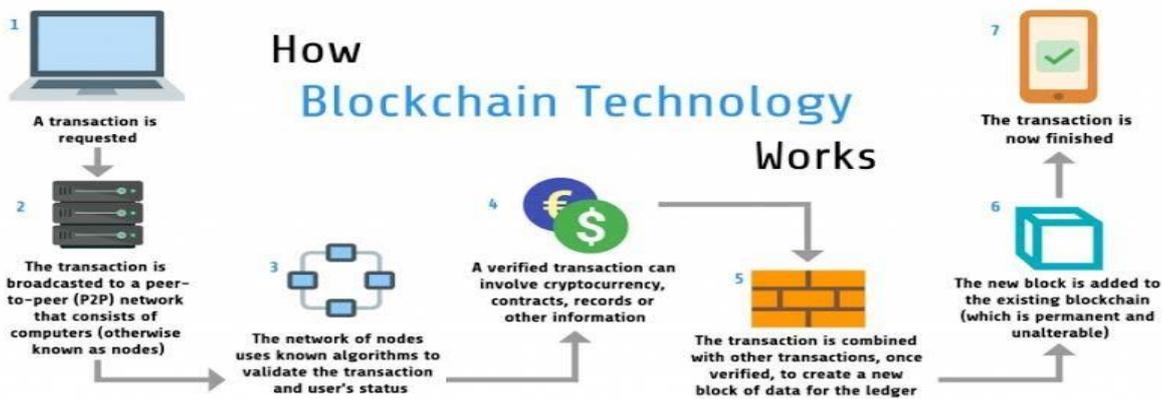
What are Cryptocurrencies?

Cryptocurrencies are digital currencies in which encryption techniques are used to regulate the generation of units of currency and verify the transfer of funds, operating independently of a central bank.

- They use Blockchain technology.



- **Examples:** Bitcoin, Ethereum etc.



Why is the RBI against the use of cryptocurrencies?

Sovereign guarantee: Cryptocurrencies pose risks to consumers. They do not have any sovereign guarantee and hence are not legal tender.

Market volatility: Their speculative nature also makes them highly volatile. For instance, the value of Bitcoin fell from USD 20,000 in December 2017 to USD 3,800 in November 2018.

Risk in security: A user loses access to their cryptocurrency if they lose their private key (unlike traditional digital banking accounts, this password cannot be reset).

Malware threats: In some cases, these private keys are stored by technical service providers (cryptocurrency exchanges or wallets), which are prone to malware or hacking.

SC Garg Committee recommendations (2019):

- Ban anybody who mines, hold, transact or deal with cryptocurrencies in any form.
- It recommend a jail term of one to 10 years for exchange or trading in digital currency.
- It proposed a monetary penalty of up to three times the loss caused to the exchequer or gains made by the cryptocurrency user whichever is higher.
- However, the panel said that the government should keep an open mind on the potential issuance of cryptocurrencies by the Reserve Bank of India.

7. Non-Fungible Token (NFT)

NFTs are gaining massive popularity now because they are becoming **an increasingly popular way to showcase and sell your digital artwork.**

- Billions of dollars have been spent on NFTs since its inception—which date backs to 2015.

What are NFTs?

An NFT is a **unique, irreplaceable token that can be used to prove ownership of digital assets** such as music, artwork, even tweets and memes.

Anything that can be converted into a digital form can be an NFT.

- Everything from your drawings, photos, videos, GIF, music, in-game items, selfies, and even a tweet can be turned into an NFT, which can then be traded online using cryptocurrency.

What makes NFTs unique from other digital forms?

It is backed by Blockchain technology.

- NFT transactions are recorded on blockchains, which is a digital public ledger, with most NFTs being a part of the Ethereum blockchain.

How do NFTs work?

NFT works on blockchain as it gives users complete ownership of a digital asset.

- For instance, if you're a sketch artist, and if you convert your digital asset to an NFT, what you get is proof of ownership, powered by Blockchain.

Differences between NFT and Cryptocurrency:

Cryptocurrency is a currency and is fungible, meaning that it is interchangeable.

- For instance, if you hold one crypto token, say one Ethereum, the next Ethereum that you hold will also be of the same value. But **NFTs are non-fungible**, that means the value of one NFT is not equal to another. Every art is different from other, making it non fungible, and unique.

Risks associated with buying NFTs:

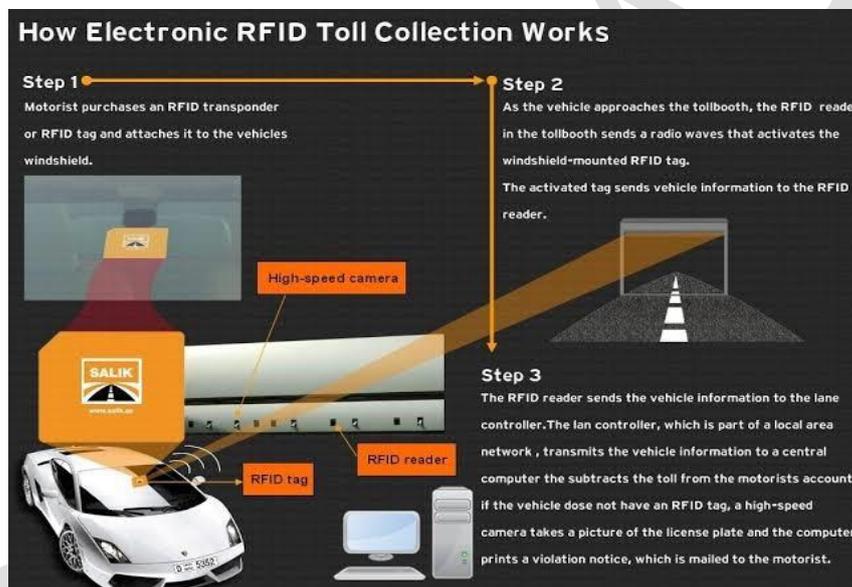
- In the recent past, **several incidents of NFT scams** have been reported including: emergence of fake marketplaces, unverified sellers often impersonating real artists and selling copies of their artworks for half prices.
- **NFRs unquestionably have negative impact on the environment.** In order to validate transactions, crypto mining is done, which requires high powered computers that run at a very high capacity, affecting the environment ultimately.

8. Radio Frequency Identification (RFID):

Indian Army has commenced implementation of RFID tagging of its ammunition inventory.

How it works?

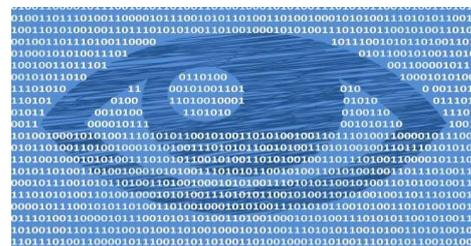
- RFID is a specific type of radio technology that uses radio waves to identify tags attached to an object and thus identify the object.
- The tag contains a transceiver chip that is triggered by the electromagnetic wave from the RFID reader and transmits an identification number back to the reader.
- The identification number is then used for the inventory of the objects with tags.



9. Doxing:

Doxing is **publishing and analysing others' personal information** on the internet with a malicious intent that can reveal the person's real identity making them victims of harassments and cyber-attacks.

- **Meta's** oversight board has suggested Facebook and Instagram to make strict doxing rules.

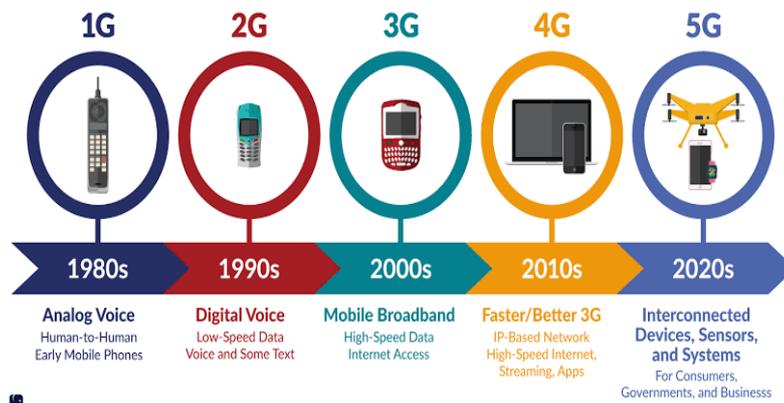


10. 5G Technology

- 5G is the next generation of mobile broadband that will eventually replace, or at least augment 4G LTE connection.

Features and benefits of the 5G technology:

1. Operate in the **millimeter wave spectrum (30-300 GHz)** which have the advantage of sending large amounts of data at very high speeds.
2. Operate in **3 bands**, namely low, mid and high frequency spectrum.
3. **Reduced latency** will support new applications that leverage the power of 5G, the Internet of Things (IoT), and artificial intelligence.
4. **Increased capacity** on 5G networks can minimize the impact of load spikes, like those that take place during sporting events and news events.



Significance of the technology:

India’s **National Digital Communications Policy 2018** highlights the importance of 5G when it states that the convergence of a cluster of revolutionary technologies including 5G, the cloud, Internet of Things (IoT) and data analytics, along with a growing start-up community, promise to accelerate and deepen its digital engagement, opening up a new horizon of opportunities.

What are the potential health risks from 5G?

To date, and after much research performed, **no adverse health effect has been causally linked with exposure to wireless technologies.**

- **Tissue heating** is the main mechanism of interaction between radiofrequency fields and the human body. Radiofrequency exposure levels from current technologies result in **negligible temperature rise in the human body.**
- **As the frequency increases, there is less penetration into the body tissues** and absorption of the energy becomes more confined to the surface of the body (skin and eye).

Provided that the overall exposure remains below international guidelines, **no consequences for public health are anticipated.**

What are the international exposure guidelines?

Two international bodies produce exposure guidelines on electromagnetic fields. Many countries currently adhere to the guidelines recommended by:

1. The International Commission on Non-Ionizing Radiation Protection.
2. The Institute of Electrical and Electronics Engineers, through the International Committee on Electromagnetic Safety.

These guidelines are not technology-specific. They cover radiofrequencies up to 300 GHz, including the frequencies under discussion for 5G.

International efforts- International Electromagnetic Fields (EMF) Project:

WHO established the International Electromagnetic Fields (EMF) Project in 1996. The project investigates the health impact of exposure to electric and magnetic fields in the frequency range 0-300 GHz and advises national authorities on EMF radiation protection.

11. Facial recognition technology

Airports at Varanasi, Pune, Kolkata and Vijaywada will be the first to roll-out the facial recognition technology-based biometric boarding system.

Implementation:

- The Airports Authority of India has engaged **NEC Corporation Private Limited** for implementing the technology as part of the DigiYatra policy, which seeks to promote paperless air travel and a seamless journey from entering an airport till boarding a plane.

What is facial recognition?

Facial recognition is a biometric technology that uses distinctive features on the face to identify and distinguish an individual.

- AFRS works by maintaining a large database with photos and videos of peoples’ faces. Then, a new image of an unidentified person — often taken from CCTV footage — is compared to the existing database to find a match and identify the person.
- The artificial intelligence technology used for pattern-finding and matching is called “neural networks”.

Benefits of facial recognition:

1. Improves outcomes in the area of Criminal identification and verification.
2. Easy identification amongst crowds.
3. Boosts the police department’s crime investigation capabilities.
4. Helps civilian verification when needed. No one will be able to get away with a fake ID.

12. UV-C technology

UV-C water purification is one of the most effective methods to disinfect water. In this technique, special “germicidal” UV-C lamps, emitting high-intensity ultraviolet light purifies the water without the use of harsh chemicals that are harmful to the environment.

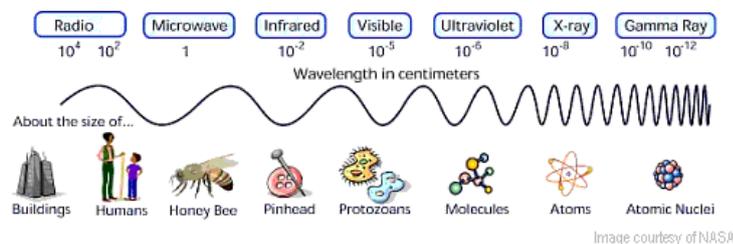
Ultraviolet-C or UV-C Disinfection Technology was installed in Parliament for the “mitigation of airborne transmission of SARS-COV-2”.

About the UV-C air duct disinfection system:

1. Developed by **CSIR-CSIO (Central Scientific Instruments Organisation)**.
2. The system is designed to fit into any existing air-ducts and the virucidal dosages using UV-C intensity and residence time can be optimised according to the existing space.
3. The virus is deactivated in any aerosol particles by the calibrated levels of UV-C light.
4. It can be used in auditoriums, malls, educational Institutions, AC buses, and in railways.

What is UV radiation?

- **Ultraviolet (UV) is a type of light or radiation naturally emitted by the Sun. It covers a wavelength range of 100-400 nm. The human visible light ranges from 380–700 nm.**



- UV is divided into three bands: UV-C (100-280 nm), UV-B (280-315 nm) and UV-A (315-400 nm).
- UV-A and UV-B rays from the Sun are transmitted through our atmosphere and all **UV-C is filtered by the ozone layer**.
- UV-A rays can penetrate the middle layer of your skin or the dermis and can cause aging of skin cells and indirect damage to cells’ DNA. UV-C radiation from man-made sources has been known to cause skin burns and eye injuries.
- UV-C radiation (wavelength around 254 nm) has been used for decades to disinfect the air in hospitals, laboratories, and also in water treatment.

Key facts:

- **UVA rays have the longest wavelengths**, followed by UVB, and UVC rays which have the shortest wavelengths.
- While UVA and UVB rays are transmitted through the atmosphere, **all UVC and some UVB rays are absorbed by the Earth's ozone layer**. So, most of the UV rays you come in contact with are UVA with a small amount of UVB.

How is it being used?

UV radiations are normally used to kill microorganisms.

- Particularly, **UV-C, also known as Ultraviolet germicidal irradiation (UVGI)** is a disinfection method that uses short-wavelength ultraviolet light to kill or inactivate microorganisms by destroying their nucleic acids and disrupting their DNA, leaving them unable to perform vital cellular functions and stops their replication.
- UVGI is used in a variety of applications, such as food, air, and water disinfection.

Is it safe for humans?

Researchers noted that the device was specifically developed to disinfect non-living things. Therefore, UV-C radiation used in this device could be harmful to the skin and eyes of the living beings.

13. Isothermal Forging Technology:

Context:

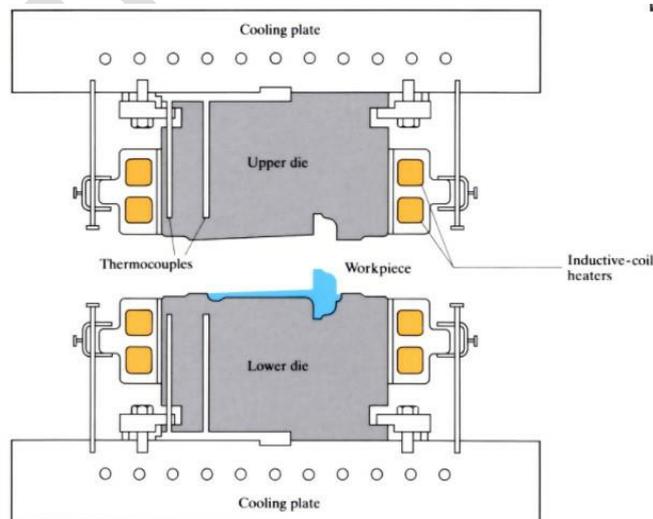
[DRDO](#) has developed Critical **near Isothermal Forging Technology** for aeroengines.



What is isothermal forging?

Isothermal forging is a **closed-die process** in which the **dies and the workpieces are heated to the same temperature**, so that forming can take place without loss of temperature in the workpiece.

- It's a **preferred process for forming engineered parts**, including jet-engine and other aerospace components in high-density lightweight alloys.
- In this process, the **workpiece is formed to shape at a slow rate** and at a temperature almost equal to that of the heated die.
- The **long forging time**, alongside forces exerted by the die, help to form an almost 'ready to use' component needing minimal supplementary machining.



Significance:

- This is a crucial technology for establishing **self-reliance in aeroengine technology**.
- With this development, **India has joined the league of limited global engine developers** to have the manufacturing capabilities of such critical aero engine components.

14. Spectrum Auctions

- Devices such as cellphones and wireline telephones require signals to connect from one end to another. These signals are carried on airwaves, which must be sent at designated frequencies to avoid any kind of interference.



- **The Union government owns all the publicly available assets within the geographical boundaries of the country, which also include airwaves.**
- To sell these assets to companies willing to set up the required infrastructure to transport these waves from one end to another, the central government through the Department of Telecommunications (DoT) auctions these airwaves from time to time.

These airwaves are called spectrum, which is subdivided into bands which have varying frequencies. All these airwaves are sold for a certain period of time, after which their validity lapses, which is generally set at 20 years.

15. Cabinet approves 5 MHz spectrum for Railways

The Union Cabinet has approved the allotment of **5 MHz spectrum in the premium 700 MHz band to the Railways** for captive use in areas of public safety and security services.

Benefits:

1. With this spectrum, the Railways will introduce **Long-Term Evolution (LTE)-based Mobile Train Radio Communication (MTRC)** on its routes.
2. This will help prevent train accidents and reduce delays by enabling real-time interaction between the Loco Pilot, Station Master and the Control Centre.
3. This will also enable the Railways to take up **Internet of Things (IoT)-based remote monitoring**, particularly of coaches, wagons and locos, and monitor live feeds of CCTV cameras in the coaches.

LTE (Long-Term Evolution) is a fourth-generation (4G) wireless standard that provides increased network capacity and speed for cellphones and other cellular devices compared with third-generation (3G) technology.

16. AmbiTAG

- **AmbiTAG is India's first indigenous temperature data logger for cold chain management.**
- It is an Internet-of-Things (IoT) device that records real-time ambient temperature during the transportation of perishable products, vaccines and even body organs and blood.
- Developed by **IIT Ropar**.

17. SWASTIIK Technology

- With water-borne diseases majorly contributing to India's disease burden, the **CSIR-National Chemical Laboratory (CSIR-NCL) at Pune** has come up with a new technique for disinfecting water by using natural oils.
- Disinfection of water is essential for removing pathogenic microorganisms that are responsible for causing a number of water-borne diseases. However, the common drawbacks of chemical methods of disinfection, such as **chlorination, include the formation of harmful or carcinogenic by-products**".
- **"SWASTIIK", which involves boiling of a liquid as a result of pressure reduction (cavitation) and also uses natural oils having antimicrobial properties.**
- This technology can **eliminate harmful bacteria, including antibiotic-resistant strains, economically.**

- The technique used—**hydrodynamic cavitation**—combines chemistry, biology, and chemical engineering, along with natural resources in the form of natural oils and plant extracts.

18. Device to diagnose dengue within an hour

Researchers at the Indian Institute of Technology Delhi have developed a handheld **Surface Enhanced Raman Spectroscopy (SERS)**-based platform for early diagnosis of dengue and also gives dengue test results within one hour (rapid diagnosis).

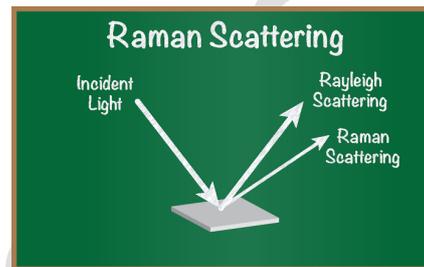
- The research work was funded by **IMPRINT India programme** of the Ministry of Education.

Need for early diagnosis:

Early diagnosis of dengue is the key to prevent deterioration of a patient's health. However, conventional diagnostic tools like nucleic acid detection using Reverse Transcriptase Polymerase Chain Reaction (RT-PCR) is a time-taking process and it also requires expensive equipment and reagents for the diagnosis of dengue.

What is SERS?

It is a surface-sensitive technique that enhances Raman scattering by molecules adsorbed on rough metal surfaces or by nanostructures such as plasmonic-magnetic silica nanotubes.



19. 'Whitest ever' paint that can reflect 99 per cent of sunlight

US engineers have created what they are calling the whitest paint yet.

How was it created?

The ultra-white paint is made up of **barium sulphate**, which makes it more white.

- The paint can keep surfaces 19 degrees Fahrenheit cooler than their ambient surroundings at night. It can also cool surfaces 8 degrees Fahrenheit below their surroundings under strong sunlight during noon hours.
- This paint may be **the closest equivalent to the blackest black paint called "Vantablack"** that is able to absorb up to 99.9 per cent of visible light.

20. High Electron Mobility Transistors (HEMTs)

Indian scientists have developed a highly reliable **HEMT from gallium nitride (GaN)**.

Significance:

- This is the first-ever indigenous HEMT device and is useful in electric cars, locomotives, power transmission and other areas requiring high voltage and high-frequency switching.
- This would reduce the cost of importing such stable and efficient transistors required in power electronics.
- It will also make India self-reliant in power transistor technology.

What are HEMTs?

High Electron Mobility Transistor (HEMT) is a normally OFF device and can switch currents up to 4A and operates at 600 V.

HEMTs are **used in integrated circuits as digital on-off switches.**

- HEMT transistors are **able to operate at higher frequencies than ordinary transistors**, up to millimeter wave frequencies, and are used in high-frequency products such as cell phones, satellite television receivers, voltage converters, and radar equipment.
- They are widely **used in satellite receivers, in low power amplifiers and in the defense industry.**

21. Aluminium-air batteries

State-owned Indian Oil Corporation Ltd. has entered into a joint venture with Israel-based battery technology startup Phinergy to develop **aluminium-air technology** based battery systems for electric vehicles and stationary storage, as well as hydrogen storage solutions.

What is an aluminium-air battery?

Aluminium-air batteries utilise oxygen in the air which reacts with an aluminium hydroxide solution to oxidise the aluminium and produce electricity.

Benefits:

- Lower cost and more energy-dense alternative to lithium-ion batteries which are currently in widespread use for electric vehicles in India.
- Offer much greater range of 400 km or more per battery compared to lithium-ion batteries which currently offer a range of 150-200 kilometres per full charge.
- The aluminium plate in an aluminium-air battery is converted into aluminium trihydroxide over time and that aluminium can be reclaimed from aluminium trihydroxide or even traded directly for industrial uses.

Challenges:

Aluminium-air batteries cannot be recharged like lithium-ion batteries. Therefore, large scale use of aluminium-air battery-based vehicles would require the wide availability of battery swapping stations.

22. Einsteinium

Researchers have been able to characterise some of the properties of **Einsteinium**.

What is Einsteinium?

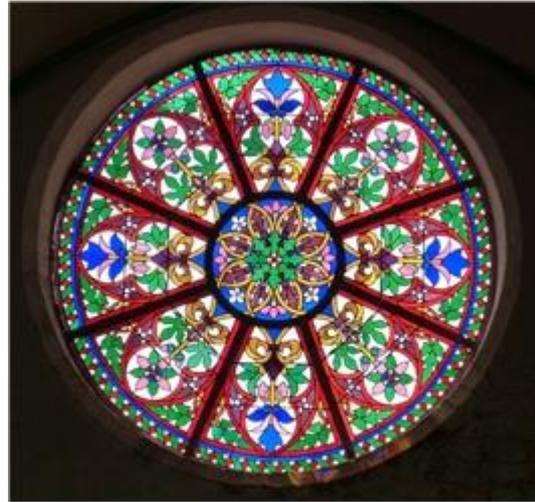
Named after Einstein, it was discovered in 1952 in the debris of the first hydrogen bomb (the detonation of a thermonuclear device called "Ivy Mike" in the Pacific Ocean).

Properties:

- It is difficult to create and is highly radioactive.
- The most common isotope of the element, einsteinium 253 has a half-life of 20 days.
- Einsteinium-254 is one of the more stable isotopes of the element that has a half-life of 276 days.
- The element is also not visible to the naked eye and after it was discovered, it took over nine years to manufacture enough of it so that it could be seen with the naked eye.
- Because of its high radioactivity and short half-life of all einsteinium isotopes, even if the element was present on Earth during its formation, it has most certainly decayed.

23. Nanotechnology

- **Nanotechnology is the understanding and control of matter at the nanoscale, at dimensions between approximately 1 and 100 nanometers**, where unique phenomena enable novel applications.
- **Some nanostructured materials are stronger or have different magnetic properties compared to other forms or sizes of the same material.**
- Although modern nanoscience and nanotechnology are relatively new, nanoscale materials have been used for centuries.
- Using nanotechnology, materials can effectively be made stronger, lighter, more durable, better electrical conductors, among many other traits.
- **Nanoscale additives to or surface treatments of fabrics** can provide lightweight ballistic energy deflection in personal body armor, or can help them **resist wrinkling, staining, and bacterial growth.**
- **Clear nanoscale films on eyeglasses, computer and camera displays, windows, and other surfaces can make them water- and residue-repellent, antireflective, self-cleaning, resistant to ultraviolet or infrared light, antifog, antimicrobial, scratch-resistant, or electrically conductive.**
- **Nanostructured ceramic coatings exhibit much greater toughness than conventional wear-resistant coatings for machine parts.**
- Nanotechnology-enabled lubricants and engine oils also significantly reduce wear and tear, which can significantly extend the lifetimes of moving parts in everything from power tools to industrial machinery.
- Nanoscale materials are also being incorporated into a variety of personal care products to improve performance.
- Nanoscale titanium dioxide and zinc oxide have been used for years in sunscreen to provide protection from the sun while appearing invisible on the skin.



Stained-glass windows are an example of how nanotechnology was used in the pre-modern era.

Natural nanomaterials, as the name suggests, are those that occur naturally in the world. These include particles that make up volcanic ash, smoke, and even some molecules in our bodies, such as the hemoglobin in our blood. The brilliant colors of a peacock's feathers are the result of spacing between nanometer-scale structures on their surface.



Agriculture	Food Processing	Food Packaging	Supplements
<ul style="list-style-type: none"> • Single molecule detection to determine enzyme/ substrate interactions • Nanocapsules for delivery of pesticides, fertilizers and other agrichemicals more efficiently • Delivery of growth hormones in a controlled fashion • Nanosensors for monitoring soil conditions and crop growth • Nanochips for identity preservation and tracking • Nanosensors for detection of animal and plant pathogens • Nanocapsules to deliver vaccines • Nanoparticles to deliver DNA to plants (targeted genetic engineering) 	<ul style="list-style-type: none"> • Nanocapsules to improve bioavailability of nutraceuticals in standard ingredients such as cooking oils • Nanoencapsulated flavor enhancers • Nanotubes and nanoparticles as gelation and viscosifying agents • Nanocapsule infusion of plant based steroids to replace a meat's cholesterol • Nanoparticles to selectively bind and remove chemicals or pathogens from food • Nanoemulsions and -particles for better availability and dispersion of nutrients 	<ul style="list-style-type: none"> • Antibodies attached to fluorescent nanoparticles to detect chemicals or foodborne pathogens • Biodegradable nanosensors for temperature, moisture and time monitoring • Nanoclays and nanofilms as barrier materials to prevent spoilage and prevent oxygen absorption • Electrochemical nanosensors to detect ethylene • Antimicrobial and antifungal surface coatings with nanoparticles (silver, magnesium, zinc) • Lighter, stronger and more heat-resistant films with silicate nanoparticles • Modified permeation behavior of foils 	<ul style="list-style-type: none"> • Nanosize powders to increase absorption of nutrients • Cellulose nanocrystal composites as drug carrier • Nanoencapsulation of nutraceuticals for better absorption, better stability or targeted delivery • Nanocochleates (coiled nanoparticles) to deliver nutrients more efficiently to cells without affecting color or taste of food • Vitamin sprays dispersing active molecules into nanodroplets for better absorption

Nanomicelles is an emerging platform for drug delivery to the eye. Conventionally nanoparticles are said to be hydrophobic and hence unsuitable for delivering water-soluble drugs. However, this has been overcome by development of **nanomicelles which are capable of delivering poorly water-soluble drug.**

DNA Origami is a process of making 2-D and 3-D nanostructures out of DNA. Since the DNA has the property of self-assembly, combination of DNA nanostructures can be used to make drug delivery systems. Given the small size of DNA-nanostructures, they can **deliver drugs at cell level.**

Researchers have developed a technique to trap and move nano-sized particles using light called as '**nanotweezers technology**'. This technique uses a focused laser beam to trap and manoeuvre nanoparticles and would enable non-invasive **manipulation of fragile biological specimens such as bacteria, viruses and proteins.**

Carbon nanotube:

- Carbon nanotube is a tube-shaped material, made of carbon, having a diameter measuring on the nanometre scale.
- Researchers have developed thin Carbon Nanotube (CNT) textiles that exhibit high electrical conductivity and a level of toughness about 50 times higher than copper films, currently being used in electronics.
- **CNTs are at least 100 times stronger than steel, but only one-sixth as heavy, so nanotube fibres could strengthen almost any material.**

24. Digital histopathology

- Indian Institute of Technology Madras researchers use a **combination of deep learning techniques and traditional machine learning to develop a tool that can diagnose cancer by looking at whole slide images of the tumour.**
- The tool has been tested on datasets of breast, liver and colon cancer tissue images. It is economical in terms of the time required to process the images and analyse them.

Digital histopathology:

- **Traditionally, histopathologists slice the tumour tissue into approximately 20-micron-thick slices which they put on slides.**
- They look at enlarged images of the slides and go over it cell by cell to manually classify it as cancerous or otherwise.
- This is highly time-consuming, and it is to alleviate this burden that digital histopathology developed. In this, after preparing the slides, the entire slide is scanned using a high-resolution microscope and digitised. This is then analysed using computerised tools.

25. Metaverse

- **Metaverse is as a parallel, virtual, world where users can have different identities, possessions and characters.**
- **Interoperability is key to metaverse's success.**
- Metaverse is not something that just one company can build. Nor is Facebook the only one working on this.
- The metaverse is being envisioned as a new world order really, where your **services could be offered virtually in exchange for other virtual assets, or Cryptocurrencies.**
- According to Facebook's definition, the metaverse will let users hang out with people who are not in the same physical space. "You'll be able to hang out with friends, work, play, learn, shop, create, and more."

Government Initiatives /Departments

1. Drone Rules, 2021

As on 31 December 2021, nine **remote pilot training organisations** have been set up by entities under Government or private ownership.

- As per **Drone Rules, 2021**, any person who intends to obtain the authorisation to establish a **Remote Pilot Training Organisation (RPTO)** shall submit **an application to the Director General of Civil Aviation** in Form D5 on the **Digital Sky Platform**, along with the specified fees.

The Union government has approved **production-linked incentive (PLI)** scheme for drones and drone components.

New drone rules:

1. **Digital sky platform** shall be developed as a business-friendly single-window online system.
2. **No flight permission required upto** 400 feet in green zones and upto 200 feet in the area between 8 and 12 km from the airport perimeter.
3. **No pilot licence required for** micro drones (for non-commercial use), nano drones and for R&D organisations.
4. **No restriction on drone operations by foreign-owned companies registered in India.**
5. Import of drones and drone components to be regulated by DGFT.
6. **No security clearance required** before any registration or licence issuance.
7. **No requirement of certificate of airworthiness**, unique identification number, prior permission and remote pilot licence for R&D entities.
8. **Coverage of drones under Drone Rules, 2021 increased from 300 kg to 500 kg.** This will cover drone taxis also.
9. **Issuance of Certificate of Airworthiness** delegated to Quality Council of India and certification entities authorised by it.
10. **Manufacturer may generate their drone's unique identification number** on the digital sky platform through the self-certification route.
11. **Maximum penalty** under Drone Rules, 2021 reduced to INR 1 lakh. This shall, however, not apply to penalties in respect of violation of other laws.
12. **Drone corridors** will be developed for cargo deliveries.
13. **Drone promotion council** to be set up to facilitate a business-friendly regulatory regime.

Drone Categories in India:

Registration is required for all but the Nano category.

- Nano: Less than or equal to 250 grams
- Micro: From 250 grams to 2kg
- Small: From 2kg to 25kg
- Medium: From 25kg to 150kg
- Large: Greater than 150kg

Where all can drones be effectively utilised?

- **Ministry of Home Affairs:** For surveillance, situational analysis, crime control, VVIP security, disaster management, etc.
- **Ministry of Defence:** Drones for combat, communication in remote areas, counter-drone solutions, etc.

The government has banned the import of drones except for research and development, defence and security purposes. Importing drones for these purposes which will require "due clearances".

- However, import of drone components will not require any approvals.
- The Directorate General of Foreign Trade of the Ministry of Commerce and Industry has notified **the Indian Trade Classification (Harmonised System), 2022** in this regard.

- **Ministry of Health and Family Welfare:** Delivery of medicines, collection of samples from remote or epidemic/pandemic-affected areas.
- **The Petroleum and Natural Gas, and Power Ministries:** For real-time surveillance of assets and transmission lines, theft prevention, visual inspection/maintenance, construction planning and management, etc. **Environment, Forests and Climate Change Ministry:** Anti-poaching actions, monitoring of forests and wildlife, pollution assessment, and evidence gathering.
- **Ministry of Information and Broadcasting:** For high-quality videography of events and difficult-to-reach-places at a fraction of the cost and approvals required. This move would also facilitate low altitude shooting without noise, and prevent dust pollution and risk of accidents.
- **Other areas:** To undertake disaster management, incidence response, inspection/maintenance works and project monitoring.

2. National Supercomputing Mission (NSM)

As per the ministry of science and technology's annual year-end review:

Under the **National Super-Computer Mission (NSM)**, four new Supercomputers have been installed since July 2021 at IIT-Hyderabad, NABI- Mohali, CDAC-Bengaluru and IIT Kanpur.

- NSM provides access to High-Performance Computing (HPC) facilities to around 75 institutions and more than thousands of active researchers, academicians working through **Nation Knowledge Network (NKN)**.

What is National Supercomputing Mission (NSM)?

It is being implemented and steered jointly by the **Department of Science and Technology (DST)** and **Department of Electronics and Information Technology (DeitY)**.

- Implemented by the **Centre for Development of Advanced Computing (C-DAC)**, Pune and the **Indian Institute of Science (IISc)**, Bengaluru.

Focus of the mission:

- The Mission envisages empowering national academic and R&D institutions spread over the country by installing a vast supercomputing grid comprising of more than 70 high-performance computing facilities.
- These supercomputers will also be networked on the **National Supercomputing grid** over the **National Knowledge Network (NKN)**. The NKN is another programme of the government which connects academic institutions and R&D labs over a high speed network.
- The Mission includes development of highly professional **High Performance Computing (HPC)** aware human resource for meeting challenges of development of these applications.

Achievements:

- The first supercomputer assembled indigenously, called **Param Shivay**, was installed in IIT (BHU).
- Similar systems **Param Shakti** and **Param Brahma** were installed at IIT-Kharagpur and IISER, Pune. They are equipped with applications from domains like Weather and Climate, Computational Fluid Dynamics, Bioinformatics, and Material science.
- The Indian Institute of Science (IISc.) has installed and commissioned **Param Pravega**, one of the **most powerful supercomputers in India**, and the largest in an Indian academic institution, under the National Supercomputing Mission (NSM). It has been designed by the Centre for Development of Advanced Computing (C-DAC).
- These systems have greatly helped faculty members and students carry out major R&D activities, including developing platforms for genomics and drug discovery, studying urban environmental issues, establishing flood warning and prediction systems, and optimising telecom networks.

Fact for Prelims:

India has developed an indigenous server (**Rudra**), which can meet the **High-Performance Computing (HPC)** requirements of all governments and PSUs. This is the first time that a server system was made in India, along with the full software stack developed by C-DAC.

3. National Technical Textiles Mission

The Centre is targeting five times' increase in export of technical textiles in three years.

Government efforts in this regard:

- In January 2019, the government issued **207 HSN Codes for technical textiles** and in less than two years, **India had become a net exporter of technical textiles.**
- It also unveiled **the National Technical Textiles Mission** in February last year.
- As many as **92 technical textile items have been made mandatory for use by government organisations** covering agriculture, horticulture, highways, railways, water resources, and medical applications.

About the National Technical Textiles Mission:

The Cabinet Committee on Economic Affairs (CCEA) had, in 2020, approved the setting up of a National Technical Textiles Mission at an total outlay of ₹1,480 Crore.

Aim:

To position the country as a global leader in technical textiles and increase the use of technical textiles in the domestic market.

The Mission will be implemented for four years from 2020-2021 and will have four components:

1. The first component will focus on **research and development and innovation**. The research will be at both, fibre level and application-based in geo, agro, medical, sports and mobile textiles and development of bio-degradable technical textiles.
2. The second component will be for **promotion and development of market** for technical textiles.
3. The third component will focus on **export promotion**.
4. The last component will be on **education, training and skill development**.

CABINET DECISIONS
26 February 2020

myGov
मेरी सरकार

Making India a Global Leader in Textile Industry
Creation of National Technical Textiles Mission

Mission to be implemented during FY 2020-21 to 2023-24 with an outlay of ₹1480 crore

Mission to have 4 components: **R&D, Market Development, Export Promotion, Education & Skill Development**

Focus on usage of technical textiles in various flagship schemes of the government

Will bring an overall improvement in **cost economy & promote Make in India**

What are technical textiles?

Technical textiles are defined as textile materials and products manufactured primarily for their technical performance and functional properties rather than aesthetic and decorative characteristics.

Depending upon their application areas, **Technical Textiles products are divided into 12 broad categories:** Agrotech, Buildtech, Clothtech, Geotech, Hometech, Indutech, Mobiltech, Meditech, Protech, Sportstech, Oekotech, Packtech.

4. Geospatial Energy Map of India:

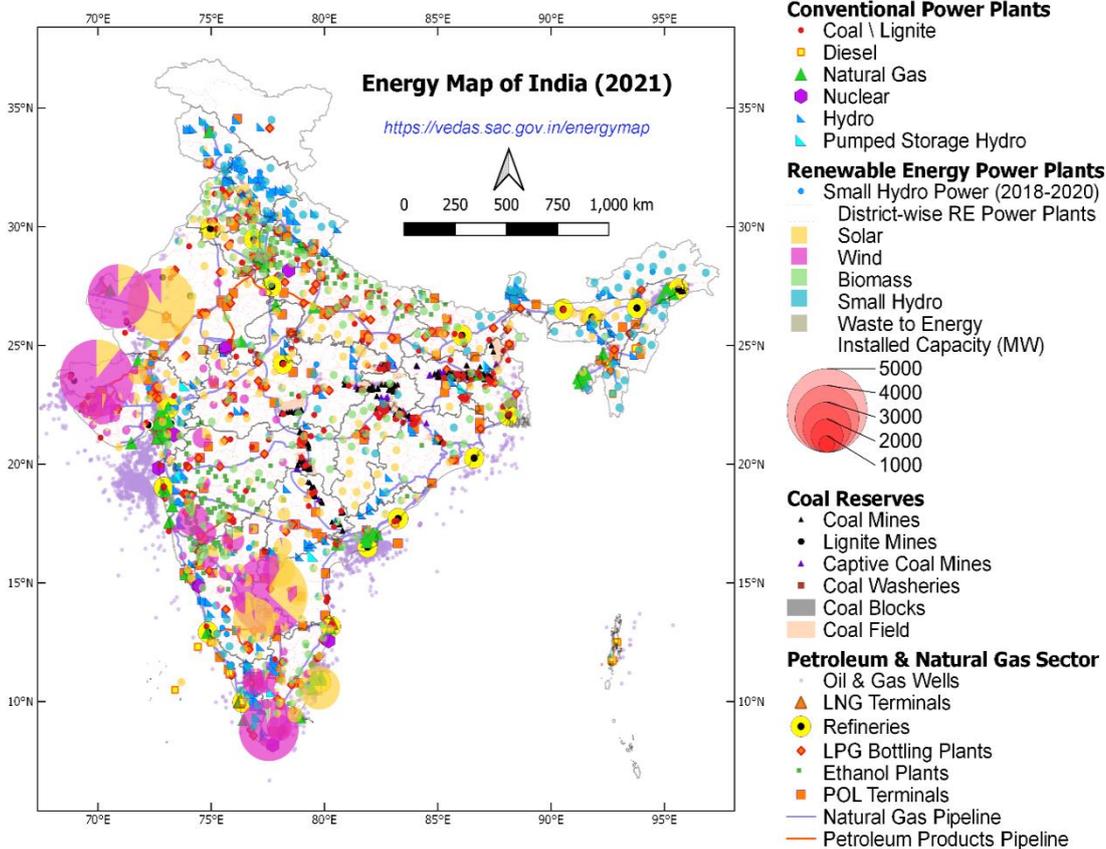
Context:

NITI Aayog Launches Geospatial Energy Map of India.

What is it?

Geospatial Energy Map, enables visualisation of energy installations such as conventional power plants, oil and gas wells, petroleum refineries, coal fields and coal blocks, district-wise data on renewable energy power plants and renewable energy resource potential, etc through 27 thematic layers.

- This comprehensive **Geographic Information System (GIS) Energy Map** of India has been developed by NITI Aayog in collaboration with Indian Space Research Organisation (ISRO).
- **The GIS map provides a holistic picture of all energy resources** of the country.



What will it do?

The map attempts to identify and locate all primary and secondary sources of energy and their transportation/transmission networks to provide a comprehensive view of energy production and distribution in a country.

Key features:

- It is a unique effort aimed at integrating energy data scattered across multiple organizations and to present it in a consolidated, visually appealing graphical manner.
- It leverages latest advancements in web-GIS technology and open-source software to make it interactive and user friendly.
- The Geospatial Energy Map of India will be useful in planning and making investment decisions.
- It will also aid in disaster management using available energy assets.

Significance of GIS-mapping:

GIS-mapping of energy assets will be useful for ensuring real-time and integrated planning of energy sector of India, given its large geographical distribution and interdependence. It will be advantageous to all concerned stakeholders and will help in accelerating the policy-making process.

5. Deep Ocean Mission

The Union Cabinet approved the Deep Ocean Mission.

About the Mission:

The mission proposes to explore the deep ocean similar to the space exploration started by ISRO about 35 years ago.

The focus of the mission will be on deep-sea mining, ocean climate change advisory services, underwater vehicles and underwater robotics related technologies.

- **The Ministry of Earth Sciences (MoES)** will be the nodal Ministry implementing this multi-institutional mission.

Key Components of the mission:

1. A manned submersible will be developed to carry three people to a depth of 6,000 metres in the ocean with a suite of scientific sensors and tools. An Integrated Mining System will be developed for mining **polymetallic nodules** at those depths in the central Indian Ocean.
2. Development of Ocean Climate Change Advisory Services.
3. Development of a component for searching deep sea flora and fauna, including microbes, and studying ways to sustainably utilise them.
4. The next component is to explore and identify potential sources of hydrothermal minerals that are sources of precious metals formed from the earth's crust along the Indian Ocean mid-oceanic ridges.
5. It has a component for studying and preparing detailed engineering design for offshore **Ocean Thermal Energy Conversion (OTEC)** powered desalination plants.
6. The final component is aimed at grooming experts in the field of ocean biology and engineering. This component aims to translate research into industrial applications and product development through on-site business incubator facilities.

Significance:

- The mission will give a boost to efforts to explore India's vast Exclusive Economic Zone and Continental Shelf.
- The plan will enable India to develop capabilities to exploit resources in **the Central Indian Ocean Basin (CIOB)**.

Potential:

India has been allotted 75,000 square kilometres in the Central Indian Ocean Basin (CIOB) by UN International Sea Bed Authority for exploration of poly-metallic nodules.

- **CIOB reserves contain** deposits of metals like iron, manganese, nickel and cobalt.
- It is envisaged that **10% of recovery of that large reserve can meet the energy requirement of India for the next 100 years.**

What are PMN?

Polymetallic nodules (also known as **manganese nodules**) are potato-shaped, largely porous nodules found in abundance carpeting the sea floor of world oceans in deep sea.

Composition: Besides manganese and iron, they contain nickel, copper, cobalt, lead, molybdenum, cadmium, vanadium, titanium, of which nickel, cobalt and copper are considered to be of economic and strategic importance.

6. Indian Space Association

Indian Space Association (ISpA) was recently launched by Prime Minister Modi.

- It will be the premier **industry association of space and satellite companies.**

Aims and objectives:

- ISpA aims to be a forum of the space industry in the Indian private sector and partner the Government of India and other key stakeholders across space industry segments in making the nation self-reliant in the area as well as to become a global service provider.
- ISpA aims to contribute to the Government of India's vision of making India [Atmanirbhar](#) and a global leader in the space arena, which is fast emerging as the next growth frontier for mankind.

Composition/members:

ISpA is represented by leading home grown and global corporations with advanced capabilities in space and satellite technologies.

- Its founding members include Bharti Airtel, Larson & Toubro, Nelco (Tata Group), OneWeb, Mapmyindia, Walchandnagar Industries and Alpha Design Technologies.
- Other core members include Godrej, Hughes India, Ananth Technology Limited, Azista-BST Aerospace Private Limited, BEL, Centum Electronics, Maxar India.

Functions:

- The association will engage with stakeholders across the ecosystem for the formulation of an enabling policy framework that fulfils the Government's vision.
- ISpA will also work towards building global linkages for the Indian space industry to bring in critical technology and investments into the country to create more high skill jobs.
- ISpA also plans to work in very close coordination with [IN-SPACE](#) to further the space vision of the Government.

- In 2020, the Government of India created a new organisation known as **IN-SPACE (Indian National Space Promotion and Authorisation Centre)** which is a "single window nodal agency" established to **boost the commercialisation of Indian space activities**.
- A supplement to the Indian Space Research Organisation (ISRO), the agency **promotes the entry of the Non-Government Private Entities (NGPEs) in the Indian space sector**.
- The agency will also felicitate a swift on-boarding of private players in the sector through encouraging policies in a friendly regulatory environment and by creating synergies through already existing necessary facilities.

7. [National Innovation Foundation \(NIF\) – India](#)

Science & Technology minister dedicates an Innovation Portal developed by National Innovation Foundation (NIF) – India to the nation.

Highlights:

Innovation Portal is **developed by National Innovation Foundation (NIF) – India**, an autonomous body of the Department of Science and Technology (DST).

- The National Innovation Portal (NIP) is **currently home to about 1.15 lakh innovations scouted from common people of the country**, covering Engineering, Agriculture, Veterinary and Human Health.
- In terms of **domain areas**, presently the innovations cover Energy, mechanical, automobile, electrical, electronics, household, nutraceuticals etc.

About National Innovation Foundation (NIF) – India:

It is an autonomous body of the Department of Science and Technology (DST), Government of India.

- Set up in February 2000 at Ahmedabad, Gujarat to provide institutional support for scouting, spawning, sustaining and scaling up the grassroots innovations across the country.
- It is India's national initiative to strengthen the grassroots technological innovations and outstanding traditional knowledge.
- Its mission is to help India become a creative and knowledge-based society by expanding policy and institutional space for grassroots technological innovators.

Biotechnology

1. mRNA vaccines

Messenger RNA or mRNA technology works by teaching our cells to recognize and protect us against infectious diseases. One of the challenges with this new technology is that it must be kept cold to maintain stability during transport and storage.

What are mRNA vaccines?

mRNA vaccines **trick the body into producing some of the viral proteins itself.**

- They work by using **mRNA, or messenger RNA**, which is **the molecule that essentially puts DNA instructions into action.**
- Inside a cell, mRNA is used as a template to build a protein.

How it works?

1. To produce an mRNA vaccine, scientists produce a synthetic version of the mRNA that a virus uses to build its infectious proteins.
2. This mRNA is delivered into the human body, whose cells read it as instructions to build that viral protein, and therefore create some of the virus's molecules themselves.
3. These proteins are solitary, so they do not assemble to form a virus.
4. The immune system then detects these viral proteins and starts to produce a defensive response to them.

Significance of mRNA vaccines:

There are two parts to our immune system: **innate** (the defences we're born with) and **acquired** (which we develop as we come into contact with pathogens).

- **Classical vaccine molecules** usually only work with the acquired immune system and the innate immune system is activated by another ingredient, called an **adjuvant.**
- Interestingly, **mRNA in vaccines could also trigger the innate immune system**, providing an extra layer of defence without the need to add adjuvants.

2. Umbilical Cord blood

A US woman has been cured of HIV after receiving a transplant of **umbilical cord blood.**

- She has become the third person in the world, and the first woman, to be cured of HIV.

What is HIV and how is it transmitted?

- Human immunodeficiency virus or HIV is an infection that attacks the immune system by destroying the body's immune cells called CD4, which help it respond to infection.
- Once HIV attacks the CD4 cells, it starts replicating and destroying the cells, weakening the body's immune system and making it more prone to certain "opportunistic infections" that take advantage of the weak immune system.

Why is this significant?

- This was the first time an umbilical cord blood transplant was successfully carried out on an HIV patient. This approach is likely to make treatment more widely available.
- Since this breakthrough treatment only requires partial matches and not exact matches, it opens up treatment options for people from diverse racial backgrounds.

Scientists attempt to turn edible plants like lettuce into mRNA vaccine factories under **the edible vaccine project.**

What makes it possible in plants?

- Key to making this work is **chloroplasts**, small organs in plant cells that convert sunlight into energy the plant can use.
- They're tiny, solar-powered factories that produce sugar and other molecules which allow the plant to grow.
- They're also an untapped source for making desirable molecules.

What is Cord Blood?

Cord blood (short for **umbilical cord blood**) is the blood that remains in the umbilical cord and placenta post-delivery.

- It contains special cells called **hematopoietic stem cells** that can be used to treat some types of diseases.

What is Cord blood banking?

Cord blood banking is **the process of collecting the cord blood and extracting and cryogenically freezing its stem cells and other cells of the immune system for potential future medical use.**

- Globally, cord blood banking is recommended as a **source of hematopoietic stem cell transplantation for haematological cancers and disorders where its use is recommended.**
- For all other conditions, the use of cord blood as a source of stem cells is not yet established.

What Can It Be Used For?

The **umbilical cord fluid is loaded with stem cells.**

- They can treat cancer, blood diseases like anemia, and some immune system disorders, which disrupt your body's ability to defend itself.
- The fluid is easy to collect and has 10 times more stem cells than those collected from bone marrow.
- Stem cells from cord blood rarely carry any infectious diseases and are half as likely to be rejected as adult stem cells.

3. Xenotransplantation

Surgeons in the US transplanted a pig's heart inside a human patient.

Xenotransplantation is the process of grafting or transplanting organs or tissues between members of different species.

- It has been pursued by modern medical science for decades, but experts have found it difficult to surmount the challenge presented by the immune system's rejection of an alien organ, ending in deadly outcomes for patients.

**How was the transplantation carried out?**

- The transplanted heart was **harvested from a pig that had undergone genetic editing** that saw scientists remove three genes "that would have led to rejection of pig organs by humans" along with one that would have led to excessive growth of pig heart tissue.
- Further, six human genes that would have facilitated the organ's acceptance by the human body were inserted into the pig genome, meaning that **a total of 10 unique gene edits were carried out in the pig** by the US biotech firm Revivicor.

Why pigs?

Pigs are increasingly becoming popular candidates for organ transplantation. This is because their organs are anatomically similar to those of humans. What's more, porcine components are more tuned for genetic engineering.

4. Genetically Modified Organism**What are Genetically Modified Organism (Transgenic Organism)?**

In GMO, **genetic material (DNA) is altered or artificially introduced using genetic engineering techniques.**

Genetic modification **involves the mutation, insertion, or deletion of genes.**

- Inserted genes usually come from a different organism (e.g. In Bt cotton, Bt genes from bacterium *Bacillus thuringiensis* are induced).

Genetic modification is done to induce a desirable new trait which does not occur naturally in the species.

GMO regulation in India:

The task of regulating GMO levels in imported consumables was initially with [the Genetic Engineering Appraisal Committee \(GEAC\)](#) under the Union environment ministry.

- Its role in this was diluted with the enactment of **the Food Safety and Standards Act, 2006** and **FSSAI was asked to take over approvals of imported goods.**

GM techniques are used in:

1. Biological and medical research,
2. Production of pharmaceutical drugs,
3. Experimental medicine (e.g. gene therapy),
4. Agriculture (e.g. golden rice, Bt cotton etc.),
5. Genetically modified bacteria to produce the protein insulin,
6. To produce biofuels from some GM bacteria, etc.

GM foods are derived from plants whose genes are artificially modified, usually by inserting genetic material from another organism, in order to give it a new property, such as increased yield, tolerance to a herbicide, resistance to disease or drought, or to improve its nutritional value.

Golden rice, which involves the insertion of genes from a plant -- both daffodils and maize have been used -- and a soil bacterium to create a grain that is enriched with Vitamin A.

India has approved commercial cultivation of only one GM crop, Bt cotton. **No GM food crop has ever been approved for commercial cultivation in the country. However, confined field trials have been allowed for at least 20 GM crops.**

Among the 75 countries which buy Indian rice, **West Asian nations, the U.S. and the U.K. are the biggest importers of basmati**, while the majority of non-basmati goes to African countries and neighbours Nepal and Bangladesh.

5. [Genome sequencing](#)

- A genome is an organism's complete set of DNA, including all of its genes. Genomics is an interdisciplinary field of science focusing on the structure, function, evolution, mapping, and editing of genomes.
- Genomics also involves the sequencing and analysis of genomes through uses of high throughput DNA sequencing.
- Advances in genomics have triggered a revolution in discovery-based research and systems biology to facilitate understanding of even the most complex biological systems such as the brain.

Purpose of sequencing:

- The **main purpose of sequencing is surveillance**. It helps to get the true picture of prevailing variants, emerging variants (like delta) and those causing reinfection.
- WHO has stressed on the fact that data of sequencing should be submitted to open-access platforms like [GISAID](#), so that a sequence done in one part of the world can be looked at by the global scientific community.

Need for genome sequencing:

- Mapping the diversity of India's genetic pool will lay the bedrock of **personalised medicine** and put it on the global map.

- Considering the diversity of population in our country, and the disease burden of complex disorders, including diabetes, mental health, etc., once we have a genetic basis, it may be possible to take action before the onset of a disease.

About Indian SARS-CoV-2 Consortium on Genomics (INSACOG):

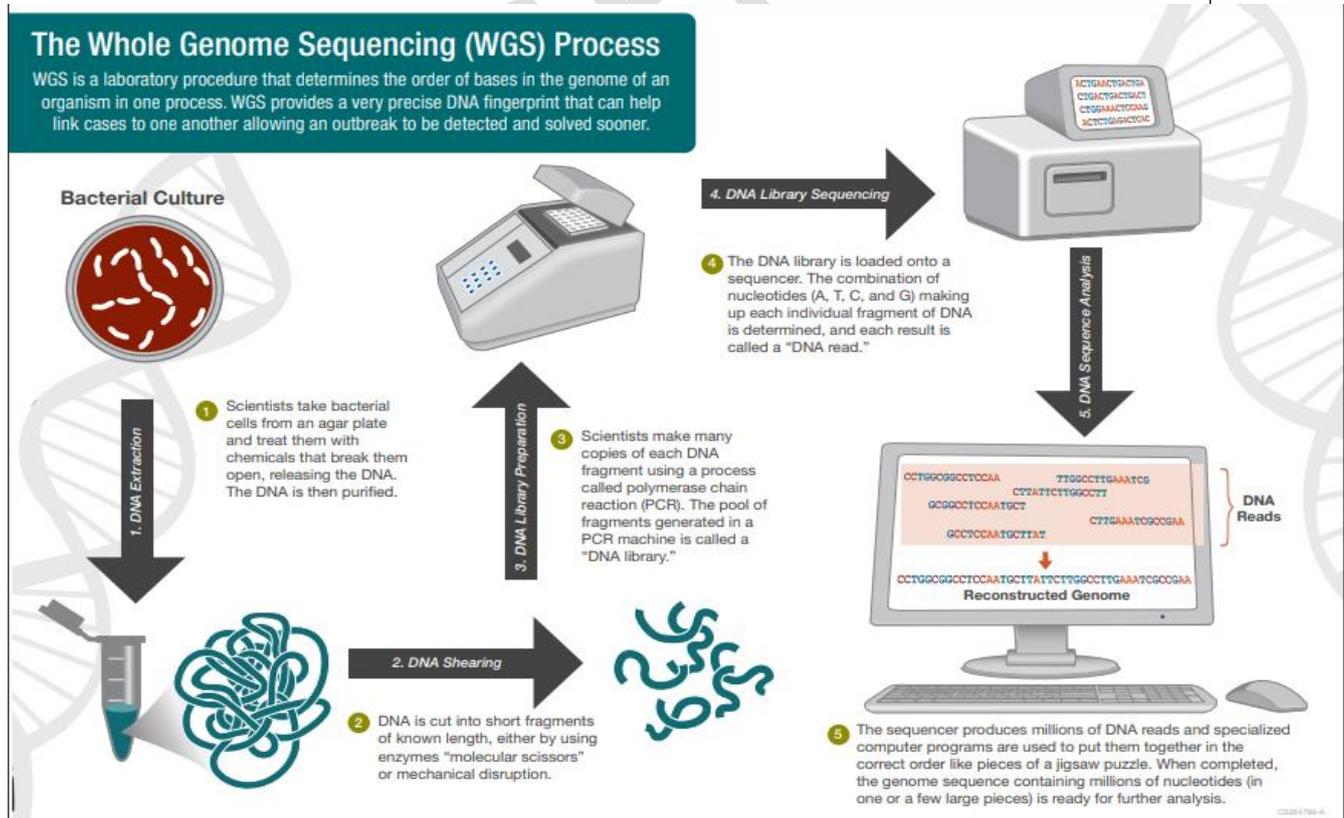
- The Indian SARS-CoV-2 Genomics Consortium (INSACOG) is jointly initiated by the **Union Ministry of Health and Family Welfare**, and **Department of Biotechnology (DBT)** with **Council for Scientific & Industrial Research (CSIR)** and **Indian Council of Medical Research (ICMR)**.
- It is a consortium of 28 National Laboratories to monitor the genomic variations in the SARS-CoV-2.
- It carries out whole **genome sequencing of SARS-CoV-2 virus across the nation**, aiding in understanding the spread and evolution of the virus.
- INSACOG also aims to focus on **sequencing of clinical samples** to understand the disease dynamics and severity.

About GISAID (Global initiative on sharing avian influenza data):

- GISAID, established in 2008, provides open-access to genomic data of influenza viruses and the coronavirus responsible for the COVID-19 pandemic.
- The genome sequences of SARS-CoV-2 available on GISAID enabled global responses to the pandemic, including the development of the first vaccines and diagnostic tests.

About the Genomics for Public Health in India (IndiGen) programme:

- CSIR initiated the Program in April 2019.
- It aims to **undertake whole genome sequencing** of thousands of individuals representing diverse ethnic groups from India.
- The objective is to enable genetic epidemiology and develop public health technologies applications using population genome data.



6. CRISPR technology

Researchers from California have developed **CRISPR-based system to safely restrain mosquito vectors via sterilization**. It is called the new **precision-guided sterile insect technique, or pgSIT**.

How it works?

pgSIT is a new scalable genetic control system that uses a CRISPR-based approach **to engineer deployable mosquitoes that can suppress populations**.

- It alters genes linked to male fertility — creating sterile offspring — and female flight in *Aedes aegypti*, the mosquito species responsible for spreading wide-ranging diseases including [dengue fever](#), [chikungunya](#), and [Zika](#).
- pgSIT uses CRISPR to sterilize male mosquitoes and render female mosquitoes, which spread disease, as flightless.

Why is this significant?

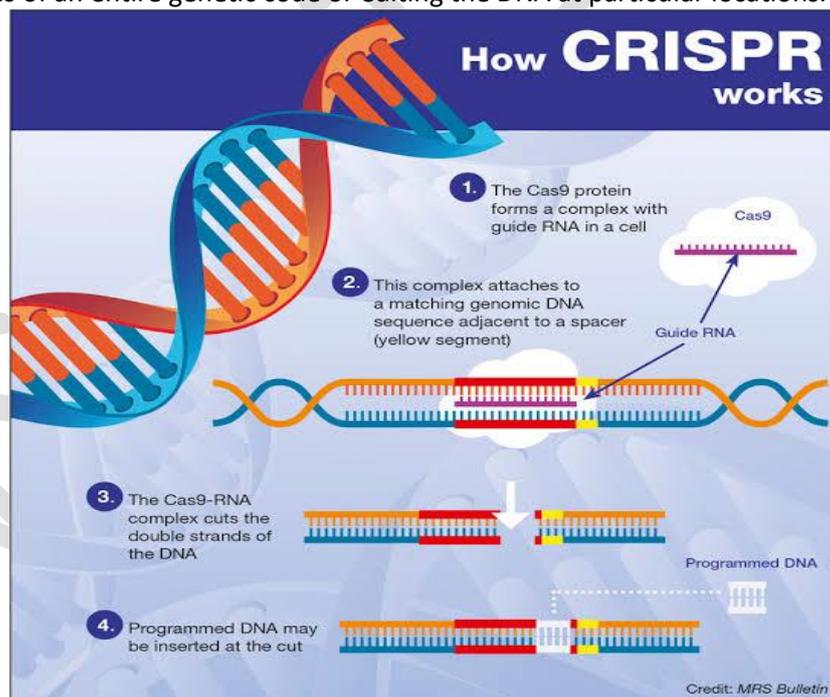
pgSIT eggs can be shipped to a location threatened by mosquito-borne disease or developed at an on-site facility that could produce the eggs for nearby deployment. Once the pgSIT eggs are released in the wild, sterile pgSIT males will emerge and eventually mate with females, driving down the wild population as needed.

What is CRISPR?

[CRISPR technology](#) is basically a gene-editing technology that can be used for the purpose of altering genetic expression or changing the genome of an organism. The technology can be used for targeting specific stretches of an entire genetic code or editing the DNA at particular locations.

Significance:

CRISPR technology is a simple yet powerful tool for editing genomes. It allows researchers to easily alter DNA sequences and modify gene function. Its many potential applications include correcting genetic defects, treating and preventing the spread of diseases and improving crops. However, its promise also raises ethical concerns.



How it works?

- The technology behaves like a **cut-and-paste mechanism on DNA strands that contain genetic information**.
- The specific location of the genetic codes that need to be changed, or “edited”, is identified on the DNA strand, and then, using **the Cas9 protein**, which acts like a pair of scissors, that location is cut off from the strand. A DNA strand, when broken, has a natural tendency to repair itself.
- Scientists intervene during this auto-repair process, supplying the desired sequence of genetic codes that binds itself with the broken DNA strand.

Applications of CRISPR

- Using CRISPR for genome editing

- Using CRISPR libraries for screening
- CRISPR/Cas9-mediated chromatin immunoprecipitation
- Transcriptional activation and repression
- Epigenetic editing with CRISPR/Cas9
- **Live imaging of DNA/mRNA**
- Therapeutic Applications
- **Enhancing crop production**
- Fighting antimicrobial resistance

Concerns and issues involved:

1. It becomes contentious when used in humans. Leading scientists in the field have for long been calling for a “global pause” on clinical applications of the technology in human beings, until internationally accepted protocols are developed.
2. Studies highlighted that CRISPR-Cas9-edited cells might trigger cancer.
3. It may increase the risk of mutations elsewhere in the genome in those cells.
4. Many things are not clear like how we should determine which disease or traits are appropriate for gene editing.
5. **Ethical concerns:** In addition, there are concerns with manipulating human embryos for own interest.

7. World's second-largest refurbished gene bank

The world's second-largest refurbished state-of-the-art National Gene Bank was inaugurated recently at the National Bureau of Plant Genetic Resources (NBPGR), Pusa, New Delhi.

What are Gene Banks?

Genetic banks serve the purpose for farmers and scientists who work to conserve rare plants and animals.

Significance:

1. Researchers or farmers can withdraw samples from these “gene” banks to help rebuild populations of rare plant varieties and animal breeds or to help increase genetic diversity within species.
2. Gene banks also preserve cells or organisms that host unusual gene variants — genes with special traits. Those genes might later prove useful when some disease epidemic strikes, when the climate changes or when other factors threaten the survival of plants or animals.
3. Farmers could use the banked deposits — stored cells or tissues — to restore genetic diversity or to introduce traits from other breeds or varieties.

About the National Gene Bank:

- Established in 1996 to preserve the seeds of Plant Genetic Resources (PGR) for future generations.
- It has the capacity to preserve about one million germplasm in the form of seeds.
- It stores different crop groups such as cereals, millets, medicinal and aromatic plants and narcotics, etc.
- Presently, the National Gene Bank has been protecting 4.52 lakh accessions, of which 2.7 lakh are the Indian germplasm while the rest have been imported from other countries.

NGB has four kinds of facilities to cater to long-term as well as medium-term conservation namely:

1. Seed Gene bank (- 18°C).
2. Cryo gene bank (-170°C to -196°C).
3. In-vitro Gene bank (25°C).
4. Field Gene bank.

Why is there a need for Gene Bank?

It will make the farmers of the country self-reliant and the government has been making every effort in that direction.

8. Monoclonal antibodies**What are Monoclonal antibodies?**

They are **artificially created antibodies** that aim to aid the body's natural immune system. They target a specific antigen — a protein from the pathogen that induces immune response.

How are they created?

Monoclonal antibodies can be created in the lab **by exposing white blood cells to a particular antigen**.

To increase the quantity of antibodies produced, a single white blood cell is cloned, which in turn is used to create identical copies of the antibodies.

- In the case of Covid-19, scientists usually work with the spike protein of the SARS-CoV-2 virus, which facilitates the entry of the virus into the host cell.

Need for monoclonal antibodies:

In a healthy body, the immune system is able to create antibodies — tiny Y-shaped proteins in our blood that recognise microbial enemies and bind to them, signalling the immune system to then launch an attack on the pathogen.

However, **for people whose immune systems are unable to make sufficient amounts of these antibodies**, scientists provide a helping hand- using monoclonal antibodies.

History:

The idea of delivering antibodies to treat a disease dates as far back as the 1900s, when Nobel-prize winning German immunologist **Paul Ehrlich** proposed the idea of a '**Zauberkegel**' (magic bullet), a compound which selectively targets a pathogen.

- From then, it took eight decades of research to finally arrive at Muromonab-CD3, the world's first monoclonal antibody to be approved for clinical use in humans.
- **Muromonab-CD3** is an immunosuppressant drug given to reduce acute rejection in patients with organ transplants.

Applications:

Monoclonal antibodies are now relatively common. They are used in treating Ebola, HIV, psoriasis etc.

9. DNA profiling

- DNA profiling (also called DNA fingerprinting) is the process of determining an individual's DNA characteristics.
- DNA profiling is a forensic technique in **criminal investigations**, comparing criminal suspects' profiles to DNA evidence so as to assess the likelihood of their involvement in the crime.
- It is also used in **parentage testing**, to establish immigration eligibility, and in **genealogical and medical research**.
- DNA profiling has also been used in the **study of animal and plant populations** in the fields of zoology, botany, and agriculture.

Events / Celebrations

1. National Science Day

28th February is celebrated as National Science Day (NSD) in India.

NSD is celebrated to commemorate discovery of **the 'Raman Effect'**, which led to **Sir C.V. Raman winning the Noble Prize**.

- The first National Science Day was celebrated on February 28, 1987.

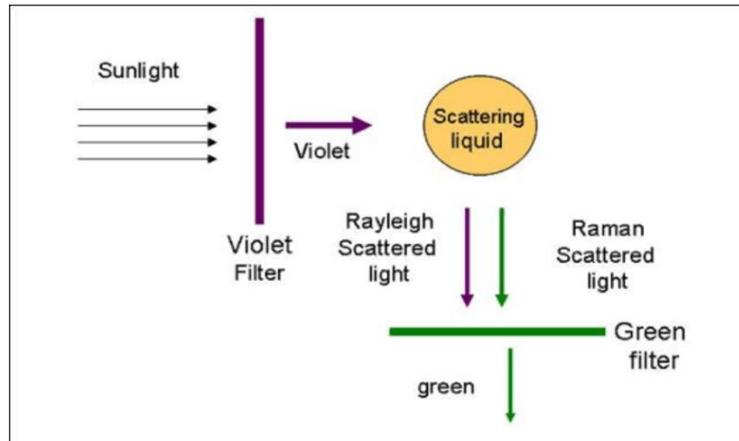
Theme: "Future of STI: Impacts on Education, Skills, and Work".

What is Raman Effect?

A phenomenon in spectroscopy discovered by the eminent physicist Sir Chandrasekhara Venkata Raman in 1928.

Raman Effect is **a change in the wavelength of light that occurs when a light beam is deflected by molecules**.

1. When a beam of light traverses a dust-free, transparent sample of a chemical compound, a small fraction of the light emerges in directions other than that of the incident (incoming) beam.
2. Most of this scattered light is of unchanged wavelength. A small part, however, has wavelengths different from that of the incident light; its presence is a result of the Raman Effect.



Miscellaneous

1. Semiconductor chip shortage

The **Economic Survey for 2021-22** has said that **Shortage of semiconductors** led to closure or lowering of production by several firms from diverse industries.

What has the government done to address the shortage?

- The government has earmarked Rs 76,000 crore for **semiconductors and display manufacturing segment**.
- **The PLI and other schemes** to boost semiconductors will not only help domestic companies to overcome the challenges posed by Covid-19 but also assist them to become globally competitive, especially in chip making.
- The government recently released a vision document for the electronics sector which envisages that the domestic electronic production has potential to reach around Rs 22 lakh crore by 2026.
- India has also launched **the Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS)** under which a budget outlay of Rs 3,285 crore is spread over a period of eight years for manufacturing of electronics components and semiconductors.

Semiconductor Chips:

Semiconductors also known as **integrated circuits (ICs), or microchips** are materials which have a conductivity between conductors and insulators. They can be pure elements, silicon or germanium or compounds; gallium, arsenide or cadmium selenide.

- It's the thing that makes electronic items smart and faster.
- Memory chips, which store data, are relatively simple and are traded like commodities.
- Logic chips, which run programs and act as the brains of a device, are more complex and expensive.

Significance of Semiconductor Chips:

They are the basic building blocks that serve as the heart and brain of all modern electronics and information and communications technology products.

- These chips are now an integral part of contemporary automobiles, household gadgets and essential medical devices such as ECG machines.

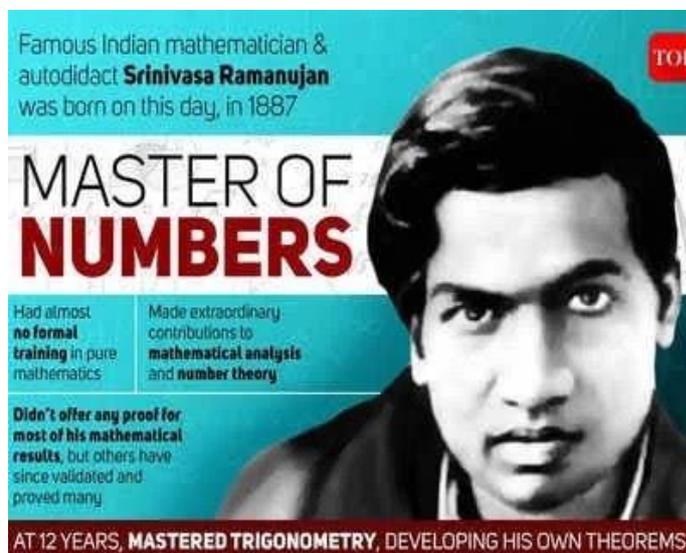
2. Ramanujan Prize

The Ramanujan Prize for Young Mathematicians was awarded to Professor **Neena Gupta**, a mathematician of the Indian Statistical Institute in Kolkata, in a virtual ceremony on 22nd February 2022.

- She received the award for the year 2021 for her outstanding work in **affine algebraic geometry and commutative algebra**.

About the Ramanujan Prize:

The **prize is awarded annually** to a researcher from a developing country funded by the Department of Science and Technology (DST) of the Government of India in association



with ICTP (International Centre for Theoretical Physics) and the International Mathematical Union (IMU).

- Eligibility: It is given to young mathematicians less than 45 years of age who have conducted outstanding research in a developing country.
- It is supported by DST in the memory of **Srinivasa Ramanujan**.

Highlights of Srinivasa Ramanujan's life:

- In 1911, Ramanujan published the first of his papers in the Journal of the **Indian Mathematical Society**.
- Ramanujan traveled to England in 1914, where Hardy tutored him and collaborated with him in some research.
- He worked out **the Riemann series, the elliptic integrals, hypergeometric series, the functional equations of the zeta function, and his own theory of divergent series**.
- The number **1729 is known as the Hardy-Ramanujan number** after a famous visit by Hardy to see Ramanujan at a hospital. It is **the smallest number which can be expressed as the sum of two different cubes in two different ways**.
- Hardy observed Ramanujan's work primarily involved fields less known even amongst other pure mathematicians.
- Ramanujan's home state of Tamil Nadu celebrates 22 December as '**State IT Day**', memorialising both the man and his achievements, as a native of Tamil Nadu.
- Ramanujan compiled around 3,900 results consisting of equations and identities. One of his most treasured findings was his infinite series for **Pi**.

National Mathematics Day is celebrated every year on **December 22**. It is **observed to honor the birth anniversary of the famous mathematician [Srinivasa Ramanujan](#)** who greatly contributed towards mathematical analysis, number theory, infinite series and continued fractions. 2021 marks **134th birth anniversary of Dr Ramanujan**.

The Dev Patel-starrer '**The Man Who Knew Infinity**' (2015) was a biopic on the mathematician.

3. [Patents and IP rights](#)

A patent represents a powerful intellectual property right, and is an exclusive monopoly granted by a government to an inventor for a limited, pre-specified time. It provides an enforceable legal right to prevent others from copying the invention.

Patents **can be either process patents or product patents**:

1. A product patent ensures that the rights to the final product is protected, and anyone other than the patent holder can be restrained from manufacturing it during a specified period, even if they were to use a different process.
2. A process patent enables any person other than the patent holder to manufacture the patented product by modifying certain processes in the manufacturing exercise.

Patent regime in India:

India moved from product patenting to process patenting in the 1970s, which enabled India to become a significant producer of generic drugs at global scale, and allowed companies like Cipla to provide Africa with anti-HIV drugs in the 1990s.

- But due to obligations arising out of the TRIPS Agreement, India had to **amend the Patents Act in 2005**, and **switch to a product patents regime across the pharma, chemicals, and biotech sectors**.

What is the TRIPS Agreement?

The TRIPS agreement was **negotiated in 1995 at the WTO**, it requires all its signatory countries to enact domestic law.

- It **guarantees minimum standards of IP protection**. Such legal consistency enables innovators to monetise their intellectual property in multiple countries.
- In 2001, the WTO signed **the Doha Declaration**, which clarified that in a public health emergency, governments could compel companies to license their patents to manufacturers, even if they did not think the offered price was acceptable.
- This provision, commonly referred to as “**compulsory licensing**”, was already built into the TRIPS Agreement and the Doha declaration only clarified its usage.

4. Protection of Plant Varieties and Farmers’ Rights (PPV&FR) Act,2001

The **Protection of Plant Varieties and Farmers Rights (PPV&FR) Authority** has revoked a **PVP (Plant Variety Protection)** certificate granted to PepsiCo India Holding (PIH) on a potato variety (FL-2027) on various grounds.

This included the following:

- The grant of the certificate of registration had been based on incorrect information furnished by the applicant.
- The certificate had been granted to a person not eligible for protection.
- The grant of the certificate of registration was not in the public interest.

Please note that **Section 39 of the Protection of Plant Varieties and Farmers’ Rights (PPV&FR) Act,2001** specifically says that a farmer is allowed to grow and sell any variety of crop or even seed as long as they don’t sell branded seed of registered varieties.

The Protection of Plant Varieties and Farmers’ Rights (PPV&FR) Act, 2001:

- Enacted by India in 2001 adopting sui generis system.
- It is in conformity with **International Union for the Protection of New Varieties of Plants (UPOV), 1978**.
- The legislation recognizes the contributions of both commercial plant breeders and farmers in plant breeding activity and also provides to implement TRIPs in a way that supports the specific socio-economic interests of all the stakeholders including private, public sectors and research institutions, as well as resource-constrained farmers.

Objectives of the PPV & FR Act, 2001:

- To establish an effective system for the protection of plant varieties, the rights of farmers and plant breeders and to encourage the development of new varieties of plants.
- To recognize and protect the rights of farmers in respect of their contributions made at any time in conserving, improving and making available plant genetic resources for the development of new plant varieties.
- To accelerate agricultural development in the country, protect plant breeders’ rights; stimulate investment for research and development both in public & private sector for the development new of plant varieties.
- Facilitate the growth of seed industry in the country which will ensure the availability of high-quality seeds and planting material to the farmers.

Rights under the Act:

Breeders’ Rights: Breeders will have exclusive rights to produce, sell, market, distribute, import or export the protected variety. Breeder can appoint agent/ licensee and may exercise for civil remedy in case of infringement of rights.

Researchers’ Rights: Researcher can use any of the registered variety under the Act for conducting experiment or research. This includes the use of a variety as an initial source of variety for the purpose of developing another variety but repeated use needs prior permission of the registered breeder.

Farmers’ Rights:

1. A farmer who has evolved or developed a new variety is entitled for registration and protection in like manner as a breeder of a variety;
2. Farmers variety can also be registered as an extant variety;
3. A farmer can save, use, sow, re-sow, exchange, share or sell his farm produce including seed of a variety protected under the PPV&FR Act, 2001 in the same manner as he was entitled before the coming into force of this Act provided farmer shall not be entitled to sell branded seed of a variety protected under the PPV&FR Act, 2001;
4. Farmers are eligible for recognition and rewards for the conservation of Plant Genetic Resources of land races and wild relatives of economic plants;
5. There is also a provision for compensation to the farmers for non-performance of variety under Section 39 (2) of the Act, 2001 and
6. Farmer shall not be liable to pay any fee in any proceeding before the Authority or Registrar or the Tribunal or the High Court under the Act.

5. Bloatware apps:

Also known as **Potentially Unwanted Programs (PUP)**, bloatware apps are needless programs that take a toll on your device's performance.

- Bloatware apps are being criticized for taking up the storage of the device unnecessarily and affecting the system's battery life and overall performance.
- Generally, these apps that run in the background are hidden and locating them becomes a tough job for the users.
- It could be any software on your computer, phone or tablet that consumes a lot of resources like — memory, storage and battery life.



There are three most common types of bloatwares that can be found on any device.

Utilities: These types of bloatwares come from manufacturers and third-party developers and are usually pre-loaded on your device. These offer added functionality to your device.

Trialware: Users can experience the app as most of them offer free trial modes in new devices. However, these programs keep on consuming your device's resources, even after the trial period is over.

Adware: These types of bloatware typically gets downloaded while downloading softwares from the internet.

6. Lithium

It is a soft, silvery-white metal. Under standard conditions, **it is the lightest metal and the lightest solid element.**

It is highly **reactive and flammable, and must be stored in mineral oil.** It is an alkali metal and a **rare metal.**

Key Characteristics and Properties:

- It has the highest specific heat capacity of any solid element.
- Lithium's single valence electron allows it to be a good conductor of electricity.
- It is flammable and can even explode when exposed to air and water.

Uses:

1. Lithium is a key element for new technologies and finds its use in ceramics, glass, telecommunication and aerospace industries.
2. The well-known uses of Lithium are in Lithium ion batteries, lubricating grease, high energy additive to rocket propellants, optical modulators for mobile phones and as convertor to tritium used as a raw material for thermonuclear reactions i.e. fusion.

Prescribed substance:

The thermonuclear application makes Lithium as “Prescribed substance” under [the Atomic Energy Act, 1962](#) which permits AMD for exploration of Lithium in various geological domains of the country.

- Under **the Atomic Energy Act, 1962**, “Prescribed Substance” means any substance including any mineral which the Central Government may, by notification, prescribe, being a substance which in its opinion is or may be used for the production or use of atomic energy or research into matters connected therewith and includes uranium, plutonium, thorium, beryllium, deuterium or any of their respective derivatives or compounds or any other materials containing any of the aforesaid substances.

7. [Antimicrobial Resistance](#)

A comprehensive estimate of the global impact of **antimicrobial resistance (AMR)**, covering 204 countries and territories, was published recently in The Lancet.

- The report is titled- **Global Research on Antimicrobial Resistance (GRAM) report**.

Highlights:

- AMR is now a leading cause of death worldwide, higher than HIV/AIDS or malaria.
- Besides, another 49.5 lakh deaths were indirectly caused by AMR (a drug-resistant infection was implicated, but resistance itself may or may not have been the direct cause of death).

AMR-RELATED DEATHS		
	Direct	Associated
INFECTION		
Lower respiratory	4 lakh	15 lakh
Bloodstream	3.7 lakh	15 lakh
Inter-abdominal	2.1 lakh	8 lakh
REGION		
Sub-Saharan Africa	2.55 lakh	10 lakh
South Asia	3.89 lakh	13.9 lakh

Pathogens analyzed:

- Of the 23 pathogens studied, drug resistance in six (**E coli, S aureus, K pneumoniae, S pneumoniae, A baumannii, and P aeruginosa**) led directly to 9.29 lakh deaths and was associated with 3.57 million.

What is Antibiotic resistance?

It is the ability of a microorganism (like bacteria, viruses, and some parasites) to stop an antimicrobial (such as antibiotics, antivirals and antimalarials) from working against it. As a result, standard treatments become ineffective, infections persist and may spread to others.



Why is Antimicrobial resistance a silent threat of the future?

- Antibiotics have saved millions of lives till date. Unfortunately, they are now becoming ineffective as many infectious diseases have ceased to respond to antibiotics.
- Even though antimicrobial resistance is a natural process, **the misuse of antibiotics in humans and animals** is accelerating the process.
- A large number of infections such as tuberculosis, pneumonia and gonorrhoea are becoming very difficult to treat since the antibiotics used for their treatment are becoming less effective.
- Globally, **use of antibiotics in animals is expected to increase by 67% by 2030** from 2010 levels. The resistance to antibiotics in germs is a man-made disaster.
- **Irresponsible use of antibiotics** is rampant in human health, animal health, fisheries, and agriculture.

- **Complex surgeries** such as organ transplantation and cardiac bypass might become difficult to undertake because of untreatable infectious complications that may result post-surgery.

8. Antimalarial drug resistance

In recent years there is increasing evidence for the failure of **artemisinin-based combination therapy** for falciparum malaria either alone or with partner drugs.

Why is there an increase in Antimalarial drug resistance?

In most malaria-endemic countries including India, Artemisinin-based antimalarial drugs are the first-line choice for malaria treatment especially against Plasmodium falciparum parasite which is responsible for almost all malaria-related deaths in the world. Overuse has led to mutations in P. falciparum cases treated with artemisinin.

What needs to be done?

The time has come to carry out **Molecular Malaria Surveillance** to find out the drug-resistant variants so that corrective measures can be undertaken in time to avert any consequences. Some experts even advocate using **triple artemisinin-based combination therapies** where the partner drug is less effective.

9. Gain-of-function

The term '**gain of function research**' has recently cropped up in the debate about the origins of the Covid-19 pandemic.

What is Gain-of-function Research?

- 'Gain of function' is a field of research **focused on growing generations of microorganisms, under conditions that cause mutations in a virus.**
- These experiments are termed 'gain of function' because they involve manipulating pathogens in a way that they gain an advantage in or through a function, such as increased transmissibility.
- Such experiments allow scientists to better predict emerging infectious diseases, and to develop vaccines and therapeutics.

How is it carried out?

Gain of function research may use **genetic engineering or serial passaging.**

1. **Genetic engineering** involves 'editing' the genetic code to modify the virus in a way predetermined by the scientists.
2. **Serial passaging** involves allowing the pathogen to grow under different circumstances and then observing the changes.

Issues related to the research:

1. Gain-of-function research involves **manipulations that make certain pathogenic microbes more deadly or more transmissible.**
2. There is also '**loss-of-function**' research, which involves inactivating mutations, resulting in a significant loss of original function, or no function to the pathogen.
3. Gain-of-function research reportedly carries **inherent biosafety and biosecurity risks** and is thus referred to as 'dual-use research of concern' (DURC).

Serial passaging involves allowing the pathogen to grow under different circumstances and then observing the changes.

How is it regulated in India?

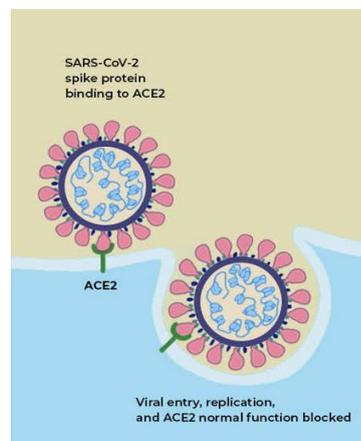
All activities related to genetically engineered organisms or cells and hazardous microorganisms and products are regulated as per **the "Manufacture, Use, Import, Export and Storage of Hazardous Microorganisms/Genetically Engineered Organisms or Cells Rules, 1989"**.

- In 2020, the Department of Biotechnology issued guidelines for the establishment of containment facilities, called '**Biosafety labs**'.
- The notification provides operational guidance on the containment of biohazards and levels of biosafety that all institutions involved in research, development and handling of these microorganisms must comply with.

10. ACE2 protein

ACE2 is an enzyme molecule that connects the inside of our cells to the outside via the cell membrane.

- In normal physiology, another enzyme called ACE alters a chemical, Angiotensin I, and converts it into Angiotensin II, which causes blood vessels to constrict. The tightening of the blood vessels leads to an increase in blood pressure.
- That's when the ACE2 molecule comes in: to counteract the effects of ACE, causing blood vessels to dilate and lowering blood pressure.
- The spikes that make up the 'crown' of coronavirus bind to ACE2 enzymes to get into our cells.



11. Nobel Medicine Prize

U.S. scientists David Julius and Ardem Patapoutian have won the Nobel Medicine Prize for discoveries on receptors for temperature and touch.

About their discoveries:

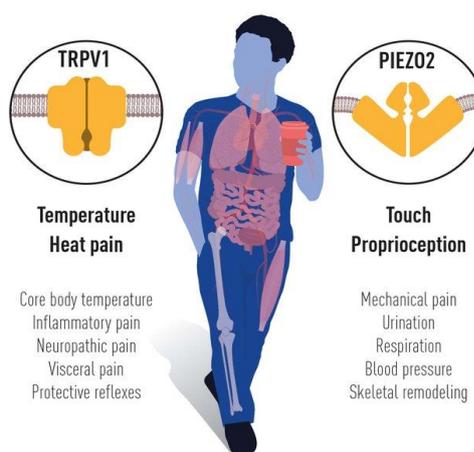
They discovered the molecular sensors in the human body that are sensitive to heat, and to mechanical pressure, and make us "feel" hot or cold, or the touch of a sharp object on our skin.

Significance of these discoveries:

Breakthroughs in physiology have often resulted in an improvement in the ability to **fight diseases and disorders**.

The identification of these receptors opens up the possibility of regulating their functioning. For example, there are receptors that make us feel pain.

If these receptors can be suppressed, or made less effective, the person would feel less pain.



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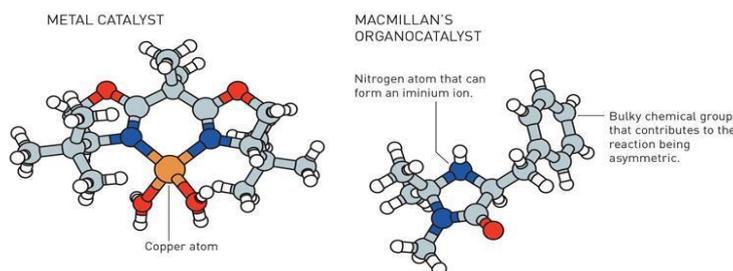
12. 2021 Nobel Prize in Chemistry

The 2021 Nobel Prize in Chemistry was awarded to **Benjamin List and David W C MacMillan** "for the development of asymmetric **organocatalysis**".

Firstly, what is a catalyst? And what is catalysis?

A catalyst is a substance that increases the rate of a chemical reaction without taking part in the reaction, or without undergoing any changes during the chemical reaction.

- Catalysis is the process of increasing the rate of a chemical reaction by adding a catalyst.



1 David MacMillan worked with metal catalysts that were easily destroyed by moisture. He therefore started to wonder whether it was possible to develop a more durable type of catalyst.

2 He designed some simple molecules that could create iminium ions. One of these proved to be excellent at asymmetric catalysis.

The major types of catalysts are **metals and enzymes**.

Applications of organocatalysis:

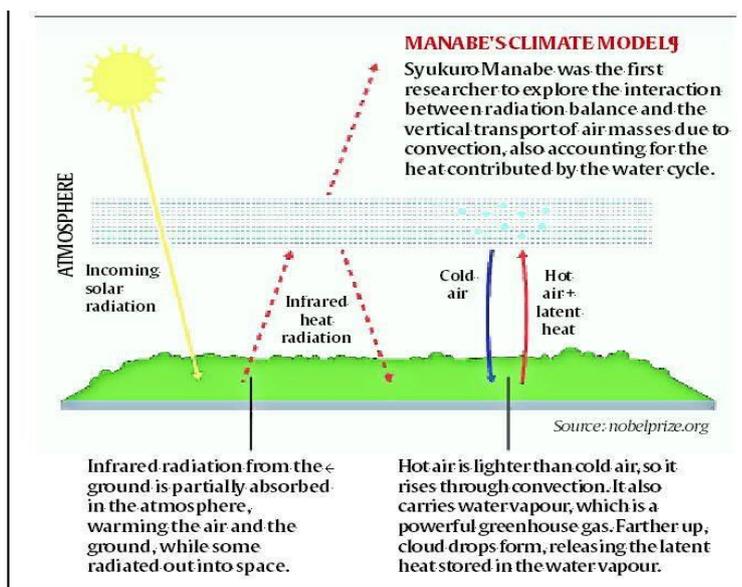
Organocatalysis finds several applications in **pharmaceutical research** and other industries.

- It has helped streamline the production of existing pharmaceuticals, including paroxetine, used to treat anxiety and depression, and oseltamivir, a respiratory infection medication.

13. Physics Nobel 2021:

Three scientists — Syukuro Manabe (90) and Klaus Hasselmann (89) and Giorgio Parisi (73) — have been awarded the Nobel Prize for physics 2021. **This is the first time climate scientists have been awarded the Physics Nobel.**

- Manabe and Hasselmann were awarded for their work in “the physical modelling of Earth’s climate, quantifying variability and reliably predicting global warming”.
- Parisi was awarded for “the discovery of the interplay of disorder and fluctuations in physical systems from atomic to planetary scales.”



In 2020, scientists Roger Penrose, Reinhard Genzel and Andrea Ghez won **the Nobel physics prize for their discoveries concerning black holes**.

14. Extra neutral alcohol (ENA):

- It is a **byproduct of the sugar industry**.
- Formed from molasses that are a residue of sugarcane processing.
- It is the primary raw material for making alcoholic beverages.

Features:

It is **colourless food-grade alcohol** that does not have any impurities.

It has a **neutral smell and taste** and typically contains over 95 per cent alcohol by volume.

Other applications of ENA:

- An essential ingredient in the manufacture of cosmetics and personal care products such as perfumes, toiletries, hair spray, etc.

EMR
 EXPERT MARKET RESEARCH

INDIA EXTRA NEUTRAL ALCOHOL (ENA) MARKET
 Historical Market and Forecast (2016-2026)

Market
 The India extra neutral alcohol (ENA) market reached a volume of around 3.13 billion litre in 2020, driven by its wide range of applications in end use industries and rising demand in the manufacturing of potable alcohol. The market is further expected to grow at a CAGR of 5% in the forecast period of 2021-2026.

Growth
 ENA is the main raw material used in the production of alcoholic drinks like whiskey and vodka. ENA is also used in items like air fresheners and detergents. These factors are contributing to the growth of the industry.

Segments
 India Extra Neutral Alcohol (ENA)
 Market segments are based on:
 • Raw Material
 • End Use

Regional Analysis
 The regional markets for the product in India include Punjab, Maharashtra, Madhya Pradesh, Uttar Pradesh, Karnataka, Andhra Pradesh and Telangana, Tamil Nadu, Haryana, West Bengal, and others.

Market Dynamics
 The comprehensive EMR report provides an in-depth assessment of the industry based on the Porter's five forces model along with giving a SWOT analysis.

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- Utilized in the production of some lacquers, paints and ink for the printing industry, as well as in pharmaceutical products such as antiseptics, drugs, syrups, medicated sprays.

15. Global Innovation Index 2021

India has climbed two spots and **has been ranked 46th** by [the World Intellectual Property Organization \(WIPO\)](#) in the Global Innovation Index 2021 rankings.

Global Innovation Index:

The Global Innovation Index (GII) is **an annual ranking of countries by their capacity for, and success in, innovation.**

- It is published by **Cornell University, INSEAD, and the World Intellectual Property Organization**, in partnership with other organisations and institutions.
- It is **based on both subjective and objective data** derived from several sources, including **the International Telecommunication Union, the World Bank and the World Economic Forum.**
- **The index was started in 2007** by INSEAD and World Business, a British magazine.
- **The GIi is commonly used by corporate and government officials** to compare countries by their level of innovation.

Ranking	Country/Territory
1	 Switzerland
2	 Sweden
3	 United States
4	 United Kingdom
5	 South Korea
6	 Netherlands
7	 Finland
8	 Singapore
9	 Denmark
10	 Germany

16. South Africa grants patent to an artificial intelligence system

South Africa, first time in the world, has granted a patent to an [‘artificial intelligence system’](#) relating to a **“food container based on fractal geometry”** innovation.

- The innovation involves interlocking food containers that are **easy for robots to grasp and stack.**

What's the issue now?

- The **patent** has been given to an artificial intelligence (AI) system (called DABUS); not a human being.

What is the DABUS?

- DABUS stands for “device for the autonomous bootstrapping of unified sentence”.
- The system simulates human brainstorming and creates new inventions.
- DABUS is a **particular type of AI, often referred to as “creativity machines”** because they are capable of independent and complex functioning.

What are the ‘Creativity machines’?

Creativity machines can **process and critically analyse data**, learning from it.

- This process is **known as machine learning.**
- Once the **machine learning phase has occurred**, the machine is able to **“autonomously” create without human intervention.**

Background:

- **The patent application listing DABUS as the inventor** was filed in patent offices around the world, including the U.S., Europe, Australia, and South Africa.
- The United States Patent and Trademark Office and the European Patent Office **rejected these applications in the formal examination phase.**

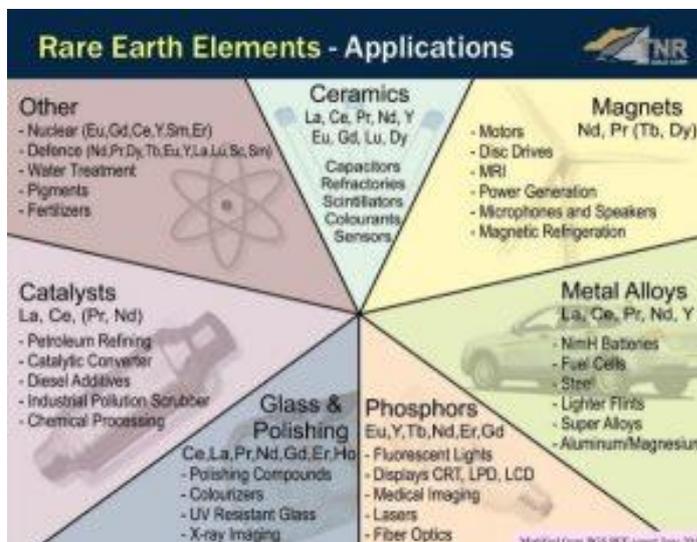
17. Rare earths minerals (REM)

What are rare earth minerals?

- The rare earths minerals (REM) are a **set of seventeen metallic elements**. These include the **fifteen lanthanides on the periodic table in addition to scandium and yttrium** that show similar physical and chemical properties to the lanthanides.
- The REMs have unique **catalytic, metallurgical, nuclear, electrical, magnetic and luminescent properties**. While named 'rare earth', they are in fact not that rare and are relatively abundant in the Earth's crust.

Strategic importance of REM

- Its usage **range from daily use** (e.g., lighter flints, glass polishing mediums, car alternators) to **high-end technology** (lasers, magnets, batteries, fibre-optic telecommunication cables).
- Even **futuristic technologies need these REMs** (For example high-temperature superconductivity, safe storage and transport of hydrogen for a post-hydrocarbon economy, environmental global warming and energy efficiency issues).
- Due to their **unique magnetic, luminescent, and electrochemical properties, they help in technologies perform with reduced weight, reduced emissions, and energy consumption**; therefore, give them greater efficiency, performance, miniaturization, speed, durability, and thermal stability.



Heavy dependence on China for REM

- In 2019, US imported 80% of its rare earth minerals from China.
- European Union (EU) gets 98% of its supply from China.
- **India** has the **world's fifth-largest reserves of rare earth elements**, nearly twice as much as Australia, but it **imports** most of its **rare earth** needs in finished form from its geopolitical rival, China.

India has granted government corporations such as **Indian Rare Earths Limited (IREL)** a monopoly over the primary mineral that contains REEs. However, IREL accounts for only a minuscule fraction of the world's production.

18. Zeolite

- National carrier Air India began the first of its **"zeolite cargo flights"** with the government of India having commenced the process of importing zeolite from across the world for use in medical oxygen plants.
- The government has appointed **the Defence Research and Development Organisation (DRDO) as the charterer for these consignments**.

Use of Zeolite in medical oxygen plants:

The technology being developed by the DRDO uses **the pressure swing adsorption process** and **molecular sieve zeolite** in oxygen generation.

- Zeolites are used as adsorbent material.
- An oxygen concentrator uses Zeolites to adsorb atmospheric nitrogen and then vents out the nitrogen. This leaves oxygen gas remaining to be used for patients.
- In high pressure, the surface area of zeolites increases and thus is capable of adsorbing large quantities of nitrogen.

Pressure Swing Adsorption:

Pressure swing adsorption (PSA) is a technology **used to separate some gas species from a mixture of gases under pressure.**

- PSA **operates at near-ambient temperatures.**
- Specific adsorbent materials (e.g., zeolites, activated carbon, molecular sieves, etc.) are used as a trap, preferentially adsorbing the target gas species at high pressure.

What are Zeolites?

Zeolites are microporous, three dimensional crystalline solid of aluminium silicate. Zeolites have small openings of fixed size in them which allow small molecules to pass through them easily but larger molecules cannot pass through them; that is why they are sometimes called molecular sieve.

- Zeolites are either formed naturally or can be synthesized.

Properties Of Zeolites:

- Zeolites are very stable solid under different environmental conditions. The melting point of zeolite is very high, i.e.1000oC.
- They are insoluble in water or other inorganic solvents.
- They do not undergo oxidation in the presence of air.
- Zeolites which are rich in alumina are attracted to polar molecules like water whereas zeolite rich in silica are attracted towards nonpolar molecules.
- Since zeolites are not reactive and are obtained from naturally occurring minerals, therefore, they do not have any harmful environmental effects; although skin contact or inhalation may have a carcinogenic effect.

19. Manufactured sand

The Rajasthan government has brought a policy on **manufactured sand (M-sand)**, giving **industry status** to the units producing it for construction work and reducing the dependence on bajri (riverbed sand).

Background:

The Supreme Court had banned illegal mining on riverbeds in 2017.

What is M-Sand?

- M-sand is a substitute of river sand for concrete construction.
- Manufactured sand is produced from hard granite stone by crushing.
- The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material.
- The size of manufactured sand (M-Sand) is less than 4.75mm.

Its significance:

- It can be dust free, the sizes of m-sand can be controlled easily so that it meets the required grading for the given construction.
- It is well graded in the required proportion.
- It does not contain organic and soluble compounds that affect the setting time and properties of cement, thus the required strength of concrete can be maintained.
- It does not have the presence of impurities such as clay, dust and silt coatings.

20. Rice bran oil

- **It refers to the oil extracted from the extreme outer layer of rice called chaff.** In recent times, it is being claimed as one of the healthiest cooking oils, because of its high smoke point

of 232 °C (450 °F) and extreme mild flavour. These qualities make it apt for stir-frying and even deep-frying.

- **Considered as a popular cooking oil in Asian countries**, it has also been recommended by The American Heart Association and The World Health Organization (WHO), as a effective choice to keep cholesterol under control.
- It is rich in Oryzanol, which is proven to reduce bad cholesterol and increase good cholesterol.
- Rice bran oil has balanced fatty acid composition which includes saturated fatty acids, monounsaturated fats and polyunsaturated fats. This oil is rich in monounsaturated and polyunsaturated fats and is also free from trans-fats.

21. Cyber Physical Systems (CPS)

- Cyber Physical Systems (CPS) are new class of engineered systems that integrate computation and physical processes in a dynamic environment.
- CPS encompasses technology areas of Cybernetics, Mechatronics, Design and Embedded systems, Internet of Things (IoT), Big Data, Artificial Intelligence (AI) and many more.
- The CPS systems are intelligent, autonomous and efficient and are expected to drive innovation in sectors as diverse as **agriculture, water, energy, transportation, infrastructure, security, health and manufacturing.**

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