

**SCIENCE &
TECH
MAINS SPECIAL
2024**



YEARLY COMPILATION

(MAY 2023 - AUGUST 2024)

- ♥ Subject wise segmentation
- ♥ User friendly layout
- ♥ Infographic aid and interactive elements

Comprehensive Current Affairs Coverage for Mains 2024

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SCIENCE & TECHNOLOGY

SPACE

Artemis Accords

News Excerpt

During his visit to the USA, Prime Minister of India signed the Artemis Accords.

Artemis Accords

- Through the Artemis program, NASA will land the **first woman and first person of colour** on the Moon, make new scientific discoveries, and explore more of the lunar surface than ever before for the benefit of all.
- While NASA is leading Artemis, international partnerships will play a key role in achieving a sustainable and robust presence at the Moon where the agency will prepare for the **first human mission to Mars**.
- With numerous countries and private companies conducting missions and operations around the Moon, a common set of principles to govern the civil exploration and use of outer space is necessary.
- NASA, in coordination with the U.S. Department of State, established the **Artemis Accords in 2020** together with seven other founding member nations.
- The accords reinforce the commitment by the United States and signatory nations to the **Registration Convention, the Rescue and Return Agreement**, as well as best practices and norms of responsible behaviour that NASA and its partners support, including the public release of scientific data.
- **Member Countries**- Australia, Bahrain, Brazil, Canada, Colombia, Czech Republic, Ecuador, France, India, Israel, Italy, Japan, Luxembourg, Mexico, New Zealand, Nigeria, Poland, South Korea, Romania, Rwanda, Singapore, Spain, Saudi Arabia, Ukraine, United Arab Emirates, United Kingdom, United States

Principles of Artemis Accord

- **Peaceful Purposes**: The core of the Artemis Accords is the requirement that all activities will be conducted for peaceful purposes, per the tenets of the Outer Space Treaty.
- **Transparency**: It is a key principle for responsible civil space exploration.
- **Interoperability**: Artemis Accords call for partner nations to utilize open international standards, develop new standards when necessary, and strive to support interoperability to the greatest extent practical.
- **Emergency Assistance**: All the partner nations commit to taking all reasonable steps possible to render assistance to astronauts in distress.
- **Registration of Space Objects**: Accords reinforce the critical nature of registration and urge any partner who

isn't already a member of the Registration Convention to join as soon as possible.

- **Others:**
 - Release of Scientific Data
 - Protecting Heritage
 - Space Resources
 - Deconfliction of Activities
 - Orbital Debris and Spacecraft Disposal

Significance

- It would facilitate **increased collaboration** between ISRO, NASA and other international space agencies involved in the Artemis program.
- This collaboration could lead to **joint missions, technology sharing, and scientific research partnerships**, fostering global cooperation in space exploration.
- The Artemis Accords addresses the **utilization of lunar resources**, including water ice, minerals, and other materials and India can participate in discussions on their extraction and utilization.
- **Technological Advancement**: The program involves advanced space technologies, including human spaceflight, robotic missions, and lunar surface infrastructure and India could gain access to expertise, technologies, and resources related to these areas.
- **Inspiring the Nation**: It could encourage the development of a skilled workforce and foster a broader interest in science, technology, engineering, and mathematics (STEM) education across the country.

Challenges

National Sovereignty: The Artemis Accords require participating nations to agree to the use of space resources in a manner that complies with international law.

International Collaboration: India would need to align its space policies, plans, and objectives with those of other countries involved in the accords.

Financial and Technological Capacity: The cost of participation in such ventures could be a significant challenge for India.

International Relations: Joining the Artemis Accords may have implications for existing collaborations with other nations. For example, India- Russia space collaboration.

Way Forward

- Engage with **relevant stakeholders**, including government agencies, space industry players, scientific institutions, and civil society organizations, to gather input and insights to identify concerns, challenges, and opportunities and address them effectively.
- India can **leverage its existing strengths** and expertise by investing in research and development, infrastructure, and human resources.
- Strengthen **bilateral and multilateral engagements** with countries already involved in the Artemis Accords to establish partnerships and foster collaboration.
- India can **negotiate provisions and safeguards** within the accords that protect its sovereignty over space resources and ensure compatibility with its existing legal framework.

Coordinated Lunar Time (LTC)**News Excerpt:**

NASA's four-member Artemis crew is scheduled to fly around the moon in preparation for the **space agency's mission** to land on the moon again.

More about News:

- National Aeronautics and Space Administration (NASA)** will establish a **Coordinated Lunar Time (LTC)** to standardize cislunar operations with the universal time followed on Earth.
- A consistent definition of time among operators in space is critical to successful space situational awareness capabilities, navigation, and communications.
- The **difference between the passage of time on the moon and Earth** is that "Time appears to pass more slowly where gravity is stronger, like near **celestial bodies.**"
 - As a result, the **length of a second on Earth** is different to an observer under different gravitational conditions, such as on the moon.
- Coordinated Lunar Time** will be the standard for measuring cislunar operations on space activities between the moon and Earth with **Coordinated Universal Time (UTC)**, the global time used to regulate time on Earth.

What is Coordinated Lunar Time (LTC)?

- The European Space Agency (ESA) launched a project called **'Moonlight'** in 2023 to design satellites for astronauts and robotic explorers to support NASA's moon mission **'Artemis.'**
- Due to the moon's slow rotation (one rotation every 29.5 Earth days),

it would be practical to have ideally a single time zone for the moon. A single time zone is similar to the **Coordinated Universal Time (UTC)** used on Earth.

- The **UTC** was formulated in the 1960s and is based on a weighted average of hundreds of atomic clocks, which measure time based on the vibration of atoms, ensuring extreme accuracy.
- The White House's Celestial Time Standardization policy** seeks to assign a time standard to each celestial body and its surrounding space environment.

Issues in defining and implementing LTC:

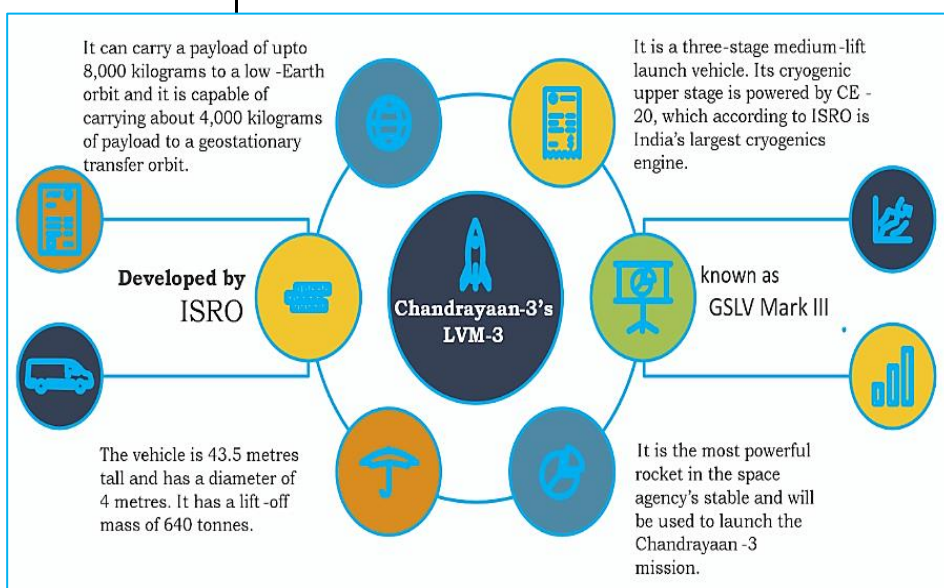
- The process of defining **lunar time is complicated** by the effect of the moon's gravitational pull.
 - The **moon's weaker gravitational pull** causes clocks on the lunar surface to run faster than those on Earth, **as per the theory of special relativity.**
- The speed of a clock on the moon would vary **depending on its position** due to the moon's rotation, further complicating time measurement.
- With the **Artemis Program aiming** for a lunar landing as early as 2026, adapting to the challenge of lunar time measurement for long-duration stays is crucial.
- Once a working time system is established for the moon, similar time standards can be developed for other planetary destinations like **Mars.**

Chandrayaan-3**News Excerpt**

Indian Space Research Organisation (ISRO) launched the Chandrayaan-3 spacecraft with the Launch Vehicle Mark-III (LVM3) at the Satish Dhawan Space Centre in Srihari Kota.

About LVM3:

- LVM3 is the new heavy lift launch vehicle of ISRO for achieving a 4000 kg spacecraft launching capability to GTO (Geosynchronous Transfer Orbit) in a cost-effective manner.



- LVM3 is a three-stage launch vehicle consisting of two solid propellant S200 strap-ons and core stages comprising of L110 liquid stage, C25 cryogenic stage, the equipment bay (EB) and the Encapsulated assembly (EA).

Chandrayaan-3

- Chandrayaan-3 is a follow-on to the unsuccessful Chandrayaan-2 mission, and it has the same objective—to **demonstrate the capability of soft landing on the Moon** by delivering a lander and a rover to the lunar surface.
- The Chandrayaan-3 spacecraft consists of **three parts—the lander module, propulsion module and a rover**.
- The lander is designed to make a soft landing at a specific site on the Moon and deploy the rover. The rover will carry out chemical analysis of the lunar surface.
- Both the lander and the rover carry many scientific payloads for experiments on the lunar surface.
- The current mission will follow the same trajectory as Chandrayaan 2, where the propulsion module will orbit earth, several times **before sling shooting towards the moon**. Once within the moon's gravitational pull, the module will lower itself to a 100 x 100 km circular orbit. Then, the lander will detach and descending to the surface.

Objectives of Chandrayaan-3

- To demonstrate Safe and Soft Landing on Lunar Surface
- To demonstrate Rover roving on the moon and
- To conduct in-situ scientific experiments.

How is Chandrayaan 3 different from Chandrayaan 2?

- Unlike Chandrayaan 2, the new moon mission spacecraft will not be carrying a rover aboard. Further, the Chandrayaan 3 spacecraft will carry a payload called Spectro-polarimetry of Habitable Planet Earth (SHAPE), which the previous mission did not have.
- SHAPE will study the spectral and polarimetric measurements of Earth from lunar orbit, which means that there are fewer chances of Chandrayaan 3 losing contact with ISRO and changing its trajectory, unlike the previous mission to the moon.

Exploring the Lunar South Pole

- **Chandrayaan-3 would be the first to land at the Lunar South Pole** to carry in situ experiments, analysis, and observations to gain insights into the moon's composition.
- The success of India's mission in this crucial location is a groundbreaking development and brings about significant changes in field of deep space exploration.

AI-Powered Moon Mission

The Pragyan rover is equipped with advanced AI technology, enabling it to communicate with the Vikram lander. This technology also assists the rover in various tasks and operations.

Key capabilities of the Pragyan Rover:

- It utilises **motion technology** to navigate the challenging terrain and successfully reach its designated landing site.
- Its AI algorithm plays a crucial role in identifying traces of water and minerals on the lunar surface.

Impacts

- **Successful landing will bolster investments.** It would attract investor confidence and more private investment in space technology.
- It will benefit industry in a way that it promotes the **cost-efficient and highly reliable** space-grade hardware.
- It can also validate India's industry to become suppliers to lunar programs by other countries.
- **Space start-ups and jobs:** India's investment in moon missions alone generated several hundreds of direct high-tech jobs and thousands of indirect jobs.
- **Global positioning Of India:** The success of the mission has positioned India among the top four technologically-advanced space nations and paved the way for important international collaborations, similar to the recent Artemis Accord signing between ISRO and the American space agency NASA.

Impact of the successful launch of Chandrayan-3 for private space industry:

- It provided more credibility to our space programme. Investors, vendors as well as customers will begin to take Indian space technology more seriously.
- The Brain Drain of highly educated and ambitious scientists from India would reduce and thus would be highly beneficial in the long term.
- This could attract more global aerospace customers, joint ventures into India, and elevate Indian space-tech companies to a position where they can design and manufacture systems for other countries.

Advantages of private players in space sector:

- Private players will enable the Indian space program to remain **cost competitive** within the global space market.
- Its involvement in the long term is believed to help spur **investment and expertise** as the space sector is highly **capital-intensive** and **demands high technology**.
- It would **create several jobs** in the space and allied sectors.
- Enhancing space technology would be beneficial to **bolster connectivity and combat climate-related implications** through more secure and effective means.

Provisions for private players in Indian Space Policy 2023:

- The entire gamut of space activities is now open to the private sector. Private sectors are allowed to undertake end-to-end activities in the space sector through establishment and operation of space objects, ground-based assets and related services, such as communication, remote sensing, navigation, etc.
- Satellites could be self-owned, procured or leased; communication services could be over India or outside;

and remote sensing data could be disseminated in India or abroad.

- NGEs (non-governmental entities) can design and operate launch vehicles for space transportation and establish their own infrastructure.
- NGEs can now make filings with the International Telecommunication Union (ITU) and engage in commercial recovery of asteroid resources.

Space economy

- As per Space Tech Analytics, India is the **sixth-largest player** in the industry internationally having 3.6% of the world's space-tech companies (as of 2021).
- The Indian Space Industry was valued at \$7 billion in 2019 and aspires to grow to \$50 billion by 2024.
- As per Tracxn data, funding into the sector's start-ups (in India) nearly tripled to \$67.2 million on a year-over-year basis in 2021.

Challenges regarding private players in the space industry:

- ISRO, since its inception, has always aimed to work on projects that can help India become self-reliant. However, **private companies will have more profitable interests** than developing solutions that cater to the immediate socio-economic needs of the country.
- Space technology is expensive and needs heavy investment. This kind of lucrative power is available only with selected rich corporates, thus can lead to monopolisation of the sector.
- IN-SPACE's role has been defined as a government regulator, 'to provide a level-playing field' for everyone. However, in the past, this has resulted in the **governments favouring the private sector** over the public sector.

Aditya-L1 Mission

News Excerpt

The Indian Space Research Organisation (ISRO) has **placed the Aditya-L1 spacecraft in a halo orbit around the Lagrangian point (L1).**

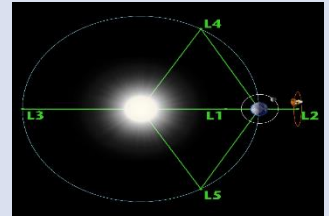
Aditya-L1 mission

- ADITYA-L1 will be ISRO's first space observatory dedicated to studying the Sun. It will fly approximately 1.5 million kilometers from Earth to the L1, or Lagrange point 1, which is one of the five favourable spots for observing the Sun.

- The mission aims to provide regular images and updates on the Sun's surface phenomena and space weather.
- The Aditya-L1 mission will carry seven different payloads

Lagrange Points

- Lagrange points are positions in space where objects sent there tend to stay put.
- At Lagrange points, the gravitational pull of two large masses precisely equals the centripetal force required for a small object to move with them.
- These points in space can be used by spacecraft to reduce fuel consumption needed to remain in position.



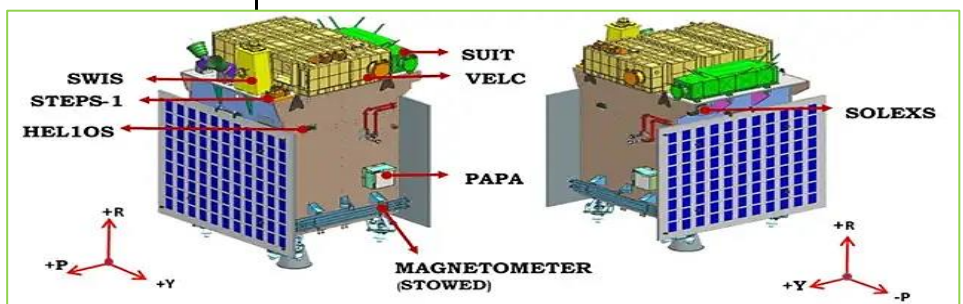
capable of studying various phenomena on the Sun across the electromagnetic spectrum and solar wind.

Science objectives of Aditya-L1 mission

- Study of Solar upper atmospheric (chromosphere and corona) dynamics.
- Study of chromospheric and coronal heating, physics of the partially ionized plasma, initiation of the coronal mass ejections, and flares
- Observe the in-situ particle and plasma environment providing data for the study of particle dynamics from the Sun.
- Physics of solar corona and its heating mechanism.
- Diagnostics of the coronal and coronal loops plasma: Temperature, velocity and density.
- Development, dynamics and origin of CMEs.
- Identify the sequence of processes that occur at multiple layers (chromosphere, base and extended corona) which eventually leads to solar eruptive events.
- Magnetic field topology and magnetic field measurements in the solar corona.
- Drivers for space weather (origin, composition and dynamics of solar wind).

Solar Ultraviolet Imaging Telescope (SUIT)

- The telescope is set to be integrated with the ADITYA-L1 mission.
- SUIT will record such images, which will be crucial for maintaining the Ozone and Oxygen content in the atmosphere of the Earth.



- SUIT will also measure the UV radiation hazardous for skin cancer.
- Integrated with Aditya-L1 mission The SUIT telescope will address fundamental questions such as the existence of a higher temperature atmosphere above the cooler surface of the Sun and the origin and variation of near-ultraviolet radiation and high-energy solar flares.
- Through SUIT, scientists will have a seamless measurement of solar radiation from Hard X-ray to Infrared, as well as in-situ measurements of particles in the solar wind, including the Sun's magnetic field at the L1 point.
- The SUIT project involved over 200-300 scientists over the last ten years. In addition to the initial grant of Rs 25 crore from ISRO for the hardware, scientists faced several challenges during the development of the payload, including building an ultra-clean room and designing special filters to capture the radiation.

Significance of Aditya-L1 mission

- It will help in understanding the effect of the Sun on the Earth and its surroundings has become very important now and Aditya-L1 aims to shed light on this topic.
- It will be able to observe the corona continuously and the data provided by it is expected to answer many outstanding problems in the field of solar astronomy.
- Its success will be ISRO's and India's big achievement and it will help to outreach the ISRO's market and India's Power and ability in the space sector.

Challenges of Aditya-L1 mission

- The distance between Sun and Earth is (approximately 15 crore km) issue.
- The chances of the collision with other satellite in space are high since it has moving components.
- This is the first time ISRO sending a satellite to sun thus well-planned implementation is a bigger challenge.

NASA'S QUESST Mission

News Excerpt:

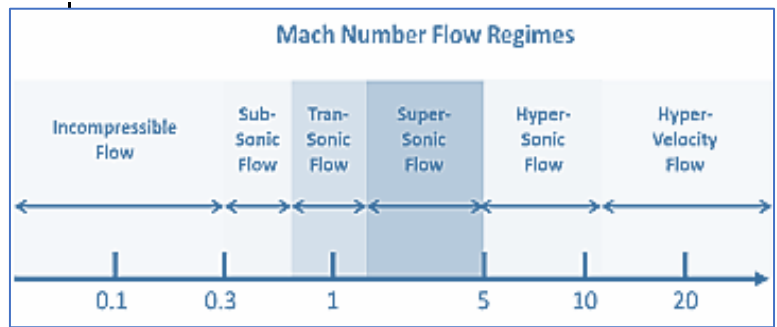
National Aeronautics and Space Administration (NASA) is developing a supersonic aircraft, called **X-59s**, as part of its **QUESST mission**.

WHAT ARE SONIC BOOMS?

A **Sonic boom** is a shock wave that is produced by an aircraft or other object flying at a speed equal to or exceeding the speed of sound and that is heard on the ground as a sound like a clap of thunder. When such an aircraft flies at a low altitude, the shock wave may be of sufficient intensity to cause glass breakage and other damage.

Key Points:

- In 1973, fifty years ago, the US federal government **had banned all civilian supersonic flights over land**. The rule prohibits non-military aircraft from flying faster than



sound so their resulting sonic booms won't startle the public below or concern them about potential property damage.

- With this in mind, NASA is exploring the possibility of designing a commercially viable and economical supersonic jet that would travel between Mach 2 and Mach 4.

About QUESST Mission:

The goal is to achieve a regulatory shift in the laws that focuses on the sound an aircraft creates, instead of a speed limit.

Objective:

- It aims to collect data that could make supersonic flight over land possible, dramatically reducing travel time in the United States or anywhere in the world.
- Design and build technology that reduces the loudness of a **sonic boom** to a gentle thump to people on the ground.
- Fly the X-59 over several U.S. communities to gather data on human responses to the sound generated during supersonic flight and deliver that data set to U.S. and international regulators.

Phases: To achieve the goals of the mission, NASA has laid out QUESST in four phases -

- **Phase 1 (2018–2024): Aircraft Development:** NASA anticipates that initial flights to prove performance and safety (also known as "envelope expansion").
- **Phase 2 (2024): Acoustic Validation:** NASA will fly the X-59 within the supersonic test range to prove the quiet supersonic technology works as designed, aircraft performance is robust in real atmospheric conditions, and the X-59 is safe for operations in the National Airspace System.
- **Phase 3 (2025-2026): Community Response Study:** The agency will use the X-59 to gather data on how effective the quiet technology is in terms of public acceptance. This will be done by flying over select U.S. cities beginning in 2025 and asking residents to share their response to the sound the X-59 produces.
- **Phase 4 - 2027: Final data to regulators:** NASA will provide a complete analysis of the community response data to U.S. and international regulators for their use in considering new sound-based rules regarding quiet supersonic flight over land.

Conclusion:

NASA will use the experimental X-59 to provide data that could lead the policymakers to change the rules that ban all civilian supersonic flight over land. **New sound-based rules** regarding supersonic flight over land can be written and adopted, which would open the doors to **new commercial cargo and passenger markets to provide faster-than-sound air travel.**

Bhartiya Space Station and Space Vision**News Excerpt:**

Recently, the visionary roadmap for ISRO was charted during a review meeting. It discussed the upcoming Gaganyaan mission, on track for 2025. It also targets Bhartiya Space Station by 2035, and an Indian on moon by 2040.

Gaganyaan mission:

- It envisages a demonstration of human spaceflight capability by launching a crew of 3 members to an orbit of 400 km for 3 days in a space mission and bringing them back safely to Earth, by landing in Indian sea waters.
- The prerequisites for the Gaganyaan mission include the development of many critical technologies like a human-rated launch vehicle, a Life Support System, crew emergency escape provision etc.

How were the previous Space Stations built?

- The space station is the place that allows astronauts to live and work for long durations in space.

master human space flights. In 2003, the first Chinese astronaut went to space. Now, the Chinese Space Station 'Tiangong- or Heavenly Palace' in Chinese is in orbit.

What is the Vision for 2040?

- Vision 2040 is designed by the Department of Space to land an Indian astronaut (Gaganauts) on the Moon.
- This will encompass Chandrayaan missions, developing a Next Generation Launch Vehicle (NGLV), constructing a new launch pad, setting up human-centric laboratories, and associated technologies.
- The Prime Minister has also urged Indian scientists to expand their horizons by working on interplanetary missions such as Venus Orbital Mission (Shukrayaan) and Mars Lander.

What are the challenges associated with the upcoming Space Vision - 2035?

While India continues to grow leaps and bounds beyond the planet's boundaries, the challenges are immense to make the 2035 target a reality.

- **Need of New Technology:** India has shown its prowess in satellite development but constructing and maintaining a space station requires a completely different set of skills. It involves life support systems, radiation protection, and long-term structural integrity.
- **Budget allocation by Government:** The financial aspect is perhaps the most significant hurdle. A space station is

a costly endeavour, and India must secure a substantial budget. Financial constraints could potentially limit the pace of the project and the range of experiments it can accommodate.

- **Expertise in Human spaceflight:** While India has achieved significant success with robotic missions, it still needs to gain experience in human spaceflight. To build and operate a space station, a well-trained team of astronauts is indispensable.

Way forward:

- **International Cooperation:** India's space station project should also be seen in the context of international cooperation.

Collaboration with established space-faring nations such as US, Japan and Europe can provide valuable insights and reduce costs. Establishing partnerships, especially with nations possessing space station experience, can be mutually beneficial regarding knowledge sharing and resource sharing.

- **Geopolitical Implications:** India's space station project could lead to concerns from other nations, which might view it as a strategic move. India must navigate



- In 1984, NASA scientists started with the building blocks of the station, which were transported to space in several missions and it became a reality in 2000, not as a NASA project but as a collaborative venture of America, Russia, Japan, Canada, and the European Space Agency. That's how the International Space Station (ISS) was born.
- China was kept out of ISS because of domestic American laws that prohibited NASA from direct collaboration with the Chinese. To build its space station, China first had to

diplomatic waters carefully to ensure that its space station ambitions do not lead to conflict or regional tensions.

Dark Matter

News Excerpt

Recently, in a study scientists estimate that up to 85% of the matter in the universe could be made of what's called dark matter.

Key Points:

- The discovery of supernova 1997ff, located about 10 billion light-years away, provided evidence for dark energy.
- About halfway into the universe's history, several billion years ago — dark energy became dominant and the expansion accelerated.
- Universe began with an explosion of space itself - the Big Bang.
- It is everything and includes all of space, and all the matter and energy that space contains.
- **It is thought to consist of three types of substance:** Normal matter, dark matter and dark energy.

About Dark Matter

The visible universe—including Earth, the sun, other stars, and galaxies makes up less than 5 per cent of the mass of the universe. The rest of the universe appears to be made of a mysterious, invisible substance called **dark matter**.

- Unlike normal matter, dark matter does not interact with the electromagnetic force.
- It is completely invisible to light and other forms of electromagnetic radiation.
- We can't see dark matter but we may see its effects through its gravitational force.

About Dark Energy

- It is the name given to the mysterious force that's causing the rate of expansion of our universe to accelerate over time, rather than to slow down. It is a hypothetical form of energy that exerts a negative, repulsive pressure, behaving like the opposite of gravity.
- It makes up approximately 68% of the universe and appears to be associated with the vacuum in space that is distributed evenly throughout the Universe.

Other Conceivable Theory of Dark Energy

Another theory states that it is a new kind of dynamical energy fluid or field, something that fills all of space but something whose effect on the expansion of the universe is the opposite of that of matter and normal energy.

Importance of Dark Energy

Dark energy is believed to make up about 70% of the mass-energy density of the entire Universe. It plays a central role in structure formation and galaxy evolution, and has measurable effects on the anisotropy of the cosmic microwave background.

Way forward

A large part of our universe is made up of so-called "dark matter," which emits no detectable energy, such as visible light, X-rays, or radio waves. However, it reveals itself by its gravity, just like a magnet underneath a table betrays its presence by attracting paperclips and pins.

3-D map of the universe hints about dark energy

News Excerpt:

Scientists have known that our universe is expanding at an increasingly faster pace. They believed that 'dark energy' is causing this expansion, but little is known about it. This may change soon.

Key points about the Dark Energy Spectroscopic Instrument (DESI):

- DESI is a unique instrument with 5,000 robotic 'eyes', i.e. the capability to observe 5,000 galaxies simultaneously, each capable of separately capturing and processing light from galaxies.
- It is mounted on the Nicholas W. Mayall 4-meter Telescope at the Kitt Peak National Observatory in Arizona, USA.
- It has been operating for **three years** and is scheduled to **continue for at least two more years**.
- Data from **the first year of DESI observations**:
 - It captures light from 6 million galaxies, some of which existed as far back as 11 billion years ago,
 - It has been used to create the most comprehensive **three-dimensional evolutionary map of the universe to date**.
- Using **the first year's observational data**:
 - The DESI collaboration has calculated that the **speed of expansion of the universe is increasing** at a rate of 68.5 km per second after **every 3.26 million light-years of expansion**.
- Some of the calculated values from DESI's observations are not consistent with current well-established theoretical models that describe the universe very well.

Dark energy intensity:

- Dark energy is causing **the universe to expand more rapidly over time**.
- It is considered a constant in the leading model of cosmology.
- The confidence level of these observations is currently around **2.5 sigma, or 95% confidence**, which is not enough for a scientific discovery of such magnitude and implications.
- A higher confidence level of 6 sigma, or near certainty, is required.
- If the **changes in dark energy density are confirmed**, it could lead to a complete overhaul of our current understanding of the universe.

- It would provide the **first glimpse into the nature of dark energy**, which is currently unknown.
- Speculations about the nature of dark energy include it being a **new invisible field (like electric, magnetic, or gravitational)** or a new particle.
- The scientific community is keenly observing the **DESI data for further insights**.
- It accounts for approximately **68% of the total energy content of the universe as:**
- Astronomers have observed other galaxies getting farther away from us over time, they know the universe is expanding.
- The pull of gravity implies this expansion should be slowing down—but over the past 7.5 billion years, it's been getting faster.
- The new research culminated in a **3D map measuring how the universe has expanded over the past 11 billion years**.
- The data was collected by **the Dark Energy Spectroscopic Instrument (DESI)**
- The **DESI collaboration plans to analyze data** from subsequent years of observations immediately to further investigate the potential changes in dark energy intensity.
- The key points focus on the theoretical implications of **constant versus changing dark energy density**, the initial hints from DESI data,
- The required confidence levels for scientific discovery, and the potential for new physics if changes are confirmed.

Space Junk

News Excerpt

Recently, a Space Debris was found in a Western Australia beach, claimed by India's space agency to be from one of its Polar Satellite Launch Vehicles (PSLV).

Key Points:

- The Subject of "Space" comes under the list 3 of Schedule 7 of the Indian Constitution i.e.- the Residual list.
- The Indian Space Research Organisation, commonly referred to as **ISRO** is the **National Space Agency of India**.
- It operates under the **Department of Space (DOS)** which is directly overseen by the Prime Minister of India, while the Chairman of ISRO also acts as the executive of DOS.

About Space Debris

- Space debris, also known as Space Junk is any piece of machinery or debris left by humans in space.
- It can refer to big objects such as dead satellites that have failed or been left in orbit at the end of their mission.

- It can also refer to smaller things, like bits of debris or paint flecks that have fallen off a rocket.

Recent Case of Space Debris in Western Australia

- India has confirmed that an object that washed up on a Western Australian beach recently was from one of its rockets.
- The giant metal dome was found at Green Head beach, about 250km (155 miles) north of Perth, in mid-July - prompting speculation about its origins.
- Australian Space Agency (ASA) said that the object was "most likely" the third stage of a PSLV, which are used by India to launch satellites into orbit.

What Australia can do with the Debris?

- There are diverse views and plan on what to do with this Space Debris by various Stakeholders.
- **Western Australia** – It has already indicated it would be happy to keep it. The state's premier, Roger Cook, suggested to local media that the object could be stored in the state museum alongside debris from Nasa's Skylab station, which was discovered in 1979.
- **Locals** -said they might be interested in turning it into a local tourist attraction, according to the Australian Broadcasting Corporation (ABC).
- The object is currently in storage with the ASA. It is still not clear which mission it was used in, nor how long it had been in the water before washing up at Green Head.

Problems associated with the Space Debris

- **Space debris represents a risk to spacecraft** - Collisions with debris have become a hazard to spacecraft; the smallest objects cause damage akin to sandblasting, especially to solar panels and optics like telescopes or star trackers that cannot easily be protected by a ballistic shield.
- **It can cause Property loss or damage** – Space debris can fall on earth and can damage properties. It could cause great heritage loss if falls on heritage like Qutab minar, Taj Mahal, Agra fort etc.
- **It can lead to loss of Human lives** – If fall on a densely populated place, it can really lead to a great human fatality and catastrophe.
- **It can lead to Space War-** Space debris is harming various costly and expensive space satellites and programmes. Due to this many countries are getting threats.
- **It has increased the cost of the Space Projects-** Currently, depending on the orbit, up to 10% of the costs of a mission correspond to tasks focusing on reducing impact risks with space debris. If this continues to grow, costs will increase.

Solutions to the problem of Space Debris

- **Technological fixing:** This include removing space debris from orbit with nets, harpoons, or lasers.
- **Managerial Fixing:** Deorbiting a satellite at the end of its life .

- **By Imposing Taxes:** Implement an orbital-use fee—a tax on orbiting satellites. Orbital-use fees could be straight-up fees or tradeable permits, and they could also be orbit-specific, since satellites in different orbits produce varying collision risks.
- **Reducing the number of mission-related debris** released in spacecraft deployment and operations (e.g., clamps, covers for lenses or sensors, de-spin devices, pyrotechnic release hardware, wraparound cables) may be one of the easier ways of decreasing the future debris hazard to space operations.
- **Reducing the Creation of Debris from Degradation -** The products of spacecraft surface deterioration include paint flecks and other surface materials that come loose from a space object under the influence of the space environment.

India's Initiatives on Space Debris:

- **Project NETRA-** It is an early warning system in space to detect debris and other hazards to Indian satellites.
- **Centre for Space Debris Research** – It has been set up by ISRO to monitor and mitigate the threat of space debris.
- **System for Safe and Sustainable Operations Management (IS 4 OM)** set up by ISRO in the year 2022 to continually monitor objects posing collision threats, predict the evolution of space debris, and mitigate the risk posed by space debris.
- ISRO also carried out **21 collision avoidance manoeuvres** of Indian operational space assets in 2022 to avoid collisions with other space objects.

Global Initiatives

- **ESA Initiatives** - Since the mid-1990s, ESA has performed **collision avoidance for their LEO satellites** via **ESA's Clean Space initiative**, the agency is committed to the development and testing of novel technological concepts aimed at the mitigation of space debris generation. Those activities are grouped under the **CleanSat project**.
- **The United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS), 2010** –It was established where the working group primarily focused on limiting the generation of space debris in the environment. The UN COPUOS guidelines are voluntary and non-binding fundamental principles which means that it has no legal obligation for the States and their nationals to comply.
- **The Inter-Agency Space Debris Coordination Committee (IADC)** is an inter-governmental forum whose aim is to co-ordinate efforts to deal with debris in orbit around the Earth founded in 1993.
- **The Outer Space Treaty** – It provides the basic framework on international space law, including the following principles:
 - The exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind;

- Outer space shall be free for exploration and use by all States;

Way Forward

- The problem of outer space safety suffers today from two broad problems.
- One is that broad international agreement on global space governance that was once possible through International Treaty and International Agreements, as in the 1960s and 1970s when the Outer Space Treaty and its four subsidiary agreements were reached and ratified, seems to be extremely difficult to achieve today.
- Today, the path forward seems to focus much more on soft law. Thus progress is more likely to involve national.

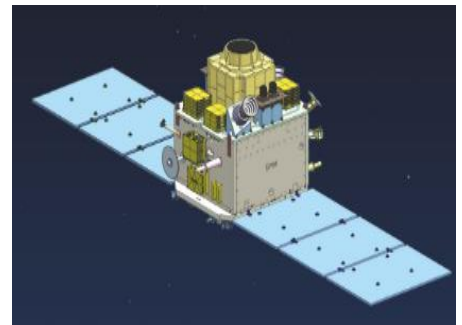
X-ray Polarimeter Satellite (XPoSat)

News Excerpt:

The successful launch of the **X-ray Polarimeter Satellite (XPoSat)** by the Indian Space Research Organisation (ISRO) ushers in a new era of astronomical exploration. This innovative payload, entirely indigenous in design and fabrication, promises to unlock profound cosmic secrets through its cutting-edge instrument, the **Indian X-ray Polarimeter (POLIX)**.

Key points:

- XPoSat (X-ray Polarimeter Satellite) is India's first dedicated polarimetry mission to study various dynamics of bright astronomical X-ray sources in extreme conditions.
- XPoSat is the world's second satellite-based mission to make X-ray polarimetry measurements.
- Its launch vehicle was ISRO's PSLV-C58.



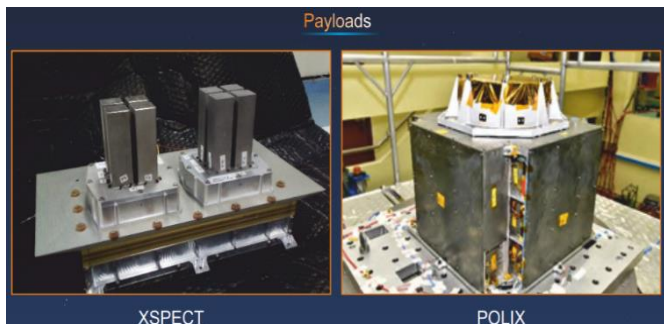
Mission Objective:

The primary goal of XPoSat is to study the polarization of X-rays coming from bright celestial sources in the medium frequency band. This is achieved through two scientific payloads: POLIX and XSPECT, developed by institutions in Bengaluru.

Payloads on XPoSat:

- **POLIX:** It is the world's first instrument operating in the 8 to 30 keV energy band. It includes a collimator and four X-ray proportional counter detectors to observe astronomical sources, particularly those emitting polarized X-rays.
- Moreover, there is a scatterer consisting of four X-ray proportional counter detectors (that prevent the trapped light from escaping).
- It will observe a few tens of astronomical sources.

- It was conceived, designed, and built at Raman Research Institute (RRI), Bangalore.
- **XSPECT:** It is designed for fast timing and high spectroscopic resolution in the 0.8-15 keV energy band. It observes various sources such as X-ray pulsars, black hole binaries, neutron stars, AGNs, and magnetars.



Significance of XPoSat:

- XPoSat will be a game-changer in enabling X-ray polarization measurements from bright sources, specifically in the medium energy band (8-30 keV), which has not been attempted previously.
- Studying polarized X-rays from sources like magnetars, black holes, and neutron stars can provide insights into the nature of radiation and the processes involved in its generation.

POLIX's Role in Astrophysical Exploration:

- XPoSat's POLIX is a complementary asset to global efforts in X-ray polarimetry.
- While previous attempts with balloon-borne instruments paved the way, recent endeavours like NASA's Imaging X-ray Polarimetry Explorer (IXPE) highlight the growing interest in this field.
- POLIX's unique capabilities promise to fill crucial gaps in understanding polarized X-rays from cosmic sources, offering a new lens to observe and decode celestial mysteries.

Conclusion:

The successful launch of XPoSat marks a significant leap for Indian astronomers, promising unparalleled opportunities to delve into the enigmatic realms of the universe. With its mission set to unravel the mysteries concealed within polarized X-rays from celestial sources, XPoSat is poised to redefine our understanding of cosmic phenomena and unveil new frontiers in astrophysics.

Gas Leakage from Venus

News Excerpts:

Recent studies have suggested that gases are escaping from Venus which explains the possible phenomenon of how the planet lost its water.

More About the News:

- Venus, often referred to as **Earth's "sister planet,"** or **Earth's "evil twin,"** shares similarities in size and composition.

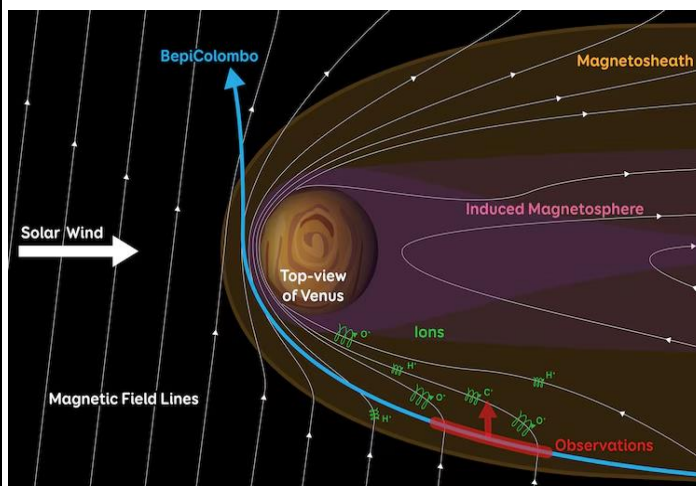
- But it exhibits stark differences, notably in its **lack of liquid water on the surface due to its extreme temperatures** and thick carbon dioxide-rich atmosphere.
- However, evidence suggests that Venus might have hosted liquid water in the distant past.

Bepi Colombo Mission Revelations:

- In 2021, the **BepiColombo mission** made significant discoveries during its **Venus fly-by**, about atmospheric escape mechanisms and Venus's evolutionary trajectory.

BepiColombo

- A collaborative effort between the **European Space Agency (ESA)** and the **Japan Aerospace Exploration Agency (JAXA)**, embarked on its journey to Mercury in October 2018.
- Comprises two spacecraft, the **Mercury Planetary Orbiter (MPO)** provided by ESA and the **Mercury Magnetospheric Orbiter (MMO)** provided by JAXA.
- **Aim:**
 - Orbit Mercury from the end of 2025 onwards,
 - Provide unprecedented insights into the innermost planet,
 - Deepen our understanding of Mercury's origin, composition, geophysics, atmosphere, magnetosphere, and history.



Understanding Venus's Evolution:

- Insights gleaned from studying atmospheric escape mechanisms are crucial for comprehending Venus's evolution and its transition to a water-deprived world.
- These findings offer valuable clues about the planet's climatic history and habitability potential.

Solar Wind Interaction and Atmospheric Loss:

- Venus's absence of a strong magnetic field exposes its upper atmosphere to the solar wind, resulting in atmospheric escape.
- The interaction between **charged particles emitted by the Sun and Venus's upper atmosphere leads to the**

gradual loss of ions, such as hydrogen and oxygen, into space, contributing to the planet's atmospheric erosion over time.

Implications for Venus's Atmospheric Evolution:

- The study highlights the importance of characterizing the escape of ions from Venus for understanding the planet's atmospheric evolution, particularly regarding the loss of water from its surface.
- These insights offer valuable perspectives on the general climate and habitability evolution of terrestrial planets and exoplanetary systems.

Future Exploration of Venus:

- Several upcoming spacecraft missions aim to investigate Venus and its environment further, promising to fill in many gaps in our understanding, including the
- **Indian Space Research Organisation's Shukrayaan orbiter,**
- **European Space Agency's Envision mission, NASA's VERITAS orbiter and DAVINCI probe.**

India's PRATUSH

News Excerpt:

Astronomers are looking forward to opening a new window on the universe by **posting high-resolution telescopes on the moon**, and in orbit around it. One of the proposals is from India called **PRATUSH**.

Shortcomings of Earth based telescopes:

- On the earth, **optical telescopes (which collect visible light at longer wavelengths)** and **radio telescopes (which collect radio waves with the shortest wavelengths)** have to peer through layers of the **planet's atmosphere**.
- While it is becoming increasingly difficult for optical instruments to see through the **polluted skies**, radio telescopes also contend with **radio and TV signals** adding to the cacophony of the **electromagnetic 'hiss' from the communications** channels used by **radar systems, aircraft, and satellites**.
- It also does not help that the earth's **ionosphere blocks radio waves** coming from outer space.

Concept of Lunar orbit telescope:

- Scientists tried to find a way out of this by launching radio telescopes into orbit around the earth. But this only made the problem worse, as **orbiting telescopes** started receiving **radio noise from the whole planet** along with signals from outer space.
- So, astronomers are now considering placing **optical and radio telescopes** on the **far side of the moon**, which **always faces away from the earth**.
- The **pristine, airless desolation** of the **moon provides optical telescopes crystal-clear seeing conditions** throughout the **two-week-long lunar night**.

- Radio telescopes on the lunar far side will also be **protected by the moon (it will blot out radio transmissions from the earth and electrically charged plasma winds blowing from the Sun)**.
- Moon promises to open up **"the most radio-quiet location in the solar system**.

About PRATUSH (Probing ReionizATIion of the Universe using Signal from Hydrogen)

- PRATUSH is a **future radiometer in lunar orbit** that will reveal the **Cosmic Dawn of our Universe**.
- It is being built by the **Raman Research Institute (RRI)** in Bengaluru with active collaboration from the **Indian Space Research Organisation (ISRO)**.
- **ISRO will place PRATUSH into orbit around the earth**. After some fine-tuning, the space agency will launch it moonwards.
- Although earth orbit will have significant **radio frequency interference (RFI)**, it will have advantages compared to ground-based experiments, such as operating in free space and lesser ionosphere impact.
- PRATUSH in lunar orbit will have the **ideal observing conditions operating in free space** with **minimal RFI** and **no ionosphere** to speak of.
- It will carry a **wideband frequency-independent antenna**, a **self-calibrating analog receiver** and a **digital correlator** to **catch radio noise** in the all-important signal from the Dark Ages.

Significance of PRATUSH:

- PRATUSH will **answer the question** of when the **first stars formed** in our universe, the **nature of the first stars**, and **what was the light from the first stars** or, in other words, **the colour of the light of Cosmic Dawn**.
- PRATUSH will be the **pioneering space telescope** that will reveal, for the first time, the **history of our infant Universe** as it **transformed after the Big Bang - from cold gas into stars and galaxies** and the universe as we know it today.
- PRATUSH will inform us of the first rays of the first Sun in the infant universe.

SETI & METI

News Excerpt:

Search for Extra-terrestrial Intelligence (SETI) is as fascinating for the casual observer as it is for an engaged specialist.

Radio Signals vis-a-vis Neutrino Signals:

- Researchers use electromagnetic wave signals across the cosmos to identify ourselves and others, ranging from narrow-frequency radio signals to wideband signals.
- However, differentiating naturally occurring waves (like radio noise from the magnetosphere of Jupiter or the environs of stars) from those transmitted from more interesting sources is challenging.
- Space waves are distorted during their journey to Earth, and their information may not survive the journey intact.

Search for Extraterrestrial Intelligence (SETI):

It is a scientific adventure that aims to discover life on other planets, particularly intelligent beings, with technological advancements equal to our own.

Messaging Extraterrestrial Intelligence (METI)



It is a scheme to communicate with intelligent alien life in outer space. It began in 1960 and has evolved over the years.



NASA launched Pioneer 10 and 11 spacecraft in 1972 and 1973 to study the outer Solar System. Each spacecraft carried a plaque depicting human bodies, hydrogen atom properties, cosmic landmarks, and an image of the spacecraft.



In 1974, scientists like Frank Drake and Carl Sagan encoded a graphical message into radio waves and broadcasted it to the M13 globular cluster.



METI has gained momentum in recent decades with satellites and astronomy programs aiming to find exoplanets orbiting other stars.

- Scientists are exploring the possibility of extraterrestrial intelligence communicating with us through neutrinos, the most abundant particles in the universe after photons.
- Neutrinos are subatomic particles. After photons, light particles are the most abundant particles in the universe.
- Neutrinos interact weakly with matter and can move relatively untouched through the same media as electromagnetic waves.

Recent developments and collaborative efforts:

- Scientists are studying instances of radioactive decay that involve neutrinos. A 2017 experiment at Purdue University found that the decay rate of radioactive manganese declined sharply due to small changes in the ambient flow of neutrinos.
- The scientists proposed setting up decay experiments at different sites worldwide and analyzing the collected data for signs of a non-uniform neutrino flux, which could be associated with events in outer space. They called their proposal **NU-SETI**.
- They premised that this is an experimental fact that advanced extraterrestrial civilizations could understand and use to communicate with us.
- Some METI efforts suggest physical structures or artefacts built by aliens, such as light from the star **KIC 8462852**, which exhibited a periodic dimming pattern.
- One hypothesis is that an alien structure obstructs our view of the star.

- SETI and METI programs have collaborated on scientific initiatives to increase technical understanding and literacy of human longevity and sustenance on multigenerational timescales.

Challenges:

- Performing SETI or METI activities is challenging due to our limited indirect methods to traverse space, and one has no clear expectations of what one should find.
- SETI and METI practitioners are likely to be intercepted or received in specific parts of space or on specific worlds, requiring attention to language, content, and medium properties.

Way Forward:

- SETI and METI practitioners have also had to consider interstellar aspirations, such as Elon Musk's aspiration to colonize Mars and a new space race to establish bases on the Moon.
- These efforts demand scholars working as a global community to understand life, its existence, forms, and identification.
- They need to pay attention to the language and the content while also considering the properties of the transmission medium.
- Efforts should include radio signals, optical telescopes, laser light, and neutrinos. The ultimate goal is to understand the universe and its potential intelligence.

How SpaceX's Starship Could Revolutionize Space Travel and Exploration

News Excerpt:

SpaceX's Starship rocket achieved a significant milestone with its first fully successful test flight, its booster and spacecraft executed a gentle splashdown after an hour-long sub-orbital journey.

More about the news:

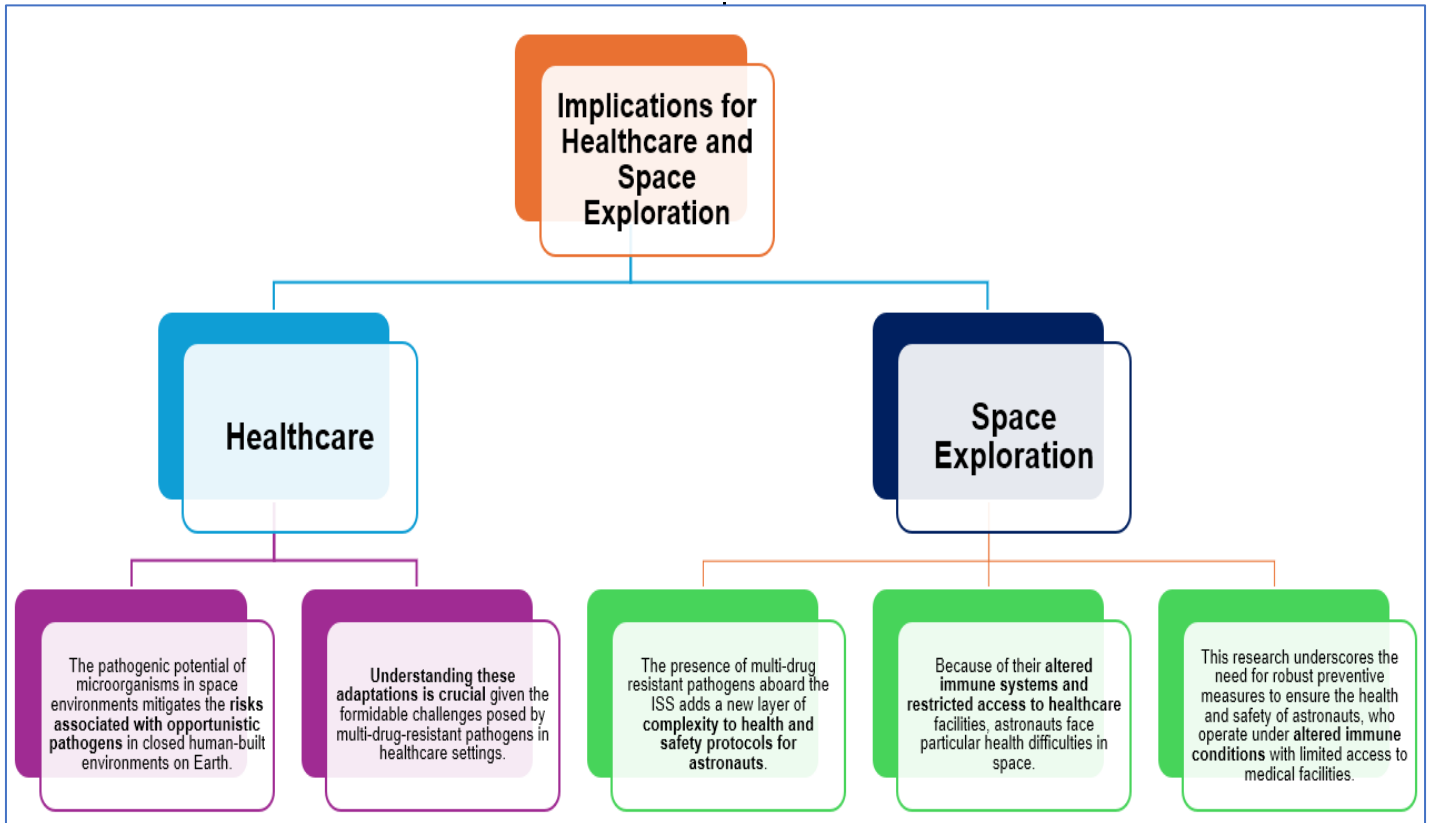
This marked SpaceX's fourth attempt to launch the colossal Starship, bringing it one step closer to revolutionizing space travel and exploration.

Starship:

- Starship is a two-stage heavy lift-off vehicle designed to transport crew and cargo to Earth orbit, the Moon, Mars, and beyond.

Space travel and exploration

Indian-origin entrepreneur and **pilot Gopichand Thotakura** made history as the first Indian tourist to journey into space, participating in Amazon founder Jeff Bezos' **Blue Origin NS-25 mission**.



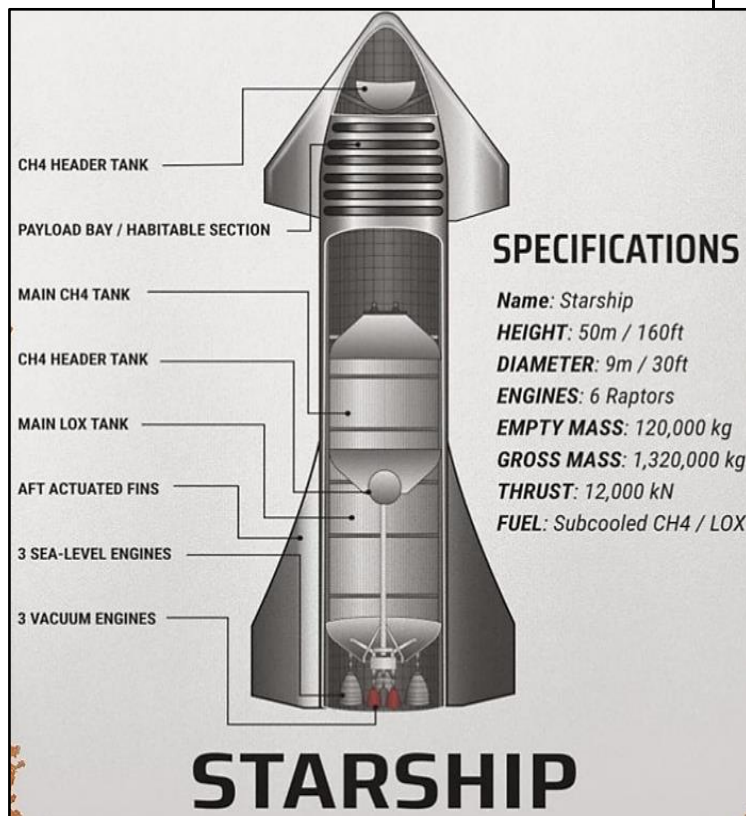
- It is the **largest rocket ever flown; its height is 120m** surpassing the **Saturn V** which was **111m** (carried Neil Armstrong to the Moon).
- The rocket's lower stage, known as **Super Heavy**, comprises **33 Raptor engines** generating **74 meganewtons of thrust**, nearly double that of **NASA's Space Launch System (SLS)** and the Saturn V.

These engines use a **mixture of liquid oxygen and liquid methane, enhancing efficiency and reusability.**

Significance of the development:

Reducing the Cost of Space Travel facilitated by:

- **High Payload Capacity:** Starship is **expected to carry up to 150 tonnes of payload to low-Earth orbit and at least 100 tonnes to the Moon and Mars** which exceeds all previous missions, enabling more extensive scientific and commercial activities in space.
- **In-Orbit Refueling:** SpaceX is developing the capability to **refuel Starship** in Earth orbit using other Starships.
 - This innovation allows for increased payload capacity and the use of more advanced scientific instruments, effectively operating like an airplane that can be quickly refueled and redeployed.
- **Complete Reusability:** Unlike other launch systems where hardware is often discarded, Starship's principal components are designed to be fully reusable.
 - Both the **Super Heavy booster** and the **Starship spacecraft** can re-enter Earth's atmosphere and land back at the launch site, significantly reducing costs associated with building new rockets for each mission.



Facilitating Space Exploration

- This will enable scientists to launch larger and more sophisticated space telescopes, built from heavier but cheaper materials.



- Future missions to the Moon and Mars could carry substantial equipment, such as full-sized drilling rigs, to explore the planets' interiors and uncover valuable resources.
- Moreover, Starship's ability to return to Earth means **it can bring back large quantities of samples from the Moon and other planets**, aiding scientists in unraveling the mysteries of our solar system and the origins of life.
- The rocket system is also integral to **NASA's Artemis program**
 - **It aims to return astronauts to the Moon by 2030 and to send humans to Mars by the end of the next decade.**

Challenges

- Historical challenges, such as those faced by NASA's Space Shuttle program, highlight the difficulty in making reusable spacecraft economical.
- Additionally, while Starship's development has been rapid compared to other launch vehicles, it has not been without setbacks.
- Balancing rapid innovation with safety and reliability remains a critical challenge for SpaceX.
 - The accelerated pace of development at SpaceX has led to at least 600 previously unreported workplace injuries, raising concerns about the safety and well-being of employees.

Superbug on ISS Raises Health Concerns for Astronauts

News Excerpt:

Researchers from the **Indian Institute of Technology Madras (IIT-M)** and **NASA's Jet Propulsion Laboratory (JPL)** have conducted a joint study examining the behavior of multi-drug resistant pathogens on the International Space Station (ISS).

What is a Superbug?

- A superbug may be a **bacteria, virus, parasite, or fungi** that has become resistant to multiple drugs typically used to treat these infections.
- Superbugs **can't be stopped by the first line of drugs.**

- This resistance makes infections caused by superbugs particularly difficult to treat and control. The development and spread of superbugs pose a **significant public health threat worldwide.**
- Superbug infections can lead to **higher rates of death** from otherwise treatable diseases.

More about this research:

- Research on **Enterobacter bugandensis** offers potential for improving hospital infection management and enhancing astronaut health.
- The study focused on the **genomic, functional, and metabolic adaptations** of **Enterobacter bugandensis**,

ESKAPE:

- The **ESKAPE** pathogens **Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacter species** are the **primary culprits behind hospital-acquired infections globally.**
- These pathogens are notably **multidrug-resistant**, posing one of the biggest challenges in clinical settings.
- **Multidrug resistance ranks among the top three global public health threats and is often driven by excessive or improper drug use, misuse of antimicrobials, and low-quality pharmaceuticals.**
- These factors contribute to the pathogens' ability to **survive traditional treatments**, making infections harder to control and increasing the need for new antimicrobial strategies.

a pathogen known for its resistance to third-generation cephalosporins and quinolones.

- These adaptations make Enterobacter infections particularly challenging to treat.
- **Enterobacter species** are part of the **ESKAPE group of pathogens**, which the World Health Organization (WHO) has identified as a priority for developing new antimicrobials.

Experiment environment and methodology

- The researchers investigated the mechanisms that enable Enterobacter bugandensis to thrive in the **unique environment** of the International Space Station (ISS).
- The ISS, with its **microgravity, heightened carbon dioxide levels, and increased radiation**, provides a distinctive setting for studying microbial dynamics.
- Researchers isolated **13 strains** of E. bugandensis from various surfaces within the ISS. These strains exhibited **accelerated mutations**, making them **genetically and functionally distinct** from their Earth counterparts.
- Strategies for controlling microbial contamination in enclosed spaces like spacecraft and hospitals can be guided by **understanding the persistence and succession patterns of E. Bugandensis in space**, according to the research.

ISRO successfully tests a 3D-printed rocket engine

News Excerpt:

Indian Space Research Organisation (ISRO) achieved a major milestone with the successful hot testing of a liquid rocket engine manufactured through **Additive Manufacturing (AM) technology** — commonly known as 3D printing. The engine used is the PSLV upper stage.

Why did ISRO use 3D printing to build the PS4 engine?

- The engine, PS4 was redesigned by ISRO for production using 3D printing using the **Laser Powder Bed Fusion technique**. This helped ISRO to bring down the number of parts in the engine from 14 to a single piece.
- **Benefit:** The space agency was able to eliminate 19 weld joints and saved 97% of the raw material. It also reduced the overall production time by 60%.
- **Other examples:**
 - NASA, in collaboration with various research institutions, has developed materials that can withstand extreme temperature fluctuations, radiation, and micrometeoroids.
 - The first metal 3D printer for space, developed by Airbus for the European Space Agency (ESA), will soon be tested aboard the Columbus module of the International Space Station (ISS).

What is Additive Manufacturing (AM)?

- 3D printing, or AM, is a process that **uses computer-created design to make three-dimensional objects layer by layer**.
- It is an **additive process**, in which **layers of a material** like plastic, composites or biomaterials are **built up to construct objects that range in shape, size, rigidity, and colour**.

Opportunities:

- Since AM can be **set up easily without any tools and different materials can be used for production**, AM can adapt to any culture or location to fit multiple approaches of circular economy.
- Additive manufacturing has the **potential to positively affect human spaceflight operations** by enabling the in-orbit manufacture of replacement parts and tools, which could reduce existing logistics requirements for the International Space Station and future long-duration human space missions.

Challenges:

- **Many AM technologies are limited by the materials they can use.** Not all metals and plastics can be temperature-controlled enough for the conditions that AM requires.
- **Energy consumption of AM is still high.** Technological development is lacking in integrating renewable energy sources to power AM.
- **Intellectual property (IP) rights may hinder this process** since organizations need to share their product design with a third party to produce a specific part/item.

India's first satellite network portal site

News Excerpt

The Gujarat government signed a memorandum of understanding with **OneWeb India Communications Pvt Ltd** for setting up a 'satellite network portal site' in Gujarat.

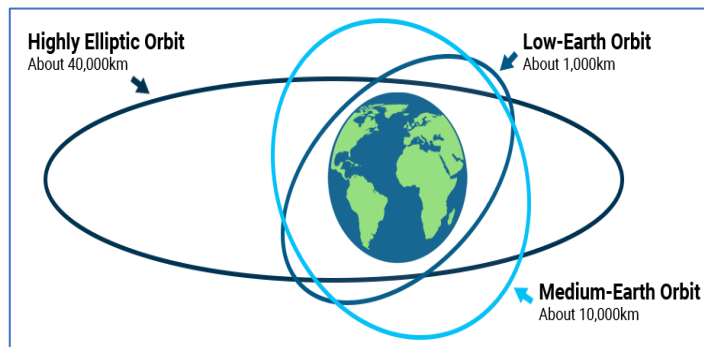
Satellite Network Portals (SNPs):

- Satellite network portals are online platforms that offer users access to satellite services.
- They serve as gateways for managing satellite communication aspects like satellite internet and navigation.
- These portals provide tools for tasks such as tracking satellite positions, analyzing imagery, and configuring settings, aiding users in effectively utilizing satellite technology.

Important Points

- According to India's inequality report of Oxfam international, **Rural internet usage in India stands at 31%**, while **urban usage is 67%**.
- **Merely 9% of students have internet-equipped computers**, and **25% can access it through various devices**, revealing digital disparities between urban and rural areas and within the student population.

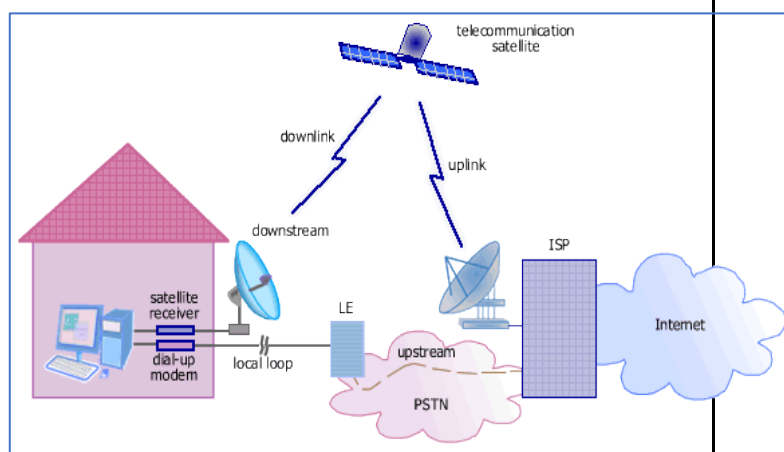
- Satellite broadband technology, including **low Earth orbit (LEO) constellations like StarLink, Kuiper, and OneWeb**, is gaining prominence for global communication.
- **LEO satellites, positioned 500-1,200 km above Earth**, offer high-speed and low-latency connectivity, reducing data transmission delays.
- According to an estimate India requires at least **2 satellite network portals (SNPs)** due to its vast geography.
- Current shift towards LEO satellite communications signifies a growing reliance on advanced satellite technologies for seamless connectivity.



Satellite Broadband Technology:

- Satellite broadband technology involves using satellites in space to provide high-speed internet access to remote or underserved areas on Earth.
- This technology has evolved with the emergence of low Earth orbit (LEO) satellite constellations like StarLink, OneWeb, and Kuiper.
- These constellations consist of numerous small satellites orbiting closer to Earth, enabling faster data transmission and reduced latency compared to geostationary satellites.

How does satellite internet work?



- Satellite internet works by transmitting an internet signal from an internet service provider to a satellite in space.
- The signal is then beamed back to users on Earth, where it is captured by a satellite dish.

- The satellite dish is typically connected to a modem, which then connects the user's computer or other devices to the internet signal.
- This process is repeated every time data is sent or received, allowing users to access the internet via satellite.

Potential in India

- As per ICRA's 2021 report, the number of satellite internet users is anticipated to increase by almost six times, hitting approximately 2 million by 2025.
- Satellite broadband holds significant potential, especially for bridging the digital divide in rural and remote regions where traditional infrastructure is lacking.
- It can provide reliable internet access to areas with challenging terrain or inadequate connectivity options.
- This technology can encourage e-learning, telemedicine, e-commerce, and communication services, empowering communities and boosting economic growth.

Significance

- Satellite broadband's significance lies in its ability to **offer global coverage, overcoming terrestrial limitations**.
- In a vast country like India, where laying cables and building infrastructure can be challenging, **satellite broadband can rapidly extend connectivity**.
- It contributes to the **government's Digital India initiative**, facilitating equitable access to information and services.

Challenges

- **Cost:** High initial expenses make satellite technology implementation too expensive for end users.
- **Spectrum Allocation:** Efficient allocation of frequency spectrum is crucial to prevent interference and ensure optimal performance.
- **Regulatory Hurdles:** Regulations around satellite deployment, spectrum usage, and licensing need to be streamlined to encourage investment and innovation.
- **Latency:** Even though LEO satellites have less latency, there are still problems, especially for applications that need real-time communication.

Way Forward:

- **Affordability:** It is important to work to reduce user prices so that more people can receive satellite broadband.
- **Infrastructure Sharing:** Collaborations between satellite operators can result in more effective resource use and lower costs.
- **Policy Reforms:** Governments should provide enabling regulations to promote private sector investment and satellite technology innovation.
- **Last-Mile Connectivity:** Widespread access must be made possible by integrating satellite broadband with local networks and taking it the last mile.
- **Skill Development:** Satellite broadband technology's acceptance and sustainability will be boosted by teaching local populations how to utilize and maintain it.

Copernicus Emergency Management Service

News Excerpt:

The European Union (EU) activated its **Copernicus Emergency Management Service (EMS) satellite mapping service** at Iran's request to locate the crashed chopper of its president.

- Grading Product: In-depth damage assessment to guide targeted interventions and decisions.

Venus water mystery

News Excerpt:

More than four billion years ago, **Venus** had enough water to **cover its surface with an ocean 3 km deep**. Today, the planet only has enough for this ocean to be **3 cm deep**.

More about News:

- Scientists have been able to account for a **lot of the water Venus lost** in this time but not all of it. Now, a team of scientists in the U.S. may have made a crucial advance.

- The team of scientists in the U.S. findings could plug a **long-standing gap** between the **amount of water scientists expected Venus to have lost** in the last 4.5 billion years and **how much satellite observations say the planet has lost**, which is a lot more.

Causes of Water loss:

- There are **two reasons** why Venus lost its water.

- The **first** is its **hellish atmosphere** as a result of its **carbon dioxide-rich composition**, which causes a **strong greenhouse**

What is the Copernicus program

The Copernicus program, a part of the EU's space initiatives, is designed to **monitor the Earth and its environment** by collecting data from a constellation of satellites known as the Sentinels.

It provides processed and analyzed data for various applications, including land management, marine environment monitoring, atmospheric studies, emergency response, security, and climate change adaptation.

It also gathers data from other missions and sources such as ground stations.

Named after the renowned 15th-century scientist Nicolaus Copernicus.

The program was initially launched in 1998 as the **Global Monitoring for Environment and Security Program (GMES)**.

What is Copernicus EMS & rapid response mapping service:

- Part of the EU's Copernicus program, established in 2012.
- Uses satellite remote sensing to provide crucial geospatial information for managing disasters and humanitarian crises.
- Comprises two main components: mapping (including rapid mapping and risk & recovery mapping) and early warning systems.
- Rapid mapping delivers timely geospatial intelligence post-disaster to aid decision-making and emergency response efforts.

How does rapid mapping work:

- Designed for fast provision of geospatial data post-disaster, aiding emergency response globally.
- Activation focuses on single events with multiple areas of interest (AOIs) for detailed analysis.
- Products include a pre-event reference and three post-event assessments:
 - Reference Product: Baseline data for preparedness and response planning.
 - First Estimate Product: Initial assessment of severely affected areas for resource prioritization.
 - Delineation Product: Detailed analysis of disaster extent and impact evolution.

effect.

- The **planet's surface is hotter than water's boiling point**, simmering at 450 degrees C. So, water can only exist as vapor in Venus' atmosphere.
- **Second**, water was a victim of the **planet's proximity to the Sun**.
 - The Sun's heat and ultraviolet radiation broke **water molecules into hydrogen and oxygen atoms** in Venus's ionosphere, where charged particles move rapidly.
- The **two theories** broadly blame **thermal and non-thermal processes for the water loss**.
 - **The thermal process** refers to **hydrodynamic escape**. As the Sun heated Venus's outer atmosphere, it expanded, allowing hydrogen gas to leak into space. This escape lasted until the outer atmosphere sufficiently cooled, about 2.5 billion years ago.
 - Research focused on how water loss occurs in the present day, specifically via a **non-thermal process**.
 - They focused on hydrogen atoms escaping Venus to space. Water levels drop as a result because the oxygen atoms left behind have fewer hydrogen atoms with which to form water.

Key Findings:

- **HCO⁺ dissociative recombination reaction (DR)** occurs at an altitude of about 125 km above the clouds of Venus, in the upper atmosphere.
 - This reaction was found to **accelerate the decline of water on Venus** after the hydrodynamic escape of **hydrogen gas ended**.
 - The **HCO⁺ DR reaction** could have doubled the rate at which Venus lost water through hydrogen escape.
- If **Venus** had oceans in the past, they could have lasted longer than expected due to the faster rate of hydrogen escape, which would have allowed more water to be lost in the same amount of time.
- According to the model, the amount of water on Venus would have stayed roughly the same from nearly 2 billion years ago until the period when the HCO⁺ DR reaction started influencing water loss.

- Collection of data on **aerosol optical depth, atmospheric water vapor, and cloud cover.**

TRISHNA Payload:

Primarily it will be equipped with two Payloads:

- **Thermal Infra-Red (TIR) payload provided by CNES:**
 - Four-channel long-wave **infrared imaging sensor capable of high-resolution surface temperature and emissivity mapping.**
- **Visible - Near Infra-Red - Short Wave Infra-Red (VNIR-SWIR) payload provided by ISRO includes Seven spectral bands for detailed mapping of surface reflectance.**

Operational details:

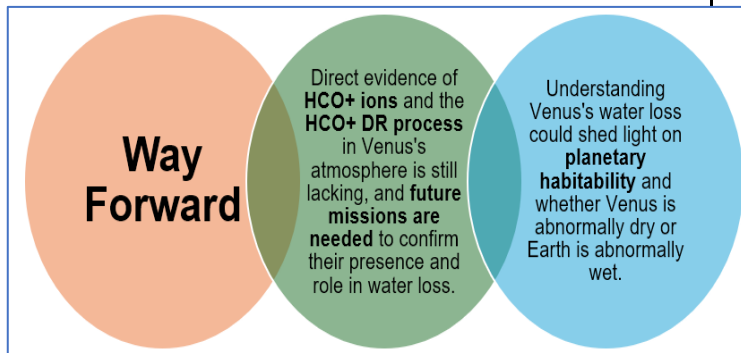
- It will be launched into a Sun-synchronous **orbit** at 761 km altitude. It has an **operational life of five years.**

Scientific and Societal Benefits:

- Assessment of irrigation water use, and issuance of advisories for water savings.
- Enhancement of crop water productivity through efficient practices and better micro-watershed management.
- **Tracking droughts, monitoring permafrost changes, and measuring evapotranspiration rates.**
- Detailed maps of urban heat islands and alerts for mitigating heatwave effects.
- Detection of pollution in coastal and inland water bodies.
- Identification of submarine groundwater discharge at coastal fringes.
- Detection of sub-surface fires.
- Assessment of geothermal resources.
- Understanding snow cover and snow-melt patterns.
- Contribution to improved hydrological models and water management strategies.

Global Contributions

- **Support for global initiatives like** the Group on Earth Observations Global Agricultural Monitoring (**GEOGLAM**) program, the United Nations' Sustainable Development Goals (**SDGs**), and the **Global Water Watch.**



TRISHNA Mission

News Excerpt:

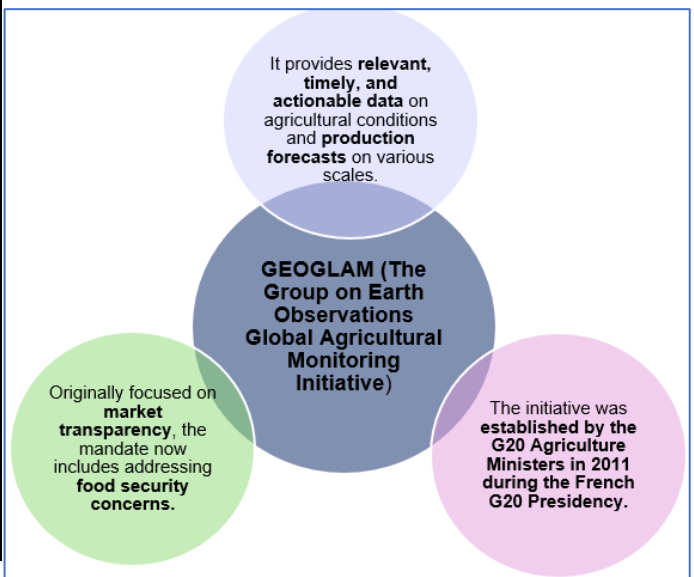
In a major boost to global efforts to monitor and mitigate climate change, the **Indian Space Research Organization (ISRO) is collaborating with the French Space Agency (CNES)** on an ambitious new satellite mission called **TRISHNA**.

More about the mission:

- **Slated for launch in 2025**, Trishna (**Thermal Infra-Red Imaging Satellite for High-Resolution Natural Resource Assessment**) will be a game-changer in using space-based thermal infrared imaging.
- It is **focused on studying the impacts of climate change and supporting sustainable management of precious natural resources like water.**

Mission Objectives and Capabilities

- Detailed monitoring of the **energy and water budgets** of the continental biosphere and **quantification of terrestrial water stress and water use.**
- High-resolution observations of **water quality and dynamics in coastal and inland waters.**
- Assessment of **urban heat islands** and detection of thermal anomalies linked to **volcanic activity** and **geothermal resources.**
- Monitoring of **snow-melt runoff and glacier dynamics.**



- Outputs serve as Essential Agricultural Variables (EAVs) and Essential Climate Variables (ECVs).

TECHNOLOGIES IN NEWS

Modified Nano Sheets

News Excerpt

Recent observations of IISC stated that chemically modified Nano-sheets are highly effective for biomedical applications.

About Chemically Modified Nano Sheets:

- Chemically modified nano sheets are atomically thin, two-dimensional materials that undergo chemical modifications to enhance their properties and functionality.
- These materials can be derived from diverse substances such as **graphene, transition metal dichalcogenides (TMDs)**, and other layered compounds.
- By altering their chemical composition, researchers can tailor their physical, electrical, optical, and mechanical properties to suit specific applications.

Chemical Modification Techniques:

- Chemical functionalization involves altering the surface properties of nanosheets by attaching various chemical groups or molecules.
- This process allows researchers to tailor the nano sheets' properties, enabling precise control over their behavior in biological environments.
- Several chemical modification techniques, such as covalent and non-covalent functionalization, have been employed to achieve desired characteristics.

Potential Applications:

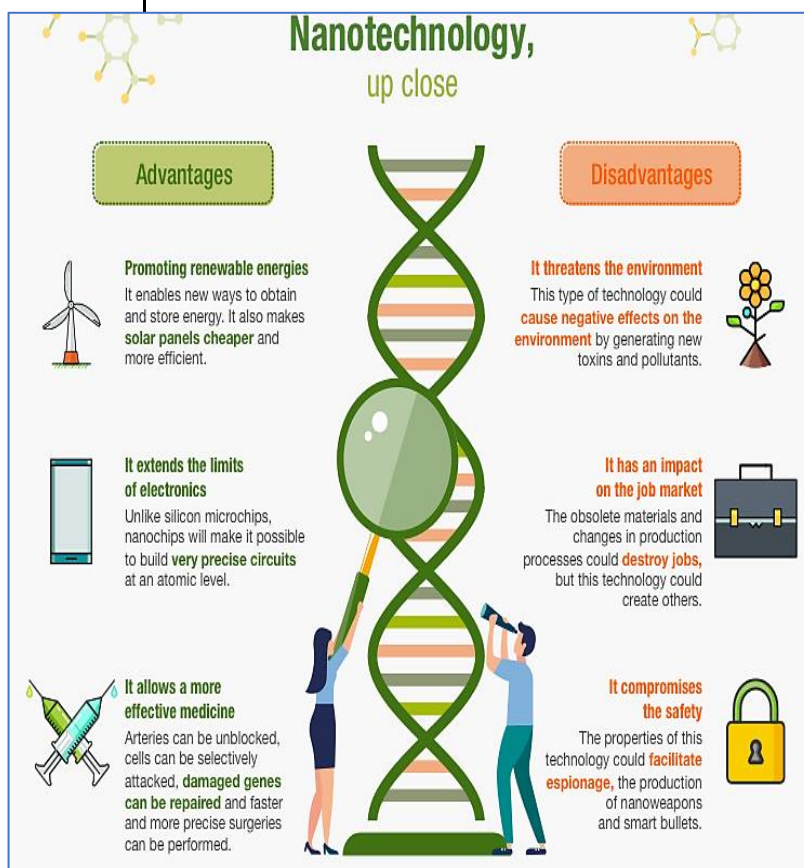
• Electronics and Optoelectronics:

- Chemically modified nano sheets exhibit exceptional electrical conductivity, high carrier mobility, and tunable band gaps. These properties make them ideal for next-generation electronic devices, ultrafast transistors, and flexible, transparent displays.
- Additionally, their unique optical properties enable their integration into optoelectronic devices like photo detectors and sensors.

• Energy Storage and Conversion:

- Nano sheets offer opportunities for significant advancements in energy storage and conversion technologies. Their high surface-to-volume ratio and mechanical flexibility make them suitable for super capacitors, batteries, and fuel cells.

- Furthermore, their efficient catalytic activity enhances energy conversion in solar cells and hydrogen production systems.
- **Biomedical Applications:**
 - Chemically modified nano sheets hold promise in biomedical applications due to their biocompatibility, large surface area, and tunable drug delivery capabilities.
 - They can be utilized for targeted drug delivery systems, biosensors, tissue engineering scaffolds, and diagnostic tools for early disease detection. Ex: Cancer detection and treatment: Gold nanoparticles, Smart pills, Nanobots
- **Tissue Engineering and Regenerative Medicine:**
 - By mimicking the extracellular matrix and providing a scaffold for cell growth and tissue formation, nano sheets can promote tissue regeneration.
 - Surface functionalization of nano sheets can enhance their biocompatibility, cellular adhesion, and integration with host tissues, facilitating the regeneration of damaged or diseased tissues.
- **Drug Delivery Systems:**
 - By modifying their surface with specific ligands or polymers, nano sheets can encapsulate therapeutic agents and transport them to the desired site within the body.
 - The controlled release of drugs from nano sheets offers several advantages, including enhanced drug efficacy, reduced side effects, and improved patient compliance.



Quantum entanglement
Quantum entanglement is when two atoms are connected, or entangled, despite being separated. If you change the properties of one of them, the other changes instantly.

Quantum tunnelling
Quantum tunnelling is a quantum mechanical phenomenon in which an object such as an electron or atom passes through a potential energy barrier that, according to classical mechanics, the object does not have sufficient energy to enter or surmount.

Quantum superposition
Quantum superposition is the theory that sub-atomic particles exist in multiple states simultaneously.

Quantum technology is a class of technology that works by using the principles of quantum mechanics (The physics of sub-atomic particles), including quantum entanglement and quantum superposition.

The field of quantum technology was first outlined in a 1997.

Quantum mechanics is a fundamental theory in physics that provides a description of the physical properties of nature at the scale of atoms and subatomic particles.

Advantages & disadvantages of Quantum technology

Advantages:

1. Increased Computing Power,
2. Improved Security,
3. Better Sensing and Measurement,
4. Enhanced AI,
5. Faster Communication

Disadvantages:

1. Expensive,
2. Limited Applications,
3. Limited Control,
4. Sensitivity to Environment

- Furthermore, the large surface area of nano sheets enables loading multiple drugs simultaneously, opening new possibilities for combination therapies.
- **Environmental Remediation:**
 - Nano sheets can be engineered to remove pollutants from air and water due to their large surface area and adsorption capacity.
 - These materials show potential for water purification, air filtration, and the remediation of toxic contaminants.

Advancements and Challenges:

- Techniques such as chemical vapor deposition, plasma-assisted methods, and chemical exfoliation enable the production of large-scale, high-quality nanosheets.
- Additionally, precise control over their chemical modifications allows for tailoring their properties.
- However, challenges persist in terms of scalability, cost-effectiveness, and environmental impact.
- Ensuring reproducibility and standardization of synthesis methods, optimizing large-scale manufacturing processes, and addressing potential toxicity concerns are critical areas of focus for future research and development.

Conclusion:

Chemically modified nano sheets have emerged as a **cutting-edge technology with vast potential in biomedicine**. Their unique properties and versatile functionality make them a promising platform for biosensing, drug delivery systems, tissue engineering, and regenerative medicine. Continued research, collaboration, and investment in this field will be essential to unlock the full potential of chemically modified nano sheets, driving innovations that will shape the future of technology and society as a whole.

Quantum Technology

News Excerpt

Recently, National Quantum Mission received cabinet approval at a total cost of Rs. 6003.65 crores, to scale up scientific and industrial R&D, for accelerating Quantum Technology-led economic growth.

National Quantum Mission

- NQM is an eight-year (2023-24 to 2030-31) mission that will focus on everything quantum-related, from its initial development to its use in industries.
- This mission is to be implemented by the Department of Science and Technology in partnership with other departments.
- This is the only mission in the country so far, where the technology is not taken from any advanced countries. we will develop the technology ourselves.
- National Quantum Mission (NQM) will fund research and development of quantum computing technology and associated applications.
- The NQM will focus on four verticals of quantum technology –
- Quantum computing, quantum communication, quantum sensing and metrology, and quantum materials and devices.

Important Features of the Mission

- The Union Cabinet approved the National Quantum Mission (NQM) at a total cost of Rs.6003.65 crore from 2023-24 to 2030-31.
- It is aiming to seed, nurture and scale up scientific and industrial R&D and create a vibrant & innovative ecosystem in Quantum Technology (QT).
- This will accelerate QT-led economic growth, nurture the ecosystem in the country and make India one of the leading nations in the development of Quantum Technologies & Applications (QTA).
- The new mission targets developing intermediate-scale quantum computers with 50-1000 physical qubits in 8 years in various platforms like superconducting and photonic technology.

- Satellite-based secure quantum communications between ground stations over a range of 2000 kilometers within India, long-distance secure quantum communications with other countries, inter-city quantum key distribution over 2000 km as well as multi-node Quantum network with quantum memories are also some of the deliverables of the Mission.
- The mission will help develop magnetometers with high sensitivity in atomic systems and Atomic Clocks for precision timing, communications, and navigation.
- It will also support design and synthesis of quantum materials such as superconductors, novel semiconductor structures, and topological materials for the fabrication of quantum devices. Single photon sources/detectors, and entangled photon sources will also be developed for quantum communication, sensing, and metrological applications.
 - Mission Implementation includes setting up four Thematic Hubs (T-Hubs) in top academic and National R&D institutes in the domains - Quantum Computing, Quantum Communication, Quantum Sensing & Metrology, and Quantum Materials & Devices.
- The hubs will focus on the generation of new knowledge through basic and applied research as well as promote R&D in areas that are mandated to them.

Benefits of the mission

- NQM can take the Technology Development ecosystem in the country to a globally competitive level. It will help in seeding, nurturing, and scaling-up scientific and industrial R&D in the country.
- The Mission would greatly benefit various sectors, including communication, health, finance, and energy with applications in drug design, space, banking, security, etc. It will lead the acceleration of QT-led economic growth.
- The Mission will also provide a huge boost to National priorities like Digital India, Make in India, Skill India and Stand-up India, Start-up India, Self-reliant India and Sustainable Development Goals (SDG).
- Creation of vibrant an innovative ecosystem in quantum technology.
- It will help in making India a leading nation in development of quantum technologies and applications.

Challenges

- Quantum computers are highly prone to interference, which makes the quantum algorithms running on them prone to errors. Thus, it may give wrong results.
- Most quantum computers need to be super-cooled to slightly above absolute zero to function because the heat introduces error or noise into the qubits.
- The expansion of quantum computing will increase the ecological footprint.

- Due to the acute shortage of candidates with doctoral degrees in quantum physics, engineering and statistics physics, engineering and statistics, finding the right talent is another major challenge.
- Metrics are not clearly defined to assess the results of India's quantum efforts. Achieving quantum supremacy alone will not necessarily protect India's national interests.

Way Forward

- The National Quantum Mission should be implemented properly. Because the success of this mission will pave the way for New India.
- The government should prioritize science and research in the country by budgetary allocation and educational support.

Quantum Engine

News Excerpt

Recently, German physicists have developed a method to transform the energy difference between two quantum states of an atom group into work. It will potentially help develop more effective quantum computers by applying the principles of the well-known classical engine to the subatomic world.

Quantum Thermodynamics

- Quantum thermodynamics is a branch of physics that focuses on how thermodynamics "emerges" in quantum-physical systems.
- **Pauli's Principle-** In a single atom, two electrons will not have a similar quantum number.
- **Quantum number-** It defines the position and energy of an electron in an atom.

Quantum Engine

The **quantum** engine, or what the researchers are calling a 'Pauli engine', has a similar set of four steps.

Third: The compression applied in the first step is eased.

First: The atoms collected in the trap are compressed and kept in a bosonic state.

Second: The strength of a magnetic field applied on the atoms is increased by a small amount. Interactions between the atoms and the field cause the former to slip into a fermionic state: they are forced to move out of the lowest energy level and progressively occupy higher levels.

Fourth: The magnetic field strength is reduced to its original value.

Efficiency of Quantum Engine

- The quantum engine's effectiveness is determined by how much more energy is released in the third step compared to the energy added to the system in the first.
- The third step increases atomic energy, which can be used to create work.
- Currently, according to the researchers' paper published in Nature, the quantum engine is 25% efficient.
- The researchers expect to increase this to 50% or more in the future.

Pauli's principle

- According to Pauli's principle, all subatomic particles can be classified as either fermions or bosons.
- The fundamental units of matter are fermions, while bosons are the particles that carry the forces that interact with them.
- Four quantum numbers, which resemble an individual particle's Aadhaar number, are used to identify all particles in a system.
 - The sum of the four numbers provides information on the energy level of a particle.
- According to the exclusion principle, no two particles in a given system can have the same four quantum numbers, meaning they can't be at the same energy level.
- This law applies to fermions specifically. As a result, they repeatedly occupy the lowest one until all potential energy levels are occupied.
- The exclusion principle does not apply to bosons, which can all occupy the same lowest energy level at a specific low temperature. This explains how phenomena like superconductivity are feasible.
- The fundamental idea is that a system of fermions will have more energy than a system of bosons at a specific temperature.

Work process of a Quantum Engine

- Classical engines convert heat into work.
- For example, the heat produced by the burning of petrol or diesel propels a piston in an internal combustion engine. Overall, the engine has four steps:
 - The fuel is compressed
 - the expansion of the fuel-air mixture brought on by ignition forces the piston out
 - the mix cools and stops expanding.
 - In the last step, the piston is brought back to the initial state.

Quantum engine as proof of concept:

- The quantum engine is still in the process to see if the idea is feasible.
- By switching between bosonic and fermionic states, the researchers have shown that their design can be used to force a group of atoms to release energy in cycles.
- The scientists must determine how to transfer this energy from the interior of the trap to a device outside.

Importance of Quantum engine:

- The application of this discovery to the construction of more effective quantum computers has the potential to advance our understanding of quantum thermodynamics.
- Quantum engines could be important in cooling the particles used in quantum computers. Quantum computers need extremely low temperatures to operate effectively, and the quantum engine could potentially serve as a cooling medium for these particles.
- It will open up new possibilities for studying quantum thermodynamics and its implications for other fields of physics.

Quantum supercomputer

News Excerpt

Recently, Microsoft publicised a plan for creating the first true quantum supercomputer.

Understanding Quantum Computing

- It is a multidisciplinary field comprising aspects of computer science, physics, and mathematics that utilizes quantum mechanics to solve complex problems faster than classical computers.
- It is an emerging field that harnesses the laws of quantum mechanics to build powerful tools to process information.
- It has the potential to solve computational problems beyond the reach of classical computers. This approach to computing can transform areas such as **chemical engineering, material science, drug discovery,**

Quantum computing



Quantum computing is a rapidly-emerging technology that harnesses the laws of quantum mechanics to solve problems too complex for classical computers.

Quantum computers are elegant machines, smaller and requiring less energy than supercomputers.

A classical processor uses bits to perform its operations. A quantum computer uses qubits (QUBITS) to run multidimensional quantum algorithms.

Quantum computers are fundamentally different in the way they handle and process information. They are meant to be useful in some very specific situations where the traditional ways of computing are inadequate.

The challenges in building a quantum computer — requirements of very cold temperatures and extreme isolation — there is a significant risk of errors.

financial portfolio optimization, and machine learning.

Characteristics

- It is a new generation of technology that is faster than the most sophisticated supercomputer.
- It has the capability of doing a task in minutes which it would take a traditional supercomputer 10,000 years to accomplish.
- They are capable to sift through huge numbers of possibilities and extract potential solutions to complex problems and challenges.
- They use qubits to store information which carries information in a quantum state that engages 0 and 1 in a multidimensional way.

Need of Quantum super computers

- It has the potential to revolutionize computation by making certain types of classically intractable problems solvable.
- It can emerge as a major frontier in cybersecurity.
- Embrace effortless Machine Learning.
- It potentially opens up new opportunities in artificial intelligence.
- It can complex problems like identifying subtle patterns of fraud in financial which cannot be solved by classical computers.
- It is manifested through applications in **secure communication, disaster management, computing, simulation, chemistry, healthcare, cryptography and imaging among others.**

Government Initiatives on Quantum computing:

- **National Quantum Mission** - for accelerating Quantum Technology led economic growth and leverage India into a leading nation in the area
- **National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS)** -to make India a leading player in Cyber-Physical System.
- **The Quantum Frontier mission of the PM-STIAC:** aims to initiate work in the understanding and control of quantum mechanical systems.

Way forward

- Quantum Computing (QC) is an emergent technology that is identified as having great potential for quantum advantage in the future.
- It has generated a growing interest among scientists, technologists, and industrialists and provided a platform for research to people in the scientific, technical, and industrial fields.

Bio-economy is the technology of tomorrow

News Excerpt:

India's Bioeconomy witnessed a double-digit growth rate.

What is Bio-Economy?

It is defined as "the production of renewable biological resources and the conversion of these resources and waste streams into value-added products **such as food, feed, bio-based products, and bioenergy.**" (EU: 2020)

The goal of bioeconomy is to drive both sustainable development and circularity. The **principles of reuse, repair, and recycling**, are an essential component of bioeconomy.

- Resource recovery from waste streams such as municipal or industrial, is one of the key components for promoting a circular city approach.
- A circular city approach transforms waste products into sustainable and environmentally friendly bio-based products to reduce resource wastage.

Why there is a need for Bio-Economy?

- **Job creation:** It would create millions of **Green Jobs**, especially in rural and coastal areas.
- **Carbon Mitigation and Carbon Neutrality:** It would reduce the overall atmospheric emissions and our dependence on fossil fuels.
- **Modernization:** These processes will introduce innovations in agriculture, aquaculture, forestry, and other industries, thus helping them to become environmentally sustainable.
- **Ecosystem and Biodiversity restoration:** It will help recover the degraded part of our ecosystem by not exploiting excess amounts of resources.
- **Achieving Sustainable Development Goals (SDGs):** The circular economy holds promise for achieving multiple SDGs, including SDG 6 on Water & Sanitation (energy), SDG 8 on economic growth, SDG 11 on sustainable cities, SDG 12 on sustainable consumption and production, SDG 13 on climate action, SDG 14 on Life Below Water (oceans), and SDG 15 on life on land.

Green jobs

- These jobs contribute to **preserve or restore the environment**, be they in traditional sectors such as manufacturing and construction, or in new, emerging green sectors such as **renewable energy and energy efficiency.**
- They **can produce goods or provide services** that benefit the environment, for example **green buildings or clean transportation.**

How is India inching Towards Bio-economy?

- India is set to **achieve \$150 billion Bio-Economy by 2025**, which stood at over \$100 billion in 2022.
- **Biotech Sector:** The biotech sector particularly for **vaccines, diagnostics, and therapeutics** has already shown to the world that India can fight global challenges like the COVID pandemic from the forefront and contribute with best-in-class solutions not only for itself but for the world.
- Biotech Startups have grown **100 times in the last 8 years (2014-2022)** from 52 odd startups in 2014 to **6,300 plus** presently.
- Bio-Pharma Industry in **2021 tripled their R&D spending to nearly \$1 billion from \$360 million in 2020.**

- **Agriculture sector:** The agriculture sector which employs nearly **60%** of India's population has a large **scope of improvement**.
- **BT Cotton, Bio-pesticides, Bio-Stimulants, and Biofertilizers** contributed to **about \$10.48 billion in 2021** for the Bio-economy of the country.
- **National Biopharma Mission (NBM):** The National Biopharma Mission (NBM) is an **industry-Academia Collaborative Mission** for accelerating biopharmaceutical development in the country. Under this Mission, the Government has launched the **Innovate in India (i3) program** to create an enabling ecosystem to promote entrepreneurship and indigenous manufacturing in the sector. This mission is implemented by the **Biotechnology Industry Research Assistance Council (BIRAC)**.

Biotechnology Industry Research Assistance Council (BIRAC):

It is a not-for-profit, **set up by the Department of Biotechnology (DBT)**, Government of India as an Interface Agency to strengthen and empower the **emerging Biotech enterprise to undertake strategic research and innovation, addressing nationally relevant product development needs.**

- **Clean Energy International Incubation Centre:** The Clean Energy International Incubation Centre is a **first-of-its-kind International Incubation Centre** jointly established by **DBT/BIRAC, Tata Trust & Tata Power in 2018** under the **Mission Innovation multilateral program**. The **Incubator provides access to advanced labs and equipment, a pool of experts & mentors, and live testbeds** with the opportunity to conduct Pilots.
- **Fostering High-Performance Biomanufacturing:** DBT has undertaken a major initiative on "Fostering High-Performance Biomanufacturing- An integrated approach towards promoting circular economy for **Green, Clean, and Prosperous India**".

Way Forward:

India has a huge unsaturated wealth of bio-resources, waiting to be harnessed. A push to bio-economy will lead to the **development of a skilled workforce, and a surge in job creation and entrepreneurship**, especially in Tier 2 and Tier 3 cities. A suitable strategy is required in the form of an action plan including both local and central governments to make full use of the bio-resources and for adequate growth of the Bio-Economy sector.

Carbon Dioxide Capture Technology

News Excerpt:

New technology for **converting CO₂ to CO** holds the potential for carbon capture and energy saving in the **steel sector**.

Importance of Carbon Monoxide in Industries

- Carbon monoxide (CO) is a widely used chemical in the industry especially in the form of **syn gas**.
- CO is a critical component in the **steel industry** for converting **iron ores to metallic iron** in blast furnaces.

Synthesis gas (also known as syngas) is a mixture of **carbon monoxide (CO) and hydrogen (H₂)** that is used as a fuel gas but is produced from a wide range of carbonaceous feedstocks and is used to produce a wide range of chemicals.

Current Technology:

- **Currently**, CO is produced by **partial oxidation of coke/coal**, which results in **extensive CO₂ production** as an end product. If this produced CO₂ can be captured and transformed into carbon monoxide, it could help to create a **circular economy while decreasing the carbon footprint** and associated costs.
- The frequently used technique for **CO₂ to CO conversion happens at elevated temperatures (400-750 °C)**, and the presence of an **equivalent amount of H₂** is required.

Proposed IIT- Bombay Technology:

The technology developed by **IIT Bombay converts carbon dioxide to carbon monoxide** under **electro-catalytic conditions** under **ambient temperatures** in the presence of water.

- It requires only minimal energy as it can proceed under **ambient temperatures (25-40 °C)** in the **presence of water**.
- The energy required for this **electrocatalysis reaction** can be harnessed directly from a renewable energy source (**in the form of a solar panel or windmill**), which ensures a **carbon-neutral** operating scenario for a **CO₂ to CO conversion**.

Need for this technology:

- India is the second-largest manufacturer of cement and steel, the third-largest consumer of energy, and the fourth-largest petroleum refiner. These are 'hard to decarbonize' sectors.
- At the 26th Conference of Parties (COP) to the United Nations Framework Convention for Climate Change

UNFCCC: United Nations Framework Convention on Climate Change.

- The Convention has near universal membership (198 parties) and is the parent treaty of the 2015 Paris Agreement.
- The main aim of the Paris Agreement is to keep the global average temperature rise this century as close as possible to 1.5 degrees Celsius above pre-industrial levels.
- The UNFCCC is also the parent treaty of the 1997 Kyoto Protocol.
- The ultimate objective of all three agreements under the UNFCCC is to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system.

(UNFCCC) in Nov 2021, India Pledged to achieve Net Zero Emissions by 2070.

- India decided to achieve its short-term and long-term targets under the Panchamrit action plan, like- reaching a non-fossil fuel energy capacity of 500 GW by 2030; fulfilling at least half of its energy requirements via renewable energy by 2030; reducing CO₂ emissions by 1 billion tons by 2030; reducing carbon intensity below 45 per cent by 2030; and finally pave the way for achieving a Net-Zero emission target by 2070.
- Thus, India has also launched the Mission Innovation Challenge on Carbon capture, utilization, and storage (CCUS) to enable near-zero CO₂ emissions from power plants and carbon-intensive industries.

Carbon capture, utilization, and storage (CCUS):

It is a method of lowering carbon emissions that could be critical in combating global warming. It is a **three-step process** that involves **absorbing carbon dioxide** produced by power generation or industrial activity such as steel or cement production, **transporting it, and storing it.**

Two National Centres of Excellence in Carbon Capture and Utilization are being established in India.

- National Centre of Excellence in Carbon Capture and Utilization (NCoE-CCU) at Indian Institute of Technology (IIT) Bombay, Mumbai
- National Centre in Carbon Capture and Utilization (NCCCU) at Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru.

Three-step Process:

- CO₂ is separated from other gases produced in industrial set-ups such as those at coal power plants, steel plants, cement plants, etc.
- The CO₂ is subsequently **compressed and transferred** to a storage location via **pipelines, road conveyance, or ships.**
- Finally, the CO₂ is pumped far below into rock formations for long-term storage.

Way Forward:

- This initiative will help in facilitating research and innovation that can lead to the development of safe and cost-effective CO₂ capture, utilization, and storage (CCUS) technologies.
- India has been ongoing in its transition to clean energy, attaining the

highest rate of renewable capacity addition among all major economies and setting aggressive transition targets.

- **India's energy-mix strategies** include a greater shift towards clean energy alternatives, increased manufacturing capacity, energy use efficiency, and a policy push for hydrogen, which includes production-linked incentives. Furthermore, developing technologies such as the **2G Ethanol Pilot, Comfort climate box** for tropical regions, **Hydrogen Valleys**, and Heating and Cooling virtual repository will help achieve India's targets.

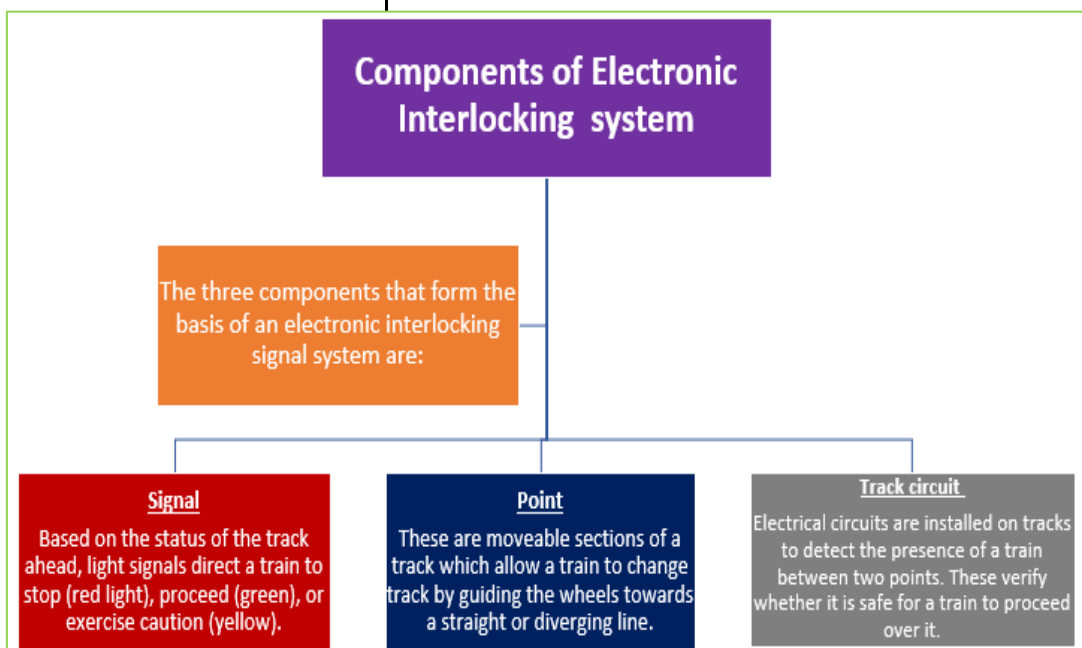
Electronic interlocking system

News Excerpt

An electronic track management system used by the railways has become the focus of investigations after horrific train crash involving two express trains and a goods train in Odisha's Balasore district.

KAVACH:

- The KAVACH is an **indigenously developed Automatic Train Protection (ATP) system** by the Research Design and Standards Organisation (RDSO) in collaboration with the Indian industry.
- It is a state-of-the-art electronic system with **Safety Integrity Level-4 (SIL-4) standards.** It is meant to provide protection by preventing trains to pass the signal at Red (which marks danger) and avoid collision. It activates the train's braking system automatically if the driver fails to control the train as per speed restrictions.
- It **prevents the collision between two locomotives equipped with functional Kavach systems.** The system also relays SoS messages during emergency situations.
- An added feature is the **centralised live monitoring of train movements** through the Network Monitor System.



- 'Kavach' is one of the **cheapest, SIL-4 certified technologies** where the probability of error is 1 in 10,000 years.

About Interlocking system

- Railway traffic is controlled and managed by railway signalling. Interlocking, an integral part of it, involves a set of apparatus placed on a track to manage the safe movement of trains and track configuration at stations and junctions.
- It prevents conflicting movements as a train gets a signal to proceed ahead only when its route is set, locked, and detected as safe.
- The signal apparatus in an interlocking system may be interconnected mechanically or electrically with the tracks or both.
- **Electronic interlocking (EI)** is an advanced version of signalling that uses computer-based systems and electronic equipment to control signals, points and level-crossing gates.
 - The Indian Railways defines it as a "microprocessor-based interlocking equipment to read the yard and panel inputs; process them in a 'fail-safe' manner and generate required output."
 - Unlike the conventional relay interlocking system, the "interlocking logic" in an EI system is managed via software and electronic components.

- It ensures all elements work together in proper sequence so that trains can move without coming in the way of one another.
- Electronic systems, communication devices that control signalling equipment and other components are kept in relay rooms with dual-lock access control. All system activities are recorded in a 'data logger', which is similar to the black box of an aircraft.

Working of system

- The system receives a command, following which information is collected from the yard and processed to set a safe route.
- The determined route is aligned, and signalling devices are interlocked at a particular position. A signal to pass is given based on which direction the track is set and whether the divergent track is free of obstruction.
- If a train is required to switch lines, then the system will direct it to the empty track at the point where two lines meet. Track circuits, meanwhile, prevent multiple trains from running on that block to avoid a collision.
- All points remain locked until the train has crossed a particular section of the track in use or the signal to proceed has been withdrawn.
- In case there is a failure in the system, the red light will be flashed, indicating that the route ahead is not clear or safe.

Superconductive Materials

News Excerpt

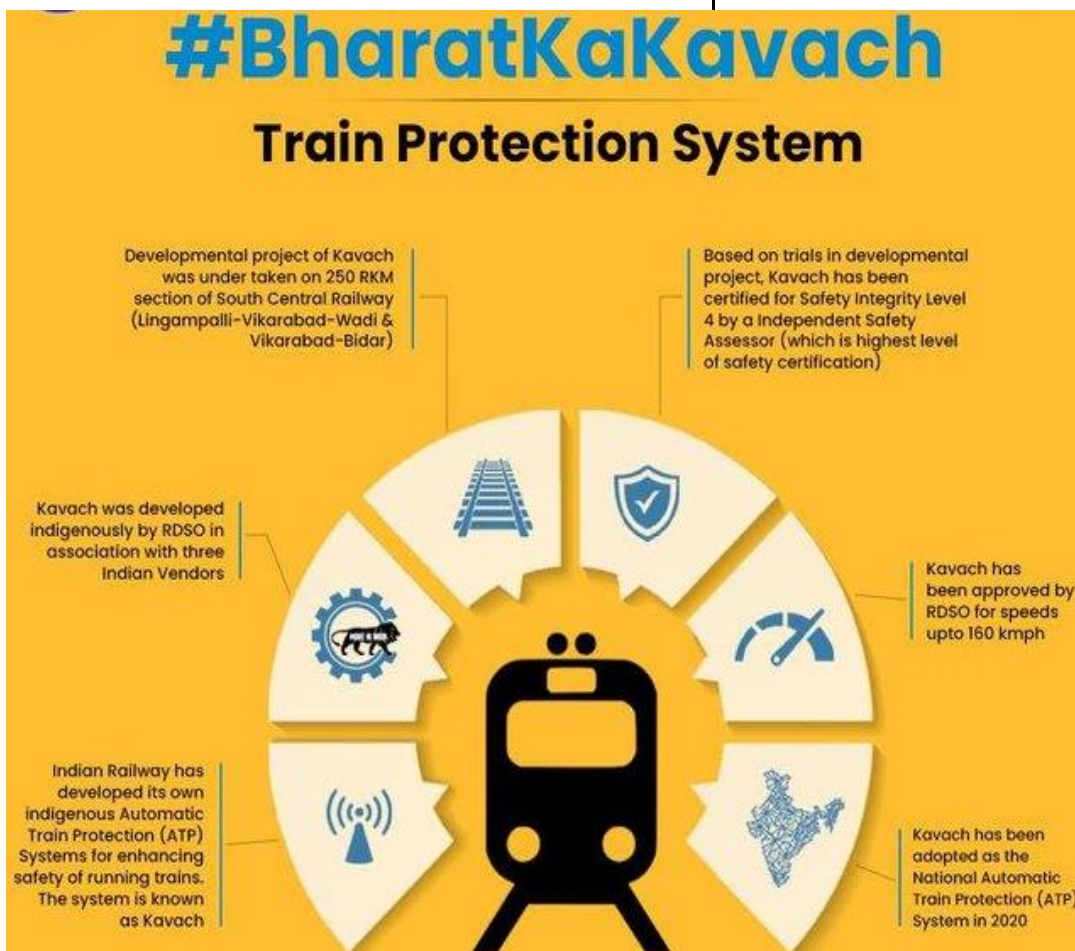
Researchers have demonstrated the ability to grow high-quality thin films of a recently discovered superconductor material.

About Superconductivity

- Superconductivity refers to a state in which a material offers zero, or near-zero, resistance to electric current. A current is nothing but the movement of charged particles, electrons in most cases, in a particular direction.

- Superconducting materials show very interesting behaviour under magnetic field which allows the functioning of systems like the MRI scan machine and the superfast Maglev trains that float above the tracks.

Current status of superconductors



- As of now, superconductivity can be achieved only at very low temperatures, more than 250 degrees Celsius below zero.
- The first material to have been discovered to show superconductive properties was Mercury, which becomes a superconductor at close to 270 degrees Celsius below zero.
- Most of the other materials commonly used as superconductors – Lead, Aluminium, Tin, Niobium, and several others – also become superconducting at comparable temperatures, called critical temperature.
- In some cases, materials can exhibit superconductivity at slightly higher temperatures as well, but under increased pressure conditions. Even the materials that are classified as ‘high-temperature’ superconductors, as of now, show superconductive properties only well below -150 degrees Celsius.

Types of Superconductors

Type 1 Superconductor	Type 2 Superconductor
These Superconductors are called soft superconductors.	These superconductors are called hard superconductors .
Only one critical field exists for these superconductors	Two critical fields Hc1 (lower critical field) and Hc2 (upper critical field) exist for these superconductors.
The critical field value is very low.	The critical field is very high.
These superconductors exhibit a perfect and complete Meissner effect.	These do not exhibit a perfect and complete Meissner effect.
These materials have limited technical applications because of their very low field strength value.	These materials have wider technological applications because of their very high field strength value.
Example: Pb, Hg, Zn, etc.	Example: Nb3, Ge, Nb3Si, Y1Ba2Cu3O7, etc.

Properties of Superconductors

- **Meissner Effect:** In 1933 Meissner discovered that not only did superconductors exhibit zero resistance but also spontaneously expel all magnetic flux when cooled through the superconducting transition, that is, that is they are also perfect diamagnets. We call this the Meissner effect.
- **Effect of Magnetic Field:** Removal of the superconducting state does not only occur by raising the temperature but also by subjecting the material to a magnetic field.
- **Frequency effect:** Superconductivity is observed for direct current (D.C.) and up to radio frequencies. It is not observed for higher frequencies. For a superconductor, the resistance is zero only when the current is steady or varies slowly.

- **Entropy:** Entropy increases on going from a superconducting state to a normal state.
- **Thermal Conductivity:** In an ideal superconductor, there is a marked drop in thermal conductivity when superconductivity sets in.
- **Isotope Effect:** It has been observed that the critical temperature of superconductors varies with isotopic mass.

Reasons behind the quest for a room-temperature superconductor

- In fact, superconductors are already being used, but their use is limited because of the extreme conditions that must be created.
- Elimination of this resistance can result in super-efficient electrical appliances, removal of transmission losses in power cables, and massive gains in energy.

Way Forward

- Scientists are looking for a material that can display superconductivity at room temperature (usually considered to be between 20 and 25 degrees Celsius) and under normal pressure conditions.
 - However, room-temperature superconductivity does not necessarily have to be at room temperature.
- The term is commonly used to describe superconductive properties in conditions that are easy to create.
 - **For example,** minus 5 or minus 10 degrees Celsius temperature conditions are not very difficult to create, nor are 70- or 90-degree Celsius conditions. Any material that would display superconductivity in an easily obtainable condition would qualify as the superconducting solution that the world is searching for.

Semiconductor Manufacturing Plant

News Excerpt

Recently, the **Foxconn Technology Group** has withdrawn its support from its joint venture with Vedanta, Ltd. to establish a semiconductor manufacturing plant in Gujarat.

Key Points

- **The AtmaNirbharta vision** (self-reliance) in electronics and semiconductors received a boost with the Union Cabinet's approval of the **Semicon India program**, allocating **INR 76,000 crore**.
- **Semicon India aims to financially support companies investing in** semiconductor, display manufacturing, and design. The goal is to establish India's presence in the global electronics value chain.
- **The India Semiconductor Mission (ISM)**, an autonomous division of **Digital India Corporation**, aims to develop semiconductor and display facilities. It introduces four schemes: supporting semiconductor and display fab setup, creating compound semiconductor/sensors fabs, and a design incentive scheme.

- Scheme for setting up of **Semiconductor Fabs** in India provides fiscal support to eligible applicants for setting up of Semiconductor Fabs which is aimed at attracting large investments for setting up semiconductor wafer fabrication facilities in the country. Following fiscal support has been approved under the scheme:
 - 28nm or Lower - Up to 50% of the Project Cost
 - Above 28 nm to 45nm - Up to 40% of the Project Cost
 - Above 45 nm to 65nm - Up to 30% of the Project Cost
- Additionally, the government has also approved **modernisation of Semi-Conductor Laboratory, Mohali** as a brownfield Fab.

About Semiconductor

- A semiconductor is a substance that has **specific electrical properties** that enable it to serve as a foundation for computers and other electronic devices.
- It is typically a **solid chemical element or compound that conducts electricity under certain conditions** but not others. This makes it an ideal medium to control electrical current and everyday electrical appliances.
- **Conductor and insulator** are substances that **conduct and repel electricity**, respectively, in semiconductors.
- **A diode, integrated circuit (IC) and transistor** are all made from semiconductors.
- The conductance can vary depending on the current or voltage applied to a control electrode or on the intensity of irradiation by **infrared (IR), visible light, ultraviolet or X-rays**. The specific properties of a semiconductor depend on impurities "known as dopants" added to it.

communications, clean energy, information technology, and medical devices, among others.

- Their critical role has led to a global chip shortage due to demand surpassing supply, resulting in economic setbacks and job losses.
- The Indian government allocated ₹76,000 crore through the Production-Linked Incentive (PLI) scheme in December 2021 to promote domestic semiconductor manufacturing.
- These semiconductors, along with displays, serve as the foundation for modern electronics, driving the ongoing digital transformation in Industry 4.0.

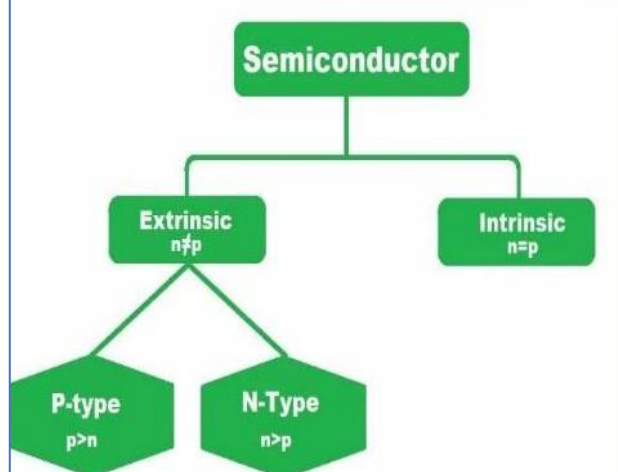
Why is it important to promote Semiconductor Industry?

- The foundation of the modern information age, semiconductor chips allow electronic devices to **compute and regulate operations** that make daily living easier.
- ICT (information and communication technologies) are developed as a result of these chips, which **promotes worldwide connectivity**.
- They are essential for the transfer of power and communications, both of which have an impact on the **nation's security**.
- Indian integration into the **global value chain** would result from supporting the semiconductor ecosystem, which would have an impact on all sectors of the economy.
- The semiconductor business is mostly controlled by a small number of nations, therefore increasing domestic production is essential.

What is a Semiconductor?


➔ A semiconductor is a material, whose conductivity properties lie between the conductor and insulator.

➔ Semiconductor Examples are: Silicon, Germanium, Gallium Arsenide etc.



```

            graph TD
            S[Semiconductor] --> E[Extrinsic n≠p]
            S --> I[Intrinsic n=p]
            E --> P[P-type p>n]
            E --> N[N-Type n>p]
            
```



➔ "n" stands for negative (free electrons)
 ➔ "p" stands for positive (holes)

Applications of Semiconductors in Daily Life

- **Computing:** The semiconductor sector manufactures memory chips and microprocessors, which are the primary parts of computers, servers, and data centres. These devices are used throughout a variety of industries, including manufacturing, logistics, banking, and healthcare.

- **Communications:** Semiconductors are used in the production of satellite systems, cell phones, and other communication tools. They are also utilised in the construction of wireless communication systems, network hardware, and other data transmission equipment.

- **Energy:** Semiconductors are used in the production of solar cells and other renewable energy sources. In power management devices like voltage regulators and power supply, semiconductors are also

Significance of Semiconductors technology

- Semiconductors hold immense significance across various sectors, including aerospace, automotive,

employed.

- **Automotive:** The sensors, safety systems, and engine control modules found in car electronics all make use of

semiconductors. They are also used in electric and driverless cars.

- **Healthcare:** Medical implants, gadgets, monitoring, imaging, and diagnostic equipment all use semiconductors.

Challenges Faced by the Semiconductor industry

- The semiconductor and display manufacturing sector demands substantial capital investments, involves high risks, long payback periods, and rapid technological changes.
- Government fiscal support for this sector remains insufficient compared to the necessary investment scale. India lacks fabrication capacities, possessing only one outdated fab.
- Setting up a semiconductor fabrication facility is exorbitantly expensive and resource-intensive, requiring significant water, power, land, and skilled labor.

Way forward

- India should work to establish itself as a key player in a **reliable, multilateral semiconductor ecosystem**, which calls for advantageous trade policies.
- Utilizing current expertise and resources, financial support should concentrate on various chip-making processes, such as **design centers, testing facilities, and packaging.**
- Create a whole ecosystem that includes semiconductor **design, fabrication, testing, and R&D.**
- **Boost communication amongst linked sectors** to create a strong chip manufacturing ecosystem.
- **Stress the advancement of chip design** while acknowledging its crucial role in value creation.

A new machine for semiconductor chips

News Excerpt:

Netherland-based **Advanced Semiconductor Materials Lithography (ASML)** has unveiled its new **'High NA EUV'** machine to manufacture the most advanced semiconductor chips.

Science of Semiconductor Chip Manufacturing-Lithography:

- We have powerful computers almost everywhere around us thanks to a technology called **semiconductor lithography.**
 - **Lithography** is the process of **using light to print tiny patterns on silicon.**
 - It is a fundamental step in mass-producing microchips.
 - Some machines automate this process.

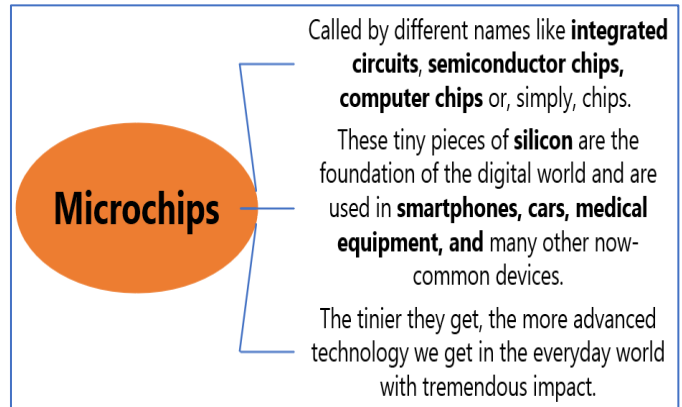
Principles of lithography:

- A lithography system is essentially a **projection system.**
- **Light is projected** through a blueprint of the pattern that will be printed (known as a 'mask' or 'reticle').

- With the pattern encoded in the light, the system's optics shrink and focus the pattern onto a **photosensitive silicon wafer.**

EUV lithography:

- EUV stands for **extreme ultraviolet**, an **incredibly short wavelength** of light that ASML generates in large quantities to print small, complex designs on microchips.
- EUV lithography does big things on a tiny scale.
- **ASML is the only maker of extreme ultraviolet (EUV) lithography machines**, needed to manufacture the most advanced chips.



- **High NA EUV** is the **next generation** of that technology.

High NA EUV:

- In the late **2010s**, the **ASML** became the **first and only company** to market a lithography tool using EUV, or **13.5 nanometre wavelength light.**
- **Existing EUV machines**, though they have supported the last decade of semiconductor process development, **can't hit the resolution needed for sub-2 Nano-Metre nodes** to be patterned into chips in a way that would be conducive to mass production.
- In February, 2024, ASML unveiled its new **'High NA EUV' machine.**
 - It costs \$350 million (Rs 2,900 crore) apiece and is as big as a double-decker bus.
 - This machine uses **extreme ultraviolet (EUV) photolithography**, a next-generation technology, to make semiconductors. The mould of the circuits of a transistor are transferred to a silicon wafer coated with a light-sensitive material called a **photoresist.**
 - Both the original and High NA machines create EUV light by **vaporizing droplets of tin with twin laser pulses 50,000 times a second.**
- This new method is functionally the same physical process as EUV lithography, but the **optics are larger** and **support higher-resolution patterns** to be printed on the wafer.
- The **High NA tool** will let chipmakers **shrink the size** of the smallest features on their chips by **up to 40%**, allowing the **density of transistors to nearly triple.**

- The High NA machine's biggest change is a **larger optical system** consisting of **irregularly shaped mirrors**, made by **Carl Zeiss**, polished so smooth they must be kept in a vacuum.
 - They collect and focus lighter than their predecessors
 - High NA stands for **high numerical aperture** - which leads to better resolution.

New low-cost MRI machine

News Excerpt:

Scientists have designed a magnetic resonance imaging (MRI) scanner that costs a fraction of existing machines, setting the stage for improving access to this widely used diagnostic tool.

What is magnetic resonance imaging?

- MRI is a non-invasive medical imaging test that uses a large magnet and radio waves to produce detailed images of almost every internal structure in the body, including organs, bones, muscles, and blood vessels.
- It is particularly useful for imaging soft tissues and is important for observing and treating cancers like prostate and rectal cancer, as well as neurological conditions such as Alzheimer's, dementia, epilepsy, and stroke.
- MRI scanners use strong magnetic fields, typically ranging between 1.5 T and 3 T, to generate these images, helping doctors diagnose and select treatments for various disorders.

Advantages of the Low-Cost MRI Machine:

- **Affordability:** The low-cost machine is around 50 times cheaper than conventional 3T MRI machines costing between 9-13 crore rupees.
- **No specialized infrastructure required:** The machine uses 0.05 T magnets and doesn't need a shielded room or helium coolant to operate.
- **Standard power supply:** It can be plugged into standard wall power outlets, eliminating the need for specialized power sources.
- **Portability:** Being lighter and more portable, it can increase accessibility in remote areas.
- **Quieter operation:** The machine is less noisy during operation, making it suitable for use in pediatric settings.
- **Open scanning environment:** It can be set up in an open scanning environment, alleviating claustrophobia that sometimes arises in conventional enclosed MRI machines.
- **Reduced artifacts:** The lower magnetic field strength may generate fewer artifacts due to metal implants or prosthetics in the final image.
- **Safety:** The reduced magnetic field strength may prevent accidents involving metallic objects being pulled into the machine.

Disadvantages of the Low-Cost MRI Machine:

- **Lower image resolution:** It can only detect tissue damage as small as 4 mm, compared to 1 mm for a more costly 1.5T scanner.
- **Missing anatomical details:** Some anatomical areas from which information needs to be extracted may not show up.
- **Potentially lower image quality:** While comparable to 3T machines with AI enhancement, the image quality may still be lower for certain applications.

Way Forward:

- While the low-cost MRI machine may not match the image quality and resolution of high-field MRI machines for certain applications, it offers several significant advantages in terms of affordability, accessibility, and safety.
- These advantages could "make a difference" by providing basic diagnostics in small centers and remote areas where high-cost MRI machines are currently unavailable.
- The low-cost machine could complement high-field scanners in radiology departments and be particularly useful in emergencies or for initial imaging before transferring patients to specialized centers.

eVTOL

News Excerpt:

The advancements in eVTOL technology indeed hold tremendous promise for revolutionizing urban transportation and emergency services globally.

More About the News:

- Imagine a taxi that utilizes electric power to soar through the skies at **speeds of up to 200 kilometers per hour, capable of vertical takeoff, hovering, and landing** without the need for a traditional helipad.
- This **futuristic vehicle, known as an electric vertical takeoff and landing aircraft (eVTOL)**, offers the promise of efficient urban air mobility without the high fuel and maintenance costs associated with conventional helicopters.
- The potential benefits in terms of reducing congestion, lowering emissions, and providing quicker access to critical services like medical care are truly remarkable.

About eVTOL:

eVTOL, or Electric Vertical Takeoff and Landing aircraft, represents a significant advancement in aviation technology.

- **Technology Overview:** eVTOLs utilize electric power for propulsion, enabling them to hover, take off, and land vertically without the need for traditional combustion engines.
 - This technology involves integrating multiple electric motors throughout the aircraft's airframe, enhancing efficiency, maneuverability, and safety.
 - High-energy-density batteries power eVTOLs, providing the necessary electrical energy for flight. Many eVTOLs incorporate sensors, cameras, and

radar for autonomous operation, enabling connectivity and enhancing safety.

- **Design Variations:** eVTOL designs vary widely, including multi-rotor configurations, fixed-wing designs, and tilt-wing configurations. Each design offers unique advantages and trade-offs in terms of efficiency, payload capacity, range, and operational flexibility.

Advantages:

- **Congestion Alleviation:** eVTOLs offer a promising solution to urban traffic congestion by providing a vertical alternative to ground transportation.
- **Direct Travel:** Their ability to take off and land vertically enables more direct travel routes, potentially reducing overall travel times.
- **Accessibility:** eVTOLs could extend air travel access to remote or inaccessible areas, enhancing connectivity.
- **Environmental Friendliness:** With zero direct emissions, eVTOLs present a greener alternative to traditional fossil fuel-powered aircraft, contributing to environmental sustainability.
- **Noise Reduction:** Their quiet operation mitigates noise pollution, especially in urban environments, enhancing public acceptance.

- **Cost Efficiency:** Lower operating and maintenance costs, coupled with simpler mechanics, make eVTOLs economically attractive compared to conventional aircraft.
- **Versatile Infrastructure:** eVTOLs can operate from various open areas, eliminating the need for dedicated infrastructure like airports or helipads.
- **Emergency Response:** eVTOLs can serve as rapid responders in emergencies, bypassing ground traffic and reaching affected areas more efficiently.

Challenges:

- **Safety:** Ensuring crash prevention systems and addressing concerns related to powerplant or rotor failure are critical for safe eVTOL operations.
- **Cybersecurity:** Protecting eVTOLs from cyberattacks is essential to safeguard their operation and data integrity.
- **Navigation and Flight Safety:** Operating eVTOLs in challenging terrain, adverse weather conditions, and unsafe environments require robust navigation systems and flight safety protocols.

Alternatives to Hazardous Cookware

News Excerpt:

In the revised **Dietary Guidelines for Indians (DGIs)**, the **Indian Council for Medical Research (ICMR)** and the **National Institute of Nutrition (NIN)** have advised **against Non-Stick Cookware** due to health risks.

What is Non-Stick Cookware?

- It refers to kitchen utensils that have a **coating designed to prevent food from sticking to the surface during cooking.**
- This type of cookware typically features a **smooth, non-porous layer** made from materials such as polytetrafluoroethylene (PTFE), commonly known as **Teflon.**
- The non-stick coating allows for **easier cooking and cleaning**, as less oil or fat is required to prevent food from adhering to the pan.
- Non-stick cookware is popular for its **convenience and efficiency** in preparing a wide variety of dishes.

How to use non-stick cookware safely?

While at **normal temperatures, cooking in them is fine**, but at high temperatures, the coating can produce toxins or poisonous fumes, which can lead to contamination of your food with PFAS, micro-, and nano plastics. **The use of non-stick cookware safely is recommended in the following ways:**

- Preheating of an empty pan must be avoided as it can heat up very fast and this will result in the release of toxic fumes.
- Cooking on low to medium flame is ideal.
- Use of a chimney or exhaust fan is advised while cooking in non-stick pans.
- Avoid scratching the non-stick coating while washing. Wash gently with a soft sponge and soapy, warm water.

What are electric aircraft?

The Union Aviation Minister while speaking at the seventh edition of the India Ideas Conclave in Bengaluru, stated that India is in 'conversation' with a number of eVTOL producers. But how are Electric Vertical Take off and Landing aircraft structured? And what are they capable of ?

Vertical Aerospace VA-X4
*Electric Vertical Take Off and Landing

Propulsion: Eight Rolls-Royce electric motors

Luggage hold

V-tail with rudders

Pilot and four passengers

Rear vertical rotors

Front rotors

Take-off and landing: Rear vertical rotors fan out, front propellers orientate vertically

Stowed

Open

Flight: Rear rotors fold into **stowed** position. Undercarriage withdraws. Front propellers tilt for forward motion

Cruise speed:	241km/h
Range:	161km
Payload:	450 kg
Wing span:	15m
Length:	13m
Height:	4m

What are PFOA and PFOS?

- Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) are **part of a large group of lab-made chemicals** known as perfluoroalkyl and polyfluoroalkyl substances (PFAS).
- **PFAS are very stable and don't interact much with other chemicals**, making them **useful for products that resist oils, stains, water, and heat**.

Key facts

- They have **been used in non-stick cookware coatings and protective coatings** for carpets and fabrics.
- PFAS can be a health concern because they **don't break down easily and can remain in the environment and the human body** for a long time, earning them the nickname **'forever chemicals'**.

- Replace cookware when coating deteriorates.
- It is better to cook in stainless steel, cast iron, and ceramic cookware.

Risks Associated with Non-Stick Cookware:

Health Related:

- **Perfluorooctanoic acid (PFOA)** and **Perfluorooctanesulfonic acid (PFOS)** are used in **producing non-stick coatings such as Teflon**. When heated to high temperatures, these chemicals can release toxic fumes into the air.
- Inhalation of these fumes is linked to health issues such as **respiratory problems, thyroid disorders, and certain types of cancer**.
- Overheating **teflon-coated cookware** can release fumes causing flu-like symptoms in humans and **can be fatal to birds**.
- PFOA, previously used in making Teflon, is a **possible carcinogen**.
- Over time, non-stick coatings **can wear off, especially with high heat** or abrasive cleaning. As the coating deteriorates, there is a **risk of it leaching into food**, particularly when cooking acidic foods or using metal utensils.

Environment Related:

- The production and **disposal of non-stick coatings** involve the use of **chemicals** that can be **harmful to the environment** and **persist in the ecosystem** for extended periods.
- **Improper disposal of non-stick cookware** can further contribute to **pollution** and **environmental degradation**.

Eco-Friendly Alternatives recommended by ICMR:

Consumers are advised to turn to **eco-friendly alternatives** for their cooking needs due to concerns about harmful chemicals in Teflon-based cookware. Following are some alternatives:

- **Ceramic Cookware:**
 - Made from natural materials such as clay and sand.
 - Coated with a ceramic glaze, offering non-stick properties without harmful chemicals.

- Durable, scratch-resistant, and safe for use at high temperatures.

- **Cast Iron Cookware:**

- Known for excellent heat retention and even heat distribution.
- Free from synthetic coatings and chemicals.
- Requires seasoning and proper maintenance to prevent rusting.
- Durable and versatile, used for centuries.

- **Stainless Steel Cookware:**

- Made from durable and recyclable materials.
- Free from harmful chemicals and coatings.
- Resistant to corrosion and staining.
- Long-lasting option for home cooks.

BIOTECH

India's New Guidelines on Genetically Modified Insects

News Excerpt:

The Department of Biotechnology (DBT) has issued the **'Guidelines for Genetically Engineered (GE) Insects'**.

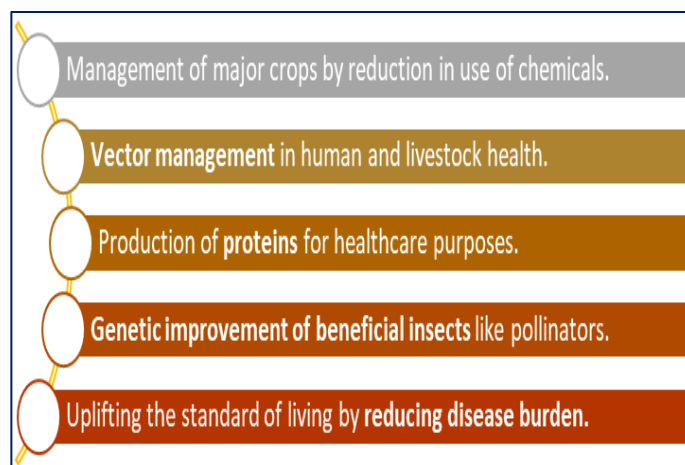
Department of Biotechnology (DBT)

- It comes under the **Ministry of Science and Technology** and supports research and applications in life sciences.
- It aims to **speed up the nation's progress towards widespread usage of biotechnology** in the fields of industry, agriculture, health care, animal sciences, and the environment.

Prospects of India's Bio-economy:

- The sector accounts for 2.6% share of India's GDP in 2021.
- According to the "Bio-economy Report 2022", this contribution in GDP should come closer to 5% by 2030.
- The current budgetary allocation for DBT is only 0.0001% of India's GDP.

Challenges in creating GE insects:



Uncertainty of purpose:

- The guidelines acknowledge that GE insects are becoming **globally available**. However, it **does not outline their permitted uses** or how the government would envision their use.
- The guidelines **only offer regulatory processes** for research and development on insects that can have some useful uses for humans.
- The guidelines are in sync with **the available guidance of the World Health Organization on GE mosquitoes**. Yet they seem to **downplay the economic opportunities** that such insects can provide.
- **Engineering honey bees** to make **better-quality/quantities of honey** will help **reduce imports and facilitate exports**.
 - Similarly, **GE silkworms** may be used to produce **finer and/or cheaper silk**, affecting prices and **boosting sales**.
 - But the **guidelines** and policy are both **quiet on how GE insects** can benefit the bio-economy sector.

Uncertainty for researchers:

- The guidelines do not apply to constrained trials or deployment, they are solely applicable to research.
 - This means, researchers can test the insects once they have been "made" and evaluated in the lab, after getting approval from the Ministry of Environment, Forests and Climate Change (**MoEFCC**)'s **Genetic Engineering Appraisal Committee (GEAC)**.
- GE insects can't be pulled back after deployment, unlike genetically modified foods. They are **not amenable to individual consumer choice**.
 - For e.g., if a consumer doesn't want to eat a GM organism, she can choose to buy organic food or food must be labelled "contains no GMO".
 - But if a company decides to release a GE insect in an individual's neighbourhood, she will have no choice but to be exposed to it.
- There's **no clarity** on whether the **MoEFCC** will actually **approve the deployment of GE insects** or what criteria it might use to consider a proposal to do so.

Uncertainty of ambit:

- The guidelines include **standard operating procedures** for genetically engineered mosquitoes, agricultural pests,

and **beneficial insects**; however, the term "**beneficial**" in the context of these insects is unclear.

- The lack of clarity will **impede funders and scientists** from investing in this research.
- In a country like **India** where low public as well as private funding persists, the absence of a precise stance to identify and promote research priorities hampers progress.
- A **gene-therapy product** is defined as "**any entity which includes a nucleic acid component being delivered by various means for therapeutic benefit**" in the **National Guidelines for Gene Therapy Product Development and Clinical Trials**.
- However, without a "**definition of therapeutic benefit**," it is **unclear** which gene therapy items will be allowed in the end.
- **Destructive products** can also be accidentally created through genetic engineering.

Way Forward:

- The **budget allocation for DBT** as well as private funding needs to be significantly increased to create an ecosystem of innovation and industrial action.
- Policies must enable **risk-taking appetite** within the scientists and should also be in line with the financial and social objectives of the country.
- Current **biotechnology-based policies** must be **in sync** with the broader commitment to contributing to the bio-economy.

In the end, it will also be necessary to monitor the effects of GE and ponder over the development both ethically and scientifically.

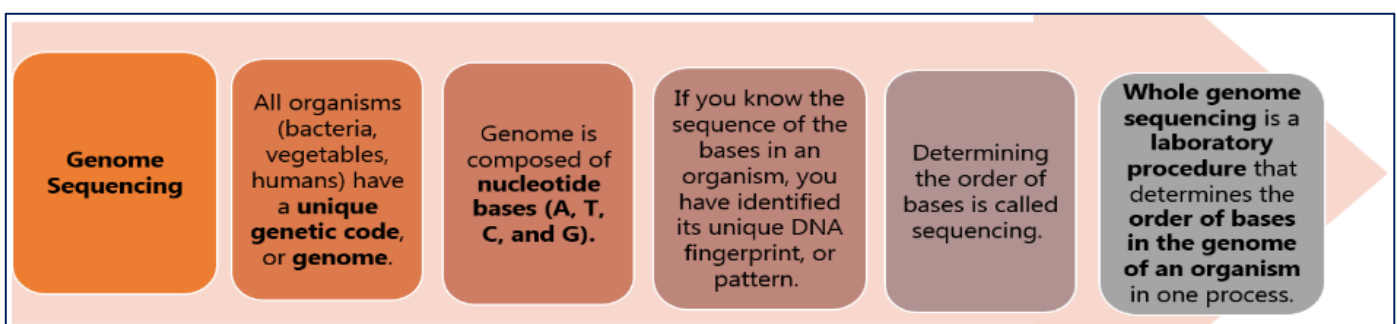
Genome India Project

News Excerpt:

The Government's ambitious **Genome India initiative** achieved a significant milestone as researchers completed sequencing 10,000 healthy genomes from different regions of the country, representing 99 distinct populations.

Genome India Project:

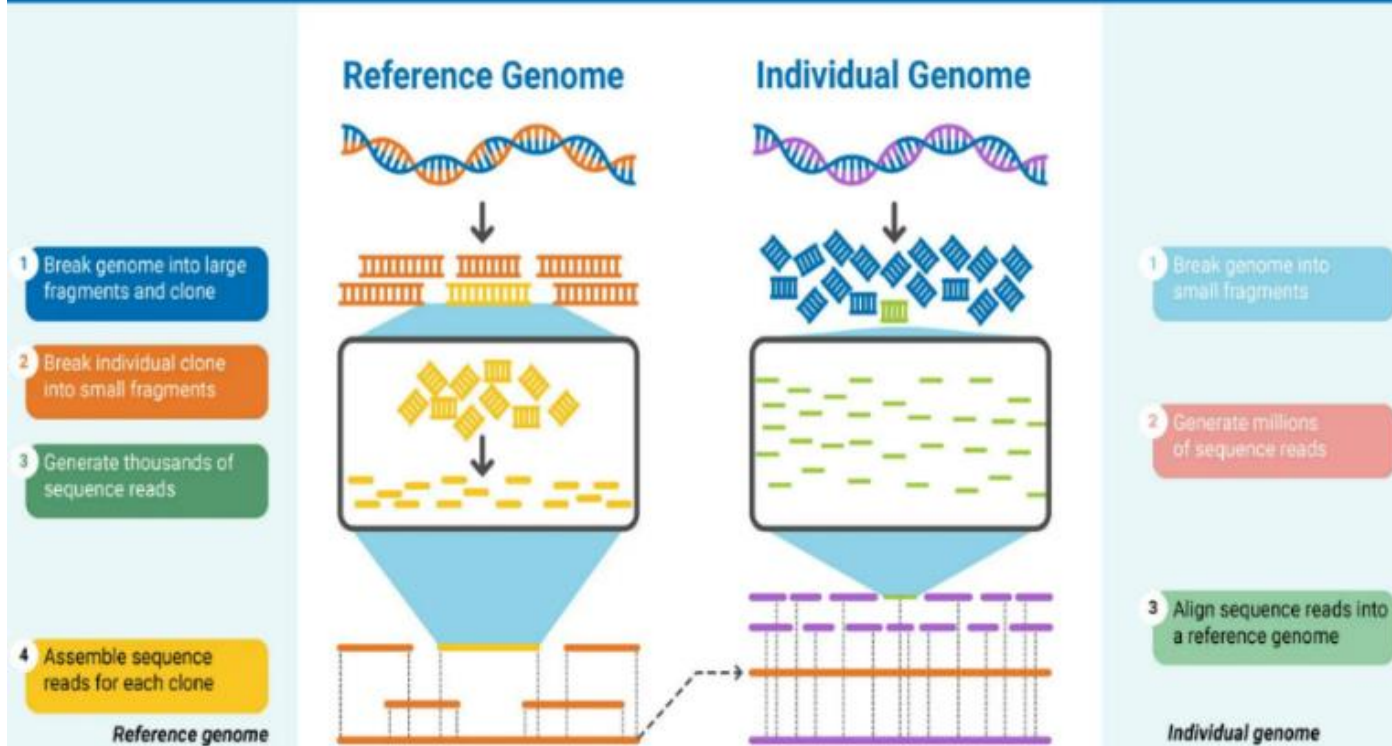
- The Department of Biotechnology (DBT) initiated the "Genome India Project" (GIP) in 2020.
- The GIP's aim was to collect 10,000 genetic samples from citizens across India, to build a reference genome.



- The project is led by the Centre for Brain Research at the Indian Institute of Science (IISc), which acts as the central coordinator between a collaboration of 20 leading institutions.
- The Department of Biotechnology (DBT) has officially announced the completion of the '10,000 genome' sequencing.

- The project would ultimately support the development of **predictive diagnostic** markers.
- It is also a key step to being able to learn about **genetic variants** that are unique to India's population groups and use that to **customise drugs and therapies**.
- Genome sequencing can also help in identifying resistance-indicating variants.

WHOLE GENOME SEQUENCING



Significance of Genome Sequencing:

- India first sequenced a complete human genome in **2006**.
- The **United Kingdom, China, and the United States** are among the countries that have programmes to **sequence at least 1,00,000 of their genomes**.

Application of Genome Research in India:

- The long-term impact of population-scale genomics extends beyond individual health, shaping our comprehension of **human evolution, migration patterns, and adaptation to diverse environments**.
- It will also contribute significantly to our **knowledge of human biology**.
- The project would bring valuable addition to existing genome research, which has so far been limited to the Western context.
- It allows India to draw upon **its tremendous genetic diversity**, given the series of large migrations historically, and thus, add greatly to the current information about the human species.

- For example, genes that might make certain medicines or anaesthetics ineffective in certain populations.
- It can also help identify targets for diagnostics and therapeutics.
 - We need an **India-specific database** because mutations found here might not be present globally.
 - For example, a **mutation MYBPC3** that leads to **cardiac arrest** at a young age is found in 4.5% of the Indian population but is rare globally.
- Another mutation called **LAMB3** that causes a **lethal skin condition** is found in nearly 4% of the population near Madurai but it is not seen in global databases.

Drug development using the learnings from genome sequencing:

- The genomic approach to mapping and sequencing the genome project has accelerated the rate of gene discovery.
- As of 1996, 62 human genes linked to human diseases had been isolated by genomic technologies and, of these, 51 (82%) were available in the public domain as clones or as DNA sequences.

- With the help of Genome Sequencing a new, but complementary, approach to drug development is now emerging which promises dramatic improvements in the **efficiency and speed of drug development**.
- This new approach may result in smaller and quicker clinical studies.
- Patients could be screened to identify the most suitable treatment, enhancing the accuracy and effectiveness of drugs.
- Close monitoring of patient responses to treatments could be facilitated.
- This approach could significantly impact the **planning and execution of clinical trials**, as well as the medical management of diseases.
- Individual genetic testing, with knowledge of disease genes, will help early diagnosis and early treatment.
 - Recent advances in the genetics of complex traits (for example, diabetes, **coronary heart disease and Alzheimer's disease**) have to some extent reshaped disease phenotypic descriptions.
 - The techniques developed for automated sequencing and analysis of DNA may eventually allow inexpensive screening of multiple loci for polymorphisms.

About Genomic Data:

- Genomic data is a powerful tool for medical researchers and doctors. It helps them understand **how variations in DNA affect our health**.
- Through genomic sequencing, they **decipher our genetic makeup and spot alterations in our genes**.
- These changes are key to understanding **how diseases such as cancer develop**.

About Genomic Testing:

- It identifies inherited DNA changes that increase a person's cancer risk.
- It can identify changes in a tumour that guide the selection of appropriate targeted therapies.
- Using the genetic changes in a patient's tumour to determine their treatment is known as precision medicine.

Way Forward:

- This initiative reflects India's progress in gene therapies and precision medicine, and its movement towards emerging next-generation medicine which yields the possibilities for greater customization, safety, and earlier detection.
- This initiative would help lay the foundation of personalized healthcare for a very large group of people in our country.

Newborn genome-sequencing

News Excerpt

Recently, Newborn screening programmes (NBS) have been deployed in some states in India.

Key Points:

Genome India: 'Cataloguing the Genetic Variation in Indians' project has been sanctioned by Department of Biotechnology (DBT) in, 2020 for a period of 3 years to 20 institutions from varied disciplines across the country.

About Genomes Sequencing

All organisms have a unique genetic code that is composed of nucleotide bases (A, T, C, and G). **Determining the order of bases is called sequencing.**

- There are two types of genome sequencing:

- Targeted sequencing:** Where only specific genes are sequenced and analysed.
- whole exome or whole genome sequencing:** Where all of the DNA (whole genome) or all of the coding segments of all genes (whole exome) are sequenced and analysed.

Newborn genome sequencing

It is an early diagnosis which allow to use effective treatments and management of conditions and save an infant from death or disability.

- It is the practice of collecting and analysing large portions of a newborn's DNA, revealing certain genetic disorders including rare inborn errors of metabolism that the newborn might be at risk of developing in infancy, childhood, or later in life.
- Many potentially treatable conditions cannot be detected in infants using current newborn screening methods.
- Novel ethical and policy issues raised by genome-wide sequencing.
- Psychological harm to patients and their families.
- Storage of personal genomic data

Way forward

As the vast potential of rapid newborn whole-genome sequencing is unfolded we stand at a crossroads of hope and introspection, that this technology will help clinicians with the means to detect rare genetic disorders, anticipate susceptibility to disease, and give them the evidence required to prescribe better treatments and shape a healthier future. Yet they should also tread carefully, considering the delicate balance between benefits and harm.

Xenotransplantation Technology

News Excerpt:

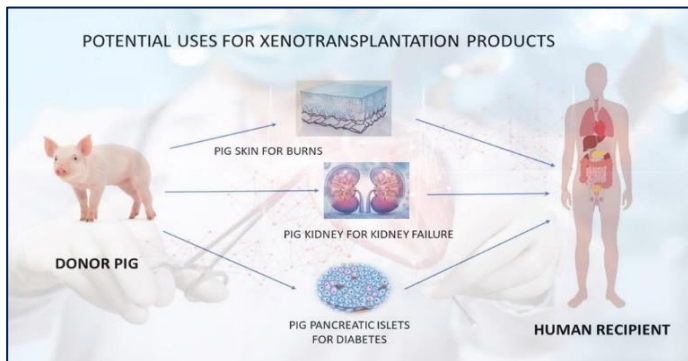
Richard Slayman, the first human recipient of a **pig kidney transplant** in March 2024, dies.

What is Xenotransplantation?

- According to the US Food and Drug Administration (FDA), "Xenotransplantation is any procedure that involves the **transplantation, implantation or infusion into a human recipient** of either (a) live cells, tissues, or organs from a nonhuman animal source, or (b) human body fluids, cells, tissues or organs that have had ex vivo contact with live nonhuman animal cells, tissues or organs."

- Essentially, it is the **use of animal cells and organs to heal humans**.
- Xenotransplantation involving the heart was first tried in humans in the 1980s.
- The need for such a procedure was felt because of the **significant gap between the number of transplants needed by patients and the availability of donor organs**.

How does Xenotransplantation happen?



- Sewing a pig kidney into a donated body isn't much different than a regular transplant, and post-surgery immune-suppressing drugs are standard, too.
- But there are several **crucial additional steps**:
 - The selected animal organ has to **undergo genetic modifications** so the human body does not reject it.
 - The gene editing technology **CRISPR-Cas9** was employed to "Remove certain pig genes that produce sugars with antibodies our immune systems react to" and "Add certain human genes to improve the kidney's compatibility with humans."
- Even after the operation, **constant monitoring needs to be done to check the body's response to the organ**.

Why are pigs often used for Xenotransplantation?

- Currently, **pigs, monkeys, chimpanzees, and baboons** are among the large animals that have been utilized in xenotransplantation.
- Because of their **similar organ sizes, physiological metabolisms, and immune systems to humans**, pigs are thought to be the best candidates to donate organs for xenografts.
- For example**, In January 2022, the first xenotransplantation of a genetically modified pig heart was done. However, the patient passed away after two months due to a range of factors, including being tainted with a latent virus in the pig's heart, which may have contributed to the dysfunction of the transplant.

What are the complications of xenotransplantation?

- It has to be ensured that **body does not reject the organ**.
 - One method of doing this is **embedding the pig's thymus gland**, which is responsible for "educating" the immune system, underneath the outer layer of the

kidney. This helps keep away any new or delayed immune responses.

- Potential infection of recipients** with both recognized and unrecognized infectious agents and the possible subsequent transmission to their close contacts and into the general human population.
- There is a possibility of **cross-species infection by retroviruses**, which may be latent and lead to disease years after infection.

Mitochondrial Donation Treatment

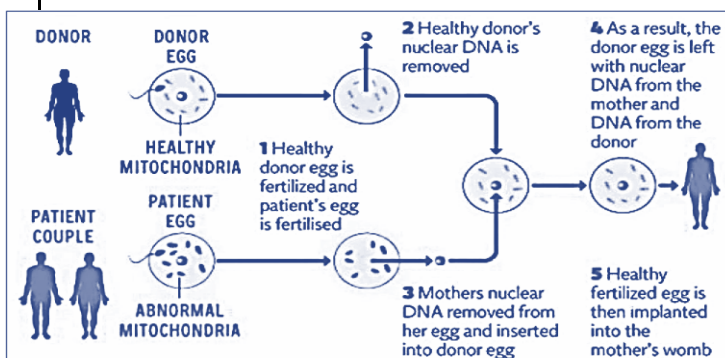
News Excerpt

The recent news of a kid born in the United Kingdom having three parents' DNA has stirred interest and debate over the technical advances behind this astounding achievement.

About Mitochondrial Disorders

- Mitochondrial disorders are a group of rare genetic conditions caused by mutations in the DNA of mitochondria, the energy-producing structures within cells.
- These disorders can lead to a wide range of debilitating symptoms, including muscle weakness, organ dysfunction, neurological issues, and impaired growth.
- Furthermore, since mitochondria are passed down exclusively from the mother, affected individuals can transmit these disorders to their offspring.

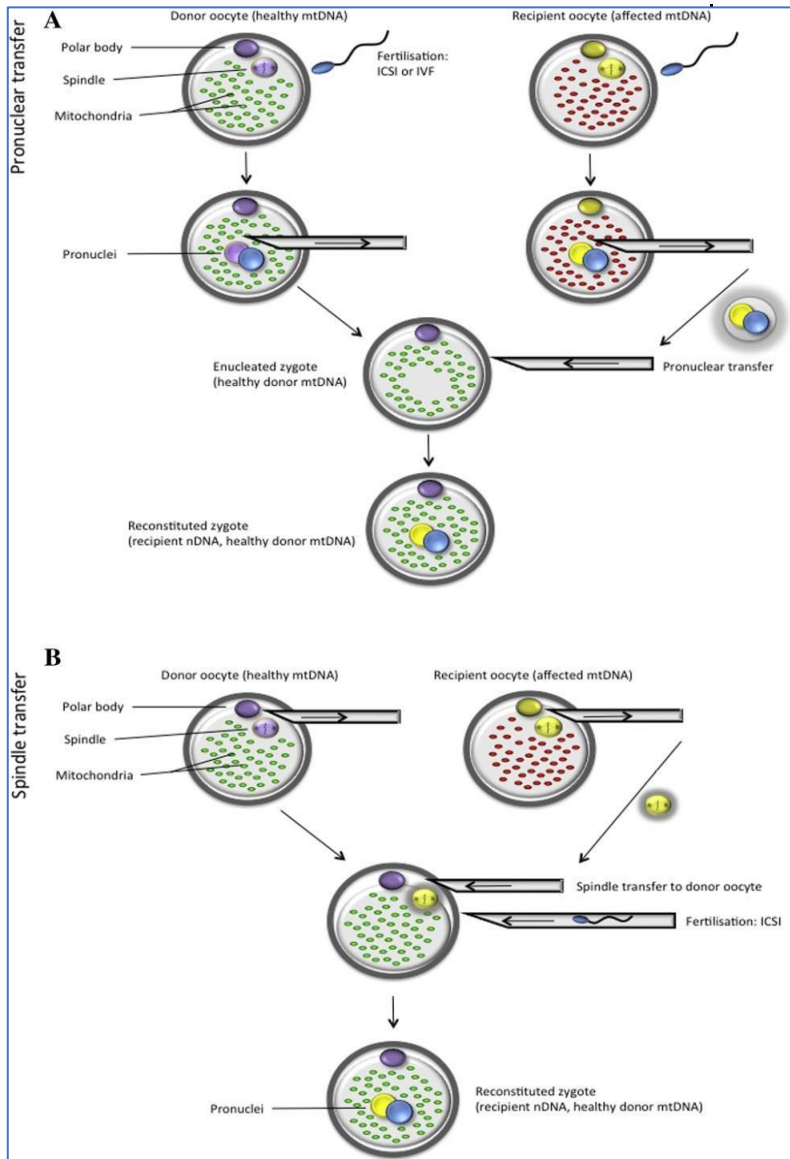
About Mitochondrial Donation Treatment



- Mitochondrial donation treatment, also referred to as **mitochondrial replacement therapy (MRT)** or **three-parent IVF**, involves the transfer of healthy mitochondrial DNA from a donor to an embryo or egg with defective mitochondria.
- This procedure aims to prevent the transmission of mitochondrial diseases to future generations by replacing the faulty mitochondria responsible for the condition.

The Three-Parent Technique

- The term "**three-parent baby**" arises from the involvement of three individuals in the conception process.
- The biological parents provide the nucleus DNA, which determines the child's genetic traits, while a donor contributes healthy mitochondria.
- The procedure involves two main techniques:**



- **Pronuclear transfer** involves transferring the nucleus of a fertilized egg from the affected mother to a donor egg with healthy mitochondria, which is then implanted into the mother's womb.
- **Maternal spindle transfer**, on the other hand, involves transferring the nucleus of the mother's egg to a donor egg before fertilization.

Analysis:

Societal Aspects

- **Health Impact:** Mitochondrial donation has the potential to prevent the transmission of mitochondrial diseases, which are often severe and debilitating. By reducing the prevalence of these diseases, the overall health and well-being of affected individuals and their families can be improved.
- **Access and Equity:** The availability and affordability of the procedure should be considered to prevent potential disparities and ensure that all individuals who could benefit from it have equal access.
- **Public Perception:** Public education and awareness campaigns are crucial to foster understanding and

support for mitochondrial donation, addressing any concerns or misconceptions.

Legal Aspects

- **Regulatory Frameworks:** Countries need to establish or update their legal and regulatory frameworks covering areas such as safety, efficacy, donor screening, informed consent, and post-treatment follow-up to address mitochondrial donation.
- **Parental Consent:** Since mitochondrial donation involves modifying the genetic material of embryos or oocytes, legal frameworks must address issues of informed consent and decision-making for prospective parents. Balancing reproductive autonomy with the potential long-term implications for the resulting child is a key consideration.

Ethical Aspects

- **Genetic Modification:** Mitochondrial donation raises ethical questions about genetic modification. While the procedure does not affect the nuclear DNA responsible for personal traits, it does involve altering the mitochondrial DNA, which can be inherited by future generations. The moral permissibility of altering the germ line is a subject of ongoing ethical debate.
- **Donor Conception and Identity:** Mitochondrial donation can involve the use of donor eggs or embryos, leading to questions around donor conception and the right of individuals to know their genetic origins. Ensuring transparency, privacy, and the rights of all parties involved, including donors, parents, and potential offspring, is ethically important.

Moral Aspects

- **Personhood and Embryo Status:** Moral considerations may arise from differing perspectives on the moral status of embryos and the beginning of human life. Some argue that the destruction of embryos involved in mitochondrial donation is morally problematic, while others emphasize the potential to prevent the suffering of future individuals.
- **Long-Term Effects:** The long-term consequences of mitochondrial donation, including the safety and efficacy of the procedure, need to be carefully considered. Monitoring the health outcomes of individuals born through this technique and assessing potential risks or unintended consequences is essential.

Way Forward

- Mitochondrial donation treatment offers hope for affected families and has broader implications for future generations.
- By preventing the transmission of mitochondrial diseases, this technique contributes to the overall improvement of public health.

- It paves the way for advancements in assisted reproduction technologies, fueling the ongoing exploration of innovative solutions to address various fertility-related issues.

Biohacking

News Excerpt:

Biohacking is picking up in India, with followers trying everything from Cryotherapy to IV therapy.

About Biohacking:

- Biohacking is the practice of employing methods drawn from fields like biology, genetics, neuroscience and nutrition to enhance **physical or mental performance**, improve overall health and well-being, or achieve a specific health outcome (like weight loss).
- It's also called **do-it-yourself (DIY) biology**.

- It's crucial to approach biohacking with caution, relying on evidence-based information and consulting with healthcare professionals when necessary.

AI

Generative AI

News Excerpt

The use of Generative Artificial Intelligence (GAI) is currently in its early phases, but its impact is expected to rise as technology evolves and improves.

About Generative AI

- GAI is a fast-emerging branch of AI that refers to the use of algorithms and models that can generate new content that resembles human-created data.

Types of Biohacking:

Almost any tactic could be considered biohacking if an individual employs it to enhance **their biology** in some way.

Lifestyle:	Molecular:	Biologics:	Technology:
<ul style="list-style-type: none"> ◦This focuses on making positive health & behaviour choices, and activate the biology of performance and longevity. ◦Lifestyle is probably the most accessible way to experience biohacking, as it includes factors like dietary shifts, meditation and exercise. 	<ul style="list-style-type: none"> ◦This involves the use of natural and synthetic molecules that can help shift one's biology. ◦For eg: Taking supplements. 	<ul style="list-style-type: none"> ◦Biologics are cellular or biological products to improve or enhance biology like cells or small information packets (exosomes), which are biological bundles of DNA, mRNA proteins and growth factors. ◦These need to be ingested, injected (like stem cells) or delivered intravenously (by IV transfusion). 	<ul style="list-style-type: none"> •Technology biohacks includes the use of devices like wearables (smartwatches), diagnostics (blood sugar monitors) and advanced machines like hyperbaric chambers or electromagnetic stimulators to stimulate more rapid physiological changes or healing. •In such cases, individuals can use that information to adjust their health for improved performance.

Age-Related Biohacking:

- **Cellular senescence** plays a role in age biohacking. As cells in the body are damaged by injury, stress or disease, they are removed by a natural process called **apoptosis**.
 - But as the body ages, it becomes less efficient at clearing these senescent cells. Their accumulation may lead to inflammation that can damage other nearby cells, accelerating the ageing process and the onset of disease.
 - If the production of senescent (damaged) cells can be stopped or reversed, then the aesthetic and physical changes that come with ageing can as well.

Is Biohacking Safe?

- Biohacking is fighting a bad reputation in some circles because it's **occasionally practised "ahead of science,"** meaning people test hacks on themselves before they're proven to work in a controlled clinical research setting.

- The aim is to develop algorithms that can capture the essence of human creativity and produce content that is indistinguishable from what humans create.

- While GAI is frequently connected with ChatGPT and deep fakes, the technology was originally developed to automate the repetitious processes needed in digital image and audio rectification.

- The Global Partnership on Artificial Intelligence (GPAI) is an international initiative aimed at fostering collaboration and promoting responsible

development and use of artificial intelligence (AI) globally.

- It was launched in 2020 and currently consists of a group of like-minded countries and organizations that are committed to addressing challenges and opportunities related to AI.

Generative Models

Three prominent models are:

- **Variational Auto Encoders (VAEs):**
 - VAEs are encoder-decoder models that learn the underlying probability distribution of a given dataset.
 - They consist of an encoder network that maps input data to a latent space representation and a decoder network that reconstructs the original data from the latent space.
 - By training VAEs to maximize the likelihood of the input data, they can generate new samples by sampling from the learned latent space distribution.
- **Generative Adversarial Networks (GANs)**

- GANs employ a two-component system: a generator and a discriminator. The generator aims to create realistic content, while the discriminator tries to distinguish between real and generated samples.
- Through an adversarial training process, GANs improve their ability to generate increasingly realistic samples. GANs have been widely used to create lifelike images, videos, and even text.
- **Autoregressive Models**
 - Autoregressive models, such as the Transformer model, generate content by sequentially predicting the next element based on previously generated elements.
 - These models have been particularly successful in natural language processing tasks, enabling the generation of coherent and contextually relevant text.

ARTIFICIAL INTELLIGENCE			
	PROS		CONS
	Efficiency and Accuracy		Uncontrollability
	Effective Data Acquisition and Analysis		AI Machines Don't (Currently) Have Any Emotion
	Reducing Costs (Cheaper Products & Services)		Degradation (unable to self-repair)
	Improving Human Decision Making		A Reduced Number of Jobs For Humans
	Improving Human Workflows		High Costs
	The Mechanical Advantage		Lacking Creativity and Out-of-the-Box Thinking
	Understanding High-Dimensional Data		Ethical Considerations

Applications of Generative AI

- **Visual Arts**
 - Generative models have revolutionized the field of computer vision, enabling the creation of realistic images and videos.
 - They can assist with image synthesis, style transfer, and even inpainting, seamlessly filling in missing parts of an image.
- **Music Composition**
 - Generative AI has become an invaluable tool for musicians and composers. By training models on vast collections of music, generative algorithms can create original compositions, imitating various styles and genres.

- These models can be used for inspiration, as collaborative tools, or even for generating background music for films and games.
- **Content Creation and Text Generation**
 - In the realm of natural language processing, generative models have been employed for text generation, translation, summarization, and even chatbots.
 - They can generate engaging stories, generate realistic dialogue, and assist with language-related tasks.
- **Data Augmentation and Synthesis**
 - Generative AI models can generate synthetic data to augment limited datasets for training machine learning models.
 - This technique helps overcome data scarcity challenges and improves the performance of AI systems.
- **Drug Discovery and Material Science**
 - Generative AI models aid in the discovery of new drugs and materials. By generating molecular structures and simulating chemical interactions, these models accelerate the research and development process in pharmaceuticals and materials science.

Ethical Considerations

- **Bias and Discrimination**
 - Generative AI models can inadvertently replicate biases present in the training data, leading to biased outputs.
 - Careful consideration must be given to ensure fair representation and prevent reinforcement of societal biases in generated content.
- **Intellectual Property and Plagiarism**
 - Generative AI raises concerns regarding copyright infringement and plagiarism.
 - Clear guidelines and regulations need to be in place to address the ownership and ethical use of generated content.
- **Misinformation and Deep-fakes**
 - The ability of generative AI to create realistic synthetic content raises concerns about the potential misuse of the technology for spreading misinformation and creating deep-fakes.
 - Robust mechanisms for content verification and authentication are necessary to address these issues.
- **Privacy and Data Protection**
 - Generative AI models often require large datasets, including personal information, for training.
 - Privacy safeguards should be implemented to protect individuals' data and ensure compliance with data protection regulations.

Conclusion

Generative AI represents a significant advancement in AI technology, offering exciting possibilities in content creation, design, and various other fields. However, it also presents ethical challenges that need to be addressed proactively.

Striking a balance between innovation, responsible development, and ethical considerations is crucial to harness the potential of generative AI while ensuring the technology is used ethically, fairly, and for the betterment of society.

AI as a Doctor

News Excerpt

Recently, AI has been in the news for discussions regarding when AI can work as a doctor.

How is AI being used in the medical field?

- AI algorithms and other applications powered by AI are being used to support medical professionals in clinical settings and in ongoing research.
- Currently, the most common roles for AI in medical settings are clinical decision support and imaging analysis.
- There are already several research studies suggesting that AI can perform as well as or better than humans at key healthcare tasks, such as diagnosing disease.
- Today, algorithms are already outperforming radiologists at spotting malignant tumours, and guiding researchers in how to construct cohorts for costly clinical trials.
- However, for a variety of reasons, we believe that it will be many years before AI replaces humans for broad medical process domains.

Types of AI relevant to healthcare

- **Machine learning** – It is a statistical technique for fitting models to data and to ‘learn’ by training models with data. Machine learning is one of the most common forms of AI
- It is basically of two types:
 - Neural networks and
 - Deep learning

Neural Networks

- A more complex form of machine learning is the neural network – a technology that has been available since the 1960s has been well established in healthcare research for several decades and has been used for categorization.
- It views problems in terms of inputs, outputs and weights of variables or ‘features’ that associate inputs with outputs.
- It has been likened to the way that neurons process signals, but the analogy to the brain’s function is relatively weak.

Deep Learning

- A common application of deep learning in healthcare is recognition of potentially cancerous lesions in radiology,
- Deep learning is increasingly being applied to radiomics, or the detection of clinically relevant features in imaging data beyond what can be perceived by the human eye.
- Both radiomics and deep learning are most commonly found in oncology-oriented image analysis.
- Their combination appears to promise greater accuracy in diagnosis than the previous generation of automated

tools for image analysis, known as computer-aided detection or CAD.

Natural language processing

- **In healthcare**, the dominant applications of NLP involve the creation, understanding and classification of clinical documentation and published research.
- NLP systems can analyse unstructured clinical notes on patients, prepare reports (eg on radiology examinations), transcribe patient interactions and conduct conversational AI.

Rule-based expert systems

- **In healthcare**, they were widely employed for ‘clinical decision support’ purposes over the last couple of decades and are still in wide use today.
- Many electronic health record (EHR) providers furnish a set of rules with their systems today.

Physical robots

- Surgical robots, initially approved in the USA in 2000, provide ‘superpowers’ to surgeons, improving their ability to see, create precise and minimally invasive incisions, stitch wounds and so forth.
- Important decisions are still made by human surgeons.
- However. **Common surgical procedures using robotic surgery include gynaecologic surgery, prostate surgery and head and neck surgery.**

Robotic process automation

- Robotic process automation (RPA) doesn't really involve robots – only computer programs on servers.
- It relies on a combination of workflow, business rules and ‘presentation layer’ integration with information systems to act like a semi-intelligent user of the systems.
- **In healthcare, they are used for repetitive tasks like prior authorisation, updating patient records or billing.**

Diagnosis and treatment applications

- Patient engagement and adherence has long been seen as the ‘last mile’ problem of healthcare – the final barrier between ineffective and good health outcomes.
- The more patients proactively participate in their own well-being and care, the better the outcomes – utilisation, financial outcomes and member experience.
- These factors are increasingly being addressed by big data and AI.

Can AI replace Doctors in future?

- **AI will alter how people define what it means to be a doctor.** Surely, some duties will change, while others will disappear totally. But neither a robot nor an algorithm can ever fully take the place of a doctor.
- **They cannot imitate or swap out empathy:** One of the fundamental components of high-quality healthcare is empathy. It encourages healing and raises patient satisfaction. Sadly, the fundamental argument against autonomous AI in healthcare is that empathy is impossible for a machine to achieve.

- **The working practices of doctors are evolving:** Making a diagnosis and creating a treatment plan are not simple processes, even if data, measurements, and analytics now play a large role in a doctor's job and will do so considerably more in the future. The innovative and problem-solving activities required of being a doctor are jobs that robots and algorithms will never be able to complete. There are numerous different patient types, and they all have various lifestyles.
- **Skilled professionals are required for complex digital technology:** Whether or not there are robotics or AI involved, there will be a need for competent, qualified medical practitioners as increasingly sophisticated digital health solutions become available.
- **Robots can't deal with a lack of data:** In actual cases, machine learning models are trained. Their performance improves as more data is supplied to them. Patients may not want to disclose certain information, or their circumstances may be unusual. Robots haven't yet been taught how to handle a shortage of data. And that's where we humans, with our intuition and creative thinking, come in.

Laws/Regulations in India for AI

- It does not have any specific law regarding application of AI.
- The Ministry of Electronics and Information Technology (MeiTY) is the regulatory body of AI in India.
- It has the responsibility development, implementation and management of AI laws and guidelines in India.
- There are certain provisions mentioned under Intellectual Property Law and several provisions as Section 43A & 72A of Information Technology Act, 2000 which implies that if anyone commits crime by using AI, then he will be liable under IT Act, criminal law and other cyber law.

Conclusion

- Healthcare can benefit greatly from artificial intelligence. It can accurately process enormous amounts of data, is always accessible, and can automate tedious time-consuming operations. Yet, when it comes to empathy, inventiveness, and non-linear thought, human doctors are unmatched.
- If we combine these two "superpowers," it's difficult to envision what healthcare could accomplish.
- AI technology is quickly becoming a major player in the healthcare sector. The ability to maintain human health and reduce the frequency of medical visits is one of the biggest potential advantages of AI.
- Although AI won't completely replace human doctors, it will increase physician performance and give people more access to healthcare at reduced rates. To fully utilize AI and serve humanity in the best and most advantageous way, proper regulations and a legal framework are necessary.

Use of AI Technology by UIDAI

News Excerpt

Recently, UIDAI has been using Artificial Technology to tackle the issue of Payment frauds.

Important points:

- To prevent AePS frauds by the use of spoofed fingerprints during Aadhaar authentication, the UIDAI has rolled out an in-house Artificial Intelligence/Machine Learning technology-based Finger Minutiae Record – Finger Image Record (FMR-FIR) modality which is able to check the liveness of a fingerprint to detect the use of cloned fingerprint during the authentication process.
- The technology uses a combination of both **finger minutiae** and **finger image** to check the liveness of the fingerprint captured.
- The measure was implemented after instances of people creating fake fingerprints using silicone to syphon off money from unsuspecting individuals' bank accounts were reported.

What are Fingerprint images and Fingerprint minutiae?

- The fingerprint image contains minutiae points, core points, ridges and valleys, background area, foreground areas, local features and global features. In a fingerprint image, the ridges appear as dark lines while the valleys are the light areas between the ridges.
- Finger Minutiae points are the locations where a ridge becomes discontinuous. A ridge can either come to an end, which is called as termination or it can split into two ridges, which is called as bifurcation.

What is AePS?

- The AePS is a bank-led model that allows online interoperable financial transactions at Point of Sale (PoS) or micro-ATMs through the Business Correspondent (BC) of any bank using the Aadhaar authentication.
- It was taken up by the National Payments Corporation of India (NPCI) - a joint initiative of Reserve Bank of India (RBI) and Indian Banks' Association (IBA).

What is the need of this technology?

- As more frauds related to the Aadhaar-enabled Payment System (AePS) come to the fore, the Unique Identification Authority of India (UIDAI), has turned to artificial intelligence-based systems in a bid to limit the cases — this includes developing technologies around fingerprinting and facial recognition.
- Minister of State for Finance Bhagwat Karad told Parliament on Monday (July 31) that to prevent AePS frauds by the use of spoofed fingerprints during Aadhaar authentication, the UIDAI has rolled out an in-house Artificial Intelligence/Machine Learning technology-based Finger Minutiae Record – Finger Image Record (FMR-FIR) modality which is able to check the liveness of a fingerprint to detect the use of cloned fingerprint during the authentication process.
- In May this year, Airtel Payments Bank collaborated with the National Payments Corporation of India (NPCI) to roll

out a facial recognition-based authentication measure for such transactions. The technology has been developed in-house by the UIDAI.

Some Data Related to Payment Frauds:

- According to the Home Ministry, in the financial year 2020-21, 2.62 lakhs financial crimes, such as money laundering, bribery, corruption and different kinds of frauds, were reported.
- The number jumped to 6.94 lakhs in 2022, a report, released by the Standing Committee on Finance — headed by BJP MP Jayant Sinha.
- Citing data it received from the supervised entities of the Reserve Bank of India (RBI), the committee noted that payment-related frauds are on the rise in India – In FY21, the volume of such frauds was a little over 700,000, which by FY23, increased to close to 20 million.
- However, due to limited awareness about cyber frauds, a significant number of people do not report them to authorities, the committee said.
- According to the information submitted to it by the Indian Cybercrime Coordination Centre (I4C), in the year 2022, out of 6,94,424 complaints related to financial frauds only in 2.6 per cent of cases an FIR was registered.
- The details shared by Karad with Parliament revealed that between November 2021 and March 2023, more than 2,000 complaints related to AePS were received by the offices of the RBI's ombudsman.

How AePS system is failing?

- Here, in this system, a business correspondent, a key member in the payment supply chain, is the culprit.
- A business correspondent (BC) is an informal bank agent equipped with a biometric Point-of-Sale (PoS) machine, which works like a micro ATM.
- If someone needs Rs 500, they have to give their bank details to the BC along with their Aadhaar-based biometric details and the BC will give them the Rs 500.
- However, officials aware of the matter said often, BCs misrepresent the amount they have paid an individual and input a higher amount in their system. Unsuspecting individuals, especially in rural areas, do not always have the wherewithal to ask for a receipt that the BC is supposed to generate after each transaction.

Way Forward

- Technology alone cannot solve the problems of Cyber Related Crimes and Frauds as it has its own limitations.

- Raising Awareness among the people is very necessary.
- Lack of reporting is also a problem. People should report the cases to the related authorities so that the proper action can be taken against the fraudulent.
- Personal and financial information should be kept secured. This includes using strong and unique passwords for online accounts, regularly updating them, and enabling multi-factor authentication whenever possible.
- It is also crucial to exercise caution while sharing sensitive information online and to be wary of phishing emails, messages, and suspicious websites.

AIIMS AI tool for cancer therapy

News Excerpt:

A supercomputer and AI (iOncology AI), developed by researchers from the All-India Institute of Medical Sciences (AIIMS) Delhi promises to identify the best cancer therapy for their patients.

- With iOncology AI, which employs a supercomputer in Pune and a **high-capacity server called Charak I** at the National Cancer Institute campus in Jhajjar, doctors are attempting to determine the most common type of genetic mutation in their patients, helping them narrow in on the best treatment option.

What does it mean for treatment?

As a result of research into the genomic changes associated with cancer, drugs have been developed to fight the disease in several ways:

- Inhibiting enzymes that trigger the abnormal growth and survival of cancer cells.
- Blocking aberrant genes
- Halting signals from cancer cells



How does this help in breast cancer for example?

Breast cancer is classified based on molecular characteristics into distinct subgroups – Luminal A, Luminal B, Triple-negative/basal-like, and HER2 type – that vary in their aggressiveness and respond differently to therapies. A doctor treating someone with breast cancer of the HER2 subtype can, for instance, cross-reference data related to therapy that has worked for patients of the similar genetic makeup, thus helping the doctor make informed, faster and precise therapy choices.



Objective of iOncology AI:

- iOncology AI aims to **sequence the genomes of 3,000 cancer patients** who are currently seeking treatment at AIIMS.
- It also aims to **address a fundamental question: Does a patient's genetic makeup correlate with the efficacy of diverse cancer therapies?**

How does the AI tool work?

- The platform, developed with Pune's Centre for Development of Advanced Computing, allows doctors to store cancer patients' blood test and lab reports, scans and ultrasound reports and their history.

- Along with collecting and collating data, the AI-enabled platform can also read the different types of datasets and help doctors make decisions.
- After studying the clinical data and genomic makeup of a couple of thousand cancer patients, the tool will help the doctors select the appropriate treatment for the next patient.
- This tool can also help in targeted treatments in resource-constrained settings where genomic studies might not be possible.
- When a scan or histopathology report is uploaded on the platform, the trained AI can automatically flag the ones with certain abnormalities.
 - For example, an extremely small tumour that a radiologist might miss at first. The AI will flag it. This can help in early detection of cancers in some cases.
- This data can help oncologists create their own prevention strategies and standard protocols.

Can the tool address all types of cancer?

- The research will focus on five types of cancers that are the most common, deadliest, or have immunotherapies available — breast, ovarian, head, and neck, colorectal, and two types of blood cancers.
- At present, the platform is trained only for breast and ovarian cancer.
- It already has various models for CT scan prediction, ultrasound image, histopath prediction, mammogram image prediction and detection and classification of the tumour.

WHAT IS AI?

- It is the intelligence demonstrated by machines, as opposed to the natural intelligence displayed by humans or animals. The term artificial intelligence was coined in 1955 by John McCarthy. **Types of AI:**
- **Weak AI:** This type encompasses systems designed to carry out one particular task such as Video games like chess and personal assistants like Amazon's Alexa and Apple's Siri.
- **Strong AI:** These systems are more complex and can perform tasks resembling human-like thinking. They are programmed to handle situations that require problem-solving without human intervention such as self-driving cars or hospital operating rooms.
- AI holds the potential to boost the national growth rate by 1.3% and add \$957 bn to India's economy by 2035.

AI and cancer care: The big shift

- Globally, there is an **increasing interest in the use of AI for cancer treatment** as it can help doctors – from developing new therapies to diagnosing patients at early stages of the disease and selecting appropriate treatments.
- Studies have shown that **certain AI-based models were able to identify individuals at high risk of developing pancreatic cancers up to three years earlier.**

- This is game-changing considering that most get diagnosed only when the cancer has advanced or metastasised.
- Similar results have been observed for breast and lung cancers as well.
 - For example, the **AI tool being developed by the Harvard Medical School**, which is similar to AIIMS but is **specific for colon cancers.**
- The model is being **trained to predict survival accurately and provide insights for treatment response based on tumour pathology, radiology images, and genomic data.**

Global Framework on The Expansion of Ethical AI

The Prime Minister of India has called for a **Global Framework for the expansion of "ethical" artificial intelligence (AI)** tools while addressing the B20 Summit in Delhi. This reflects a shift towards formulating regulations based on a "risk-based, user harm" approach.

Key Points:

- Telecom Regulatory of India (TRAI) has released a new consultation paper that recommended a **domestic statutory authority** to regulate AI in India following a "risk-based framework".
- NITI Aayog released a series of papers on Responsible AI for All.
- The Indian government intends to introduce the **Digital India Bill** that will replace the IT Act 2000. This bill aims to draw a clear distinction between different types of online intermediaries.
- **Microsoft** released a paper titled "**Governing AI: A Blueprint for India**", prescribing safety and security requirements. It also offered to share its "specialised knowledge" about advanced AI models to help the government define the regulatory threshold.

APPLICATIONS OF AI:

- **Healthcare-** AI improves disease diagnostics, enables personalized medicine, accelerates drug discovery, enhances telemedicine and integration of wearable devices and IoT-enabled health monitoring systems.
- **Education-** AI helps in plagiarism detection, and transcription for faculty lectures, and employs chatbots for student enrolment and retention.
- **Agriculture-** AI improves soil and crop health with weather forecasting, precision farming and predictive analytics, chatbots, and autonomous robots assisting farmers, etc. E.g.- Saagu-Baagu pilot of Telangana under AI for Agriculture Innovation (AI4AI) of WEF provides agri-tech services to farmers.
- **Transportation-** AI applies computer vision services, such as object detection or tracking to support traffic management, delay prediction, fleet integration, automatic traffic incident detection law enforcement, etc. E.g.- iRASTE (Intelligent Solutions for Road Safety through

Technology and Engineering) for road safety, Intelligence Traffic Management System (ITMS) By Delhi Police.

- **Space-** AI can be used for spacecraft navigation, satellite imaging, mission planning, and identifying new astronomical phenomena.
- **Cybersecurity:** AI provides crucial analysis and threat identification to reduce breach risk and improve security posture. It can also identify and prioritize risk, promptly detect malware on a network, guide incident response, and prevent intrusions.
- **Issues with AI:** The ethical concerns associated with the use of AI include privacy, system or algorithm bias, and violation of intellectual property rights. AI can also have a disruptive impact on society necessitating efforts in skilling and reskilling.

Related: World's First A.I. Law

The E.U. has become the **first continent to set clear rules for the use of A.I.** and have passed the World's first comprehensive regulation for artificial intelligence called the A.I. Act.

Highlights:

- Governments can only use real-time biometric surveillance in public areas when serious threats are involved, such as terrorist attacks.
- E.U. legal framework broadly divides A.I. applications into various risk classes:
 - Some applications will be largely banned, including the deployment of facial recognition on a mass scale, with some exemptions for law enforcement.
 - A.I. applications focused on behavioural control will also be banned.
 - High-risk applications such as the use of A.I. tools for self-driving cars will be allowed but subject to certification and an explicit provision for the backend techniques to be made open to public scrutiny.
 - Those applications in the "medium risk" category can be deployed without restrictions, such as generative A.I. chatbots but must be explicitly made aware that they are dealing with an A.I. and not interacting with a human.

AI laws and initiatives in India- The Ministry of Electronics and Information Technology (MeitY) is the regulatory body of AI in India.

- **IT Act, 2020:** Section 43A and 72A are relevant in the context of AI systems, that provides compensation for data privacy breach due to negligent handling of personal information.
- **The Digital Personal Data Protection Act, of 2023-** This act excludes publicly available personal data, raising concerns about data usage for scraping and AI development.
- **NITI Aayog** released the **National Strategy on AI** in 2018 and drafted a document on **Responsible AI for all.**
- **AIRAWAT-** AI Research, Analytics, and Knowledge Assimilation is an AI-based cloud computing

infrastructure under the **National AI program** designed to meet India's AI requirements.

- **INDIAai-** The National AI Portal of India, a joint venture of the MeitY, the National E-Governance Division of the Department of Electronics and Information Technology, and the National Association of Software and Service Companies prepares the nation for an AI future.

Conclusion

Expansion of AI is a double-edged sword. As we embrace the potential of AI, we must also understand our ethical responsibilities. It is imperative that human control over AI is maintained and a balance is kept between AI usage and effective governance.

News Media V/S ChatGPT

News Excerpt

A group of news media organisations, including The New York Times, Reuters, CNN, and the Australian Broadcasting Corporation, recently shut off OpenAI's ability to access their content.

ARTIFICIAL INTELLIGENCE:

The cycle of AI innovation:

- The use of AI to produce pieces of journalism has been in experimentation for some time. AI innovation is categorized into three waves: **automation, augmentation, and generation.**
- During the **first phase**, the focus was on automating data-driven news stories, such as financial reports, sports results, and economic indicators, using natural language generation techniques.
- **Second wave** arrived when the emphasis shifted to augmenting reporting through machine learning and natural language processing to analyse large datasets and uncover trends.
- The **third and current wave** is generative AI. It is powered by large language models capable of generating narrative text at scale. Now, we could ask a chatbot to write a longer, balanced article on a subject or an opinion piece from a particular standpoint.

About ChatGPT:

ChatGPT is an AI conversational chatbot. Users can ask questions on just about anything, and it will respond accurately with answers, stories, and essays. It can even help programmers write software code. All of this output is generated within minutes.

Face-off between News Media and ChatGPT:

- Software products like ChatGPT are based on what AI researchers call '**large language models**' (LLMs). These models require enormous amounts of information to train their systems.
- Tech companies that work on LLMs like Google, Meta or Open AI are secretive about what kind of training data they use.
- But it is clear that online content found across the Internet, such as social media posts, news articles,

Wikipedia, e-books, form a significant part of the dataset used to train ChatGPT and other similar products.

- This data is put together by scraping it off the Internet. Tech companies use **software called 'crawlers' to scan web pages**, hover up content and put it together in a dataset that can be used to train their LLMs.
- Besides ChatGPT, OpenAI makes money by selling access to its AI models for developers and enterprises directly.
- Recently, New York Times and others blocked a web crawler known as GPT bot, through which OpenAI used to scrape data. **They told OpenAI that the company can no longer use their published material and their journalism, to train their chatbots.**

Concerns of News Media companies:

- Search engines like Google or Bing also use web crawlers to index websites and present relevant results when users search for topics. The only difference is that search engines represent a mutually beneficial relationship.
- While Google profits off of the news content, it also directs a significant amount of user traffic to news websites.
- OpenAI, on the other hand, provides no benefit, monetary or otherwise, to news companies. It simply collects publicly available data and uses it for the company's own purposes.

Way forward:

- OpenAI should not infringe the copyrights or intellectual property of any news media company.
- It should focus on compensating adequately in order to access the online content for uninterrupted and mutual survival.
- The ability of ChatGPT to produce ideas and content makes it a valuable asset for all of us. But the benefits derived should be shared with the resource providers as well.

Global Partnership on A.I.

News Excerpt:

The Global Partnership on AI has unanimously adopted the **New Delhi Declaration**, pledging their commitment to a collaborative approach for A.I. applications.

About Global Partnership on Artificial Intelligence (GPAI):

- The GPAI is an attempt **to adopt a global risk-based approach to A.I.** largely led by the democratic world, including India.
- It is an alliance of 29 members (28 countries and the European Union) established in June 2020.
 - **GPAI's 29 members are** Australia, Argentina, Belgium, Brazil, Canada, Czech Republic, Denmark, France, Germany, India, Ireland, Israel, Italy, Japan, Mexico, the Netherlands, New Zealand, Poland, the Republic of Korea, Singapore, Slovenia, Spain, Sweden, Senegal, Serbia, Turkey, the United Kingdom, the United States and the European Union.

- **Notably, China**, a major tech superpower, is **not part of the multilateral grouping.**
- **GPAI endeavours to bridge the gap between theoretical understanding and practical implementation** of A.I. by endorsing cutting-edge research and applied endeavours in AI-related priorities.
- GPAI structures its working groups around **four core themes**:
 - Responsible A.I., Data Governance, Future of Work and Innovation and Commercialization

New Delhi Declaration by GPAI:

- This summit aims to finalize a comprehensive framework encompassing shared principles for **Safe and Trusted AI.**
- **Flagged Concerns:** The declaration flagged concerns emanating from such systems, including **misinformation, unemployment, lack of transparency and fairness, protection of intellectual property and personal data, and threats to human rights and democratic values.**
- **Win for India:** This is a significant win for India, which will push its **Digital Public Infrastructure (DPI)** model worldwide. Besides, access to computing capabilities from member nations will also boost New Delhi's plans of building a sovereign A.I. system,
- **Available to all countries:** The declaration seeks to ensure that A.I. and its benefits are inclusive and open to all the countries of the world, including the Global South.
- **Agriculture Sector:** GPAI members also agreed to support A.I. innovation in the agriculture sector as a new "thematic priority". India was pushing for the inclusion of agriculture as a priority sector in A.I. innovation.
- There is a need to mitigate risks arising from the development and deployment of A.I. systems and promote equitable access to critical resources for A.I. innovation including computing and high-quality diverse datasets.

Way Forward:

Multiple conversations on A.I., **including the G7 Hiroshima Process, Bletchley Declaration, and GPAI**, will contribute to the global discussions on how the framework of A.I. evolves soon.

G7 Hiroshima A.I. Process:

- In 2023, as the G7 President, Japan hosted the G7 Hiroshima Summit.
- It had significant implications as the leaders of the G7 gathered for discussions in Hiroshima. This city has recovered from the catastrophic damage caused by an atomic bomb and continues to seek lasting world peace.

Bletchley Declaration:

- It was signed by the countries who attended the A.I. Safety Summit in the U.K.
- In an agreement, 29 countries, including the U.S., the U.K., China, Australia, Brazil, India and the European Union, have mutually agreed that A.I. has the potential to transform and enhance human well-being, peace and prosperity.

NUCLEAR

'Artificial Sun': The ITER

News Excerpt:

Scientists from South Korea have been able to produce heat of 100 million Celsius from their reactor for a record period of 48 seconds.

More About the News:

- The **Korea Institute of Fusion Energy's (KFE) Korea Superconducting Tokamak Advanced Research (KSTAR)** fusion reactor has achieved a groundbreaking milestone by **reaching temperatures seven times hotter than the Sun's core**.
- During testing between December 2023 and February 2024, the KSTAR reactor sustained temperatures of **180 million degrees Fahrenheit (100 million degrees Celsius) for 48 seconds**, surpassing previous records.
- This accomplishment demonstrates progress towards **sustaining high-temperature plasma, which is crucial for nuclear fusion reactions**. Maintaining the **high**

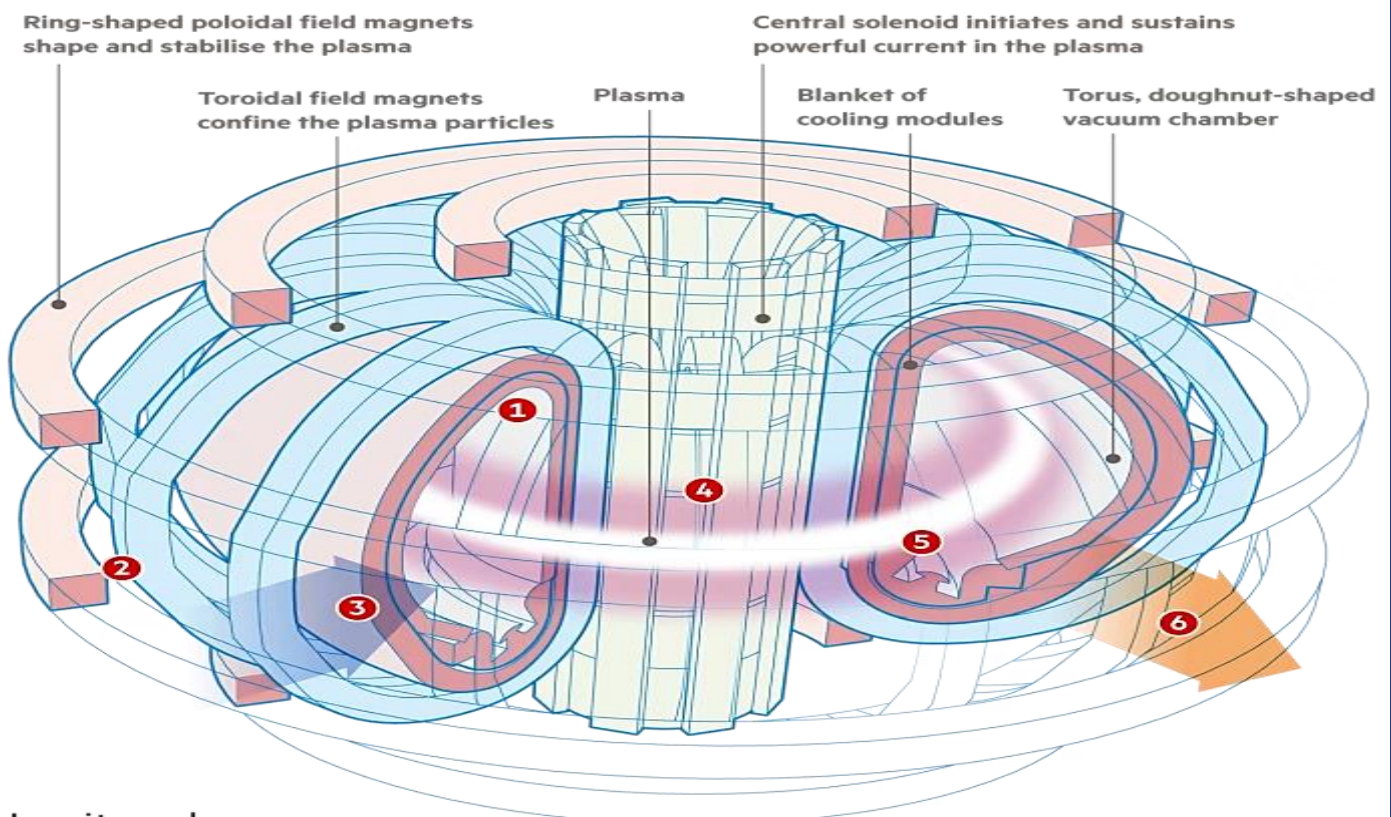
confinement mode (H-mode) for over 100 seconds further showcases KSTAR's capabilities.

- **H-mode** provides a **stable plasma state** essential for efficient fusion reactions. By employing tungsten diverters instead of carbon, the KSTAR team successfully extended plasma stability.

Nuclear Fusion:

- Process where **two atomic nuclei combine to form a heavier nucleus**, releasing a significant amount of energy in the process.
- **Tokamak:**
 - A tokamak is a **device used to confine and control hot plasma in the process of nuclear fusion**. It consists of a **torus-shaped chamber surrounded by magnetic coils**.
 - Inside the chamber, **hydrogen isotopes are heated to extremely high temperatures, forming a plasma**. Magnetic fields generated by the coils confine the plasma, preventing it from contacting the walls of the chamber.

Magnetic confinement fusion (the tokamak)



How it works

- 1 Air is extracted from the vacuum chamber, the torus
- 2 The magnets are charged up
- 3 Fuel is introduced, typically deuterium and tritium
- 4 Current is run through the torus, stripping electrons from the fuel and forming a plasma
- 5 The energised plasma particles collide and begin to heat up. Helped by auxiliary heating and confined by the magnets, they reach a condition where fusion can occur
- 6 The heat can be transferred out for electricity generation, typically using steam turbines

International Thermonuclear Experimental Reactor (ITER)

The International Thermonuclear Experimental Reactor (ITER) is a major international nuclear fusion research and engineering project. It aims to demonstrate the feasibility of generating energy through nuclear fusion on a commercial scale.

ITER is a collaborative effort of members of the European Union (EU), the United States, China, Russia, India, Japan, and South Korea, with its headquarters located in France.

ITER's design is based on a concept known as magnetic confinement fusion, where the plasma is heated to temperatures exceeding 100 million degrees Celsius, allowing hydrogen isotopes to fuse and release energy.

- This confinement allows the plasma to reach the temperatures and densities necessary for nuclear fusion reactions to occur.
- **Tungsten diverters** are critical components in fusion reactors, as they expel waste gases and impurities while enduring high surface heat loads.
- Earlier the Carbon diverters were used but with the coming of tungsten diverters there is a **25% increase in Surface temperatures** ultimately enhancing the reactor's operational capabilities.
- Tungsten has one of the highest melting points of all metals, making it capable of withstanding the intense heat generated in fusion reactions.
- **Artificial Sun:** The term is used to **describe tokamak reactors because they replicate the conditions found in the Sun's core where nuclear fusion naturally occurs.**
- By creating a controlled fusion reaction on Earth, scientists aim to unlock a nearly limitless source of clean energy that could help address the world's energy needs while reducing reliance on fossil fuels and mitigating climate change.

Nuclear waste and its treatment

News Excerpt:

India recently advanced its nuclear program by loading the core of the **Kalpakkam PFBR**, nearing **stage II** of its nuclear programme. With **stage III** aimed at utilizing thorium reserves for energy, India faces the challenge of effective nuclear waste management amidst its nuclear power expansion.

What is nuclear waste?

- Nuclear waste refers to the radioactive materials produced during nuclear reactions in nuclear power

plants, research reactors, nuclear weapons production, and other nuclear processes.

- In a fission reactor, neutrons bombard the nuclei of atoms of certain elements. When one such nucleus absorbs a neutron, it destabilizes and breaks up. This process produces energy and creates nuclei of different elements.
 - **For example**, when the uranium-235 (U-235) nucleus absorbs a neutron, it can fission to barium-144, krypton-89, and three neutrons. If the 'debris' (barium-144 and krypton-89) constitute elements that can't undergo fission, they become nuclear waste.
- **Nuclear waste** is highly radioactive and needs to be stored in facilities reinforced to prevent leakage into and contamination of the local environment.
- Apart from the byproducts from nuclear fission reaction nuclear waste can come in various forms, including spent nuclear fuel rods, contaminated equipment and materials.

How do we handle nuclear waste?

- Handling nuclear waste, particularly spent fuel, poses significant challenges due to its **heat and radioactivity.**
- **Spent fuel** is initially stored underwater for several decades before being transferred to **dry casks** for **longer-term storage.**
- Countries with nuclear power programs have accumulated substantial inventories of spent fuel, such as the **U.S. (69,682 tonnes in 2015)**, **Canada (54,000 tonnes in 2016)**, and **Russia (21,362 tonnes in 2014).**
- Storage periods for nuclear waste can extend up to millennia, requiring isolation from human contact for longer than modern humans have existed.
- Nuclear power plants also have **liquid waste treatment** facilities to manage **aqueous wastes** containing **short-lived radionuclides.**
- Depending on their hazard levels, liquid wastes may be discharged after treatment or processed through methods like **evaporation, chemical precipitation, absorption on solid matrices, or incineration.**
- **Liquid high-level waste**, containing **most fission products** produced in the fuel, is **vitrified into a stable glass form for storage.**
- In certain cases, such as in **India's pressurized heavy-water reactors**, where **spent fuel is reprocessed, fission products that cannot be used as fuel** must be **stored as liquid waste**, posing **potential accident hazards.**

How is nuclear waste dealt with?

- After spending at least, a year in the spent-fuel pool for cooling, the spent fuel can be transferred to dry-cask storage.
- It is enclosed within **substantial steel cylinders** and surrounded by **inert gas.**
- These cylinders are **securely sealed** and then placed within larger chambers made of steel or concrete.
- Some experts have also rooted for **geological disposal:**

- The waste is sealed in “**special containers**” and **buried underground** in granite or clay.
- The upside here is **long-term storage away from human activity**.
- However, studies have highlighted the **risk of radioactive material exposure** if containers are disturbed, potentially through nearby **excavation activities**.
- **Reprocessing**, which involves **separating fissile from non-fissile material** in spent fuel, is another method for handling nuclear waste.
- First the material is **chemically treated to separate fissile material** left behind from the **non-fissile material**.
- Reprocessing facilities **require specialized protections and personnel** due to the **hazardous nature of spent fuel**.
- These facilities offer the **advantage of higher fuel efficiency** but come with **significant expenses**.
- **Reprocessing** also yields **weapons-usable plutonium**.

What are the issues associated with nuclear waste?

- The issues associated with nuclear waste include its **long-term storage, potential for environmental contamination, health hazards** from radiation exposure, the need for **safe disposal methods**, and societal concerns regarding **transportation and storage security**.
- Additionally, the management of nuclear waste involves **significant costs** and **regulatory challenges**, while the long-lasting radioactive nature of some materials poses challenges for future generations.

How does India handle nuclear waste?

- According to a 2015 report from the International Panel on Fissile Materials (IPFM), India has reprocessing plants in Trombay, Tarapur, and Kalpakkam.
- According to the PMO, the wastes generated at the nuclear power stations during the operation are of low and intermediate activity levels and are managed at the site itself.
- Nuclear waste is treated and stored in on-site facilities.
- Such facilities are located at all nuclear power stations”, and that the surrounding area “is monitored for radioactivity” for safety.

India's first indigenous Fast Breeder Reactor at Kalpakkam

News Excerpt:

The Prime Minister witnessed the commencement of “**core loading**” at India's first indigenous **Prototype Fast Breeder Reactor (PFBR)** (500 MWe) at **Kalpakkam, Tamil Nadu**.

More about the news:

- The **PFBR** has been fully designed and constructed indigenously by Bharatiya Nabhikiya Vidyut Nigam

Limited (**BHAVINI**) with significant contributions from more than 200 Indian industries, including MSMEs.

- PFBR is an advanced **third-generation reactor** with inherent passive safety features ensuring prompt and safe plant shutdown in an emergency.

Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI)

BHAVINI is a government company under the administrative control of the Department of Atomic Energy (DAE).

It was incorporated in **2003** with the objective of constructing and commissioning the first 500 MWe Fast Breeder Reactor (FBR) at Kalpakkam in Tamil Nadu.

Objective: To pursue the **construction, commissioning, operation and maintenance of subsequent Fast Breeder Reactors** for the generation of electricity in pursuance of the schemes and programmes of the Government of India under the provisions of the **Atomic Energy Act, 1962**.

BHAVINI has constructed a 500 MWe Prototype Fast Breeder Reactor (PFBR) at Kalpakkam.

The PFBR is the forerunner of the future Fast Breeder Reactors and is expected to provide **energy security** to the country.

The PFBR is built with the design and technology developed at the **Indira Gandhi Center for Atomic Research (IGCAR)** located at **Kalpakkam**.

What is the Prototype Fast Breeder Reactor (PBFR)?

- The PFBR is a nuclear reactor that produces more nuclear fuel than it consumes.
 - PFBR uses fast neutrons to generate more nuclear fuels than they consume while generating power, dramatically enhancing the efficiency of the use of resources.
- The Fast Breeder Reactor (FBR) will initially use the Uranium-Plutonium Mixed Oxide (MOX) fuel.
- PFBR also uses liquid sodium, a highly reactive substance, as a coolant.
 - Sodium absorbs fewer neutrons than light water, and more neutrons remain within the reactor.
 - An increased number of neutrons causes a higher proportion of Uranium 238 to convert into Plutonium 239, yielding more plutonium than the original nuclear fuel.
- FBRs are designed to produce more plutonium than the uranium and plutonium they consume.
- Since it uses the spent fuel from the first stage, FBR also offers a great advantage in significantly reducing the amount of nuclear waste generated, thereby avoiding the need for large geological disposal facilities.
- The core-loading event of the PFBR is being hailed as a “milestone” because the operationalisation of the PFBR will mark the start of stage II of India's three-stage nuclear power programme.

India's three-stage nuclear power programme:

- The **Department of Atomic Energy (DAE)** has planned the use of large deposits of **Thorium** available in the country as a long-term option.
- A three-stage nuclear power programme has been chalked out to use Thorium as a viable and sustainable option right at the inception of India's nuclear power programme.
 - In the **first stage**, India used **pressurised heavy water reactors (PHWRs)** and **natural uranium-238 (U-238)**, which contain minuscule amounts of **U-235**, as the **fissile material**.
 - The first stage produces **plutonium-239 (Pu-239)** and **energy**.
 - In **stage II**, India will use **Pu-239** and **U-238** in the **PFBR** to produce **energy, U-233**, and more **Pu-239**.
 - In **stage III**, **Pu-239** will be combined with **thorium-232 (Th-232)** in reactors to produce **energy and U-233**.
- The three-stage nuclear power programme aims to **multiply the domestically available fissile resource** through the use of natural Uranium in Pressurised Heavy Water Reactors, followed by the use of Plutonium obtained from the spent fuel of Pressurised Heavy Water Reactors in Fast Breeder Reactors.

Significance of stage II:

- On a significant scale, **commercial utilisation of Thorium** can begin only when **abundant** supplies of **Uranium-233** or **Plutonium** resources are available.
 - Large-scale introduction and utilization of Thorium in the programme has been contemplated after an **adequate inventory of Plutonium** becomes available from our Fast Breeder Reactors (**FBRs**), comprising the second stage of the Indian nuclear power programme.
 - This will be after a few decades of large-scale deployment of FBRs.
- In preparation for the utilisation of Thorium in the Third Stage of India's Nuclear Power Programme, efforts towards **technology development** and **demonstration** are made now so that a mature technology for Thorium utilisation is available in time.

Amending nuclear law to spur 'pink' hydrogen generation**News Excerpt:**

India is in talks with large domestic companies to invest in the regulated nuclear sector, including promoting clean power.

Important Points:

- **The Atomic Energy Act of 1962** restricts private ownership of nuclear plants. The central government

holds the power to produce, develop, use and dispose of **'atomic energy'**.

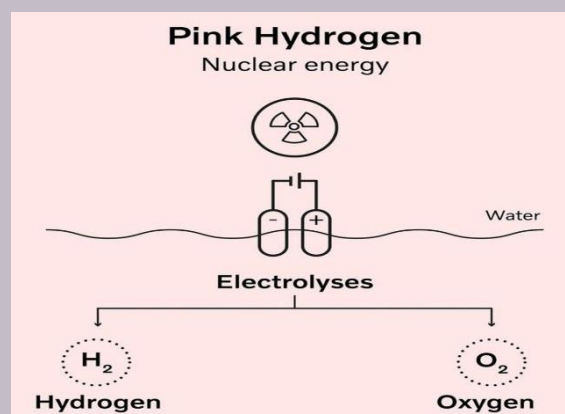
- After legislative amendments, such powers can be exercised through any authority/corporation established by the government in which the former holds at least **51 percent of the paid-up share capital**.

Significance of hydrogen:

- As India's aim to bolster nuclear capacity appears to be driven by clean energy goals, the hydrogen economy has gathered strong political patronage — especially with respect to **'green' hydrogen**.
- However, nuclear power can also enable large-scale hydrogen production without emitting greenhouse gases, making it promising.
 - Similar to green, **'pink' hydrogen is also generated through electrolysis but powered by nuclear energy**.
- Recent studies claim that **pink hydrogen** facilities can achieve a high-capacity factor due to the steady base load profile of nuclear power (involving both stability and density) relative to the intermittent supply from renewable sources.

Pink Hydrogen

- It is made using renewable energy to electrolyze water while emitting zero carbon dioxide.
- Pink hydrogen is a promising replacement for fossil fuels in the **cement industry, steel industry, aviation, and heavy transportation**.
- Nuclear power offers significant advantages for pink hydrogen production, including reducing production costs and emissions, making it a sustainable and more cost-effective alternative to conventional methods.



- High temperatures from nuclear reactors may also be used in other industrial processes.

Way Forward:

- Significant investments will be necessary to develop better technologies at scale.
- Amending the **Atomic Energy Act** to facilitate private investments is an idea whose time has come.

- Future collaborations could focus on research, technology transfer, and scaling up hydrogen projects — whether green or pink. After all, **India's net-zero transition** will require multiple pathways — including **nuclear power and renewable energy**.

Fission Surface Power Project

News Excerpt:

NASA announced that it is finishing the **initial phase** of its ambitious plan to build a **small electricity-generating nuclear reactor on the Moon**.

About the Fission Surface Power Project:

- Fission surface power can provide abundant and **continuous power** regardless of environmental conditions on the **Moon and Mars**.
- The project aims to develop **safe, clean and reliable energy sources** on the **Moon**.
- Such a system would play a big role in **NASA's Artemis program for lunar exploration**.
- It is focused on developing concept designs for a **small, electricity-generating nuclear fission reactor** that could be used during a future demonstration on the Moon and to inform future designs for Mars.
- Under this project, NASA is aiming to power a **sustained human presence** on the lunar surface for **at least 10 years**.
- **NASA** worked with the Department of Energy (DOE, U.S.A.) and industry to design a fission power system that would provide at least **40 kilowatts of power** to continuously **run 30 households for ten years**.

Significance of the Nuclear fission reactor in the project:

- Solar power systems have limitations on the Moon; a nuclear reactor **could be placed in permanently shadowed areas** (where there may be water ice) and still **generate power continuously during lunar nights**, which are 14-and-a-half Earth days long.
- NASA's Fission Surface Power Project marks a **pivotal step** in **lunar exploration**, aiming to establish a **sustainable energy source** through nuclear fission.
- By leveraging its partners' expertise, the project seeks to **overcome the limitations of solar power**, ensuring **continuous electricity supply** for future missions and prolonged human presence on the Moon.

HEALTH & DISEASES

Aspartame: an artificial sweetener

News Excerpt

Recent reports stated that Artificial sweetener Aspartame may increase cancer risk in human and WHO is gearing up to declare it as 'possibly carcinogenic to humans'.

Key Points:

- Report stated that Sugar alternatives had undesirable effects like increased risk of type 2 diabetes, cardiovascular diseases, and mortality in adults.
- As per JECFA (the Joint WHO and Food and Agriculture Organization's Expert Committee on Food Additives), which is the WHO's expert committee on food additives, an adult weighing 60 kilos has to drink more than 12 cans of diet soda everyday to be at risk.

About Aspartame

- Aspartame, a popular artificial sweetener found in Diet Coke, chewing gum, yoghurt and other food products.
- It was discovered in 1965 by American chemist James Schlatter.
- Aspartame is about 200 times sweeter than the regular table sugar.
- It was approved by the US Food and Drug Administration in 1974 for use as a tabletop sweetener and as an additive in chewing gum, breakfast cereals and dry bases for foods.

Significance of Aspartame

- Despite its intense sweetness, aspartame has an almost zero calorific value and no bitter aftertaste like saccharin, and grew in popularity as a more diet-conscious consumer emerged.
- According to The European Food Safety Authority, aspartame is made of the two naturally occurring amino acids, phenylalanine and aspartic acid. They are also components of proteins in our body and in food.
- The phenylalanine in aspartame gets slightly modified by adding a methyl group which gives aspartame its sweet taste.
- Aspartame also doesn't leave a bitter aftertaste like saccharine, which is 400 times sweeter than sugar but has to be mixed with other artificial sweeteners to curb its unpleasant side.

Concern with Aspartame

- Aspartame, one of the world's common artificial sweeteners is likely to be declared a possible carcinogen.
- Aspartame has been linked to behavioural and cognitive problems including learning problems, headache, seizure, migraines, irritable moods, anxiety, depression, and insomnia.
- Several studies link aspartame to weight gain, increased appetite, diabetes, metabolic derangement and obesity-related diseases.

Switch to natural alternatives

- Artificial sweeteners increase the risks of metabolic disorders, weight gain, and even negative impacts on gut health. Beverages that utilize non-sugar sweeteners have indeed become prevalent among individuals aiming to lose weight. However, it is important to recognize that these beverages can pose major health risks.

- "Regarding weight loss, rather than relying solely on artificial sweeteners, individuals should focus on adopting a balanced and nutritious diet.
 - This includes consuming whole foods, such as fruits, vegetables, lean proteins, and whole grains, while minimizing processed foods and added sugars. Hydration can be achieved through water, herbal teas, or infusions.
- Portion control and mindful eating are also crucial aspects of weight management. Moreover, staying physically active through regular exercise helps burn calories and maintain overall health.

Other foods that can cause cancer

- Certain ways of cooking like heating food in plastic utensils, overuse of microwave and certain processed foods such as frozen sausages, preserved food, pickle preserved by nitrate, can be a cause of cancer.
- Ajinomoto, artificial sweeteners, artificial colouring agents all are possible carcinogenic food items.
- These foods can cause Oesophagus cancer, liver cancer, gall bladder cancer, stomach, colon, rectal cancers are on rise due to carcinogenic in our food.

Regulations

- Different countries have implemented regulations and policies regarding the use of aspartame. In the United States, the Food and Drug Administration (FDA) oversees the regulation of aspartame as a food additive.
- The FDA has established an Acceptable Daily Intake (ADI) limit for aspartame, which is set at 50 milligrams per kilogram of body weight.
- This means that on a daily basis, the average adult can safely consume up to this amount of aspartame without experiencing any harmful effects.
- Similarly, the European Union has also put forth regulations for aspartame. The European Food Safety Authority (EFSA) has recommended a slightly lower ADI for aspartame, specifically 40 milligrams per kilogram of body weight per day.
- The Indian government will set its own standards on artificial sweeteners such as aspartame.
- FSSAI is the major institution who research in the field of artificial sugar and give recommendation related to use of it.

Way Forward

- Artificial sweetener should be use carefully and in minor level.
- Proper research and study on it are required.
- People have to try to use natural sweetener rather than artificial sweetener.

Skin-lightening creams laden with mercury

News Excerpt:

Researchers from Kerala have reported a series of cases from **Malappuram district** where the regular use of fairness creams has been linked to **nephrotic syndrome**.

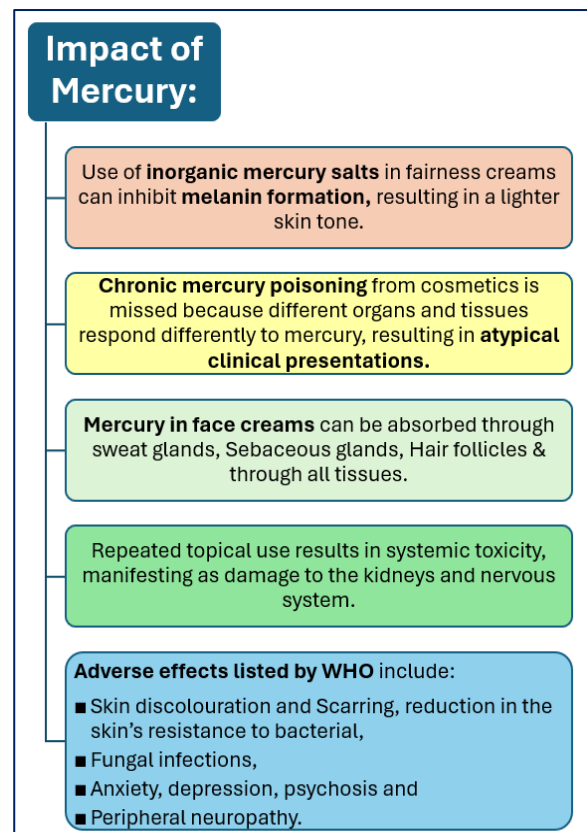
- Heavy metal screening of blood and urine samples from these patients revealed high levels of mercury.

More about News:

- An analysis of the fairness creams used by these patients also showed that some creams contained very **high levels of mercury**.
 - In some cases, **10,000 times above the permissible limit of 1 ppm**.
- The study published in **Kidney International journal** describes 15 such cases of **membranous nephropathy (a type of nephrotic syndrome)** traced to the use of these mercury-containing fairness creams.

About High proteinuria:

- A **nephrologist in Kozhikode** noticed a **specific pattern in cases of membranous nephropathy (MN)** diagnosed among his patients since 2021.
 - These patients had non-specific symptoms like **fatigue, mild edema, and frothy urine** but exhibited high levels of **proteinuria**, ranging from **6.5 to 22.2 g/day**.
- **Membranous nephropathy (MN)** is an autoimmune disease resulting in nephrotic syndrome, a condition where excessive protein is released into the urine (proteinuria), ultimately leading to **renal failure**.
- The link between **face creams containing mercury and nephrotic syndrome** is well-established worldwide.



How does Fairness cream affect?

- The patients admitted to fairly regular usage of fairness creams before they began experiencing **non-specific or subtle symptoms**.
- The research team found **15 cases of Membranous Nephropathy (MN) linked to NELL-1**, which is a type of kidney disease.
 - In 13 out of the 15 cases, patients had a history of using fairness creams, many of which were unregulated brands promising rapid results and sold locally or online.
- The obsession with fair skin and the use of skin-lightening products is prevalent beyond **India and in African and Asian countries**.
- Despite widespread use, the serious systemic health issues caused by toxic cosmetic creams are not yet perceived as a **global public health issue**.
- The **Minamata Convention on Mercury**, to which India is a signatory, is a global treaty "to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds" and it has been in force since 2017.
- According to a new **Zero Mercury Working Group (ZMWG) report** released in October 2023, despite being banned by a **global treaty** it is widely used in various such products.

Zero Mercury Working Group (ZMWG)

- It is an **international coalition** of more than 110 public interest environmental and health non-governmental organizations from over 55 countries, formed in 2005 by the **European Environmental Bureau** and the **Mercury Policy Project**.
- ZMWG strives for **zero supply, demand, and mercury emissions from all anthropogenic sources, aiming to reduce** mercury in the global environment to a minimum.
- **Their mission** is to advocate and support the adoption and implementation of a legally binding instrument that contains mandatory obligations to eliminate or minimize the global supply and trade of mercury, the global demand for mercury, anthropogenic releases of mercury into the environment, and human and wildlife exposure to mercury.

Way Forward:

- Larger, **multi-centric systemic studies on chronic mercury poisoning** are required not just to understand the extent of the problem but also to persuade policymakers and regulators to clamp down on all cosmetics containing mercury.

New WHO sodium benchmarks

News Excerpt:

Poor dietary habits contribute to an estimated 8 million deaths globally, with **2 million attributed to excessive sodium consumption**. To increase awareness, WHO has released the second list of Sodium Benchmarks.

More about the news:

- In 2020, the World Health Organization (WHO) initiated the development of global standards, establishing maximum sodium levels in various food categories.
- **The goal is to achieve the global noncommunicable diseases (NCDs) target of a 30% reduction in average salt intake by 2025**, aiming for less than **5 grams of salt (< 2 grams of sodium) daily**.

Initiatives undertaken by the World Health Organization (WHO) and other stakeholders to address the issue of excessive sodium intake:

- **WHO Guidelines on Sodium Intake (2012):** The WHO emphasized the importance of reducing sodium intake in both adults and children in its 2012 guideline, recognizing it as crucial for preventing noncommunicable diseases (NCDs).
- **Efforts and Initiatives:** WHO has recognized reducing salt intake through food reformulation and setting target salt levels as a cost-effective intervention to combat unhealthy diets and prevent NCDs. This strategy has been labelled a **"best buy"** by WHO.
- **General Programme of Work 2019–2023:** WHO further emphasized the significance of salt reduction in its program, acknowledging that current efforts have been insufficient but experiences from various countries show progress is possible with clear targets.
- **Collaborative Efforts with Industry:** WHO collaborated with Chatham House and engaged the food and non-alcoholic beverage industry to enhance involvement in reducing sodium intake.
- **Engagement with the International Food and Beverage Alliance (IFBA):** WHO has been actively engaged in dialogue with IFBA to improve the nutritional quality of food and beverage products.
- **Focus on Sodium Reduction:** WHO highlighted sodium consumption as a significant dietary risk factor during meetings with industry representatives.
- **Establishing Sodium Benchmarks:** WHO proposed establishing sodium benchmarks as maximum limits to guide countries in formulating national policies and strategies.

About Sodium Reduction:

- **Importance of Sodium Reduction:** Elevated sodium intake elevates blood pressure, increasing the risk of cardiovascular diseases, the primary cause of NCD-related deaths globally. Additionally, it mitigates other health complications associated with high sodium intake, including chronic kidney disease, obesity, gastric cancer, and liver diseases.

- **Source of Sodium:** A significant portion of dietary sodium originates from processed foods like bread, cereal, grains, processed meats, and dairy products.

Way Forward:

- The World Health Organization (WHO) recommends individuals consume less than 5 grams of salt (<2 grams of sodium) daily, implying that the average population intake should be substantially lower than this threshold.
- There is an urgent need for accelerated progress to meet globally agreed-upon targets for reducing sodium intake and the associated NCD burden.

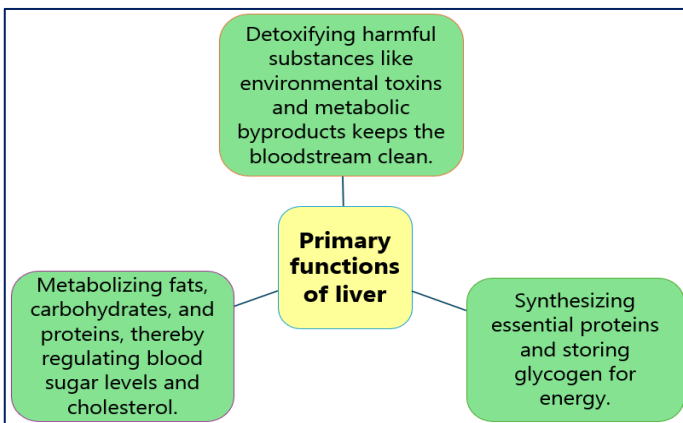
The dynamic duo: The liver & the gut

News Excerpt:

This article focuses on the **symbiotic relationship** between liver function and gut health, **shedding light on how nurturing one benefits the other.**

Understanding liver function:

- The liver, referred to as the body's powerhouse, boasts a repertoire of functions crucial for our overall well-being due to its numerous essential roles.



Factors that can strain the liver include:

- Excessive alcohol consumption
- Poor dietary choices
- Viral infections
- Certain medications
- Prolonged strain on the liver can potentially **lead to liver diseases** such as: Fatty liver disease, Hepatitis, Liver cirrhosis etc.

The Gut: Gateway to Health

- The gut, or digestive tract, hosts trillions of microorganisms known as the **gut microbiota**. The gut microbiota aids in **Breaking down food, Synthesizing vitamins & bolstering the immune system**
- Maintaining a diverse and balanced gut microbiome is crucial for overall health. Modern lifestyles characterized by **processed foods, antibiotics, and chronic stress** often disrupt the delicate equilibrium of the gut microbiota.

- Disruption of the gut microbiota can pave the way for gastrointestinal disorders such as: **Irritable bowel syndrome (IBS), Inflammatory bowel disease (IBD), Leaky gut syndrome.**

Liver-gut axis:

- The liver and gut are involved in a **bidirectional communication system** where various molecules, hormones, and immune cells shuttle between the two organs, influencing each other's function.
- The **bile produced by the liver aids** in fat digestion and also acts as a signalling molecule in the gut, modulating the composition of the gut microbiota.
- Metabolites produced by **gut bacteria can influence liver** metabolism and inflammation.
- A healthy gut microbiome contributes to the **integrity of the gut barrier**, preventing harmful substances from leaking into the bloodstream and burdening the liver. **A compromised gut barrier can trigger systemic inflammation and liver dysfunction.**

Way Forward:

Because of this mutual interaction, supporting gut health appears to be the most viable way to support liver function. Some **strategies to optimize both** include:

- **Embrace a fibre-rich diet:** Fiber-rich foods like fruits, vegetables, whole grains, and legumes serve as prebiotics, nourishing beneficial gut bacteria.
 - Moreover, soluble **fibre binds to bile acids, aiding in their excretion.** It reduces **cholesterol levels**, thus alleviating **the liver's workload.**
- **Incorporating probiotic-rich foods** like yoghurt, kefir, and kimchi introduces beneficial bacteria into the gut, fostering a diverse microbiome.
 - These microbes can **metabolize bile acids** and **modulate inflammation**, indirectly benefiting liver health.
- **Limit sugar and processed foods:** Excessive sugar and processed foods not only **disrupt the gut microbiota but also contribute to fatty liver disease** and insulin resistance.
- **Stay hydrated:** Hydration supports liver function by aiding in the **elimination of toxins** through urine and optimizing bile production for digestion.
- **Manage stress: Chronic stress** can wreak havoc on **gut health. Prioritizing stress management techniques** like meditation, yoga, or deep breathing exercises can mitigate its adverse effects.

Neurotoxins

News Excerpt

A gas leak in the Giaspura neighborhood of Ludhiana, Punjab, resulted in 11 fatalities and four hospitalizations for illness.

Ludhiana Gas Tragedy

- According to the police preliminary investigation, the neighborhood manhole may have let out a deadly gas that travelled to the adjacent stores and homes.
- Hydrogen Sulphide, a neurotoxic gas, has been speculated as the cause of the catastrophe by forensic professionals.
- **Expert view:** It's likely that some acidic garbage was dumped into the sewer, where it mixed with other sewer gases like methane and carbon monoxide to create hydrogen sulphide.

About Neurotoxins

- Neurotoxins are harmful compounds that have a direct impact on the neurological system.
- Neurotoxicity occurs when the nervous system's normal activity is disrupted by exposure to hazardous substances, whether natural or man-made.
- These compounds have the potential to damage or even kill neurons or nerve cells, which are essential for signal transmission and processing in the brain and other sections of the nervous system.

Neurotoxic gases

- Neurotoxic gases include methane, hydrogen sulphide, carbon monoxide, and carbon dioxide.
- While methane and carbon monoxide are odourless gases, hydrogen sulphide has a strong odour and can be lethal in large concentrations.
- Chemical oxidation is used to remove gases such as hydrogen sulphide from wastewater. Oxidants such as hydrogen peroxide are applied to the wastewater.

Reasons behind Gas leaks

- **Inadequate Waste Management:** Improper disposal of industrial waste might result in the discharge of neurotoxic gases. Dumping poisonous chemicals into sewers, for example, can result in dangerous chemical reactions, as witnessed in the Ludhiana gas leak incident.
- **Inadequate Industrial Plant Maintenance:** Poorly maintained plants and storage facilities might result in gas leakage. The Bhopal gas tragedy is an example of a catastrophic gas leak caused by insufficient chemical plant safety and maintenance.
- **Lack of regulation and Monitoring:** Weak environmental regulatory enforcement and insufficient monitoring of industries and government bodies can result in dangerous gas leaks. Inadequate oversight causes industries to operate without basic safety measures, increasing the likelihood of gas leaks.
- **Overcrowding in Cities:** The presence of industrial and residential structures in highly populated areas raises the risk of gas exposure. As demonstrated in the Vizag gas leak event, insufficient urban planning and zoning rules contribute to this problem.
- **Infrastructure Failures:** Gas leaks can occur as a result of damaged or poorly maintained pipes and storage tanks.

In some cases, deteriorating infrastructure and a lack of regular maintenance can lead to dangerous scenarios.

Safety Measures taken by Government against Gas leaks:

- **The Bhopal Gas Leak (Processing of Claims) Act of 1985** empowered the central government to secure claims resulting from or associated with the Bhopal gas tragedy.
- **The Environment Protection Act (EPA) of 1986** empowers the central government to take actions to improve the environment, set standards, and inspect industrial units.
- **The Public Liability Insurance Act of 1991** is a type of insurance designed to help people who have been injured while working with hazardous substances.
- Importers must provide complete product safety information to the competent authorities under the **Manufacture, Storage, and Import of Hazardous Chemicals Rules, 1989**, and transport imported chemicals in conformity with the modified rules.
- **The Chemical Accidents (Emergency, Planning, Preparedness, and Response) Rules, 1996** mandate the central government to form a central crisis group for chemical accident management and to build up a rapid response mechanism known as the crisis alert system.
- **The National Environment Appellate Authority Act, 1997:** Under this Act, the National Environment Appellate Authority can hear appeals concerning the restriction of areas in which any industries, operations, processes, or class of industries shall not be carried out or shall be carried out subject to certain safeguards under the EPA 1986.

Challenges

- **Lack of disaster preparedness:** In the Kochi rubbish fire event (2022), a mountain of waste caught fire and spewed hazardous vapors for more than a week. This underlined the importance of enhanced emergency planning in order to minimize harm to human health and the environment.
- **Issues with India's legal structure-** include insufficient and obsolete laws, fragmented and overlapping rules, insufficient fines and deterrents, and an insufficient emphasis on prevention, among other things.
- **Non-transparent industrial operations-** such as unauthorized activities, unsafe working conditions, and insufficient money for upkeep all contribute to higher chances of industrial disasters in India.
- **Lack of awareness:** In the Bhopal gas tragedy (1984), poor safety precautions were implemented due to a lack

of information about the hazards linked with methyl isocyanate, which contributed to the fatal leak.

- **Improper maintenance:** The Vizag gas leak (2020) at LG Polymers India's facility in Visakhapatnam was caused by a technical malfunction in the refrigeration unit, emphasizing the significance of good infrastructure maintenance.
- **Rapid urbanization:** Initially a barren area near the LG Polymers plant in Visakhapatnam, the Gopalapatnam area became heavily populated as the city expanded, increasing the risk of exposure to the styrene gas leak.
- **Inadequate trash disposal:** The Surat toxic waste dumping disaster (2022) resulted in six deaths, highlighting the consequences of unlawful dumping and poor waste management. This can lead to dangerous circumstances.

Way Forward:

- **Strengthen the legal framework**-Examine and update existing laws and regulations governing hazardous materials and industrial safety to ensure they are comprehensive, effective, and in accordance with international standards.
- India should follow in the footsteps of the **European Union's Seveso Directive and REACH regulation**, which enforce severe safety requirements and promote responsible chemical management, and could assist India in strengthening its regulatory system.
- **Improve workplace safety** -By implementing tight safety measures in industries and developing effective emergency preparedness plans to prevent accidents and safeguard workers from harmful gas exposure.
- **Support the development of new technologies and safer alternative**-To dangerous substances by encouraging research and technological innovation. This can help to reduce the danger of neurotoxic gas leaks and the effects they have on human health and the environment.

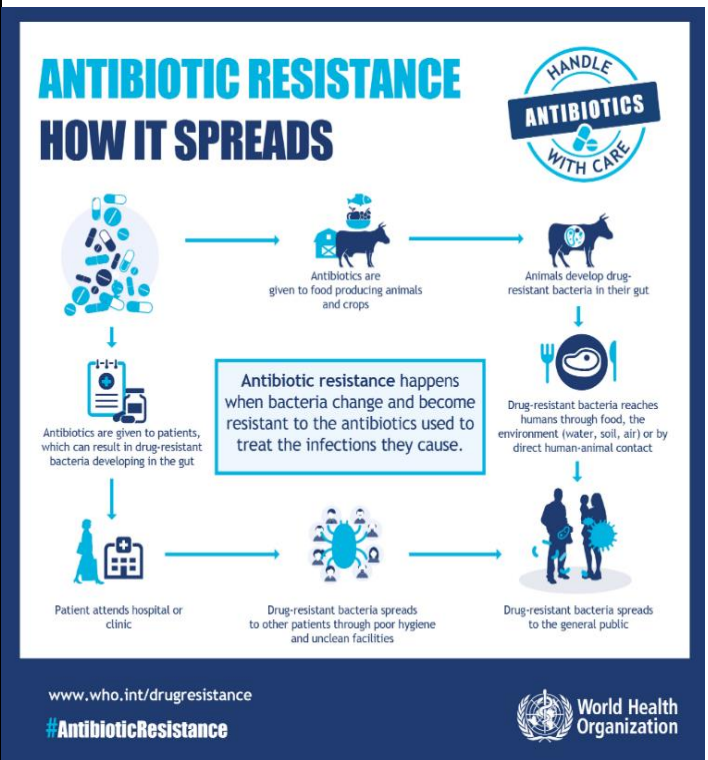
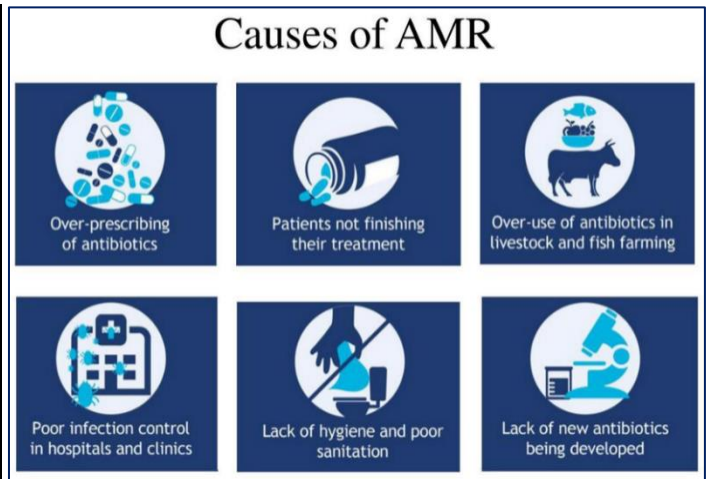
Urgency in Combating Antibiotic Resistance

News Excerpt:

Innovation in antibiotics research and development is urgently needed.

About Antimicrobial Resistance (AMR):

- AMR occurs when bacteria, viruses, fungi, and parasites evolve over time and no longer **respond to medicines**, making infections more challenging to treat and increasing the risk of disease spread, severe illness, and death.
- As a result, the medicines become **ineffective, and infections persist** in the body, increasing the risk of spreading to others.
- AMR threatens the effective prevention and treatment of an ever-increasing range of infections.



- Antimicrobials - including **antibiotics, antivirals, antifungals, and antiparasitics** - are medicines used to prevent and treat human, animal, and plant infections. Microorganisms that develop AMR are sometimes referred to as **"superbugs"**.

Status of AMR in India:

- India has one of the highest age-standardized infectious disease mortalities in South Asia, and the rates of antibiotic resistance **are alarming**.
- India has one of the highest uses of human antibiotics, a prime driver of antimicrobial resistance, at **10.7 units per person**.
- Over the past four years, the number of isolates reported has gradually increased from 25,833 to 1,19,686.
 - Similar to the previous five years, Escherichia coli (33%) remained the most commonly isolated pathogen in the **AMR Surveillance data 2022**.

Hurdles Faced in Antibiotic Innovation:

- **Lack of Innovation:** Limited exploration of alternative pathways and mechanisms hampers the emergence of groundbreaking antibiotic solutions.
- **Challenges in Identifying New Druggable Targets:** Unraveling suitable bacterial targets for antibiotics is a complex puzzle, often compounded by evolving resistance mechanisms.
- **The exit of Major Pharmaceutical Companies:** The withdrawal of prominent pharmaceutical players from antibiotic development diminishes collective expertise and resources dedicated to combating bacterial infections.
 - **For example-** Between 2016 and 2018, four big companies – AstraZeneca, Sanofi, Novartis, and Allergan exited from antibiotic R&D.
- **Less Attractive Profit Margin:** The comparatively lower profitability of antibiotics discourages investment, diverting attention and resources toward more lucrative therapeutic areas like cancer or chronic diseases.

Way Forward:

- **Recognition:** Combined effort is required from major regulatory bodies to treat AMR as a global challenge akin to climate change, E.g., A call for integrated action on AMR by the World Federation of Public Health Associations.
- **Encourage innovation:** Treat AMR as a national issue, make policies and arrange funding to encourage innovation.
- **The Global Antibiotic Research and Development Partnership (GARDP)** proposes to focus on public health-driven, non-profit antibiotic development.
- **Government support:** There is a need for the Government's push for R&D, infrastructure, clinical development, organized market forces, and incentives for novel antimicrobial discovery. E.g., **India's National Action Plan (NAP) for AMR 2017** by the Union Ministry of Health and Family Welfare.
- **One Health approach:** As AMR affects human, animal, plant, and environmental health, a One Health approach is required to tackle its complexities.

Revamp of the blood management system

News Excerpt:

A recent report by the World Health Organization (WHO) has brought attention to the **global disparities in blood collection**.

Key findings of the report:

- Despite having **14%** of the **global population**, countries in the **WHO African region** could **only collect 5%** of the global donations.
- **Low-income** and **lower-middle-income** nations received **2%** and **24%** of the worldwide contributions,

respectively, even though their populations account for **only 8% and 40%** of the global population.

- According to **WHO's standards** for self-sufficiency, **India** collected around **1.27 crore blood units** and faced a **shortage** of over **six lakh units** in 2019-20.
 - While India has improved its blood management ecosystem, the country still faces a **perennial shortage** of blood units, impacting critical healthcare services.
- Such shortages can have **serious implications** on the functioning of the healthcare system and, if addressed promptly, can significantly contribute to **saving lives**.

Significance of blood availability:

- Blood and its various products play a crucial role in several **medical scenarios**, including scheduled **surgeries** and **emergency procedures**, as well as in treating conditions such as **cancer**, **thalassemia**, and **postpartum haemorrhage (PPH)**.
- For example, according to a **Savitribai Phule Pune University study**, an **automobile accident victim** needs up to **50 units of blood**.
- In 2019-20, the shortage was significant enough to put approximately **12,000 accident victims'** lives at risk.
- Moreover, this deficit could impact **1,00,000 heart surgeries** and approximately **30,000 bone marrow transplants**.

Challenges and concerns:

- According to the data tabled in **Parliament**, from 2014-15 to 2016-17, a surplus of **30 lakh blood units** and related products were **discarded**.
- The primary reasons were **expiration** from not being used, **degradation** during storage and the presence of **infections** such as human immunodeficiency virus (**HIV**) and **syphilis**.
- Another aspect of the blood management system that perpetuates the **inequities** associated with it is the **propagation of myths** and **misinformation** around voluntary blood donation.
- Many people still refrain from donating blood voluntarily because of the **fear of infections** damaging their **immunity** or simply because they assume it to be **time-consuming**.

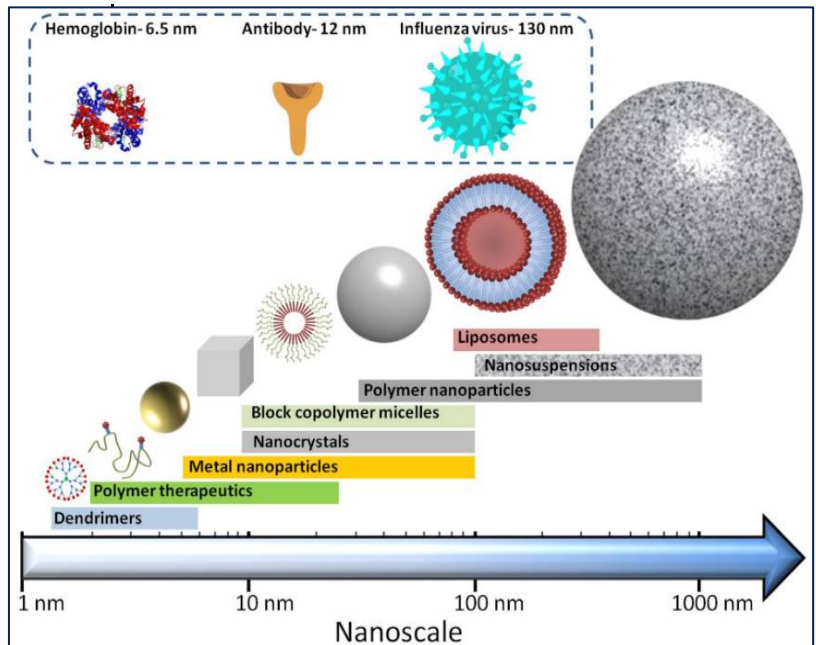
Hub and Spoke model of blood management system:

- It is an innovative method with **high-volume blood banks as a hub** for smaller blood centres.
- This model can be particularly relevant for **resource-constrained settings** in Low- and Middle-Income Countries (**LMIC**) as it can **address critical gaps in blood availability and distribution**, thereby enhancing the accessibility and availability of blood and its products.
- As the shelf life of blood and its products is short, a hub and spoke model would help **optimize their utilization** by the smaller blood centres.

- This approach **streamlines distribution**, ensuring these vital resources reach their maximum potential while reducing losses from expiration.
- Moreover, implementing a hub and spoke model can **improve accessibility** to safe blood and its products in **community health centres** and smaller **sub-district hospitals**, especially in geographically challenging topographies.

Way Forward:

- The private sector can collaborate with the government to form robust public-private partnerships (**PPP**) and launch **grassroots campaigns** using **social media** and innovative tools like **multilingual comics**.
- These creative strategies can engage diverse audiences and promote informed, voluntary blood donation, fostering a **culture of informed donation**.
- Simultaneously, the **active participation of the citizenry** should also be a pivotal aspect of this concerted effort.



Indian Spices to treat cancer

News Excerpt:

Recently, researchers at the Indian Institute of Technology (IIT), Madras, have **patented** the use of **Indian spices** to develop **Nanomedicines** to treat cancer.

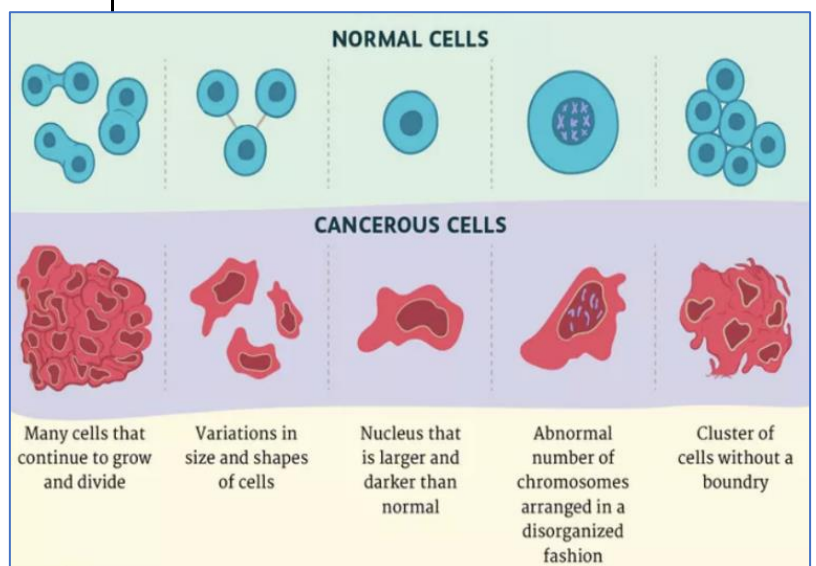
About the Nanomedicines:

- The application of nanotechnology for medical purposes has been termed nanomedicine and is defined as the use of nanomaterials for diagnosis, monitoring, control, prevention and treatment of diseases.
- **It uses the properties developed by a material at its nanometric scale of 10⁻⁹ m.**
- The patented Indian spice-based nano-formulations have **proven effective** in **common types of cancers** through in-vitro studies.
- **The nanomedicines** have shown **anti-cancer activity** against lung, breast, colon, cervical, oral and thyroid cell lines.
- They were found to be safe in normal cells.
- **Animal studies** have been carried out on the patented anti-cancer nano-formulations.
- Animal validation to adjust the dosage (**GLP phase**) and efficacy studies (**non-GLP phase**) have been carried out successfully.
- The drug dosage adjustment and efficacy are under investigation through animal models.
- Clinical trials will follow this.

Significance of the newly patented Nanomedicine:

- India is the world's largest spice producer. Hence, large-scale production could be achieved at a low cost.

- The medical benefits of Indian spice oils have been known through the ages, but their bioavailability has limited their application and use.
- Formulation as a nano-emulsion effectively overcomes this limitation.
- The stability of the nano-emulsion was a key consideration in the process of making medicine effective.
- The spices chosen are edible. Hence, biocompatibility is good, reducing toxic side effects.
- This cancer nanomedicine is being developed to reduce the cost and pain of cancer treatment.
- The formulations are developed for an oral route of administration to ease the treatment process.
- Cancer nanomedicine is considered superior to conventional treatment strategies owing to its reduced toxicity, improved drug accumulation, suitable size spectrum in the nanometre range and increased circulation time.



How does cancer develop?

- Cancer is a genetic disease in which some of the body's cells grow uncontrollably and spread to other body parts.
- Genetic changes that cause cancer can happen because:
 - Of errors that occur as cells divide.
 - Of damage to DNA caused by harmful substances in the environment, such as the chemicals in tobacco smoke and ultraviolet rays from the sun.
 - Of inheriting offspring from their parents.
- The body normally eliminates cells with damaged DNA before they turn cancerous. However, the body's ability to do so decreases as one ages.
 - This is part of the reason why there is a higher risk of cancer later in life.
- Each person's cancer has a unique combination of genetic changes. As the cancer continues to grow, additional changes will occur.
 - Even within the same tumour, different cells may have different genetic changes.

Reason Behind the nanotechnology-based cancer drug development:

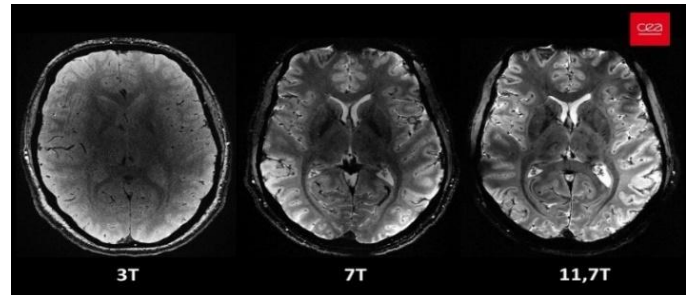
- The global surge in cancer cases as well as cancer deaths in all age groups. Of these, breast, lung and colorectal cancers are considered the most common worldwide.
 - A major concern is that according to the World Health Organisation in 2020 around 4,00,000 children develop cancer annually.
- Chemotherapy has been in use as a treatment strategy since 1930 with other common treatment options being radiotherapy and surgery. However, conventional treatment options are often associated with pain, toxic side effects, lack of targeting efficiency and high cost.
- As the complete eradication of cancer remains elusive through the existing therapies, the role of nanomedicine is assuming greater importance.

World's most powerful MRI machine**News Excerpt:**

The world's **most powerful MRI scanner** has produced its initial images of human brains, achieving an unprecedented level of precision.

More About the News:

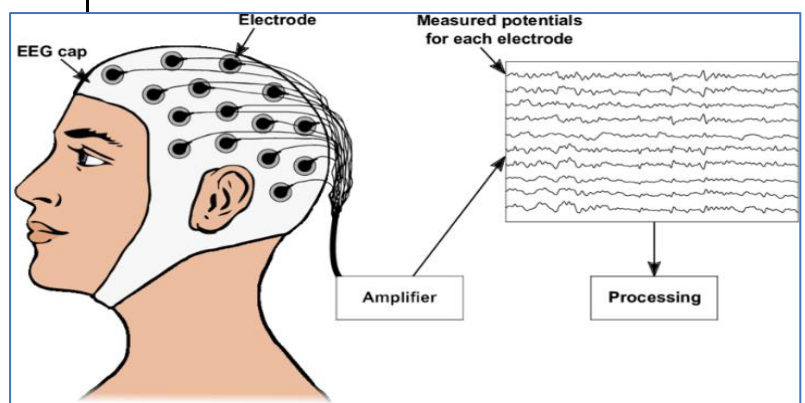
- The machine was developed by **France's Atomic Energy Commission (CEA)** situated in the **Plateau de Saclay region south of Paris**, known for its concentration of technology firms and academic institutions.
- The scanner generates a **magnetic field of 11.7 teslas**, a measurement unit named after inventor **Nikola Tesla**.



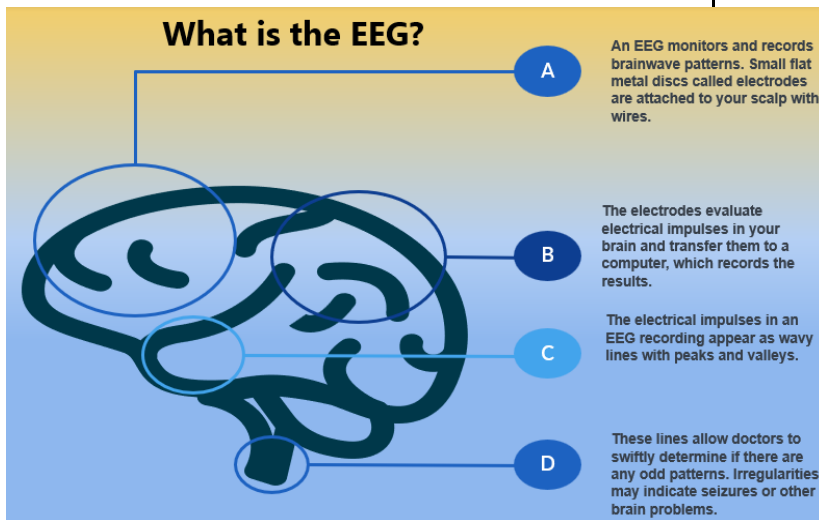
- This capability enables the machine to capture images with tenfold greater precision compared to the commonly used hospital MRIs, typically with a power of up to 3 teslas.
- The researchers previously utilized the machine to scan a pumpkin in 2021. Recently, health authorities authorized the scanning of humans.
- This Machine has observed an **unprecedented level of precision**, we can **visualize the minuscule vessels supplying the cerebral cortex** or discern details of the cerebellum that were previously nearly invisible, which will enable improved detection and treatment of brain pathologies.
- **Objective:** To enhance our comprehension of brain anatomy and the specific brain regions activated during various tasks.
- Utilizing MRIs, scientists have already demonstrated that the brain's cerebral cortex exhibits distinct patterns of activation when recognizing specific stimuli such as faces, locations, or words.

How do electrical patterns arise in the brain?

- Electrical patterns arise in the brain due to the natural **repetitive activity, or oscillations, of neurons**.
 - This oscillatory activity is a result of the way **neurons are connected** and how they interact through **excitation and inhibition, creating push-pull effects**.
- These local oscillations serve as **fundamental building blocks**, contributing to the overall EEG (**electroencephalogram**) activity across the brain.
- Interestingly, these oscillations can **synchronize, or coalesce**, into a common **rhythm**, leading to patterns observed in EEG, including **seizure-like patterns in patients**.



Electroencephalography (EEG) remains a crucial tool for understanding the brain



Cell-Free DNA: Promises to transform how we find diseases

News Excerpt

Recently, Cell-free DNA has been in news as it promises to transform how we find diseases.

About Cell-Free DNA

- Cell-free DNA are short fragments of DNA released into the bloodstream through a natural process of cell death.
- During pregnancy, the mother's blood contains cell-free DNA (cfDNA), both from her own tissue and from the fetus via the placenta. Approximately 2-20% of total cfDNA in maternal blood is placental.
- It was first discovered by Mandel and Métais in 1948.
- cfDNA can be found in plasma and other body fluids such as, Cerebral Spinal fluid, Pleural Fluid, urine, saliva and others.
- Scientists have been aware of such degraded fragments of nucleic acids in body fluids since 1948. But only in the last two decades or so, since genome sequencing technologies started to become more accessible, have they really figured out what to do with that knowledge.

c-f DNA in blood

- cfDNA can be generated and released from a cell in a number of possible situations, including when a cell is dying and the nucleic acids become degraded. Since an array of processes modulates the degradation, the amount, size, and source of the cfDNA can vary across a range as well.
- The release of cfDNA could occur together with a variety of processes, including those required for normal development, those related to the development of certain cancers, and those associated with several other diseases.

Applications of cfDNA.

- It helps in keeping a check on baby's health: It helps in screening foetuses for specific chromosomal abnormalities, an application known as non-invasive

prenatal testing. They can then use it to understand specific chromosomal abnormalities that involve changes in the chromosomal copy number. Such changes can lead to conditions like Down's syndrome.

- In Early Cancer Detection: Another emerging application of cfDNA is in the early detection, diagnosis, and treatment of cancers. In Genome-wide Mutational Incidence for Non-Invasive detection of cancer', or 'GEMINI'. They adopted a whole-genome-sequencing approach to cfDNA extracted from patients.

- In Organ Donation and Transplantation: It helps in understanding why a body is rejecting a transplanted organ. Here, some cfDNA obtained from the donor who is donating the organ – called donor-derived cfDNA, dd-cfDNA – could provide an early yet accurate estimate of how well the organ is being taken up. This is an attractive proposition

because changes in the levels of cfDNA in the blood would precede any biochemical or molecular markers that researchers currently use as a proxy for organ acceptance. That is, the cfDNA could send a signal earlier than other markers if something is going to go wrong.

- As a Biomarker: cfDNA could be used as a biomarker for neurological disorders like Alzheimer's disease, neuronal tumours, stroke, traumatic brain injury, and even metabolic disorders like type-2 diabetes and non-alcoholic fatty liver disease.

Wastewater Surveillance for Vector-Borne Diseases

News Excerpt:

There is a debate on the feasibility of using wastewater surveillance to track malaria and dengue in India.

More details on the news:

- Wastewater surveillance has proven effective in certain contexts, but its application to tracking vector-borne diseases in India presents unique challenges.
- The debate revolves around the issue of whether India should also use wastewater surveillance to track vector-borne diseases like developed countries.

Vector-Borne Diseases

- Vectors act as a medium for transmitting infectious germs from animals to humans and, in some cases, between humans.
- These organisms first get infected by the disease-causing pathogens, and once infected, they can transmit the pathogen to humans throughout their lives whenever they come in contact with a human host.
- Diseases transmitted through such vectors are called vector-borne diseases.
- Some vector-borne disease examples are Malaria, Dengue, Lymphatic Filariasis, Kala-azar, Japanese Encephalitis and Chikungunya.

Vector-Borne Diseases in India

- Vector-borne diseases (VBDs) have been a public issue in India for decades. VBDs have become a serious threat to the health and well-being of the population.
- In 2021, the leading cause of death due to vector-borne diseases was dengue, with a total of 247 deaths across the country.
- The reasons for the spread of diseases include climate change, lack of sanitation and cleanliness, and stagnant water, which can be a breeding ground for mosquitoes.

Steps taken by the government to control vector-borne disease

- In view of its vector-borne disease burden like malaria, dengue, chikungunya, Japanese encephalitis, lymphatic filariasis and kala-azar, India has set ambitious goals to eliminate and eradicate malaria and lymphatic filariasis by 2030.
- **The National Vector Borne Disease Control Programme (NVBDCP)** is an umbrella programme for preventing and controlling vector-borne diseases.
- The Directorate of **National Vector Borne Disease Control Programme (NVBDCP)** is the central nodal agency for the prevention and control of six vector-borne diseases (VBDs): Malaria, Dengue, Lymphatic Filariasis, Kala-azar, Japanese Encephalitis and Chikungunya in India.
- Through the Union Health Ministry, the government has proactively responded to the heightened risk of vector-borne diseases in India.
- The ministry occasionally issues advisories to states and Union Territories, urging collaboration with civic agencies for swift action.

Way Forward:

- **Comprehensive surveillance approach:** A comprehensive approach combining wastewater and mosquito surveillance is crucial to address the complexities posed by these diseases.
- **Careful pathogen selection for wastewater surveillance:** The selection of priority pathogens for wastewater surveillance should carefully consider India's specific context, sanitation systems, and host-parasite geography.
- **Integrated surveillance strategy:** While wastewater surveillance holds promise, a balanced strategy integrating multiple surveillance methods is essential for a more effective and accurate disease monitoring system.
- **Digital public infrastructure:** The role of **Digital Public Infrastructure (DPI)** is important in advancing **SDG 3 (Good Health and Well Being)** by leveraging digital technologies for healthcare solutions.
- **Collaborative efforts for SDG 3:** There is a need for active participation and collaboration between the

government, private sector, and non-governmental social welfare organizations to collectively contribute to achieving the 2030 target for SDG 3.

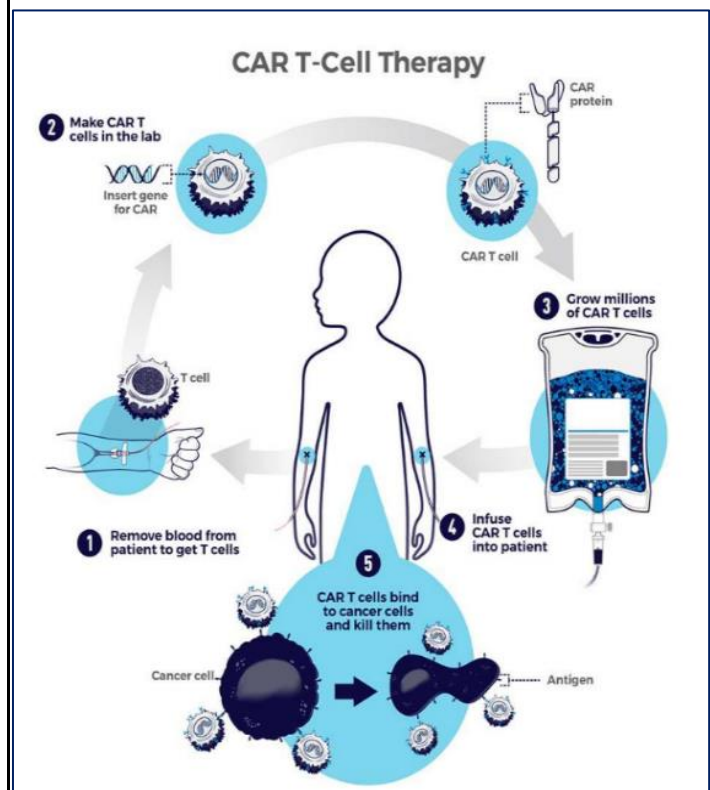
India's own CAR-T Cell Therapy

News Excerpt:

The **Central Drugs Standard Control Organization (CDSCO)** has granted market authorization to India's breakthrough **Chimeric Antigen Receptor (CAR)** T-cell therapy for patients with B-cell lymphomas who didn't respond to standard treatments like chemotherapy.

About CAR-T Cell Therapy:

- CAR-T is a revolutionary therapy that **modifies immune cells**, specifically T-cells, by turning them into potent cancer fighters.
- **(CAR)- T cell therapy** involves genetic modification of a patient's autologous T-cells in a laboratory so that they will bind to specific proteins (Antigens) on cancer cells and kill them.



NexCar19: A type of CAR-T therapy indigenously made in India:

- The Food and Drug Administration (FDA) has approved **six CAR-T-cell treatments since 2017**. All are licensed for the treatment of blood cancers such as **lymphomas, leukaemia**, and, most recently, **multiple myeloma**.
- **NexCar19** is a type of **CAR-T and gene therapy** developed indigenously in India by **ImmunoACT and Tata Memorial Centre (TMC)**. **ImmunoACT** is a company incubated at IIT Bombay.

- **Immunoadoptive Cell Therapy Private Limited (ImmunoACT)** obtained **CDSDO** approval for NexCAR19, a CAR-T treatment, to treat relapsed or refractory **B-cell lymphoblastic leukaemia**.
- The approval came after a Phase I/II trial of 60 patients showed a **70% overall response rate** and significant delay in cancer progression.

B-cell acute lymphoblastic leukaemia is a disease that affects your "B lymphocytes" – white blood cells that form in the soft centre of your bones, known as marrow. **B-cell leukaemia is most common among children.**

B lymphocytes are meant to develop into cells that can help in the fight against infections. However, with this disease, they transform into "leukaemia" cells, which live longer than normal cells and proliferate rapidly. They accumulate in your bone marrow and then enter your bloodstream. They can then spread to other organs in your body.

How NexCar19 Works:

- The Patient's white blood cells are extracted by a machine through **leukapheresis** and genetically modified, equipping them with the tools to identify and destroy the cancer cells.
- **NexCar19** is manufactured to an optimal dose for a patient and is typically administered as a single intravenous infusion. Before this, the patient is put through chemotherapy to prime the body for the therapy.

The Central Drugs Standard Control Organisation (CDSCO)

- It comes under Directorate General of Health Services, **Ministry of Health & Family Welfare**.
- It is the **National Regulatory Authority of India** for cosmetics, pharmaceuticals and medical devices, headquartered at New Delhi.
- **Under the Drugs & Cosmetics Act, 1940 and rules 1945**, CDSCO is responsible for **approval of Drugs**, Conduct of **Clinical Trials**, laying down the **standards for Drugs**, control over the quality of imported Drugs in the country and coordination of the **activities of State Drug Control Organizations** by providing expert advice.
- It along with other state regulators, is jointly responsible for the **grant of licenses** of certain specialized categories of critical Drugs such as blood and blood products, **I. V. Fluids, Vaccine and Sera**.

Way Forward:

India is now one of the **first developing countries** to have its **indigenous CAR-T** cell and gene therapy platform, a technology not even owned by all developed countries. **CD19-targeted CAR-T** cells are now offering hope to adults and children with advanced aggressive **lymphomas**. This therapy can show tremendous results to those patients whose cancers return, or relapse, after chemotherapy or a stem-cell transplant.

First human clinical trial of gene therapy for haemophilia A

News Excerpt:

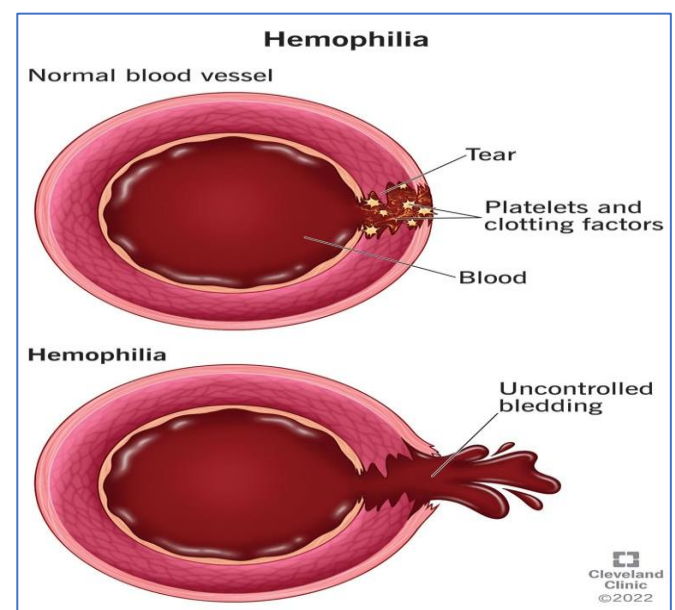
Union Minister of Science & Technology revealed on **National Science Day (28 Feb)** that India has conducted the **first human clinical trial of gene therapy for haemophilia A** (FVIII deficiency) at Christian Medical College (CMC) Vellore.

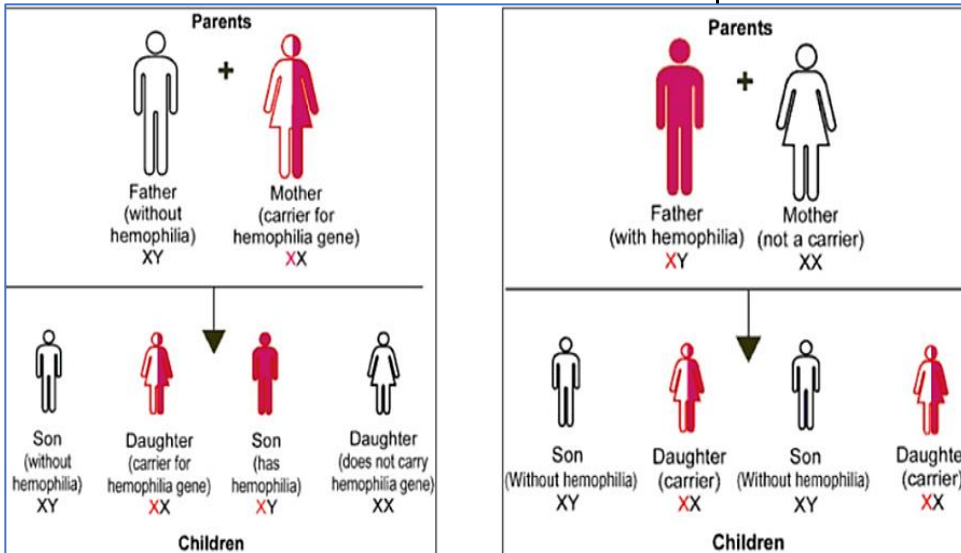
About the Haemophilia Gene Therapy trial:

- The programme is supported by the **Department of Biotechnology**, the Centre for Stem Cell Research - a unit of InStem Bengaluru, in collaboration with Emory University, USA at **Christian Medical College, Vellore**.
- The trials involved deploying a novel technology of **using a lentiviral vector** to express **an FVIII transgene in the patient's own haematopoietic stem cell** which will then express FVIII from specific differentiated blood cells.

About Haemophilia:

- Haemophilia A, also called factor VIII (8) deficiency or classic haemophilia, is a **genetic disorder** caused by missing or defective factor VIII (FVIII), a clotting protein.
 - Although it is passed down from parents to children, about 1/3 of cases found have no previous family history.
- Haemophilia is passed down from parents to children.
- Haemophilia is a **sex-linked disorder**. The X and Y sex chromosomes help determine haemophilia inheritance patterns.
- **The gene for haemophilia is carried on the X chromosome**. Haemophilia is inherited in an X-linked chromosome in the following recessive manner.
 - Females inherit two X chromosomes, one from their mother and one from their father (XX).
 - Males inherit an X chromosome from their mother and a Y chromosome from their father (XY).





- That means if a son inherits an X chromosome carrying haemophilia from his mother, he will have haemophilia.
- It also means that **fathers cannot pass haemophilia on to their sons.**

Symptoms of Haemophilia:

- People with haemophilia A **bleed longer than other people.** Bleeds can occur internally, in joints and muscles, or externally, from minor cuts, dental procedures, or injuries.
- How often a person bleeds and the severity of those bleeds depends on how much FVIII a person produces naturally.
- **Normal levels of FVIII range from 50% to 150%.** Levels below 50% – or half of what is needed to form a clot, determine a person’s symptoms.

Treatment for Haemophilia:

- The main medication to treat haemophilia A is a concentrated FVIII product, called clotting factor or simply factor.
- There are **two types of clotting factor:**
 - Plasma-derived and recombinant.
 - Plasma-derived factors are made from human plasma.
 - Recombinant factor products are developed in a lab using DNA technology.
 - While plasma-derived FVIII products are still available, approximately **75% of the haemophilia community takes a recombinant FVIII product.**
- Many new treatments for haemophilia A are being developed, **from gene therapy to new non-factor replacement therapies.**

Gene therapies for Sickle Cell Disease

News Excerpt:

The U.S. Food and Drug Administration (FDA) has approved two gene therapies for Sickle Cell disease.

About the Gene Therapies:

- CASGEVY™ (exagamglogene autotemcel) and LYFGENIA™ (lovotibeglogene autotemcel) are the first two gene therapies for the treatment of sickle cell disease in patients 12 years and older with recurrent vaso-occlusive crises (VOCs).

- A VOC occurs when sickled red blood cells block blood flow to the point that tissues become deprived of oxygen. This, in turn, sets in motion an

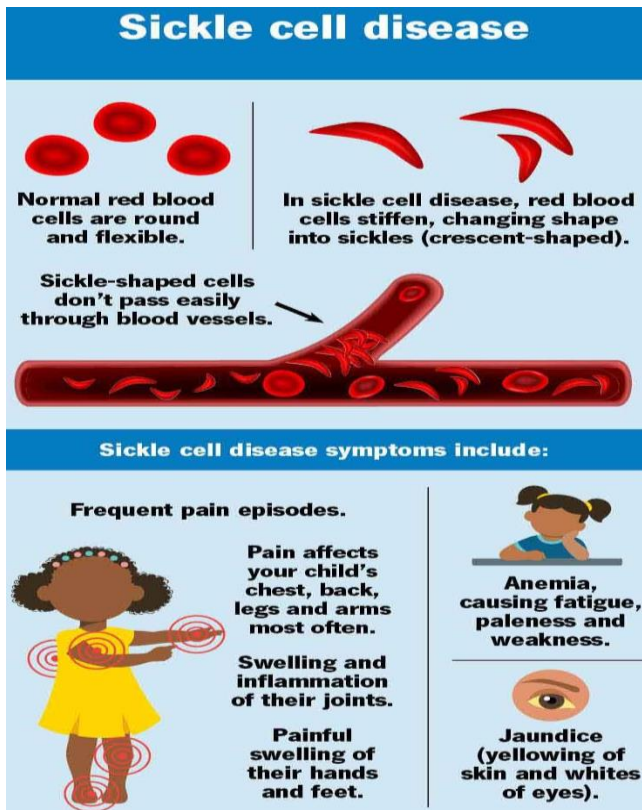
inflammatory response as the body tries to rectify the problem.

- Both therapies, pitched as one-time treatments, will be available in early 2024.

CASGEVY	LYFGENIA
<p>It is based on CRISPR, which uses molecular "scissors" to trim faulty parts of genes that can be disabled or replaced with new strands of normal DNA.</p> <ul style="list-style-type: none"> ○ Patients must have stem cells harvested from their bone marrow for this therapy. ○ The cells are then sent to manufacturing facilities and edited using CRISPR/Cas9 technology. ○ Once the cells are incubated, they are infused back into the patient. 	<p>It uses a more conventional form of gene therapy that uses a virus to ferry a gene into cells.</p> <ul style="list-style-type: none"> ○ It uses a lentiviral vector (gene delivery vehicle) for genetic modification. ○ The patient's blood stem cells are genetically modified to produce haemoglobin that functions similarly to the normal adult haemoglobin produced in persons unaffected by sickle cell disease. These modified stem cells are then delivered to the patient.

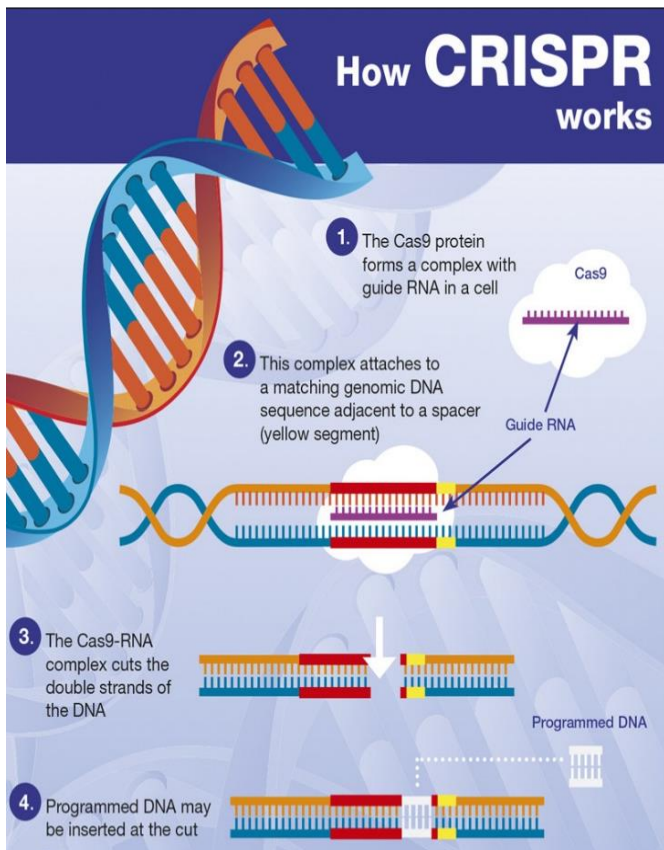
About Sickle Cell Disease:

- Sickle cell disease is a **group of inherited red blood cell disorders that affect haemoglobin**, the protein that carries oxygen through the body.
- Normally, red blood cells are **disc-shaped** and flexible enough to move easily through the blood vessels.
- In sickle cell disease, red blood cells **become crescent- or "sickle"-shaped** due to a genetic mutation.
 - These sickled red blood cells do not bend or move easily and can block blood flow to the rest of the body.
- **Every year, between 30,000 and 40,000 babies in India** are thought to be born with **this disorder.**
- Those who receive a **pair of faulty genes from both parents** have the symptoms.
 - One can lead a normal life even if they only have one copy of the gene from one parent.



What is CRISPR Technology?

- **CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats)** are short DNA sequences found in the genome of prokaryotic organisms such as bacteria, which are reminders of the previous bacteriophage (viruses) attacks that the bacteria successfully defended against.



- **Cas9 (CRISPR-associated protein 9)** enzyme (part of bacteria's defence mechanism) uses these flags to **target and cut any foreign DNA precisely**, thus protecting the bacteria from future attacks by similar bacteriophages.
- The unprecedented precision of targeting the DNA sequences and then efficiently cutting them is the basis for CRISPR-Cas9 technology, as demonstrated in editing genes in cells and organisms.

Challenges involved:

- The **procedure cost** is very **high**. Since many sufferers of these illnesses reside in poorer nations, it is unlikely that they will be able to pay for the therapy.
- **The lack of local manufacturing facilities** necessitates sending the extracted blood stem cells across the countries, causing delays.

Related:

Recently, the Delhi-based Akmus Drugs and Pharmaceutical Limited **announced the development of a new drug for sickle cell disease.**

About the newly developed drug:

- The development of **the room temperature stable, oral suspension of Hydroxyurea** is tailored specifically for patients battling sickle cell disease, spanning across all age groups.
- Oral syringes would be provided for precise dosage administration.
- The drug would be the **country's first indigenous, room-temperature stable drug** for sickle cell disease to be available at **only 1% of the global price.**

About National Sickle Cell Anaemia Elimination Mission:

- It was introduced in the Union Budget 2023 and focuses on addressing the significant health challenges posed by sickle cell disease, particularly among tribal populations of the country.
- Implemented in **17 high-focus states across the country**, this program aims to improve the care and prospects of all sickle cell disease patients while reducing the prevalence of the disease.
 - The 17 states are- Gujarat, Maharashtra, Rajasthan, Madhya Pradesh, Jharkhand, Chhattisgarh, West Bengal, Odisha, Tamil Nadu, Telangana, Andhra Pradesh, Karnataka, Assam, Uttar Pradesh, Kerala, Bihar, and Uttarakhand.
- The program is executed in a **mission mode as part of the National Health Mission (NHM).**
- It aims to eliminate sickle cell genetic transmission **by the year 2047**, showing a long-term commitment to eradicating the disease.
- Over a period of three years, spanning from the fiscal year 2023-24 to 2025-26, the program **targets screening approximately 7.0 crore people.**

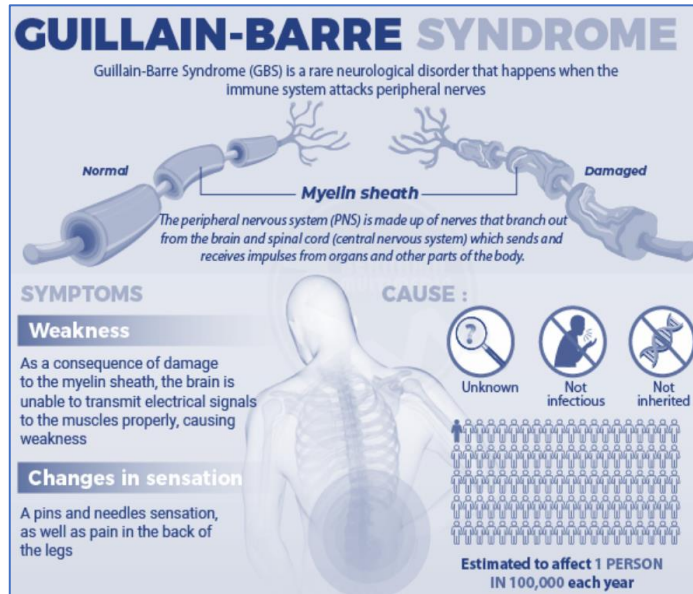
Guillain-Barré Syndrome

News Excerpt

The Peruvian government recently declared a state of national emergency due to a spike in the number of cases of a rare neurological disorder called Guillain-Barré Syndrome.

About Guillain-Barré Syndrome (GBS)

- In GBS, body's immune system — which normally protects it from infections and other foreign bodies mistakenly attacks its own peripheral nerve cells.
- It's also called:
 - **Acute Inflammatory Demyelinating Polyneuropathy**
 - **Landry's Ascending Paralysis**



Causes of GBS

- Approximately 50% of cases occur shortly after a microbial infection (viral or bacterial), like flu or food poisoning. It may be triggered by:
 - Infection with campylobacter: A type of bacteria often found in undercooked poultry.

Autoimmune trigger: In this, the patient's defense system of antibodies and white blood cells are called into action against the body, damaging myelin (nerve covering or insulation), leading to numbness and weakness.

- **Risk factors:** GBS can affect all age groups, It's slightly more common in males than females.
- **Vaccinations:** The chances of developing the condition of GBS after having a vaccination are extremely small.

Treatments of GBS

The most commonly used treatments:

- **Intravenous immunoglobulin (IVIG).**
 - IVIG is a treatment made from donated blood that contains healthy antibodies.
 - It is given directly into a vein.
 - These are given to help stop the harmful antibodies damaging the nerves.
- **Plasma exchange (plasmapheresis):** A plasma exchange, also called plasmapheresis, is sometimes used instead of IVIG.

- This involves being attached to a machine that removes blood from vein and filters out the harmful antibodies that are attacking your nerves before returning the blood to body.

Variants of GBS

- **Acute Inflammatory Demyelinating Polyneuropathy (AIDP)** -75% – 80% of cases fall into this 'classic' category.
- **Acute Motor Axonal Neuropathy (AMAN)** -Similar to AIDP, but without sensory symptoms.
- **Acute Motor Sensory Axonal Neuropathy (AMSAN)**- A severe variant of GBS more prevalent in Asia, Central America, and South America.
- **Miller Fisher Syndrome** -Characterized by double vision, loss of balance, and deep tendon reflexes.

India's stand:

- India is far behind in GBS research as compared to other countries like USA, as there might be a low case report of the GBS in Indian population.
- Still, the research focusing on this disease is quite prominent and needs a careful medical attention through research capacity building to look for better treatment of the disease in Indian cases. This study shall help enhance the awareness of the GBS by Indian scientists.

Way forward

- As the field of GBS research develops, and ongoing studies aim to improve diagnostics, treatment and prognostic modelling.
- Investigators of large, worldwide, collaborative studies of the spectrum of Guillain-Barré syndrome are accruing data for clinical and biological databases to inform the development of outcome predictors and disease biomarkers. Such studies are transforming the clinical and scientific landscape of acute autoimmune neuropathies.

WHO report on neglected tropical diseases

News Excerpt:

The World Health Organization (WHO) has released its Global Report on Neglected Tropical Diseases 2024.

More about the Report:

- The Report provides the Member States and the global community of partners with an **account of progress made in 2023** towards the **implementation of the Road map for neglected tropical diseases 2021–2030**.
 - Notably, the progress report is one of the agenda items included in the **World Health Assembly (WHA77)** agenda.
 - The upcoming 77th session of the World Health Assembly (**WHA77**) will take place in **Geneva** on 27 May–1 June 2024.

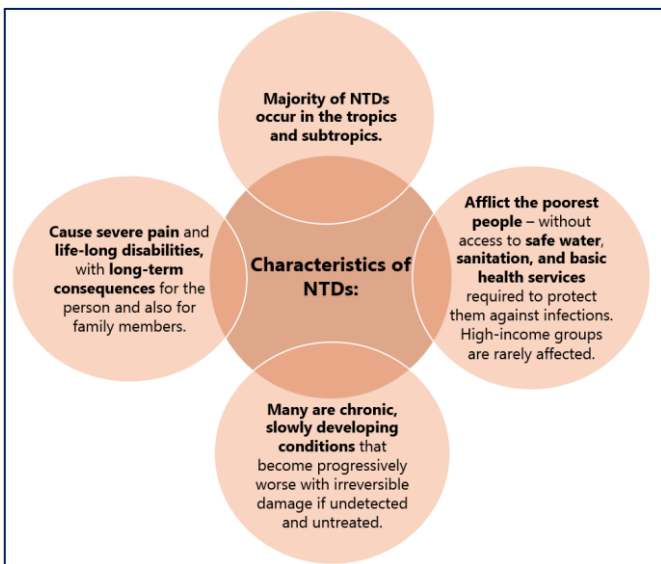
Neglected tropical diseases (NTDs):

- **Neglected tropical diseases (NTDs)** are a diverse group of conditions caused by a variety of pathogens (including viruses, bacteria, parasites, fungi and toxins) and associated with **devastating health, social and economic consequences**.
- NTDs are mainly **prevalent among impoverished communities in tropical areas**, although some have a much larger geographical distribution.
- It is estimated that NTDs **affect more than 1 billion people**, while the number of **people requiring NTD interventions (both preventive and curative) is 1.6 billion**.

The infectious agents responsible for some NTDs include:

- **viruses (rabies and dengue)**
 - **bacteria (leprosy, yaws, trachoma and Buruli ulcer)**
 - **protozoa (leishmaniasis and trypanosomiasis)**
- helminth parasites (schistosomiasis, lymphatic filariasis, onchocerciasis, intestinal worms and Guinea worms)**

- The Report **highlights encouraging advancements in the battle against NTDs**.
- It highlights **key challenges**, ranging from a **slow post-COVID-19 recovery** to **funding uncertainties**, from **geopolitical disruptions to climate change**, from **gaps in knowledge and tools** to **insufficient data**, to illustrate the complexities inherent in addressing NTDs.



Key highlights of the Report:

- In **2022, 1.62 billion people** required interventions against neglected tropical diseases (NTDs).
- In **2023, five countries** were acknowledged by WHO for **eliminating one NTD**, and **one country for eliminating two NTDs**.
- As of **December 2023, a total of 50 countries** have **successfully eliminated at least one NTD**, marking the **halfway point towards the 2030 target of 100 countries**.

- As of the end of **2022**, the number of **reported deaths from vector-borne NTDs** has **increased by 22% (as compared with 2016)**.
- Access to **water supply, sanitation, and hygiene** is **85.8% overall in NTD-endemic countries** and **63%** among the **population requiring interventions** against NTDs.
- In 2023, **noma (cancrum oris, gangrenous stomatitis)** was added to the list of NTDs.
 - Noma is a **rapidly progressing severe gangrenous disease of the mouth and the face**.
 - It mostly affects **children aged 2–6 years** suffering from malnutrition, infectious diseases, living in extreme poverty with poor oral health or weakened immune systems.
- **NTD medicine donation programmes** achieved significant milestones in 2023, delivering **2.1 billion tablets and vials**, 200 million more than in 2022.
- Key advocacy events carried out in 2023 included the **Global NTD Programme Partners' Meeting** and the **Reaching the Last Mile Forum**, which raised the visibility of NTDs in the global health agenda and increased resource mobilization.

Road map for neglected tropical diseases 2021–2030:

- **Ending the Neglect to Attain the Sustainable Development Goals: A Road Map for Neglected Tropical Diseases 2021–2030** was endorsed by the **73rd World Health Assembly in November 2020**.
- The road map **sets global targets and milestones to prevent, control, eliminate or eradicate 20 diseases and disease groups**, as well as **overarching and cross-cutting targets** aligned with the **Sustainable Development Goals**.

Overarching global targets for 2030:

The overarching global targets for 2030 are in line with the Sustainable Development Goals and WHO's 13th General Programme of Work:

- **90% fewer people** are requiring interventions against NTDs.
- **75% fewer NTD-related Disability-adjusted life years (DALYs)**.
- **100 countries** achieving elimination of at least 1 NTD.
- **Eradication of 2 NTDs** – dracunculiasis and yaws.

Cross-cutting targets for 2030:

The road map aims to renew momentum, proposes strategies that intersect multiple diseases, and advances actions focused on integrated platforms for the delivery of interventions. Consequently, a set of cross-cutting targets has been devised to measure progress in four areas:

- **Integrated approaches**
 - Reduce deaths from vector-borne diseases by 75%

- Achieve 75% integrated treatment coverage index for preventive chemotherapy
 - 40 countries adopting skin NTD strategies
 - **Multisectoral coordination**
 - Ensure 100% access to basic water supply, sanitation and hygiene in NTD-endemic areas.
 - Get 90% of countries integrating NTDs in national strategic plans
 - Protect at least 90% of the population from catastrophic out-of-pocket health expenditures due to NTDs
 - **Universal health coverage**
 - Get 90% of countries include NTD interventions in their package of essential health services and budgeting for them
 - Ensure that 90% of countries have guidelines for the management of NTD-related disabilities within national health systems
 - **Country ownership**
 - Ensure that 90% of countries report on all relevant NTDs
 - Ensure that 90% of countries collect and report NTD data disaggregated by gender
- Three foundational pillars will support global efforts to achieve the targets:**
- accelerate programmatic action (pillar 1)
 - intensify cross-cutting approaches (pillar 2)
 - change operating models and culture to facilitate country ownership (pillar 3).

India receives 'Measles and Rubella Champion' Award

News Excerpt:

Recently, India has been bestowed with the prestigious Measles and Rubella Champion Award by the Measles and Rubella Partnership at the American Red Cross Headquarters in Washington D.C., USA.

About the Measles and Rubella Partnership:

- The Measles & Rubella Partnership is a **global initiative** to lead and coordinate efforts to achieve a world without measles and rubella.
- **The American Red Cross, the Bill & Melinda Gates Foundation, Gavi the Vaccine Alliance, the United Nations Foundation, the U.S. Centers for Disease Control and Prevention, UNICEF and the World Health Organization** lead the Measles & Rubella Partnership (M&RP).
- The **M&RP** aims to achieve a world without measles and rubella by:
 - **Supporting countries to raise coverage** of vaccines;
 - Fund, plan, implement and monitor **quality supplementary campaigns**;

- **Investigate outbreaks and provide technical and financial support** to strengthen immunization delivery;
 - **Support a global laboratory network** for measles and rubella.
 - Since 2001, the Partnership has helped to raise measles vaccination coverage to 83% globally and **reduced measles deaths by 82%**.
 - In 2022, the M&RP supported vaccination **campaigns in 44 countries** that reached more than 115 million children with bundled vaccines, operational costs or technical assistance.
 - **The M&RP supports the implementation of the Measles & Rubella Strategic Framework 2021-2030 (MSRF 2021-2030).**
 - It aims to provide a **high-level framework** that will guide the development of regional and national strategies and operational plans.
 - The MSRF 2021-2030 **envisions "A world free from measles and rubella"**.
- Significance of the Award:**
- It recognizes India for providing **regional leadership to the measles & rubella elimination programme** by using 'measles as a tracer' to strengthen routine immunization under the country's **Universal Immunization Programme (UIP)**.
 - The award recognises that India has **demonstrated remarkable progress in reducing measles and rubella cases** and preventing outbreaks through a series of comprehensive interventions.

Measles	Rubella
Measles is caused by a single-stranded, enveloped RNA virus with 1 serotype.	Rubella is an acute, contagious viral infection.
It is classified as a member of the genus Morbillivirus in the Paramyxoviridae family.	The rubella virus is transmitted by airborne droplets when infected people sneeze or cough. Humans are the only known host.
Humans are the only natural hosts of the measles virus.	In children, the rubella remains usually mild, with symptoms including a rash, low fever (<39°C), nausea and mild conjunctivitis.
It spreads easily when an infected person breathes, coughs or sneezes.	The rash usually starts on the face and neck before progressing down the body and lasts 1-3 days. Swollen lymph glands behind the ears and neck are the most characteristic clinical features.
Measles infects the respiratory tract and then spreads throughout the body.	Once a person is infected, the virus spreads throughout the body in about 5-7 days.
Symptoms include a high fever, cough, runny nose and a rash all over the body.	Woman infected with the rubella virus early in pregnancy, has a 90% chance of passing the virus on to her fetus.
Measles can affect anyone but is most common in children.	In unvaccinated pregnant women, rubella can lead to miscarriage, stillbirth or multiple birth defects that together are called congenital rubella syndrome (CRS).

Steps taken to prevent the Measles and Rubella (MR) in India:

- Measles and Rubella are vaccine-preventable diseases (VPDs) and the MR Vaccine has been **part of India's UIP since 2017**.
- The government of India's proactive **MR vaccination campaign** in high-risk areas and innovative strategies to reach underserved populations, robust surveillance systems, and **effective public awareness initiatives** have played a key role in safeguarding the health and well-being of its population.
- Measures that have strengthened India's MR elimination strategy:
 - The development and implementation of the **National Strategic Plan for MR elimination**;
 - **Introduction of rubella-containing vaccine** into the routine immunization programme;
 - Launching a **nationwide MR supplementary immunization catch-up campaign**;
 - Transitioning from outbreak-based surveillance to **case-based acute fever and rash surveillance**;
 - **Expansion of the MR Laboratory network** to 27 labs across the country and implementation of the roadmap plan for MR Elimination across the country.

The Measles-Rubella (MR) 2020 program:

- It had the goal to eliminate measles by 2020, but due to the COVID-19 outbreak, it was revised to **2023**.
- The MR campaign targets around **41 crore children** in the age group of 9 months to 15 years (covering $\frac{1}{3}$ of the total population of the country) followed by 2 doses in **routine immunization at 9-12 months and 16-24 months**.

Current Status of Measles and Rubella in India:

- **Measles cases dropped by 62% between 2017 and 2021**, from 10.4 to 4 cases per million population, while rubella cases decreased by 48%, from 2.3 to 1.2 cases per million population.
- India is conducting three rounds of Intensified **Mission Indradhanush 5.0 (IMI 5.0)** under the theme "**A big leap towards measles and Rubella Elimination**", to **identify and vaccinate all unvaccinated** and under-vaccinated children till five years of age, from August 2023.

Way Forward:

- **India should continue its proactive vaccination campaigns**, surveillance efforts, and public awareness initiatives to eliminate measles and rubella.
- Strengthening routine immunization under the Universal Immunization Programme (UIP), expanding the MR Laboratory network, and **implementing the roadmap plan for MR Elimination are crucial**.
- **Collaboration with international partners** and continued support for the Measles & Rubella Partnership

will be key to **achieving the goal of a world free from measles and rubella**.

Non-Melanoma Skin Cancer

News Excerpt:

Nearly one in every three **deaths from Nonmelanoma Skin Cancer is caused by working under the sun**, according to a joint report released by the **World Health Organization (WHO)** and the **International Labour Organization (ILO)**.

Key Highlights of the Report:

- A staggering 1.6 billion working-age individuals (15 years or older) were exposed to solar ultraviolet radiation while working outdoors in 2019, representing 28% of the global working-age population.
- In that same year (2019), almost 19,000 people across 183 countries succumbed to non-melanoma skin cancer due to their occupational sun exposure, with the majority (65%) being male.

About Nonmelanoma Skin Cancer:

- Nonmelanoma skin cancer refers to a group of cancers that **develop in the upper layers of the skin**.
- The **two main subtypes** of this cancer are **Basal cell carcinoma** and **Squamous cell carcinoma**.
- **Basal cell carcinoma** – starts in the cells lining the bottom of the epidermis and accounts for about 75% of skin cancers.
- **Squamous cell carcinoma** – starts in the cells lining the top of the epidermis and accounts for about 20% of skin cancers.
- The term 'non-melanoma' distinguishes these more common kinds of skin cancer from the less common skin cancer known as melanoma, which spreads faster in the body.
 - The **first sign** of non-melanoma skin cancer is usually the **appearance of a lump or patch on the skin** that doesn't heal after a few weeks.
 - In most cases, **cancerous lumps are red and firm**, while **cancerous patches are often flat and scaly**.

Causes:

- It is mainly caused by **overexposure to ultraviolet (UV) light**. UV light comes from the sun, as well as artificial sunbeds and sunlamps.
- In addition to UV light overexposure, certain things can increase the chances of developing non-melanoma skin cancer, such as -
 - a family history of the condition
 - pale skin that burns easily
 - a large number of moles or freckles

Way Forward:

- Death caused by unprotected exposure to solar ultraviolet radiation while working is largely preventable through cost-effective measures.
- Measures at the workplace can include providing shade, adjusting working hours away from the solar noon

period, and equipping workers with sunscreen and personal protective clothing such as hats for coverage.

- Additionally, when the Ultraviolet Index, a measure of skin-damaging ultraviolet radiation, reaches level three or higher, it becomes essential to take added steps.

Bubble Baby Syndrome - SCID


News Excerpt:

A **two-month-old girl** with bubble baby syndrome has become one of the youngest patients in the country to undergo a **bone marrow transplant (BMT)** from an unrelated donor.

About the Bubble Baby Syndrome:

- Severe combined immunodeficiency (**SCID**) is a group of **rare disorders** caused by mutations in different genes involved in the development and function of infection-fighting immune cells.
- SCID is often called bubble baby disease.
- Most often, SCID is inherited in an **autosomal recessive pattern**, in which **both copies** of a **particular gene**—one inherited from the mother and one from the father—contain defects.
- Infants with SCID **appear healthy at birth** but have **no functioning immune system**, meaning that even a normally mild infection can be fatal.

ONLY 1 IN 60K AFFECTED BY DISEASE	
<ul style="list-style-type: none"> > Severe combined immunodeficiency (SCID) is a rare, genetic disorder, affecting 1 in 60,000 babies > It is often called 'bubble boy disease', as the child has to stay in a sterile environment or "bubble" > Children with SCID don't have an immune system 	<ul style="list-style-type: none"> > Child with SCID is treated with a stem cell transplant, also known as bone marrow transplant > With new bone marrow, the child's body can build a whole new, functional immune system



Types of SCID:

- The **best-known form** of autosomal recessive SCID is caused by adenosine deaminase (**ADA**) deficiency, in which infants **lack the ADA enzyme** necessary for **T-cell survival**.
- **X-linked SCID**, which is caused by **mutations in a gene** on the **X chromosome**, primarily **affects male infants**.
- Children with this type of SCID have **white blood cells** that grow and develop **abnormally**.
- Consequently, they have **low numbers of T cells** (white blood cells that identify and attack perceived "invaders"), and their **B cells** (white blood cells that produce antibodies against infection) **do not function**.

Symptoms and Diagnosis:

- Symptoms of SCID occur in infancy and include **serious or life-threatening infections**, especially **viral infections**, which may result in **pneumonia** and **chronic diarrhoea**.
- Research supported by the National Institute of Allergy and Infectious Disease (**NIAID**), **USA** and other

organizations has shown that **early diagnosis** of SCID through newborn screening leads to **prompt treatment** and **high survival rates**.

- To confirm a SCID diagnosis, a doctor will **evaluate the numbers and types of T and B cells present and their ability to function**.

Treatment:

- The condition is fatal, usually within the first year or two of life, unless infants receive immune-restoring treatments, such as transplants of blood-forming **stem cells**, **gene therapy**, or **enzyme therapy**.
 - **Stem cell transplantation:** Hematopoietic (blood-forming) stem cell transplantation is the **standard treatment** for infants with SCID.
 - Transplants from **matched siblings** lead to the best restoration of immune function, but if a matched sibling is unavailable, infants may receive stem cells from a **parent or an unrelated donor**.
 - These transplants are life-saving but often only **partially restore immunity**.
 - **Enzyme replacement therapy:** Children with SCID with Adenosine deaminase (**ADA**) deficiency have been successfully treated with **PEG-ADA** enzyme replacement therapy.
 - **Gene therapy:** Studies also have shown that gene therapy can be an effective treatment for some types of SCID, including **X-linked SCID**.
 - In gene therapy, **stem cells** are obtained from the **patient's bone marrow**, the **normal gene** is **inserted** into the stem cells using a carrier known as a vector, and the **corrected cells** are **returned** to the patient.
- ### Way Forward:
- Rare diseases are a big issue in our country. There will be a need for proper health practices, ensuring the availability of new health technology and its training.
 - There should be a specific budgetary grant in the general budget for rare diseases.

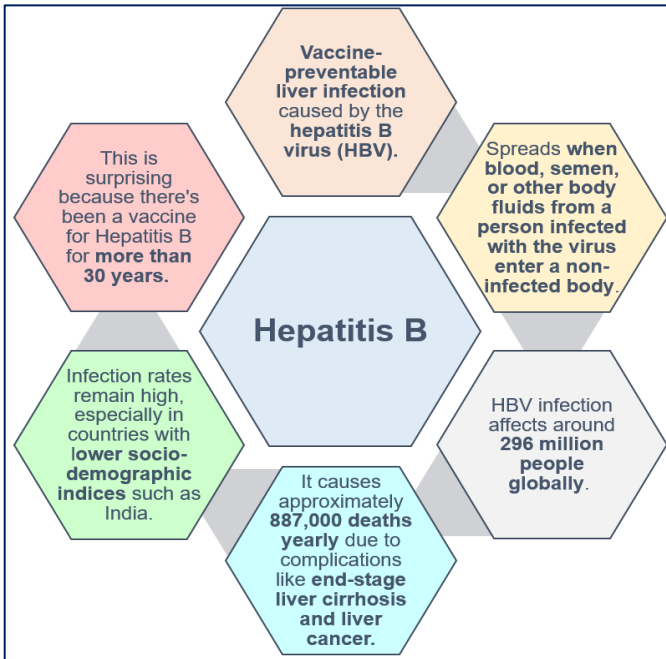
India second highest in hepatitis B & C after China

News Excerpt:

According to a WHO's 2024 Global Hepatitis Report report, **India has the second-highest cases of hepatitis B and C** after **China**, with **3.5 crore cases in 2022**.

Hepatitis:

- Hepatitis is an **inflammation of the liver** that is caused by a variety of infectious viruses and non-infectious agents leading to a range of health problems.
- It is the **second-leading infectious cause of deaths globally** — with 1.3 million deaths per year, the same as **tuberculosis**, a **top spreadable killer**.
- There are **five main strains** of the hepatitis virus, referred to as types **A, B, C, D and E**.



- While they all cause liver disease, they differ in important ways including modes of transmission, severity of the illness, geographical distribution and prevention methods.

- Hepatitis B and C are responsible for 96% of overall hepatitis mortality.
- Hepatitis B and C are transmitted by unsafe injection practices and through contaminated syringes and needles, infected blood and blood products, sexual transmission, from infected mother to child.

Key highlights of the report:

- India was second only to China in the viral hepatitis burden.
- It registered 2.98 crore hepatitis B cases in 2022 while the number of hepatitis C infections stood at 55 lakhs.
- The number of deaths globally from viral hepatitis increased from 1.1 million in 2019 to 1.3 million in 2022.
 - 83% deaths were caused by hepatitis B, and 17% by hepatitis C.
 - Every day, there are 3,500 people dying globally due to hepatitis B and C infections.
- WHO estimates indicate that 254 million people lived with hepatitis B and 50 million with hepatitis C in 2022.
- Half the burden of chronic hepatitis B and C infections is among people between 30 and 54 years old, with 12% among children under 18 years.

HEPATITIS	How it spreads	Prevention	Treatment
A	Feces Contaminated food or water	<ul style="list-style-type: none"> Vaccine Practice good hygiene 	<p>No specific medication available</p> <p>Treated through supportive care (rest, adequate nutrition, and fluids) to help relieve symptoms</p>
B	Through contact with the blood or bodily fluids of an infected person	<ul style="list-style-type: none"> Vaccine Practice safe sex Blood screening 	Combination antiviral therapies (with Tenofovir or Tenofovir derivatives plus lamivudine)
C	Blood-to-blood contact	<ul style="list-style-type: none"> Practice safe sex Avoid sharing needles, toothbrushes, razors or nail scissors 	Combination therapies with direct acting antivirals (DAAs)
D	Contact with infected blood (only occurs in people already infected with hepatitis B)	<ul style="list-style-type: none"> Hepatitis B vaccine Avoid sharing needles, toothbrushes, razors or nail scissors 	Interferon
E	Feces Contaminated food or water	<ul style="list-style-type: none"> Practice Good Hygiene Avoid drinking water that has come from a potentially unsafe source Cook food well 	<p>No specific medication available</p> <p>Supportive Care</p>

- Men account for 58% of all cases.

Bangladesh, China, Ethiopia, India, Indonesia, Nigeria, Pakistan, the Philippines, the Russian Federation and Vietnam, collectively contribute nearly two-thirds of the global burden of hepatitis B and C.

India's hepatitis challenge:

- In India 98,305 people died due to hepatitis B while 26,206 succumbed to hepatitis C in 2022.
- Only 2.4% of those infected in the country had received diagnosis coverage.
- Chronic hepatitis B infection, which is vaccine preventable, accounts for 40 to 50% of hepatocellular carcinoma (a type of liver cancer) and 20 to 30% of cirrhosis cases in India.
- The hepatitis B vaccination was first introduced in India in 2002–2003 as part of the Centre's

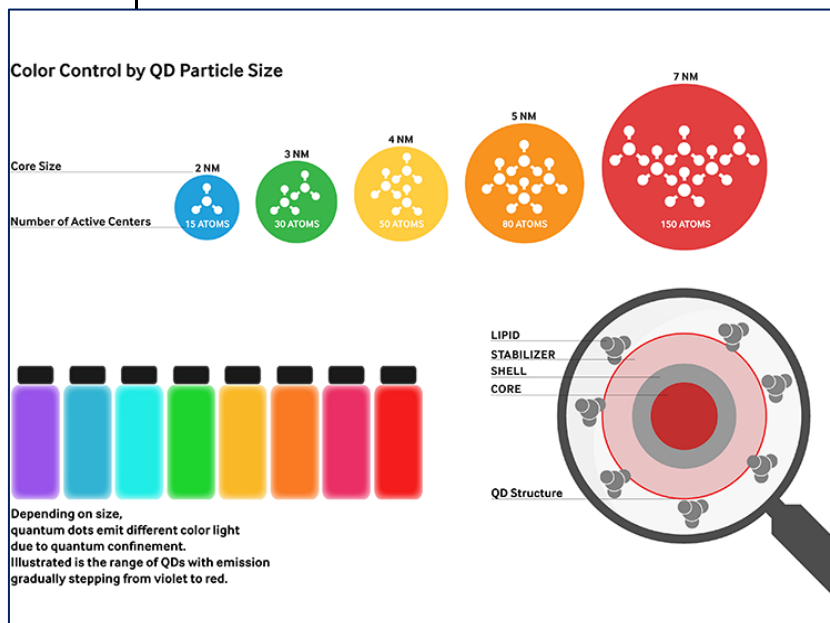
Universal Immunisation Programme.

- The vaccine was then **expanded throughout the nation in 2010**.
- It is now provided as part of the **pentavalent vaccine** at **6, 10 & 14** weeks apart from the **birth dose of hepatitis B vaccine**.

Way Forward:

- Emphasize targeted public health interventions to **enhance awareness and increase vaccination coverage** among **vulnerable populations**, including women, older individuals, those with lower education levels, and rural residents.
- Focus **educational campaigns on the general public**, with specific attention to the aforementioned groups, aiming to raise awareness about **Hepatitis B transmission**, its impact, and the critical need for vaccination.
- Ensure people understand the importance of completing the full vaccination schedule** for optimal protection against Hepatitis B, emphasizing the necessity for adherence to the recommended vaccination regimen.
- Implement **comprehensive strategies that integrate efforts to improve health literacy** and enhance vaccination coverage,
- Recognize the importance of these measures in achieving both **national and global targets for Hepatitis B control**.

- QDs are a really small assembly of atoms (just a few thousand) around a few nanometres wide. The 'quantum' in its name comes from the fact that the electrons in these atoms have very little space to move around, so the crystal as a whole displays the quirky effects of quantum mechanics.
- Quantum dots have also been called '**artificial atoms**' because the dot as a whole behaves like an atom in some circumstances.

**World Hepatitis Summit (WHS) 2024:**

- WHS 2024 is being hosted in **Lisbon, Portugal**.
- WHS is bringing together global experts to discuss the latest advances in hepatitis **prevention, diagnosis, and treatment**.
- Theme of the 2024 summit is "**Integrate, Accelerate, Eliminate**".

WHS 2024 was organised by the **World Hepatitis Alliance** with the support of the **Ministry of Health of Portugal**.

INNOVATIONS**Nobel Prize for Chemistry 2023****News Excerpt:**

The 2023 Nobel Prize in Chemistry has been awarded to **Moungi G. Bawendi, Louis E. Brus** and **Alexei I. Ekimov** for the discovery and synthesis of **quantum dots**.

Quantum dots:

- Quantum dots (QDs) are **man-made nanoscale crystals** that exhibit unique optical and electronic properties, including the ability to transport electrons and **emit light of various colors when exposed to UV light**.

Reasons for interest in quantum dots:

- There are two broad types of materials: atomic and bulk. Atomic refers to individual atoms and their specific properties. Bulk refers to large assemblies of atoms and molecules.
- Quantum dots lie somewhere in between and behave in ways that neither atoms nor bulk materials do. One particular behavior distinguishes them: **the properties such as Melting Point and chemical reactivity of a quantum dot change based on how big it is**.
- Just by tweaking its size, scientists can change, say, the quantum dot's melting point or how readily it participates in a chemical reaction.
- When light shines on a quantum dot, it absorbs and then re-emits it at a different frequency. Smaller dots emit blueish light and larger dots, redder light. This happens because light shone on the dot energizes some electrons to jump from one energy level to a higher one, before jumping back down and releasing the energy at a different frequency.

Applications of quantum dots:

- If one of the energy levels an electron jumps between in a quantum-dot atom is the conduction band, the dot can operate like a **semiconductor**.

- Solar cells when made with quantum dots are expected to have a thermodynamic efficiency as high as 66%.
- Quantum dots have unique properties and spread their light from **television screens and LED lamps**.
- They **catalyze chemical reactions**, and their clear light can illuminate **tumour tissue for a surgeon**.
- Researchers have primarily utilized quantum dots to create coloured light. They believe that in the future, quantum dots can contribute to **flexible electronics, miniscule sensors, slimmer solar cells, and encrypted quantum communication**.
- Quantum dots can be easily adapted for a variety of applications, **including surgical oncology, advanced electronics, and quantum computing**.

Nobel Prize for Physics 2023

News Excerpt:

The 2023 Nobel Prize for Physics was shared by three scientists - **Pierre Agostini, Ferenc Krausz and Anne L'Huillier** - for their experimental methods that generate **attosecond pulses** for the study of **electron dynamics** in matter, potentially leading to better detection of disease and developing electronic machinery.

About their experiment:

- An atom, a tiny unit into which matter can be divided, is composed of a nucleus of protons and neutrons and electrons that travel around this nucleus. Electrons move so fast that it is impossible to observe them in real-time.
- Their work has brought humanity closer to observing and studying the movement of electrons by producing pulses of light that last only attoseconds, which is 1×10^{-18} of a second.
- Roughly, this can be compared to a high-shutter-speed camera. If a regular camera is used to capture a moving train, the image will be blurred. But a high shutter-speed camera can freeze motion and capture a clear image of the train.

Electron dynamics:

- Electrons are the negatively charged particles of an atom. They travel around the denser nucleus in orbits.
- The movement of an atom in a molecule can be studied with the short pulses produced by a laser. These movements and changes in the atoms occur on the order of femtoseconds—a millionth of a billionth of a second. But electrons are lighter and interact faster in the attosecond realm. An attosecond is a billionth of a billionth of a second.

Attosecond science:

- It is a branch of strong field physics.
- Strong field physics: it is a research field of laser matter interaction which aims to induce & control ultrafast processes.
- It helps reveal ultrafast phenomena in nature in unprecedented clarity.

- Attosecond (10^{-18} s) is the characteristic time scale for ultrafast electron dynamics in atoms, molecules, and solids.

Significance of attosecond physics:

- **For medical diagnostics**, attosecond pulses can be used to check for the presence of cancer and find therapies for it
- It could also be used to develop faster electronic devices and better telecommunications, imaging, and spectroscopy.
- It also holds promise in areas such as a new **in-vitro diagnostic technique** to detect characteristic molecular traces of diseases in blood samples.
- The investigation of electron transition or ionization in solids and nanostructures may bring radical improvement in communications and computing.

Nobel Prize in Medicine 2023

News Excerpt:

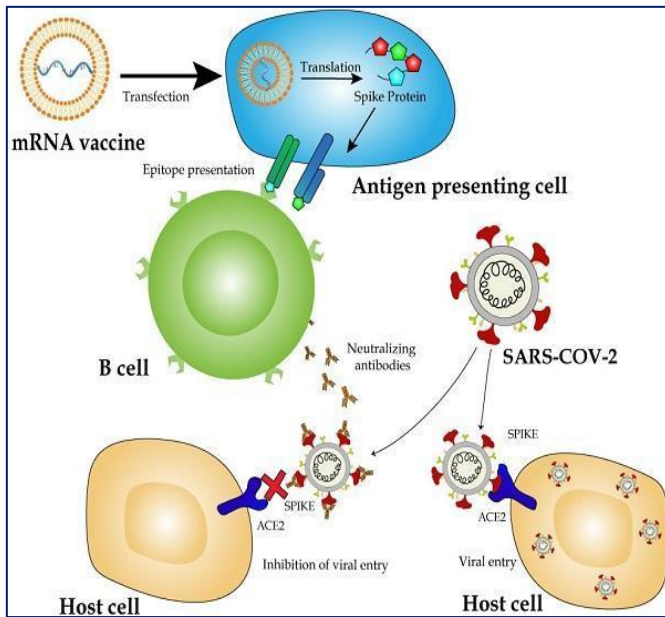
The 2023 Nobel Prize in Physiology or Medicine has been awarded to **Katalin Karikó** and **Drew Weissman** for their "discoveries concerning **nucleoside base modifications** that enabled the development of effective **mRNA vaccines** against COVID-19".

Findings of their discovery:

- Kariko and Weissman realized that the immune system recognized the lab-developed mRNA molecules as foreign substances, leading to inflammatory reactions.
- However, this did not happen when mRNA derived from animal cell assays were used. This led them to look for properties in the lab-developed mRNA molecules that were tripping off the immune system.
- They found that the mRNA derived from the animal cell assays frequently contained modifications not seen in the lab-developed uniform mRNA molecules.
- Their discoveries have allowed the covid-19 vaccine to be produced at lighting speed in 2020.

Vaccines available before the pandemic:

- **The first one** includes a live, attenuated vaccine, which has a weakened version of the pathogen, like the oral polio vaccine.
- **The second type** involves an inactivated vaccine that uses killed pathogens to elicit an immune response, such as the rabies vaccine.
- With the progress of molecular biology and techniques to edit genetic codes, vaccines using small, non-lethal parts of the pathogen have been developed. These are called **sub-unit vaccines**.
- Some vaccines also encode these non-lethal parts to another pathogen that carries and distributes it through the body - an example of this was the AstraZeneca vaccine available in India as Covishield that used parts of the COVID-19 virus attached to an adenovirus. These are called **vector vaccines**.



Challenges to mRNA technology before the pandemic:

- The lab-based mRNA molecules were considered unstable and challenging to deliver into the body in addition to the inflammatory responses.
- Developing efficient fat molecules to carry the mRNA inside the body was the key to the development of the vaccines.

Advantages of mRNA technology as compared to other vaccines:

- Not only are nucleic acid-based vaccines easy to manufacture, but they are also flexible since the sequence can be easily modified for different pathogens.
- In the future, the technology may also be used to deliver therapeutic proteins and treat some cancer types.
- mRNA technology also could produce proteins missing in certain diseases like cystic fibrosis, sickle cell anaemia, or diabetes.
- **mRNA Vaccines:**
- mRNA, which stands for **messenger RNA**, is a form of nucleic acid that carries genetic information.
- Like other vaccines, the mRNA vaccine also attempts to activate the immune system to produce antibodies that help counter an infection from a live virus.
- mRNA vaccines introduce a piece of the genetic material that corresponds to a viral protein.
- This protein is usually found on the virus's membrane and is called **spike protein**. Therefore, the mRNA vaccine does not expose individuals to the virus itself.

Biodegradable paper supercapacitor

News Excerpt

Recently, Scientists at Gujarat Energy Research and Management Institute (GERMI) have developed the thinnest, lightweight and biodegradable paper-based supercapacitor.

About Super capacitor

- A supercapacitor is an electrochemical charge storage device with a fast charging/discharging cycle, high power density and a longer lifecycle.
- A supercapacitor, also called an ultracapacitor, is a high-capacity capacitor, with a capacitance value much higher than other capacitors but with lower voltage limits.
- It bridges the gap between electrolytic capacitors and rechargeable batteries.
- Supercapacitors are constructed with two metal foils (current collectors), each coated with an electrode material such as activated carbon, which serve as the power connection between the electrode material and the external terminals of the capacitor.

About research

- The research was led by marine biopolymer scientist Dr. Syed Zaheer Hassan and Dr. Priyank Bhutiya.
- The cellulose nanofibers were extracted from green seaweed *Cheatomorpha antennia* which was collected from Porbandar, Gujarat in India.
- The fibers underwent bleaching treatment and were shaped into architectural structure like that of a spider web.
- Cellulose is found to be as most suitable biopolymer material for manufacturing paper-based electrode materials such as paper supercapacitors or batteries for energy storage applications. Cellulose itself is an insulating material that requires to be coated with conductive material to make a paper-based energy storage device.
- A very simple and handmade process was used by the researchers in making paper anode. They only have to make sure that the supercapacitor can be used as anode material in devices. To make this possible, the researchers grew the nanowires made from reduced graphene oxide (rGO) and zinc oxide (ZnO) over the cellulose nanofibers using a simple hydrothermal process. Then, it underwent a simple press method to turn the cellulose nanocomposite into a form of paper supercapacitor.
- The developed seaweed-based electrode is used in an asymmetrical supercapacitor by sandwiching a sodium chloride electrolyte-soaked paper separator between two seaweed cellulose nanocomposites and activated charcoal powder slurry.
- The technology was supported by Brijesh Tripathi from Pandit Deendayal Energy University and Rahul Kapadia, who assisted in testing the device to 6,000 cycles for performance, which remained the same at all cycles without any noticeable degradation.
- The supercapacitor device was tested with various analytical techniques. The research was co-authored by M Abdul Rasheed and PL Srinivasa Rao from GERMI.

Biodegradable paper supercapacitor

- This supercapacitor which can fully charge a device within 10 seconds, has been developed from seaweed (marine macroalgae). The device is of high tensile strength and performance, as well as cost-effective, according to the researchers.
- The product can be used in electronics, memory backup systems, airbags, heavy machines, electric vehicles, etc.; hence, it holds a huge business prospect.
- It is the need of the hour to develop a flexible, lightweight, or cost-effective technology that can also work as a biodegradable energy storage device, according to the researchers.

Role of Biodegradable Materials in Sustainable Supercapacitors

- In the recent years, the impact of climate change due to carbon emission has become a major concern in the scientific community. The potential solution for this problem is by generating clean and sustainable energy, but it depends on the availability of renewable resources. Utilization of energy from these resources can only be made possible when there are efficient storage devices.
- Experts in the energy industry express their interest in using batteries and supercapacitors, but the rising demand for smart electronics leads to the unwanted accumulation of toxic wastes. Because of this, researchers are trying to look for affordable and environment-friendly components.
- Biodegradable nanomaterials are effective components of energy storage devices. Because the production and recycling of these electrodes are based on biodegradable substances, then they almost leave zero waste in the environment.

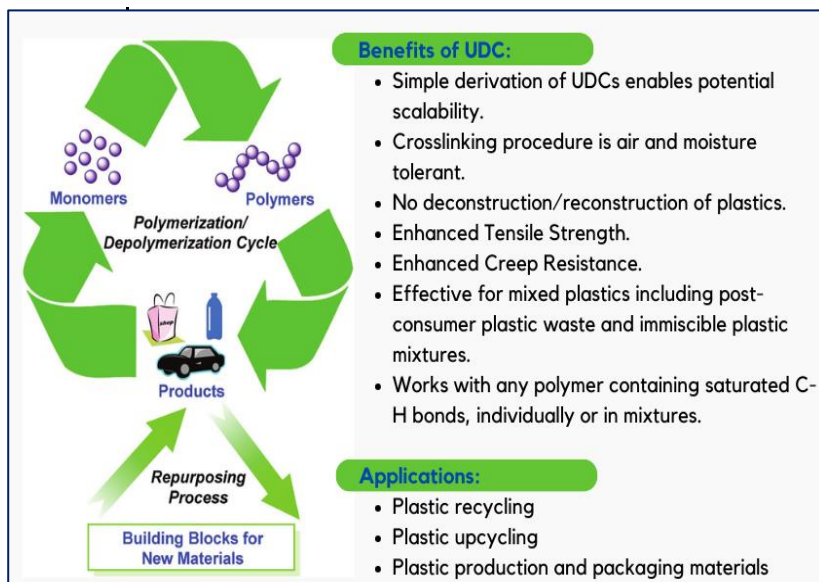
Universal Dynamic Crosslinker (UDC)

News Excerpt:

Researchers at IIT Madras, Columbia University and Colorado State University in the U.S. have developed a **technique to merge diverse plastics into strong and recyclable materials.**

Key findings:

- The technique **combines** different types of plastics to create **new composite plastics** that are **strong, processable, and recyclable.**
- The research, published in the peer-reviewed **journal Nature**, addresses the **plastic waste crisis** and promises to transform society's **perception** and **management** of plastic recycling.
- The team employed a **specially designed** universal dynamic crosslinker (**UDC**) to successfully blend usually incompatible plastics.



- The team has developed a **process** that can **stitch the interface** between **immiscible phases** and make the **mechanical strength good**, allowing for the recycling of mixed plastic waste.
- Through a process called "**compatibilization**", one can make them blend without compromising their individual characteristics.

Issues with recycling of plastic:

- Plastic waste is made up of many **different kinds of polymers**, which do not mix easily.
- Recycling currently involves a lot of separation, which is **time-consuming** and **inefficient.**
- To recycle plastic mixtures effectively, different plastics **must blend** together without losing their unique properties.
- Reprocessing mixed plastic waste tends to be **immiscible**, meaning that the material formed tends to be **mechanically weak.**

Universal Dynamic Crosslinker (UDC):

- The design and development of several UDCs enable an optimal **closed-loop upcycling path** for immiscible multicomponent plastics.
- UDCs **reactivate dead chains** in the mixed plastics to dynamically **crosslink** them into compatibilized, grafted multiblock copolymers with superior properties and **without** the need for **deconstruction** or **reconstruction.**
- The resulting upcycled materials can be used and reprocessed through **multiple cycles** and have enhanced performance over **virgin plastics.**
- The **key barrier** in the technique is **cost.**

Way Forward:

India has a **plastic recycling rate** of **13%**, higher than the **global average** of **9%**. Adopting techniques such as Circular Economy as well as providing alternatives to the industry are crucial. However, certain **technical obstacles** are preventing

further progress in plastic recycling. It is important to conduct adequate **research** on the technique of **UDC**, which can make the process more **economical** and **viable** for plastic recycling.

Electronic Soil - "eSoil"

News Excerpt:

Linköping University's study introduces an innovative **hydroponics method** using an **electrically conductive substrate** called "**electronic soil**" or "**eSoil**".

About e-soil:

- eSoil is based on the blend of the **conjugated polymer PEDOT: PSS** (poly(3,4-ethylenedioxythiophene): polystyrene sulfonate) and carboxymethylated cellulose nanofibrils).
- Its **active material** is an **organic mixed ionic electronic conductor**, while its **main structural component** is **cellulose**, the most abundant biopolymer.
- It offers a **low-energy, safe alternative** to previous methods that relied on high voltage and non-biodegradable materials like **mineral wool**.
- It can **stimulate** the plant's **root system** and growth environment in hydroponics settings.

Barley seedling experiment:

- Barley seedlings were grown within the eSoil with the **root system integrated** within its porous matrix.
- Simply by **polarising** the eSoil, seedling growth is accelerated, **increasing dry weight** on average by 50% after 15 days of growth.
- The effect is evident in **root and shoot** development and occurs during the growth period after the stimulation.
- The stimulated plants **reduce** and **assimilate** NO_3 more efficiently.
 - This may have implications for **minimizing fertilizer use**.

Significance:

- eSoil consumes **little power**, and its main structural component is **cellulose**, the most abundant polymer.
- This work opens the pathway for using physical stimuli to **enhance plant growth** but also provides a platform to understand better plant responses to **electric fields**.
- This discovery expands the **range of crops** suitable for hydroponic cultivation and demonstrates the potential for **more efficient growth** with **fewer resources**.
- eSoil's low energy consumption and safety features, combined with the benefits of hydroponic cultivation, including **space efficiency** through **vertical farming**, present a sustainable solution to the **growing demands for food**.
- The research is a significant step toward **enhancing urban agriculture**.

- Areas with limited **arable land**, **poor soil quality**, and **harsh environmental conditions** can benefit from hydroponic food production.
- Hydroponics have several advantages over soil cultivation, particularly higher water use efficiency and less use of fertilizers.
- Water use efficiency (WUE)**, in terms of the amount of harvested product per unit of water supply, is maximized in hydroponics as the water is reused, which cannot be done in soil cultivation.
- Regarding **fertilizer use**, hydroponics also has an advantage as, in Soil, the crops take up less than 50% of the nutrients, while in hydroponics, the **nutrient solution** can be **recirculated** in the system.

Way Forward:

- eSoil **opens the pathway** for developing active hydroponic scaffolds that may sustainably increase crop yield.
- However, **more studies are required** to explain mechanistically the physical and biological processes involved.
- E-soil can solve the Soil-related problems that affect the world's food system, but proper research and implementation are needed.

MXenes-coated devices can guide microwaves in space

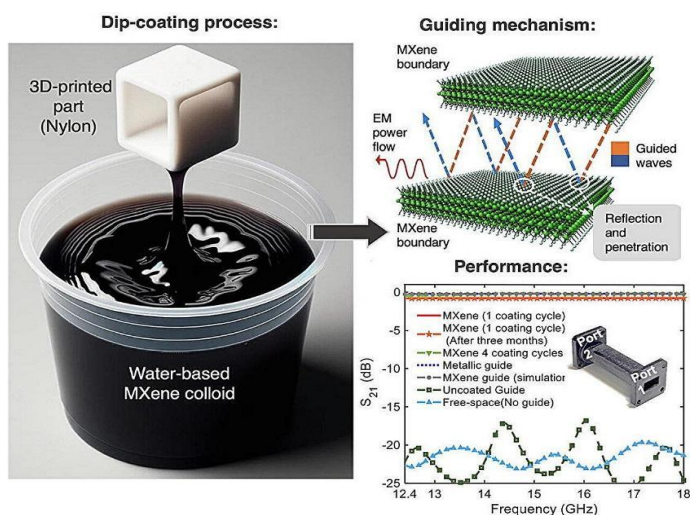
News Excerpt:

Researchers from Drexel University and the University of British Columbia are trying to **lighten the load** by **creating and testing a waveguide made from 3D-printed polymers coated with a conductive nanomaterial** called **MXene**.

Background:

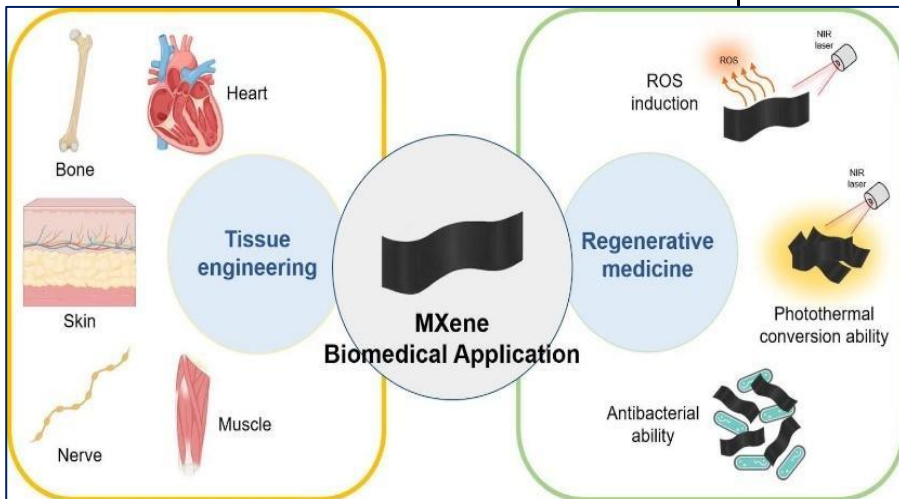
- One of the most important components of satellites that enable telecommunication is the **Waveguide**, which is a metal tube for guiding radio waves.
 - It is also **one of the heaviest payloads that satellites carry into orbit**.

About MXene material:



- MXene is an inorganic compound made up of atomically thin layers of transition metal carbides, nitrides or carbonitrides.
- MXene materials provide one of the thinnest possible coatings.
 - Their flakes are a few atoms thick and can create a conductive surface.
- It is highly conductive, functions as an electromagnetic shield, and can be produced simply by dipping the Waveguide in MXenes dispersed in water.
- The MXene-coated nylon waveguides weigh about eight times less than the standard aluminium ones currently being used.
- The waveguides are typically made from metals like silver, brass, and copper. In satellites, aluminium is the lighter-weight choice.

MXene Biomedical Applications:



- Due to their large surface area, the materials have the potential to **absorb carbon dioxide molecules from the atmosphere**, which could help reduce the harmful effects of climate change by safely sequestering carbon dioxide.
- MXene was **first used for energy conversion and storage in electrochemical capacitors, batteries, and energy collection devices.**
- It has also been **applied to catalysts, sensors, electromagnetic interference, and biopharmaceuticals.**
- Some MXenes are **used in photothermal therapy (PTT) and posterior-anterior (PA) imaging of the chest** because of their strong light absorption and high light conversion in the near-infrared (NIR) areas.
- Because various atoms of the transition metals of MXene have high atomic numbers (Ta and W), they exhibit excellent electron conductivity and magnetism.
- Thus, MXene is also used in **computed tomography (CT) imaging** and as a contrast agent for **magnetic**

resonance imaging (MRI) based on paramagnetic transition metal components (Cr and V).

- A wide range of applications of MXenes have been realized through their properties. It is **hydrophilic** owing to the **functional groups such as -F, -OH, and -O on the surface.** MXene has a large surface area and several functional groups, therefore making it easy to functionalize by loading drugs, hydrophilic biomolecules, and functional nanoparticles.
- MXene applies to **tissue engineering** and **regenerative medicine.**

Way Forward:

- The MXene-coated waveguides **still need to undergo extensive testing and be certified for space use** before they can be used on satellites. However, this finding could be an important step toward the next generation of space technology.

- Proper research and development and its utilization should be prioritized.

E Ink Displays

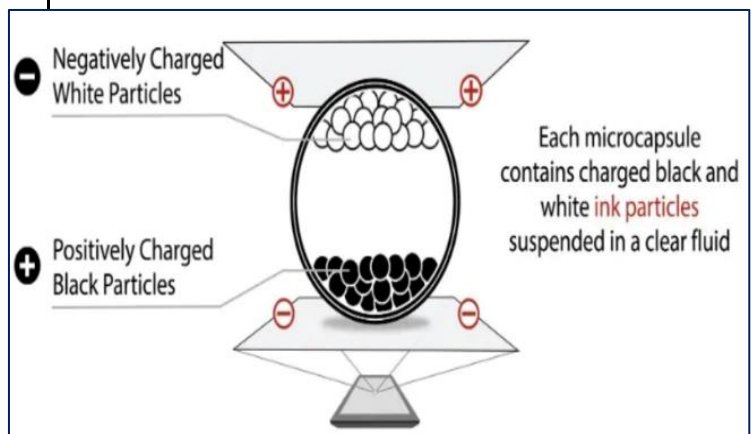
News Excerpt:

In recent times, e-books have become common for reading, and with the use of e-books, 'E Ink' has also come to light.

What are E Ink displays, and how do they work?

- E Ink displays are a **special type of screen technology** often used by e-readers like Amazon Kindle.
- The technology was **originally developed at MIT in the 1990s** and is now **owned by E Ink Corporation.**

- The screens **use tiny microcapsules filled with positively charged white particles and negatively charged black ones suspended in the fluid inside the display.**
- By applying positive or negative electrical charges to different areas of the screen, the white or black particles can be made to rise to the surface, creating the text and images on the display.



Advantages of E Ink displays:	Disadvantages of E Ink displays:
<ul style="list-style-type: none"> • They consume very little power compared to LCD and OLED displays. • An E Ink display only draws power when the image is changed, meaning it can display a static image for weeks or months without needing a charge. • E Ink displays cause less eye strain for the user. • The lack of a backlight and the paper-like visual experience means users can read on an E Ink device for hours without fatigue. • The matte surface and high contrast also make them easily readable outdoors and under bright light. 	<ul style="list-style-type: none"> • Their slow refresh rate is the biggest compared to LCD and OLED displays, leading to their limited video or animation use. • E Ink also has limitations on colour and resolution compared to other display technologies. • The niche nature of E-Ink manufacturing means the displays remain expensive, especially in larger sizes. • This limits their use to mostly e-readers and a handful of other products where their particular advantages outweigh the higher cost.

Uses of E Ink displays:

- E Ink displays were very popular among all e-readers in the 2000s.
- E Ink is used at **bus stop displays, walking direction signs, and restaurant menu boards.**
- Therefore, LCDs and OLEDs remain superior to E Ink alternatives for most display applications demanding speed, responsiveness and high resolution.
 - However, for a subset of use cases valuing long battery life, outdoor visibility, and eye comfort, they retain unique benefits over other display tech.

Magnetic Refrigeration

News Excerpt:

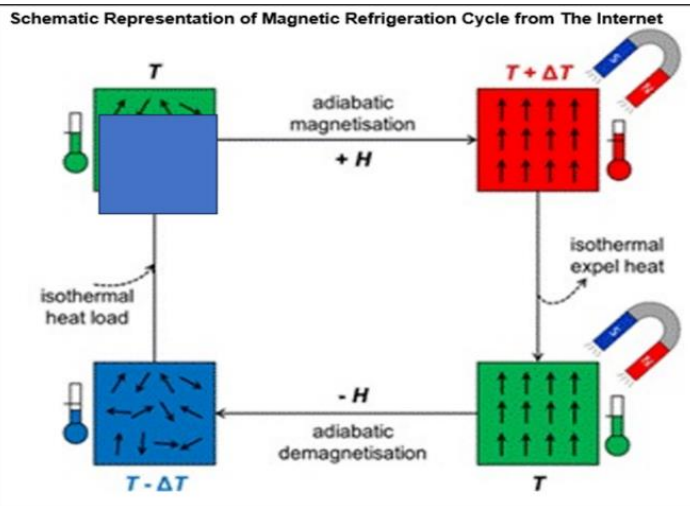
Researchers have found a new alloy (**Heusler alloys**) that can act as an effective magnetic refrigerant and an alternative cooling agent.

About Magnetic Refrigeration:

- Magnetic refrigeration offers an energy-efficient and environment-friendly cooling technology as an alternative to the current vapour-cycle refrigeration technology.
- Magnetic cooling effect (MCE) is the reversible temperature change of a magnetic material when subjected to an externally applied magnetic field.
- In the magnetic refrigeration cycle, a magnetic field is applied to the magnetic material under an adiabatic process where randomly oriented magnetic moments

align along the external magnetic field, heating the magnetic material.

- This heat is transferred from the material to the ambience. When the magnetic field is removed during adiabatic demagnetization, the magnetic moments of the material absorb heat from the surrounding medium.



Properties required for new magnetic materials:

- The material must be capable of operating for millions of cycles without any fatigue and failure.
- The material must have high thermal conductivity.
- The material should respond to an external magnetic field of about 2 T (Tesla), which permanent magnets can generate.

About Heusler alloys:

- A team at S.N. Bose National Centre for Basic Sciences, an autonomous institute of the Department of Science and Technology (DST), experimented with a certain type of alloy called **all-transition metal-based Heusler alloys (magnetic intermetallics with a face-centred cubic crystal structure)** in their search for material exhibiting **giant reversible MCE (MagnetoCaloric Effect).**

India's First Hypervelocity Expansion Tunnel Test Facility

News Excerpt:

A crucial milestone has been achieved with **India's first Hypervelocity Expansion Tunnel Test Facility, which was successfully established and tested by the Indian Institute of Technology, Kanpur (IITK).**

About the test facility:

- The Facility, named **S2**, can generate flight speeds between 3-10 km/s, simulating the hypersonic conditions encountered during atmospheric entry of vehicles, asteroid entry, scramjet flights, and ballistic missiles.
- **The S2, nicknamed 'Jigarthanda',** is a 24-meter-long facility located at IIT Kanpur's **Hypersonic Experimental Aerodynamics Laboratory (HEAL)** within the Department of Aerospace Engineering.

- The S2 was **indigenously designed and developed** over three years with funding and support from the Aeronautical Research and Development Board (ADRB), the **Department of Science & Technology (DST) and IIT Kanpur**.
- It was indigenously designed and developed and is a valuable test facility for **ISRO and DRDO's ongoing missions**, including Gaganyaan, RLV, and hypersonic cruise missiles.

Significance of this facility for India:

- Hypersonic research activities are **fast growing in India**, and implementing the Hypersonic Test Facility will **enable more aerospace engineers** and researchers to pursue **hypersonic research**.
- The research activities and **data generated** in the facility will serve **as input for the optimization of existing vehicles** and futuristic defence and Space Missions.
- The establishment of such a facility will **position India globally for advanced experimental hypersonic research**.
- With its indigenous development, it promises to bolster India's position in hypersonic technology and strengthen its defence and space sectors.

Small-scale LNG as fuel for India

News Excerpt:

Recently, the Union Ministry of Petroleum and Natural Gas dedicated to the nation India's **first small-scale liquefied natural gas (SSLNG) unit at GAIL (India) Ltd's Vijaipur complex in Madhya Pradesh**.

Why small-scale LNG?

- The government **aims** to increase the **share of natural gas in its primary energy mix to 15% by 2030** from a little more than 6% at present.
- Natural gas is **far less polluting** than conventional hydrocarbons like coal and oil.
- It is also **cheaper than oil**, more than 85% of India's requirement for which is met through costly imports.
- Natural gas is seen as a **key transition fuel** in India's journey **towards green energy and future fuels**.

Why is the use of LNG in long-haul trucks and buses attractive?

- **LNG is significantly cleaner** than diesel- with **reduced carbon dioxide emissions and negligible amounts of particulate matter, nitrogen oxide, and sulphur dioxide emissions**.

- **LNG offers a slightly longer range to vehicles than diesel** with similar-sized fuel tanks and is usually **cheaper than crude oil**, from which diesel is derived.
- Although **India imports around half of its natural gas requirement, this dependency level is much lower than that for crude oil**.
 - Replacing a major chunk of India's diesel consumption by LNG could lead to **substantial foreign exchange savings**.
- LNG has been **used successfully and aggressively in medium and heavy commercial vehicles in many countries, most notably in China**.

Challenges:

- A major challenge in scaling up gas consumption lies in **transporting gas to places that are not connected by India's natural gas pipeline grid**.
 - This problem also hinders the direct use of LNG as fuel for long-haul trucks and inter-city buses.
- **Large-scale pipeline projects** that are in the works **will take years to be completed**; even so, **last-mile delivery challenges may persist** in many parts of the country.
- The **challenges in India** include -
 - Lack of easy availability of LNG-powered vehicles,
 - The higher initial cost of these vehicles compared with diesel,
 - Absence of an LNG vehicle financing ecosystem,
 - The virtually non-existent LNG retail network.

What is SSLNG?

SSLNG refers to the liquefaction and transportation of natural gas using unconventional means in a significantly smaller-scale operation than the usual large-scale liquefaction, regasification, and transportation infrastructure and processes.	LNG - gas in its liquid or super-chilled form - is supplied in specialised trucks and small vessels to industrial and commercial consumers in regions that are not connected by pipelines.	The SSLNG chain can start from a large-scale LNG import terminal from where the LNG can be transported to consumers by cryogenic road tankers or small vessels instead of being regasified and supplied through pipelines. <ul style="list-style-type: none"> ◦ The chain can also start at locations with ample natural gas supply or production, where small liquefaction plants can be set up.
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Way Forward:

- **Road toll-fee exemption for LNG HDV:** Fiscal incentive in the form of toll-fee exemption to LNG HDV will reduce the total cost of ownership and could incentivize adoption.
- **Reduction of VAT on LNG sale to HDV and natural gas to be under GST** - A reduction of VAT to 5 percent on the sale of LNG to HDV will help in LNG price harmonization across states and further bring down the LNG HDV operating costs. In addition, natural gas should

come under GST to ensure the availability of input tax credits.

- **Demand aggregation model for LNG HDV adoption** – Currently, the unavailability of LNG HDV models in the market is due to a lack of clear demand signals to the vehicle manufacturers.
 - Demand aggregation would help optimize the cost of LNG HDV and further improve its adoption.
- **Non-fiscal incentives for demand creation:** A procurement policy could be formulated to adopt LNG HDVs in PSUs for transportation service contracts.
 - Non-fiscal incentives play a key role in signalling the government’s push for adopting a certain alternative fuel.
 - Such incentives for LNG could lead to the private sector getting involved in the market development for the alternative fuel.
- **Regulatory interventions** – Regulations for mobile refuelling of LNG HDV are to be approved to alleviate fuel availability concerns, which have been raised by fleet operators.
- **Signalling and outreach** – A “Natural Gas Mobility Dashboard” must be created with information on LNG refuelling stations, locations, and retail prices for fleet operators to plan and deploy LNG HDVs accordingly.

- Its mass is twice the electron mass and enjoys the unique distinction of being a **pure leptonic atom**.
- This hydrogen-like system, with **halved frequencies for excitation**, makes it a **great contender for attempting laser cooling** and thereby performing tests of fundamental theories in physics.
- A usual atom is made up of a mixture of baryons and leptons. Since Positronium is only made up of electrons and positrons, and no usual nuclear matter, it has the unique distinction of being a purely leptonic atom.

Antihydrogen experiment

News Excerpt:

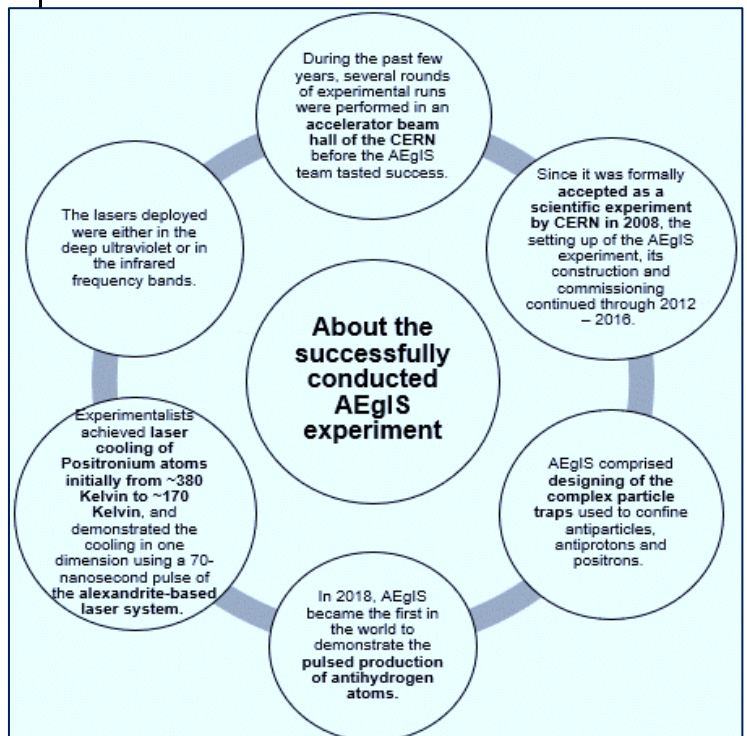
Recently, an international team of physicists from the **Anti-hydrogen Experiment: Gravity, Interferometry, Spectroscopy (AEGIS)** collaboration has achieved a breakthrough by demonstrating the **laser cooling of Positronium**.

What is Positron:

- Positronium is a fundamental atom that comprises an electron (e^-) and a positron (e^+). Electrons and positrons are leptons. They interact through **electromagnetic and weak forces**.
- Due to its very short life, it annihilates with a **half-life of 142 nano-seconds**.

Leptons:

- Leptons are said to be elementary particles; that is, they do not appear to be made up of smaller units of matter.
- Leptons can either carry one unit of electric charge or be neutral.
- The charged leptons are the electrons, muons, and taus.
- Each of these types has a negative charge and a distinct mass.
- Leptons respond only to the electromagnetic force, weak force, and gravitational force and are not affected by the strong force.



About the Experiment:

- The experiment was conducted by 19 European and one Indian research group comprising the Antihydrogen Experiment: Gravity, Interferometry, Spectroscopy (AEGIS) collaboration.
- The experiment was performed at the European Organization for Nuclear Research, more popularly known as CERN, in Geneva.
- This is an important precursor experiment to the formation of anti-hydrogen and the measurement of Earth’s gravitational acceleration on antihydrogen in the AEGIS experiment.
- In addition, this scientific feat could open prospects to produce a gamma-ray laser that would eventually allow researchers to look inside the atomic nucleus and have applications beyond physics.

Significance of the experiment:

- This experiment is expected to pave the way for performing spectroscopic comparisons required for **Quantum Electrodynamics (QED)**.
 - **Quantum Electrodynamics (QED):** It is a study of the light and its interaction with charged matter, and a

possible degenerate gas of Positronium down the road.

- According to CERN, the new scientific development will allow **high-precision measurements** of the properties and gravitational behaviour of this exotic but simple matter–antimatter system, which could **reveal newer physics**.
- It also allows the production of a positronium **Bose–Einstein condensate**, in which **all constituents occupy the same quantum state**.
 - A Bose-Einstein condensate of antimatter would be an **incredible tool** for both fundamental and applied research, especially **if it allowed the production of coherent gamma-ray light** with which researchers could peer into the atomic nucleus.
 - Such a condensate has been proposed as a **candidate to produce coherent gamma-ray light** via the matter-antimatter annihilation of its constituents; it would be a **laser-like light** made up of **monochromatic waves** that have a **constant phase difference between them**.

MISCELLANEOUS

Junk DNA led to humans being tailless

News Excerpt:

According to new research, a genetic change in our ancient ancestors may partly explain why humans don't have tails like monkeys.

More about the research:

- Scientists have traced our tail loss to a short sequence of genetic code that is abundant in our genome but had been dismissed for decades as junk DNA, a sequence that seemingly serves no biological purpose.
- They identified the snippet, known as **Alu element**, in the regulatory code of a gene associated with tail length called **TBXT**.

About TBXT (T-box transcription factor T) gene:

- The **TBXT gene** provides **instructions for making a protein called brachyury**.
- **Brachyury** is a member of a protein family called **T-box proteins**, which play critical roles **during embryonic development**.
- **T-box proteins regulate the activity of other genes by attaching (binding) to specific regions of DNA**.
- On the basis of this action, T-box proteins are called **transcription factors**.

What is a gene?

- A gene is a **segment of DNA** that contains **sequences of many bases**, varying in **size from a few hundred to 2 million**.
- Parents pass on their genes to their **biological children**. As a result, each person has **two copies of each human gene** — **one from each parent**.

What is a genome?

- Every cell of an organism contains a **full copy of that organism's DNA**, called the **genome**.
- The genome contains the information that the cell uses to make proteins, the workhorses of the cell.
- Genome refers to **all the genetic material in an organism**. The human genome consists of around **3 billion DNA base pairs**.
 - Almost **every cell** in the body contains a **complete copy of the organism's genome**, tightly packaged inside its chromosomes.

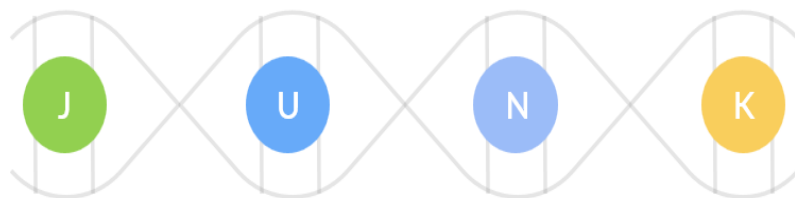
Compact Genome:

- Scientists in the mid-1990s observed that simple organisms like **bacteria** maintain **highly compact genomes**.
- Bacterial genomes exhibit a **tandem arrangement of genes**, where **one gene end, another begins**.

Alu Element:

- One such **transposable element, called Alu**, is unique to **primates (both apes and monkeys)**.
- It is **tiny**, being made up of **around 300 base-pairs** (the **human genome** is approximately **3 billion base-pairs**), but has the ability to **copy** itself and **'jump'** within the genome.

Junk DNA



In genetics, the term junk DNA refers to regions of DNA that are noncoding.

DNA contains instructions (coding) that are used to create proteins in the cell. 'junk' DNA is responsible for various functions including controlling when to make a protein and when not to.

However, the amount of DNA contained inside each cell is vast and not all of the genetic sequences present within a DNA molecule actually code for a protein.

A significant fraction of the 'junk' also contains transposable elements. These are pieces of DNA that can shift their positions within the genome.

Negative Leap Second

News Excerpt:

The melting of **polar ice** due to global warming is affecting Earth's rotation and could impact **precision timekeeping**, according to a paper in the journal Nature.

Making the leap:

- The establishment of **two versions of time** — **astronomical and atomic** came more than **55 years** ago when **atomic clocks were adopted as the official time standard**.

- In atomic time, a second is defined as **9,192,631,770** oscillations of a Cesium atom and thus, **these clocks do not slow down**.
- In the early **1970s**, Earth was slowing down in its rotation, and a gap formed between atomic time and astronomical time. **Astronomical time fell behind atomic time by 2.5 milliseconds every day**.
 - Thus, the “leap second” was born to adjust that the “day” was **getting longer**.

What is a Leap Second?

- Coordinated Universal Time (UTC) is based on International Atomic Time (TAI) but is adjusted by seconds to **account for the difference between the definition of the second and the rotation of the Earth**.
- Occasionally, 1s is added to the UTC time scale. **This second is called a leap second**.
- Its purpose is to keep the UTC time scale **within ± 0.9 s of the Universal Time (UT1) time scale**, which changes slightly due to variations in the rotation of the Earth. **UT1 refers to astronomical time**.
- **Twenty-seven leap seconds have been added** to Universal Coordinated Time since 1972. The addition of a leap second happens at the last tick of the clock on the night of Dec. 31 or June 30.
- In a **leap second**, instead of 11:59 and 59 seconds turning to midnight, there is another second at 11:59 and 60 seconds.

India is deploying atomic clocks across the country to ensure that the **time shown in our digital watches, smartphones, and laptops** is truly based on **Indian Standard Time (IST)**.

Background:

- Currently, most **software operating modules in India** rely on **US-based Network Time Protocol servers**.
- The Indian government wants **all software to be synchronised with indigenous atomic clocks** instead, both for **uniformity in time** and as a **defence mechanism, especially in times of war**.
- The **Consumer Affairs Ministry's Legal Metrology Department** and the **National Physical Laboratory**, or NPL, the nation's timekeeper, are installing the atomic clocks.
- So far, **India** has **atomic clocks** in **Ahmedabad** and **Faridabad**, and more are being installed in Bhubaneswar, Jaipur, and Hyderabad.
- **Only four** other countries - **the US, the UK, Japan, and Korea** - have their **own atomic clocks**.

About Atomic Clock:

- An **atomic clock works like a conventional clock**. Still, the **time-base of the clock**, instead of being an oscillating mass as in a pendulum clock, is **based on the properties of atoms** when **transitioning between different energy states**.
 - An atom, when excited by an external energy source, goes to a higher energy state. Then, from this state, it goes to a lower energy state. In this transition, the

atom releases energy at a very precise frequency, which is characteristic of the type of atom.

Need of the adjustment:

- **Timekeeping is an exact science** in a highly technological society, which is why a need was felt to invent the concept of the “leap second” and “negative leap second”.
- **Global Positioning System (GPS) as well as Stock Trading** requires split-second accuracy thus, this new difference of a leap second could impact them vastly.

Now:

- But now, the Earth is not slowing down anymore. **There hasn't been a leap second added since the end of 2016**.
- Earth's rotation has been speeding up, overtaking atomic time. This means that to bring the two measurements in sync, timekeepers may have to introduce the first-ever negative leap second.
- The melting of the ice caps in **Antarctica and Greenland** shifts mass (i.e. all that extra liquid is **redistributing weight across the planet**) toward the equator. That process increases the equatorial bulge of the planet.
- **A negative leap second would go from 11:59 and 58 seconds directly to midnight, skipping 11:59:59**.
- Overall, the Earth's rotation is too unpredictable to definitively say when (or if) we'll need that negative leap second in 2026, 2029, or anytime soon.

Telegram Bots

News Excerpt

Recently, reports came out which alleged that a Telegram bot had access to Citizen's documents

Key points:

In 2021, security researchers reportedly found a network of deep fake bots on the platform that were generating non-consensual images of people submitted by users, some of which involved children.

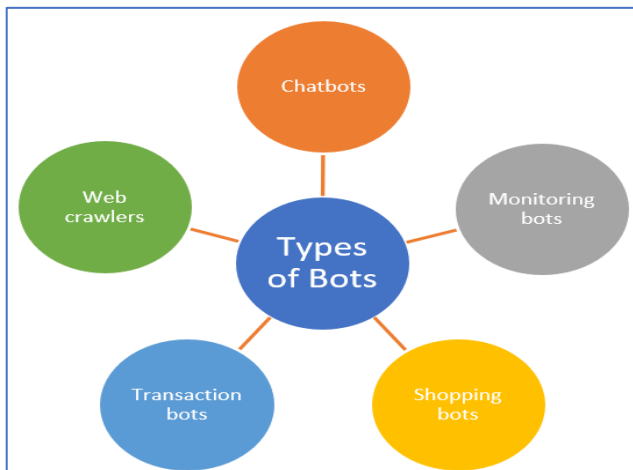
What are bots?

- A bot is an automated software application that performs repetitive tasks over a network. It follows specific instructions to imitate human behaviour but is faster and more accurate.
- It can also run independently without human intervention.

What are Telegram bots?

- Bots are computer programs that act as agents of a user or another computer program. Bots on Telegram are small applications that run entirely within the platform and can be designed to support any kind of task or service.
- They can host full Web Apps.
- They can be designed to support everything from online stores to arcade games.

- They can also be designed to make it easier for users to access information held within large databases they are connected to.



Threats from Malicious bots

They perform activities that create security risks for organizations. For example, create disrupt operations, unfair disadvantages, send out unwanted emails, or attempt unauthorized access to sensitive data.

Major Privacy concerns about Chatbots

- One of the main concerns about chatbots and privacy is the collection of personal information (such as PI, PII, PHI, SPDIs).
- They are often connected to the internet, which means that they are vulnerable to hacking and cyberattack.
- Chatbot data may be shared with third parties without the user's knowledge or concern.
- The lack of transparency around how chatbot data could be collected, stored, and accessed.

Protection measures

- Using anti-malware programs and run regular scans to detect and isolate bots in computer systems.
- Install a firewall to prevent bots from accessing your computer
- Enforcing strong endpoint security policies
- Regulate sharing of portable storage drives.
- Training employees to avoid clicking on unknown or suspicious links in emails

Way forward

- AI chatbots have the potential to be a significant enabler at the same time they also raise important privacy concerns.
- Developers of chatbots must be transparent and responsible with the data they collect, while users must be aware of the potential risks and take steps to protect their personal information.

Voice over New Radio (VoNR)

News Excerpt:

Voice calling over VoLTE (Voice over Long term Evolution) was a game-changer. Now it's time for this feature to showcase itself in 5G-enabled VoNR (Voice over New Radio).

About the technology:

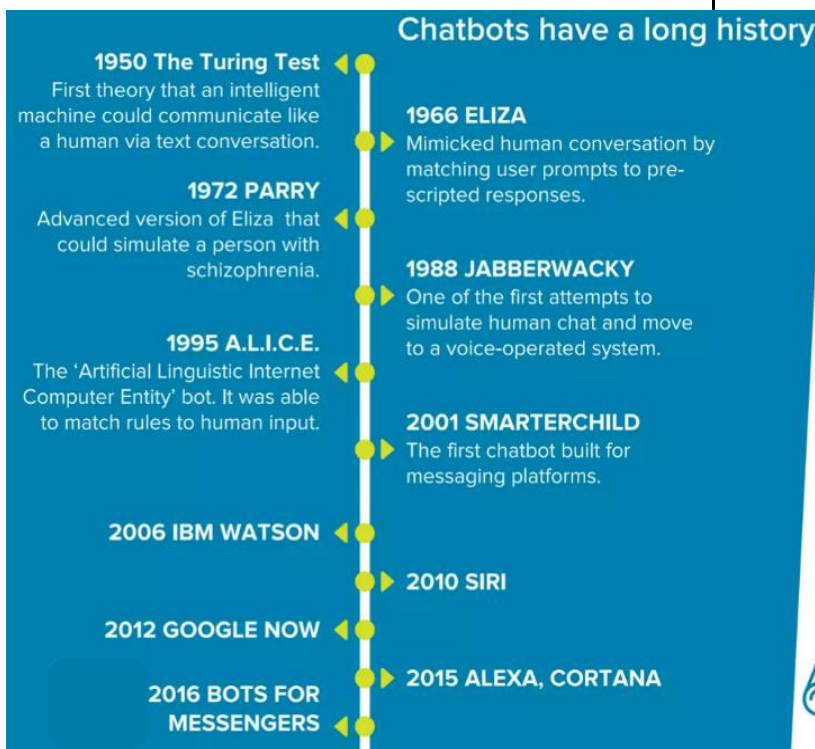
The introduction of VoLTE in India and its significant improvements to voice calling quality is remarkable. With the advent of 5G, there's anticipation surrounding the evolution to Vo5G or Voice over New Radio (VoNR), seen as the future standard for voice calls on 5G networks.

- **VoLTE in India (2016):** VoLTE revolutionized voice calling with its **clear quality**, contrasting the previous muffled 3G/2G call experiences. It marked a significant upgrade, ensuring WhatsApp-like voice clarity without constant repetitions.

- **Introduction of Vo5G (Voice over 5G):** Vo5G, also known as VoNR (Voice over New Radio), represents the future standard for voice calls on 5G networks. It utilizes 5G network advancements—**speed, capacity, responsiveness**—to enhance voice calling experiences.

- **Advantages of VoNR over VoLTE:** VoNR offers superior call quality due to advanced audio codecs leveraging 5G's increased data capacity. Faster call connection times are attributed to **reduced network latency of 5G, enhanced reliability and continuity in calls** with lower packet loss, and reduced voice cutouts.

- **Improvements over Drop Issues in India:** VoNR aims to resolve drop issues experienced during network switches from 5G to 4G for VoLTE calls. With VoNR, 4G should remain dormant on 5G-supported phones, eliminating delays or drops during calls.



- **VoNR's Status in India:** VoNR is yet to arrive in India, despite ongoing 5G rollout by major carriers. Reports suggest Reliance Jio has been testing VoNR to ensure seamless integration with existing 4G VoLTE and new 5G networks.
- **Anticipated VoNR Availability:** The specific timeline for VoNR in India remains uncertain, but Reliance Jio might be among the first to roll out VoNR services. Competitors like Airtel and Vi are expected to follow suit quickly after its introduction by Reliance Jio.

How Vo5G Works:

- **Packet-Switched Architecture:** Vo5G operates on a packet-switched network, where voice data is broken into packets and transmitted over the 5G network. This approach allows for more efficient use of network resources, optimizing voice data delivery.
- **Low Latency and Quality of Service (QoS):** The ultra-low latency of 5G networks contributes to faster call setup times, reduced delays, and improved service quality. Vo5G is designed to prioritize voice traffic, ensuring a seamless and reliable communication experience.
- **Vo5G-Compatible Devices:** To take advantage of Vo5G, users will need devices that support 5G connectivity and Vo5G technology. Modern smartphones are increasingly equipped with these capabilities, enabling users to experience the benefits of Vo5G.

Way Forward:

The introduction of VoNR signifies a **natural progression** as networks continue to evolve with the adoption of 5G technology.

- The goal is to ensure **smooth interoperability, enhanced user experience** and capture the attention of consumers and industries.
- The service providers can embed 5G voice services to **remote diagnostics in telemedicine or real-time language translation services.**
- VoNR can also be used to **stream live event broadcasting with immersive audio, and interactive gaming experiences** with **integrated voice** functionalities.

Sodium-ion batteries

News Excerpt

In recent years, considerable attention has been focused on the development of sodium-ion batteries.

About Sodium Battery

- Sodium batteries are a burgeoning field in energy storage research, aiming to supplant conventional lithium-ion batteries by leveraging sodium ions for electrochemical energy storage and retrieval.

- These batteries employ sodium as a viable alternative to lithium, capitalizing on its greater abundance, enhanced cost-effectiveness, and reduced environmental impact.
- Sodium is widely available and less expensive compared to lithium. Sodium batteries utilize sodium ions, making them a cost-effective option for large-scale energy storage.
- Sodium batteries offer a greener alternative as they don't deplete scarce resources or pose significant environmental concerns.
- Sodium batteries are considered safer than traditional lithium-ion batteries. They have higher thermal stability, reducing the risk of thermal runaway or fire hazards, which improves overall battery safety.

Possible Advantages

- **Electric Vehicle Adoption:** Sodium batteries can help boost India's EV adoption by providing a viable alternative to traditional lithium-ion batteries. The abundance and lower cost of sodium make it a promising choice.
- **Enhanced Energy Storage:** Sodium batteries offer significant energy storage capabilities, which can support the integration of renewable energy sources like solar and wind power.
- **Improved Energy Access:** Sodium batteries can play a crucial role in providing reliable and sustainable energy access to remote and off-grid areas in India.
 - By storing electricity from renewable sources, sodium batteries can power off-grid communities, improving their quality of life and supporting economic development.
- **Sustainable Electric Mobility:** By reducing reliance on fossil fuels, sodium-powered EVs can help decrease greenhouse gas emissions and combat air pollution, thereby improving air quality and public health.
- **Domestic Manufacturing and Job Creation:** Developing a robust sodium battery industry will create job opportunities across India.

Limitations

- Sodium-ion batteries generally have lower energy density, they can store less energy per unit of weight or volume, which may result in shorter operating times or reduced driving ranges in electric vehicles.
- Sodium-ion batteries currently have a limited cycle life, meaning they may degrade and lose their capacity to store and deliver energy after a certain number of charge and discharge cycles.
- Finding suitable electrode materials for sodium-ion batteries is still a challenge.
- Sodium-ion batteries generally exhibit slower charging rates, that can lead to longer charging times, which may be inconvenient for users.
- Sodium-ion batteries are still in the early stages of development and commercialization. The infrastructure to support their widespread adoption, including

manufacturing facilities, recycling systems, and charging networks, is not as well-established as it is for lithium-ion batteries.

Difference between Lithium Batteries and Sodium Batteries	
Sodium-ion batteries	Lithium-ion batteries
Sodium is more than 500 times more abundant than lithium. It can also be extracted from seawater at a low cost.	Lithium availability is limited to a few countries, which is why prices have risen more than seven-fold since 2021.
Sodium is more environmentally friendly and can be transported at zero volt, making it safer.	Lithium is less environmentally friendly than sodium and must be always stored with a minimum charge, increasing fire risks.
A Sodium-ion battery uses aluminium which is cheaper than copper.	Lithium-ion battery uses copper, which is three or four times more expensive than aluminum used on sodium batteries
Sodium-ion battery has a higher operating temperature range. This means these can be used in more extreme temperatures without the risk of thermal runaway.	Lithium-ion battery has lower operating temperature range and can cause fire if operated in higher temperatures.
Sodium-ion battery charges faster than lithium-ion variants and have a three times higher lifecycle.	Lithium-ion battery has a slow charge rate and smaller lifecycle compared to sodium-based batteries.

Conclusion

Sodium-ion batteries offer promise as a cost-effective and environmentally friendly alternative. However, challenges remain in terms of energy density, cycle life, and infrastructure development, necessitating further research and development efforts for their widespread adoption.

Deep Sea Mining

News Excerpt

The International Seabed Authority which is the United Nations body that regulates the world’s ocean floor is preparing to resume negotiations that could open the international seabed for mining, including for materials critical for the green energy transition.

What Is Deep Sea Mining?

- Deep sea mining involves removing mineral deposits and metals from the ocean’s seabed.
- There are three types of such mining:
 - Taking deposit-rich polymetallic nodules off the ocean floor.
 - Mining massive seafloor sulphide deposits.
 - Stripping cobalt crusts from rock.
- These nodules, deposits and crusts contain materials, such as nickel, rare earths, cobalt etc that are needed for

everyday technology like cellphones, batteries and computers.

- Governments view these as strategically important resources that will be needed as onshore reserves are depleted and demand continues to rise.

Regulation of Deep-Sea Mining

- Countries manage their own maritime territory and exclusive economic zones.
- The high seas and the international ocean floor are governed by the United Nations Convention on the Law of the Seas (UNCLOS).
- UNCLOS is considered to apply to states regardless of whether or not they have signed or ratified it.
- Under the treaty, the seabed and its mineral resources are considered the common heritage of mankind that must be managed in a way that protects the interests of humanity.
- Such measures include the sharing of economic benefits, support for marine scientific research, and protecting marine environments.
- Mining companies interested in deep sea exploitation are partnering with countries to help them get exploration licenses and around 30 exploration licenses have been issued so far.

Challenges Associated with Deep Sea Mining

- Only a small part of the deep seabed has been explored and conservationists worry that ecosystems will be damaged by mining, especially without any environmental protocols.
 - Damage from mining can include noise, vibration and light pollution, as well as possible leaks and spills of fuels and other chemicals used in the mining process.
- Sediment plumes from some mining processes can harm filter-feeding species like corals and sponges and could interfere with some creatures.
- The full extent of implications for deep sea ecosystems is unclear, but scientists have warned that biodiversity loss is inevitable and potentially irreversible.
- The distribution and concentration of valuable minerals on the seabed are not well understood, making it challenging to locate and extract them economically.
- The governance of deep-sea mining activities is complex, as it involves multiple stakeholders, including governments, international bodies, mining companies, and environmental organizations.

Way Forward

- The International Seabed Authority’s Legal and Technical Commission will soon discuss the future mining code draft.
- Engineering and technology used for deep sea mining are still evolving.
 - Some companies are looking to vacuum materials from seafloor using massive pumps.

- Others are developing artificial intelligence-based technology that would teach deep sea robots how to pluck nodules from the floor.
- Some are looking to use advanced machines that could mine materials off side of huge underwater mountains and volcanoes.
- To reduce the demand for new mineral extraction, emphasis should be placed on resource efficiency and recycling and promoting circular economy.
- Certain areas of the deep sea should be designated as protected areas to safeguard fragile ecosystems and biodiversity hotspots which can help promote the recovery and resilience of deep-sea habitats.
- There should be transparent and equitable benefit-sharing mechanisms that ensure that the economic gains from mining activities are shared with the local communities and contribute to their sustainable development.

Worldcoin - Biometric Project

News Excerpt

OpenAI CEO Sam Altman has formally re-introduced Worldcoin, a project of his that was eclipsed by the popularity of ChatGPT.

About World coin

- World coin is an initiative to create a digital network in which everyone can claim some kind of stake, and join the digital economy.
- Using a device called "Orb," World coin volunteers known as 'Orb operators' scan a person's iris pattern to collect their biometric data and help them get a World ID through the World app.
- With the app, scanned participants can collect a cryptocurrency called World coin [WLD] at regular intervals or make transactions with their World ID where possible.
- This process is called "**proof of personhood**" and makes sure that people do not sign themselves up multiple times in exchange for crypto.

World coin's working procedure

- To make the World coin network possible, users need to be willing to scan irises and/or get their own irises scanned.
- Volunteers sign up to be "Orb operators" in their locality and receive basic training and a biometric device with which to scan irises. Orb operators can even rent out the Orb to others to let them scan eyeballs as well.
- Those who have their irises scanned and collect a World ID can use this to claim the WLD crypto, which they may use for transactions (if possible and legal) or hold on to the asset in the hope that its price might rise, as it did after launching.
- However, users can also buy or sell WLD without getting scanned or using the app. In this sense, it resembles a standard digital currency.

Criticism of World coin:

- Even if a person's biometric scans were deleted for privacy reasons, the unique identifier for the scan would match future scans of the same person's eyes.
- World coin scanned the eyes of underprivileged people in emerging economies across South America, Asia, and Africa during the COVID-19 pandemic.
- The report observed that several people whose irises were scanned did not understand the project's aims, or were tempted by Orb operators who promised rewards such as cash and Air pods in exchange for scans.

DEEP OCEAN MISSION - 'SAMUDRAYAAN'

News Excerpt:

India's first and unique manned Deep Ocean Mission 'Samudrayaan' plans to send 3 humans to 6000m (6 km) ocean depth in a submersible, to study the deep-sea resources and biodiversity assessment while ensuring minimal disruption to the ecosystem.

Estimated Ocean Resources: India has been allotted a site of 75,000 sq. km. in the Central Indian Ocean Basin (CIOB) by the UN International Sea Bed Authority for the exploitation of polymetallic nodules (PMN). Just by utilizing 10% of the PMN reserve available in the area, the country can meet its energy requirements for the next 100 years.

About Samudrayaan:

- Samudrayaan is a project under the Deep Ocean Mission. The Deep Ocean Mission was launched in September 2021 as the **Central Sector Scheme of the Ministry of Earth Sciences (MoES)** with the approval of the Cabinet.
- With this step India joined the **elite club of nations such as USA, Russia, Japan, France and China** in having such underwater vehicles for carrying out subsea activities.
- It will facilitate MoES in carrying out deep ocean exploration of the non-living resources such as polymetallic manganese nodules, gas hydrates, hydrothermal sulphides, and cobalt crusts, located at a depth between 1000 and 5500 metres.

BLUE ECONOMY POLICY: It envisages the optimal utilization of all sectors of the maritime domain, (living, non-living resources, tourism, ocean energy, etc.) for sustainable development of coastal areas. This includes Ocean Governance, Coastal Marine Spatial Planning and Tourism Priority, Marine Fisheries, Aquaculture and Fish Processing.

BIO-PROSPECTING: Exploration of biodiversity for new biological resources of social and economic value.

MATSYA 6000

- Preliminary design of the **manned submersible MATSYA 6000** is completed and realization of the vehicle has been started with various organizations including the Indian Space Research Organisation (ISRO), Indian Institute of Tropical Meteorology (IITM) and

Defence Research and Development Organisation (DRDO) roped-in to support the development.

- Sea trials of 500 metre-rated shallow water version of the manned submersible are expected to take place in the last quarter of 2022 and MATSYA 6000 will be ready for trials by the second quarter of 2024.
- MATSYA 6000 is expected to have an endurance of 12 hours of operational period and 96 hours in case of emergency.

- Identify technological innovations and conservation methods for sustainable utilization of marine bioresources.
- Develop offshore-based desalination techniques.
- Develop renewable energy generation techniques.
- Provide clean drinking water and explore the avenues of desalination of water as well as extracting minerals from the ocean belt.

Components of Deep Ocean Mission

Development of Technologies for Deep Sea Mining, and Manned Submersible

i.e. A manned submersible as well as an Integrated Mining System will be also developed as per the requirements to sustain 6000 m depth in the central Indian Ocean.

Development of Ocean Climate Change Advisory Services:

A suite of observations and models will be developed to understand and provide future projections of important climate variables on seasonal to decadal time scales under this proof-of-concept component. This component will support the **Blue Economy** priority area of coastal tourism.

Technological innovations for exploration and conservation of deep-sea biodiversity:

The main focus will be bio-prospecting of deep-sea flora and fauna, including microbes and studies on sustainable utilization of deep-sea bio-resources. This component will support the Blue Economy priority area of Marine Fisheries and allied services.

Deep Ocean Survey and Exploration:

The primary objective of this component is to explore and identify potential sites of multi-metal hydrothermal sulphide mineralization along the Indian Ocean mid-oceanic ridges. This component will additionally support the Blue Economy priority area of deep-sea exploration of ocean resources.

Energy and freshwater from the Ocean:

Studies and detailed engineering design for offshore Ocean Thermal Energy Conversion (OTEC) powered desalination plant are envisaged in this proof-of-concept proposal. This component will support the Blue Economy priority area of offshore energy development.

Advanced Marine Station for Ocean Biology: This component is aimed at the development of human capacity and enterprise in ocean biology and engineering. This component will translate research into industrial application.

THE RACE TO THE BOTTOM
Indian scientists begin an ambitious project to explore the seabed. Inside India's Deep Ocean Mission to extract resources from the seabed
By SANDEEP UNNITHAN / Graphic by NILANJAN DAS

SHIP SUPPORT AND CONTROL STATION
Includes a frame winch controls with LARS (launch and recovery system), control console with underwater telephone, positioning devices and maintenance equipment

THE VESSEL: MATSYA 6000
A manned submersible, to be made of space grade titanium alloy
Deployment: The central Indian Ocean, between the 10 and 25 degrees south latitude (just above the Tropic of Capricorn)

DEPTH RATING ACHIEVED BY OTHER NATIONS
FRANCE 6,500 M
JAPAN 6,500 M
RUSSIA 6,000 M
AUSTRALIA 11,000 M
USA 10,925 M
CHINA 10,309 M

EMERGENCY LIFE SUPPORT PERIOD
96 HOURS

Cost
Rs 300 CRORE

YEAR OF MISSION
2024

ENDURANCE
21 HOURS

PROJECT STATUS (NOV. 2021):
Personnel sphere being designed by NIOT Chennai in association with ISRO
The titanium cabin sphere, the life support systems, the vehicle frame and the control systems are being developed indigenously

Dimensions:
LENGTH: 9 m
WIDTH: 4 m
HEIGHT: 4.5 m
WEIGHT: 25 tonnes

Size comparison: A city bus

Components:
Crew, Pilot, Spherical personnel cabin (DIAMETER: 2.1m), Manipulator, Lateral thruster, Camera, Frame, Vertical thruster, High pressure air tank, Hydraulic power pack, Light

Major objectives of the Deep Ocean Mission

- Address issues arising from long-term changes in the ocean due to climate change.
- Develop technologies for deep-sea missions of living (biodiversity) and non-living (minerals) resources.
- Develop underwater vehicles and underwater robotics.
- Provide ocean climate change advisory services.

This component will support the Blue Economy priority area of Marine Biology, Blue trade and blue manufacturing.

CONCLUSION:

As India moves ahead to develop a sustainable ocean-based economic model to harness coastal resources, we need to create awareness amongst the public and user communities about the various achievements as well as services rendered by MoES.

How can gravity solve green power's problem?

News Excerpt:

Gravity batteries are emerging as the best bet in solving renewable energy's biggest problem –**intermittency** (to balance out the variability in demand and supply of electricity).

After the **USA & China**, an energy company is in talks with **Indian firms** offering to deploy **gravity-based storage** that could be installed alongside green power generation generated through renewable power.

Need for Energy storage systems:

- Unlike **thermal plants** powered by fossil fuels that can operate **day and night**, renewable sources like the **sun and the wind** are **intermittent**, and the power generation drops or, worse stops on a **cloudy or wind-lull day**.
- The reliance on renewables for consistent power is, therefore, only possible with energy storage.

Gravity batteries vs Lithium-ion batteries:

- Gravity batteries are not the only way to store renewable energy. **Lithium-ion batteries** and **Green Hydrogen** are other options, but gravity storage has many advantages over them.
- Gravity storage is **free, easily accessible, and environmentally friendly**. Gravity batteries last longer, up to 50 years, and are **highly repairable**.
- Lithium-ion batteries **degrade** over time, are more **expensive**, and are associated with **human rights abuses** and **environmental damage**.
- As decarbonization efforts increase, the demand for more durable and efficient energy storage systems will increase. While **lithium-ion batteries** are useful for **short-term energy storage**, gravity batteries are better suited for long-term storage.

What is Gravity-based energy storage?

It depends on the vertical movement of a heavy object in a gravitational field to store or release electricity. This technology accomplishes energy storage by converting the electrical energy in the power system to the gravitational potential energy of the weight through electromechanical equipment. There are two types of GBES.

Mechanical Elevator Storage System:

- It is a type of electricity storage device that involves lifting (charging) and lowering (discharging) a heavyweight.
- The platform **utilizes gravity** and a **mechanical elevator system** to stack **25-tonne blocks** made of composite material at the top of a **towering structure**.
- It mimics the broad attributes of a pumped hydroelectric plant, which uses moving water to store and discharge power.
- When the electricity **demand** is **low**, the elevator uses **surplus electricity** already generated to raise these blocks and line them up at the **top** of the structure.
- When electricity demand picks up, the blocks are lowered one by one, **releasing kinetic energy** used to rotate a motor and generate electricity, which can then be supplied.
- This would mean one could **store power** captured by a **solar farm** during the **day** when the sun is shining and then **release** that electricity to the grid in the **evening** when **demand rises** because people are at home using electricity to watch TV, cook, and heat their homes.

Water-Based Gravity Systems:

- Pumped hydro is an established technology responsible for about **96%** of the world's high-capacity **energy storage**, according to the **International Hydropower Association**.
- In this, **excess energy** on the grid is used to **pump water uphill** to a **high-elevation reservoir**. When there is **energy demand**, the water is released, driving a **turbine** as it flows into a reservoir below.
- However, these facilities are **expensive** to build and are **restricted by geography**, as the technology requires hills and access to water.

Indian Perspective:

- India's push for deployment of large-scale renewable power makes storage a **prerequisite** to support this expansion.
- As per the updated India's Nationally Determined Contribution (**INDC**), India is committed to reducing the emissions intensity of its GDP by 45% by 2030 from the 2005 level and achieving about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030.
- India, in its **PANCHAMRIT PLEDGES** of climate change (Five Nectar Elements), is determined to become net zero by 2070.
- The Indian government now plans to accept bids for a **100MW** round-the-clock clean **energy system with storage**. **National Hydrogen policy** was already cleared by the cabinet last year to increase green hydrogen production.
- The Union Power Ministry has finished **surveying pumped hydro sites** and tasked hydro PSUs with taking

up pumped hydro schemes. There is also a proposal to consider **opencast mines** as **potential sites** for pumped hydro.

- The **World Economic Forum (WEF)** founded the Global Battery Alliance (**GBA**) in 2017 to establish a sustainable battery **supply chain** by 2030.
 - GBA is a body of over 100 leading international organizations, NGOs, industry actors, academics, and multiple governments.
 - It started working independently from WEF in 2021, and its membership is collectively working towards the goals set out in the **GBA 2030 Vision**.

Way forward:

- As India is a major producer of renewable energy, with **nearly 40%** of its **installed electricity capacity** coming from **non-fossil** fuel sources.
- The government should explore other options, such as **hydrogen** and **hybrid generation models** that are combined with off-stream pumped storage.
- It would be beneficial to use full-scale **energy storage** in **former mines**, which can take **advantage** of existing **infrastructure** and **generate jobs** in the areas where they are most needed.

Flight Turbulence

News Excerpt:

The London to Singapore flight encountered sudden extreme turbulence over the Irrawaddy Basin [a river in Myanmar] at 37,000 feet, about 10 hours after departure.

What is turbulence?

- Turbulence occurs when a **plane flies through clashing bodies of air** moving at widely different speeds.
- With **light and moderate turbulence**, passengers might feel a strain against their seatbelts, and unsecured items could move around the cabin.
- But in **severe cases turbulence** can throw passengers around the cabin, causing severe injuries and occasionally death.

Reasons for the turbulence:

1. Due to thunderstorms:

- Tropical thunderstorms can form **moisture quickly** in the early afternoon as the land heats up, especially near the coastline.
- Such thunderstorms **may not appear on radar in their earliest stages**, even though the quick rising motion within them can still produce turbulence. The storm cells likely grew from **20,000-**

30,000 feet to well over 50,000 feet in less than an hour.

2. Due to cloud:

- Most turbulence occurs in clouds where there are **up and downdrafts of wind**.
- Much of that will be fairly mild but in bigger clouds - such as the **Cumulonimbus thunderstorm cloud** - the chaotic movements of air can cause moderate or even severe turbulence.

3. Clear Air Turbulence (CAT):

- This is **cloudless** and can't be seen, and happens around the **jet stream**, a fast-flowing "river" of air that's typically found at **40,000-60,000 ft**.
- You can easily have a **100mph speed difference between the air in the jet stream and the surrounding air**, this friction around the jet stream between the slower and faster air causes turbulence.

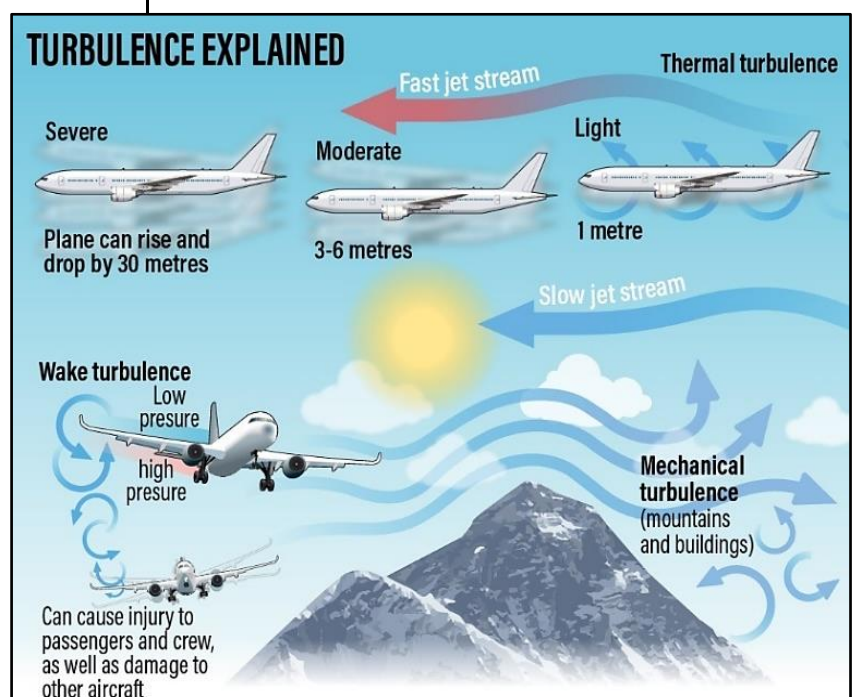
Threats involved:

- It can cause **structural damage** to a plane because of how strong the winds can be.
- It can be dangerous to air passengers because of the **violent motion** it can cause, which can throw anyone who is not wearing a seatbelt across the cabin.

Why is turbulence becoming frequent?

As per the research done on **clear air turbulence** by Reading University in the UK, the **turbulence has increased by 55%** between **1979 and 2020**. The reasons behind this could be:

- **Changes in wind speed** at high altitudes due to **warmer air from carbon emissions**.
- Due to **climate change**.



Way forward:

- Investing more in improved turbulence forecasting and detection systems,
- Satellites can be used to see the structure and the shape of the jet stream, allowing it to be analyzed to understand any upcoming turbulence.
- Proper training of the pilot and crews after every interval to efficiently manage and deal with turbulence.

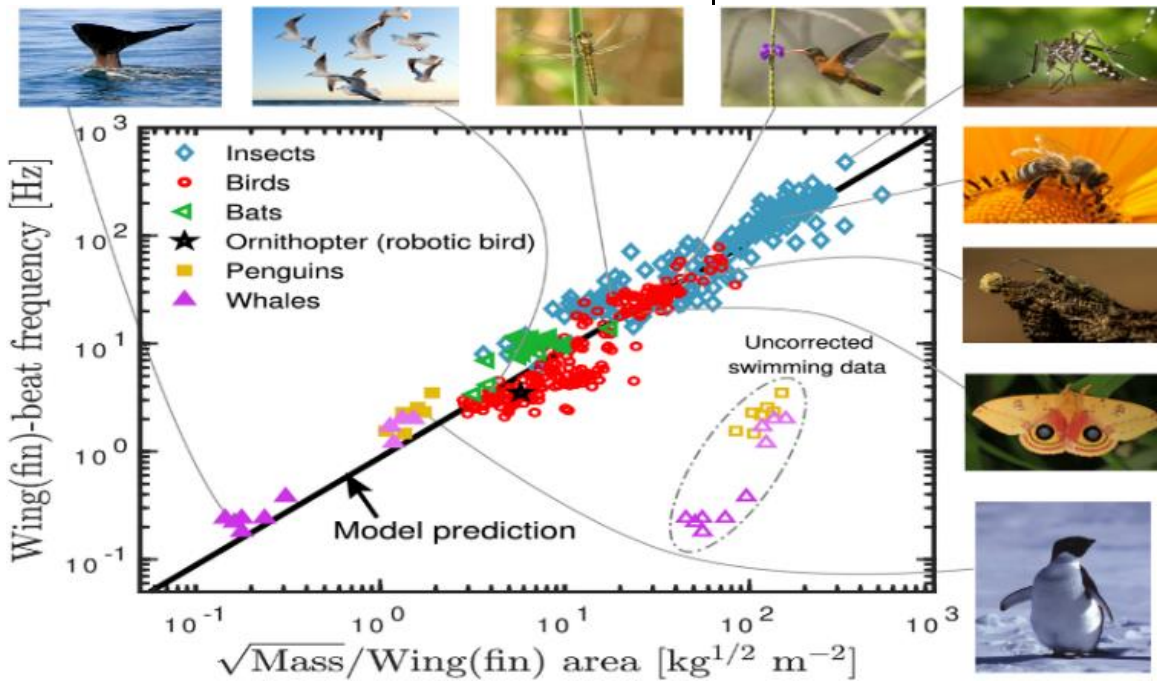
Universal Equation Predicting Wingbeat Frequency in Birds, Bats, and Insects

News Excerpt:

Three scientists from Roskilde University in Denmark have made a groundbreaking discovery: a universal equation that accurately predicts the flapping frequency of wings in almost all flying animals and many swimming creatures.

More about the findings:

- Their findings reveal that the frequency at which wings or fins beat is determined by a simple formula, which relates the flapping frequency to the animal's mass and the size of its wings or fins.



The Formula:

- $f \propto \sqrt{m/A}$. (\propto stands for 'is proportional to').
 - f is flapping frequency,
 - m is the mass of the airborne animal, and
 - A is the area of the wings

When the researchers calculated $\sqrt{m/A}$ number of various animals, birds, and insects and plotted it on the x-axis and their respective frequencies on the y-axis, they found a nearly straight line as shown in the figure. The black line follows the model based on the formula as predicted.

Application to Swimming Animals

- Interestingly, the researchers found that their equation also applies to swimming animals like whales and penguins.
- For positively buoyant diving animals that need to continuously move water to stay submerged, the same principle holds.
- The equation needs minor adjustments for swimming animals, replacing air density with water density and adjusting mass for buoyancy. However, this does not apply to fish with a swim bladder.

Validation and Limitations:

- The researchers validated their equation using data from older studies, encompassing 176 insect species (including bees, moths, dragonflies, beetles, and mosquitoes), 212 bird species (from hummingbirds to swans), and 25 bat species.
- They noted that the equation assumes certain physical conditions, such as the Reynolds number (Re), which affects fluid flow characteristics.
 - At high Re , density matters more than viscosity, which fits the conditions for flying animals. The equation needs modification for low Re , where

viscosity becomes more significant.

Significance of the findings:

- This universal equation offers a powerful tool for understanding the mechanics of flight and swimming across a wide range of species.
- It not only explains current wingbeat frequencies but also provides insights into the evolution of future flying or

swimming animals and the design of winged robots.

- The discovery marks a significant advancement in our understanding of biomechanics and the principles governing animal locomotion.

