TOPICS & POINTERS

Exclusively For
UPSC Mains 2023

SCIENCE & TECHNOLOGY
GENERAL STUDIES-1
MAINS WORK BOOK

METIS 2023

Mentoring and **E**nabling **T**hrough **I**ntelligent **S**upport **S**ystem

GS PAPER III – Science and Technology

THEMES FROM PREVIOUS YEAR QUESTION PAPERS

Space Technology

1. James Webb Space - unique features which make it superior - key goals - potential benefits for the human race
2. Indian space station - how it benefit our space programme?
3. India success with unmanned space missions but not manned space missions - explain critically
4. 'Standard Positioning Systems' and 'Protection Positioning Systems' - advantages from IRNSS programme

Biotechnology

1. Basic principle behind vaccine development - How do vaccines work - approaches adopted by the Indian vaccine manufacturers to produce COVID-19 vaccines
2. Stem cell therapy - advantages it has over other treatments
3. Allelopathy - role in major cropping systems of irrigated agriculture
4. Overuse of antibiotics - emergence of drug-resistant diseases - available mechanisms for monitoring and control
5. Fixed-Dose drug Combinations - merits and demerits

IPR

1. How India protects traditional knowledge of medicine from patenting
2. India's Traditional Knowledge Digital Library - pros and cons of making this database publicly available under open-source licensing
3. Distinguish – copyrights, patents and trade secrets.
4. Section 3(d) in Indian Patent Law, 1970 - Supreme Court in its judgement in rejecting Novartis' patent application for 'Glivec' - pros and cons of the decision

Defence

1. How S-400 air defence system technically superior

Nuclear Technology

5. Growth and development of nuclear science and technology in India - advantage of a fast breeder reactor programme
6. Facts and fears associated with nuclear energy

Nanotechnology

1. 'Bose-Einstein Statistics' - how it revolutionized the field of Physics
2. Why nanotechnology key technologies of the 21st century - Mission on Nanoscience and Technology - scope of its application in the development process of the country
3. Nanotechnology - how it helps the health sector

Robotics

1. Areas of prohibitive labour managed by robots - initiatives for substantive and gainful innovation.

TOPICS AND POINTERS
2023- MAINS STUDY MODULE

Information Technology

1. Advantage and security implications of cloud hosting of servers vis-a-vis in-house machine-based hosting for government businesses
2. Digital signature - What its authentication mean - salient built-in features of a digital signature
3. How 3D printing work - advantages and disadvantages

Science and Society

4. Nobel Prize in Physics in 2014 to Akasaki, Amano, and Nakamura for Blue LEDs How it impacted everyday life
5. Research and developmental achievements in applied biotechnology - how it helps to uplift the poorer sections of society?
6. How science interwoven with our lives? What are the striking changes in agriculture triggered off by science-based technologies?
7. COVID-19 pandemic - how technology was sought to aid the management of the pandemic
8. How biotechnology improve the living standards of farmers
9. Why so much activity in biotechnology - How it benefitted the field of biopharma
10. India's achievements in Space Science and Technology - How it helped socio-economic development
11. How 'Digital India' programme help farmers to improve farm productivity and income - steps taken in this regard
12. Declining scientific research in Indian universities - because a career in science is not as attractive as our business operations, engineering or administration, and the universities are becoming consumer-oriented
13. FRP composite material - How manufactured - application in the aviation and automobile industries

S.No	THEMES	Notes
	SPACE TECHNOLOGY	
1	**CHANDRAYAAN-3: MISSION TO MOON**	
	– It is a follow-on mission to Chandrayaan-2 to demonstrate end-to-end capability in safe landing and roving on the lunar surface.	

- It is a follow-on mission to Chandrayaan-2 to demonstrate end-to-end capability in safe landing and roving on the lunar surface.
- Launched using India's heaviest rocket, the Launch Vehicle Mark-III
- *Need* - unsuccessful landing of the Vikram lander during Chandrayaan-2.
- This new mission is designed to demonstrate the essential landing skills required for the proposed lunar polar exploration mission in 2024, which India intends to carry out in collaboration with Japan.
- Following its predecessor's, Chandrayaan-3 will attempt to land Vikram and Pragyan near the lunar south pole in hopes of using their respective scientific payloads for conducting in situ experiments, analysis, and observations to gain insights into the Moon's composition.
- These include gaining insights into the:
  - i. lunar surface composition
  - ii. presence of water ice in the lunar regolith
  - iii. the history of impacts on the Moon
  - iv. the Moon's atmospheric evolution
- The Chandrayaan-3 spacecraft consists of three parts:
  - ❖ *Lander*: powered by four throttle-able engines and will feature a Laser Doppler Velocimeter.
  - ❖ *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.
  - ❖ *Propulsion module*: to carry the lander and rover from "launch vehicle injection" to a 100-kilometre circular polar lunar orbit before it separates from the other modules.

Chandrayaan-3's LVM-3
- It is a three-stage medium-lift launch vehicle developed by ISRO and earlier known as the GSLV Mark III.
- It is the most powerful rocket in the space agency.
- Lift-off mass: 640 tonnes.
- Payload capacity - upto 8,000 kilograms to a low-Earth orbit - Upto 4,000 kilograms of payload to a geostationary transfer orbit
- Its cryogenic upper stage is powered by CE-20 (India's largest cryogenics engine).
- The core stage is powered by two L110 liquid-stage Vikas rockets.

4	*Why is Chandrayaan-3 taking weeks to reach the cratered sphere?*	

Why is Chandrayaan-3 taking weeks to reach the cratered sphere?
– While the Chandrayana-3 mission was launched on India's heaviest rocket, the Launch Vehicle Mark-III, it is still not strong enough to propel the mission on a direct path of the Moon. Hence, the longer journey.
– *Clever use of gravity*: In order to counter the lack of a powerful rocket, ISRO uses Earth's gravity to slingshot its way around the Moon, the same way as it used the slingshot around the planet to push the Mars Orbiter Mission (MoM) a.k.a Mangalyaan towards Mars.
– Chandrayaan-3 employs a series of Earth-bound maneuvers and lunar orbit insertion burns to gradually raise their orbits and synchronize with the Moon's orbit.
– These missions used a method called a series of "bi-elliptic transfers," which involved multiple engine burns to gradually increase the spacecraft's energy and adjust its trajectory.
– This method allows for more fuel-efficient and cost-effective missions but takes longer compared to the direct trajectory used by the Apollo missions.

Chandrayaan-3's mission is not just about reaching the Moon, it also aims to conduct scientific experiments to study the lunar environment, including its history, geology, and potential for resources. If all proceeds as planned, sometime around 23 August, Chandrayaan-3 will accomplish a groundbreaking feat as the first mission ever to successfully soft-land in the vicinity of the lunar south pole.

2   EFFECT OF MOON ON HUMAN EVOLUTION

How Moon helped in Earth's evolution?

Tidal Phenomenon
– Biggest impact of moon on life - through tides - tides resulting from the gravitational force of the moon affect animal life in the intertidal zone, where the ocean meets the land between high and low tides.
– The tides eroded the coastal areas, adding minerals to the oceans which have been essential for life to evolve quickly.
– Tides affect the reproductive cycles of marine life, where the laying and hatching of turtles' eggs depend on the timings of tides.
– Influences animal behaviours as tides change the coastal environment.
– Climate change and stabilising seasons - The moon's gravitational pull helps to transport heat away from the equator and towards the poles, fundamentally shaping earth's climate.

|		

5	*Rotation axis*
	
	  – Moon stabilises the Earth's rotation on its axis by slowing Earth's rotation on its axis.
	  – In the absence of the moon, the poles would be burning hot and the equator freezing cold, seasons would be a thing of the past, and night and day would be equally long all year round.
	  – Affects Tectonic activity: The moon's pull of gravity might have set our tectonic plates. It raises the level of the world's oceans towards the equator. Without this gravity, the oceans would redistribute, raising levels at the poles.	

3	**NEW TREATY TO ENSURE PEACE AND SECURITY IN OUTER SPACE**	

	– The United Nations (UN) has recommended a new treaty for ensuring peace and security as well as preventing an arms race in outer space.
	  – Outer Space - refers to the relatively empty regions of the universe outside the atmospheres of celestial bodies - used to distinguish it from airspace (and terrestrial locations) - begins about 100 km above the Earth (*Kármán line*), where the shell of air around our planet disappears.
	
	The proposed Treaty
	  – Currently, there is no agreed international framework on space resource exploration, exploitation & utilisation.
	  – A combination of *'binding and non-binding norms'* to address emerging risks to outer space security, safety and sustainability.
	  – *Key areas to address* - effective framework for coordinating space situational awareness, space object manoeuvres and space objects and events - develop norms and principles for space debris removal - an effective framework for sustainable exploration, exploitation and utilisation of the Moon and other celestial bodies.
	
	Key Problems
	  – Issues of Space debris - More than 24,000 objects which are 10 centimetres or larger, about one million smaller than 10 cm and likely more than 130 million smaller than one cm have been recorded.
	  – Increase in Number of satellites - shot up exponentially in the past decade after it stayed consistent from 1957-2012 - In 2013, there were 210 new launches, which increased to 600 in 2019, and 1,200 in 2020 and 2,470 in 2022.
	  – Increased involvement of countries - Due to the increased involvement of private sector in counties like the United States, China, India and Japan can develop a situation of conflict in future space.	

6	*Existing treaties* − In 1959, the United Nations established the Committee on the Peaceful Uses of Outer Space to review and enable international cooperation in the peaceful uses of outer space. − In 1963, countries agreed to prohibit testing nuclear weapons in outer space; in 1977, the prohibition of altering the space environment as a weapon was agreed upon. − More recently, member states have set up a series of guidelines, frameworks and recommendations on issues such as mitigation of space debris, nuclear power source safety, the long-term sustainability of outer space activities and transparency and confidence-building measures in outer space activities.	
4	**NAVIC SATELLITE: WHY A REGIONAL NAVIGATION SYSTEM MATTERS TO INDIA**	
	Context ISRO successfully launched the GSLV-F12 NVS-01 mission, deploying the second-generation NavIC satellite into space. The NVS-01 satellite is the first of the new series aimed at enhancing the Navigation with Indian Constellation, NavIC services. 	
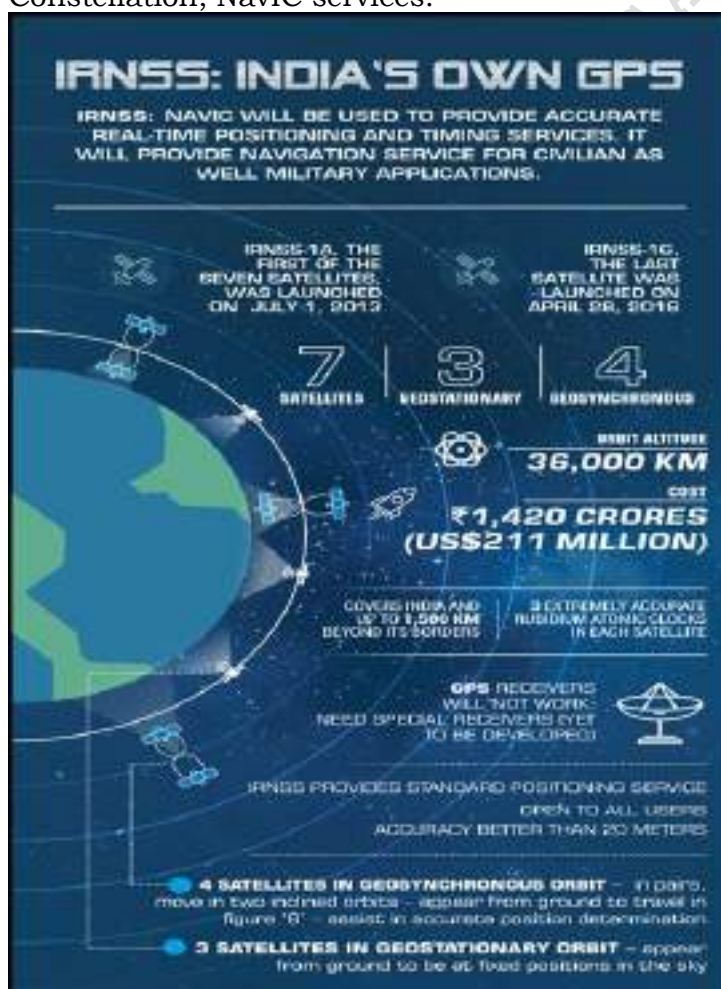
What's new in the second-generation NavIC satellite?

- *Atomic Clock* - will have a Rubidium atomic clock onboard, a significant technology developed by India. "The space-qualified Rubidium atomic clock indigenously developed by Space Application Centre-Ahmedabad is an important technology which only a handful of countries possess.

- *L1 frequency* - L1 signals for better use in wearable devices: The second generation satellites will send signals in a third frequency, L1, besides the L5 and S frequency signals that the existing satellites provide, increasing interoperability with other satellite-based navigation systems.

- *Frequency* - The L1 frequency is among the most commonly used in the Global Positioning System (GPS), and will increase the use of the regional navigation system in wearable devices and personal trackers that use low-power, single-frequency chips.

- *Longer mission life* - will have a longer mission life of more than 12 years - existing satellites have a mission life of 10 years.

Significance of the atomic clock on board the NVS-01 payload

- The launch of a replacement satellite in 2018 was due to the failure of existing satellites' onboard atomic clocks.

- This meant that only four IRNSS satellites are able to provide location services, while the other satellites can only be used for messaging services such as disaster warnings and fishing zone messages.

Practical purpose of NAvIC constellation

- The receivers have now been developed, and NavIC is in use for projects like public vehicle safety, power grid synchronisation, real-time train information systems, and fishermen's safety.

- Other initiatives such as common alert protocol based emergency warning, time dissemination, geodetic network, and unmanned aerial vehicles are in the process of adopting NavIC system.

- Some cell phone chipsets such as the ones built by Qualcomm and MediaTek integrated NavIC receivers in 2019.

- The Ministry of Electronics and IT is in talks with smartphone companies to urge them to make their handsets NavIC compatible.

Advantage of regional navigation system

- NavIC provides coverage over the Indian landmass and up to a radius of 1,500 km around it, and uses satellites in high geo-stationery orbit.

- NavIC signals come to India at a 90-degree angle, making it easier for them to reach devices located even in congested areas, dense forests, or mountains.

	– India is the only country that has a regional satellite-based navigation system. There are four global satellite-based navigation systems - the American GPS, the Russian GLONASS, the European Galileo, and the Chinese Beidou. – Japan has a four-satellite system that can augment GPS signals over the country.	
5	**INDIAN SPACE POLICY – 2023**	
	– It was formally published by ISRO *Key highlights* – *Research & Development* - aims to keep India at the cutting edge of space R&D – ISRO is tasked with focusing on applied research, technology development, and human spaceflight capabilities. – *Efficient collaboration between public and private sector* - sharing technologies, products, processes, and best practices with New Generation Entities and Government companies. – *Privatising* - permits non-government entities to undertake end-to-end activities in the space sector through the establishment and operation of space objects, ground based assets and related services such as communication, remote sensing and navigation. – *Democratizing Data for All* - Data with a Ground Sample Distance (GSD) of 5 meters and higher will be made freely accessible on a timely basis - promises to empower researchers, industries, and the general public with valuable information for various applications - data with a GSD of less than 5 meters will be available for free to Government entities and at fair pricing for NGEs. – *Focus on human spaceflight capabilities* - ISRO will work on developing the necessary technologies, infrastructure, and ecosystem for sustained human presence in space. This ambitious goal promises to propel India into the ranks of spacefaring nations – *Celestial Prospecting and In-situ Resource Utilization* - to undertake studies and missions focused on in-situ resource utilization, celestial prospecting, and other aspects of extra-terrestrial habitability – *Applicability* - applicable to any space activity to or from Indian territory or within the jurisdiction of India, including the area to the limit of its exclusive economic zone. *Roles and responsibilities of organisations* – *NewSpace India Limited* - The Public Sector Undertaking, NewSpace India Limited (NSIL), has been assigned responsibilities for commercializing space technologies and platforms, as well as servicing space-based needs of users, whether Government entities or NGEs - By manufacturing, leasing, or procuring space	

components and assets, NSIL will operate on sound commercial principles, furthering the growth of India's space industry.

- *Indian National Space Promotion and Authorization Center (IN-SPACe)* - will serve as the interface between ISRO and non-governmental entities.
- *Department of Space* - will oversee the implementation of the Indian Space Policy-2023, ensuring that stakeholders are suitably empowered to carry out their respective functions -
- will play a pivotal role in the successful execution of the policy.

India's space sector

- India's space sector is globally recognized for cost-effective satellite building, and it advocates for peaceful and civilian use of outer space.
- ISRO has an exceptional success rate and is the 6th largest space agency globally.
- India has over 400 private space companies and ranks fifth globally in terms of the number of space companies.

Recent developments include

- setting up the Defence Space Agency (DSA)
- expanding satellite manufacturing capabilities, which are expected to reach USD 3.2 billion by 2025
- ISRO launched SAMVAD, a student outreach program to encourage space research among young minds

Challenges

- lack of regulations on commercialisation which could lead to monopolisation
- rising space debris from increasing expeditions
- China's rapid growth in the space industry and potential weaponization
- increasing global trust deficit creating an environment of suspicion and potential conflict

Expected benefits of the new policy

- *Enhancing Indian space economy* - expected to have a significant impact on the Indian space economy. It aims to increase India's share in the global space economy from less than 2% to 10%.
- *Making India a global space leader* - through a combination of research and development, collaboration, and innovation, the nation is poised to reach for the stars and solidify its position as a global space leader.

6	ISRO LAUNCHES NEW ROCKET SSLV-D2	
	– In 2023, ISRO launched the second edition of the Small Satellite Launch Vehicle (SSLV-D2) *Key features* – It placed the Indian Space Research Organisation (ISRO) earth observation satellite EOS-07 and two co-passenger satellites — Janus-1 and AzaadiSat2 — developed by start-ups, in a 450-km circular orbit around the Earth. – The objectives of the SSLV-D2 mission are the demonstration of a designed payload capacity of SSLV in low-Earth orbit, and the injection of an Earth Observation Satellite and two passenger satellites into a 450.7-kilometre circular orbit. EOS-07 – Primary mission - to gather data for Geographic Information Systems (GIS) applications, such as cartography, regulation of use of coastal land, urban and rural management, and many more. Janus-1 – Janus-1 is a technology demonstrator satellite built by United States-based Antaris and its Indian partners XDLinks and Ananth Technologies - – It is a standardised satellite bus on which multiple payloads can be attached just like lego blocks. This will enable companies to quickly and cheaply launch their payloads. – A satellite bus is the main structure of a satellite on which the payloads — which can be used for multiple applications such as earth observation, signal monitoring, or ship tracking — rest. AzaadiSat2 – built by 750 girl students from across India – a similar satellite by SpaceKidzIndia was launched aboard SSLV-D1 in 2022. – The payloads remain the same — LoRa amateur radio, a sensor to measure radiation levels in space, and sensors to measure the health of the satellite such as temperature, reset count, and inertial data — but this second satellite has an additional feature. – SpaceKidzIndia — which aims to promote space awareness among children — has made the satellite expandable: the 8-unit satellite will have a spring mechanism-based external frame, which will open up once the satellite is in orbit. *SSLV* – SSLV is a three-stage launch vehicle configured with three solid propulsion stages and a terminal stage. – A solid propulsion rocket stage uses solid propellants as the fuel. – The terminal stage is a liquid propulsion-based Velocity Trimming Module (VTM).	

Key features of SSLV
- low cost, flexibility in accommodating multiple satellites
- 'launch on demand' feasibility
- low turnaround time (the time taken to complete a process)
- minimal launch infrastructure requirements
- increased production rate from industries
- Also, SSLV has the minimum launch pad occupancy, which means that integration of the vehicle and subsequent launch can be completed within 24 hours.
- SSLV has multiple satellite mounting options for nanosatellites, micro satellites, and mini satellites. The launch vehicle can carry a single satellite weighing up to 500 kilograms to a 500-kilometre planar orbit.

7	THE UNCONTROLLED RE-ENTRIES OF SATELLITES	

- More than 140 experts have signed an open letter published by the Outer Space Institute (OSI) calling for both national and multilateral efforts to restrict uncontrolled re-entries.
- Outer Space Institute (OSI) is a network of world-leading space experts united by their commitment to highly innovative, transdisciplinary research.

Uncontrolled re-entry
- It is the phenomenon of rocket parts falling back to earth in an unguided fashion once their missions are complete.
- In an uncontrolled re-entry, the rocket stage simply falls.
- Its path down is determined by its shape, angle of descent, air currents, and other characteristics.
- It will also disintegrate as it falls.
- As the smaller pieces fan out, the potential radius of impact will increase on the ground.

Why are scientists worried about the re-entries?
- Striking Land instead of Oceans: Parts of a Russian rocket in 2018 and China's Long March 5B rockets in 2020 and 2022 had fallen into Indonesia, Peru, India, and the Ivory Coast.
- If re-entering stages still hold fuel, atmospheric and terrestrial chemical contamination is another risk.
- Increasing Risk: The casualty risk from uncontrolled rocket body re-entries as being on the order of 10% in the next decade.
- Disproportionate Risk: Countries in the 'Global South' face a "disproportionately higher" risk of casualties.

Any international agreement for safer re-entries?
- There is no international binding agreement to ensure rocket stages always perform controlled re-entries.

	– The Liability Convention 1972 requires countries to pay for damages, not prevent them. *What can minimize the damage?*
	 – Bodies aim for an ocean to avoid human casualties.
	 – A re-entry notification plan and a retrieval plan.
	 – Using the techniques like:
	   ❖ wing-like attachments
	   ❖ de-orbiting brakes, and extra fuel on the re-entering body
	   ❖ design changes that minimize debris formation
	   ❖ Design-for-demise solutions to modify the characteristics of spacecraft components:
	   ❖ Changing the material of a tank to make it demisable.
	 – Using smaller satellites: They experience more atmospheric drag than if they had been bigger, and are likelier to burn up during re-entry.	

8	**NASA'S ARTEMIS MISSION**	
	NASA's Artemis 1 launch has been postponed due to a malfunctioning RS-25 engine on the Space Launch System (SLS) rocket. *Artemis Mission* – In Greek mythology, Artemis, the goddess of wild animals, the hunt, and vegetation, as well as of chastity and childbirth, was the twin sister of Apollo, the much-loved god of music and divination. – NASA's Artemis program aims to land astronauts on the moon's South Pole by 2024. – The program is part of an international effort to build a sustainable human presence on the lunar surface. – First Step: The program's first step will be the upcoming test flight of the Moon rocket, known as the Space Launch System (SLS), with the Orion capsule on top where astronauts will sit during future missions. *Significance* – NASA will land the first woman and the first person of colour on the Moon. – In the complex mission, astronauts will live and work in deep space and will develop the science and technology to send the first humans to Mars. – NASA is also hoping to jump-start companies looking to set up a steady business of flying scientific instruments and other payloads to the moon and to inspire students to enter science and engineering fields.	

	Artemis I
	   – Artemis I will be the first integrated flight test of NASA's deep space exploration system: the Orion spacecraft, Space Launch System (SLS) rocket, and the ground systems at Kennedy Space Centre in Cape Canaveral, Florida.
	   – Artemis I will be an uncrewed flight that will provide a foundation for human deep space exploration, and demonstrate our commitment and capability to extend human existence to the Moon and beyond.
	   – During this flight, the uncrewed Orion spacecraft will launch the most powerful rocket in the world and travel thousands of miles beyond the Moon, farther than any spacecraft built for humans has ever flown, over the course of about a three-week mission.
	
	NASA's Space Launch System
	   – NASA's Space Launch System, or SLS, is a super heavy-lift launch vehicle that provides the foundation for human exploration beyond Earth's orbit.
	   – SLS is the only rocket that can send Orion, astronauts, and cargo directly to the Moon on a single mission.
	   – All SLS configurations will similarly utilize a core stage with four RS-25 engines.
	   – The Block 1 configuration uses twin solid rocket boosters and an Interim Cryogenic Propulsion Stage (ICPS). The ICPS will be used for the first three Artemis missions.
	   – Later Artemis flights will use a mightier Exploration Upper Stage (EUS).
	
	NASA's Orion spacecraft
	   – NASA's Orion spacecraft is built to take humans farther than they've ever gone before.
	   – Orion will serve as the exploration vehicle that will carry the crew to space, provide emergency abort capability, sustain the crew during space travel, and provide safe re-entry from deep space return velocities.
	   – Orion will launch on NASA's new heavy-lift rocket, the Space Launch System.	

9	**INTERNATIONAL LIQUID-MIRROR TELESCOPE (ILMT)**
	– It is a new telescope facility launched in top of the Himalayan range - can identify transient or variable objects such as supernovae, gravitational lenses, space debris, and asteroids. – It is the first liquid mirror telescope in the country and the largest in Asia.

14	- The novel instrument employs a 4-meter-diameter rotating mirror made up of a thin film of liquid mercury to collect and focus light. - It has been developed by the scientists of India, Belgium and Canada. - It is located at an altitude of 2450 metres at the Devasthal Observatory campus of Aryabhatta Research Institute of Observational Sciences (ARIES). What is liquid mirror telescope? - Liquid-mirror telescopesare telescopes with mirrors made with a reflective liquid - most common liquid used is mercury, but other liquids will work as well (for example, low-melting alloys of gallium). - The liquid and its container are rotated at a constant speed around a vertical axis, which causes the surface of the liquid to assume a paraboloidal shape. - This parabolic reflector can serve as the primary mirror of a reflecting telescope. - The rotating liquid assumes the same surface shape regardless of the container's shape; to reduce the amount of liquid metal needed, and thus weight, a rotating mercury mirror uses a container that is as close to the necessary parabolic shape as possible. - Liquid mirrors can be a low-cost alternative to conventional large telescopes. - Compared to a solid glass mirror that must be cast, ground, and polished, a rotating liquid-metal mirror is much less expensive to manufacture. *Significance* - ILMT is the first liquid-mirror telescope designed exclusively for astronomical observations. - Devasthal Observatory now hosts two four-meter class telescopes – the ILMT and the Devasthal Optical Telescope (DOT). - Both are the largest aperture telescopes available in the country. - It is based on the application of Big Data and Artificial Intelligence/Machine Learning (AI/ML) algorithms that will be implemented for classifying the objects observed. - The data collected from ILMT will be ideally suited to perform a deep photometric and astrometric variability survey over a period of typically 5 years. *Consequences* - Cost: The greatest advantage of a liquid mirror is its small cost, about 1% of a conventional telescope mirror. This cuts down the cost of the entire telescope at least 95%. - Alignment problem: But the greatest disadvantage is that the mirror can only be pointed straight up.	

15	– Research is underway to develop telescopes that can be tilted, but currently if a liquid mirror were to tilt out of the line and it can lose its shape. – Health: Since mercury metal and its vapour are both toxic to humans and animals, there remains a problem for its use in any telescope where it may affect its users and others in its area.	

	INFORMATION TECHNOLOGY	
1	**QUANTUM COMPUTING**	

Recently, IBM published a paper in which it claimed to have demonstrated that a 'quantum computer 'could solve problem using technology and are expected to perform complicated calculations that are out of reach of the best supercomputers today.

Key findings
- The team found that photons interact with the comb just like phonons interact with an optical beam-splitter.
- The researchers developed an acoustic beam-splitter – a tiny device resembling a comb, with 16 metal bars jutting out of it.
- It was placed in the middle of a 2-mm-long channel of lithium niobate.
- Each end of the channel had a superconducting qubit – a qubit whose circuit components were superconducting – that could both emit and detect individual phonons.
- The whole setup was maintained at an ultra-low temperature.
- If these phonons were converted to sound, their frequency would be too high for humans to hear.
- Each photon in the study represented the "collective" vibration of around one quadrillion atoms.

What are phonons?
- Photons are packets of light energy; similarly, phonons are 'packets of vibrational energy'.
- The researchers can manipulate electrons using electric currents, magnetic fields, etc., and they can manipulate photons with mirrors, lenses, etc.

What is a beam-splitter?
- Beam-splitters are used widely in optics research. Imagine a torchlight shining light along a straight line.
- This is basically a stream of photons.
- When a beam-splitter is placed in the light's path, it will split the beam into two: i.e. it will reflect 50% of the photons to one side and let the other 50% pass straight through.

Quantum Technology
- 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.
- Example-Smartphone is a type of quantum technology – its semiconductors use quantum physics to work.

What is Qubit?
- A qubit (or quantum bit) is the quantum mechanical analogue of a classical bit.
- In classical computing the information is encoded in bits, where each bit can have the value zero or one.
- In quantum computing the information is encoded in qubits.

National Quantum Mission:
- Duration: Eight years
- Verticals: The mission involving research institutions and industry will have four verticals - three on quantum computing, communication and sensing and fourth one on developing novel materials and devices that would aid in the three core programmes
- Aim - To accelerate quantum technology-led economic growth and nurture the ecosystem in the country.
- The new mission targets developing intermediate scale quantum computers with 50-1000 physical qubits in eight years in various platforms like superconducting and photonic technology.
- Global race: India will be the seventh country to have a dedicated quantum mission after the US, Austria, Finland, France, Canada and China.
- All these countries are also at the R&D stage.

2	**E-EDUCATION PLATFORMS & GENERATIVE AI**	

- India's SWAYAM has yet to define its approach to AI; however, the SWAYAM-user community will drastically scale up by 2025, when India's active Internet users become 900 million.

Artificial Intelligence (AI)
- The term was coined in 1956 by John McCarthy.
- AI is a way of making a computer, a computer-controlled robot, or software perform humanlike tasks.

Features
- It refers to the ability of machines to perform cognitive tasks like thinking, perceiving, learning, problem-solving and decision making.
- It describes the action of machines accomplishing tasks that have historically required human intelligence.

- It includes technologies like machine learning, pattern recognition, big data, neural networks, self-algorithms etc.
- Generative AI enables users to quickly generate new content based on a variety of inputs. Inputs and outputs to these models can include text, images, sounds, animation, 3D models, or other types of data.
- There are two subsets under the umbrella term AI: Machine learning and deep learning.

Industrial Revolution 4.0:
- It includes Artificial Intelligence, Robotics, Blockchain AR, VR, IoT, Supercomputing, Machine Learning, Deep Learning, and 3D printing.
- IoT (Internet of Things): is defined by ICT as a dynamic global network infrastructure with self-configuring capabilities.
- Deep Learning or Hierarchical Learning is part of machine learning methods based on learning data representations.
- In deep learning, each level learns to transform its input data into a slightly more abstract and composite representation.
- Applications like speech recognition, facial recognition, bioinformatics and drug discovery, financial fraud detection, AI in healthcare, etc.

India and Artificial Intelligence
- G20 Osaka Summit: PM underscored the significance of the Digital Economy & Artificial Intelligence. He emphasised the government's reliance on the 5 'I's that stand for Inclusiveness, Indigenization, and Innovation, Investment in infrastructure & International cooperation in developing these two areas.
- According to Global AI Report 2019, India is 9th in terms of the number of AI specialists working in the field. US, China and UK topped.
- CBSE has AI as an elective subject for its 9th Class.
- IIT Hyderabad is the 1st Indian Educational Institute starting B Tech in AI. It is 3rd in the World after Carnegie University and MIT.
- IIIT Hyderabad has also introduced popular executive programmes on AI, Machine Learning and Blockchain.
- Defence, IBM's Blue Project, many start-ups are now foraying into AI.
- It is estimated that AI will add 957 billion $ to India's GDP by 2035 boosting India's annual growth by 3% points.

SWAYAM
- "Study Webs of Active Learning for Young Aspiring Minds (SWAYAM)",was launched on July 9, 2017 by the Ministry of

Human Resource Development to provide one integrated platform and portal for online courses.
- This covers all higher education subjects and skill sector courses.
- The objective is to ensure that every student in the country has access to the best quality higher education at the affordable cost.
- Academicians from hundreds of institutions throughout the country are involved in developing & delivering Massive open online courses (MOOCs)through SWAYAM in almost all disciplines from senior schooling to Post Graduation.

Benefits of public-sector involvement in AI
- Governments can use AI to design better policies and make better decisions, improve communication and engagement with citizens and residents, and improve the speed and quality of public services.

Measures to be taken
- To help governments learn about and explore AI in an effective and ethical way, there is a need to keep in mind the below given points:
- Providing support and clear direction and create space for flexibility and experimentation
- Determine whether AI is the best solution for a given problem
- Providing for multi-disciplinary, diverse, and inclusive perspectives
- Developing a trustworthy, fair, and accountable approach to using AI
- Securing ethical collection of, access to, and use of quality data
- Ensure government organisations have access to adequate funding, capability, capacity, & infrastructure
- Recognising the potentially significant shifts that AI might bring in the future

3	**KAVACH SYSTEM**	

The death of over 288 passengers in triple train accident at Bahanaga Bazaar railway station in the Balasore district of Odisha has brought into sharp focus the safety mechanisms needed to prevent such tragedies.

About the Technology
- 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.
- The trials were facilitated by the South Central Railway to achieve safety in train operations across Indian Railways.
- 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.
- In addition, 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.

How does Kavach work on Railway Systems?

- The Traffic collision avoidance system (TCAS), with the help of equipment on board the locomotive and transmission towers at stations connected with Radio Frequency Identification (RFID) tags helps in two-way communication between the station master and loco-pilot to convey any emergency message.
- The instrument panel inside the cabin helps the loco-pilot know about the signal in advance without visual sighting, and the permissible speeds to be maintained.
- If a red signal is jumped and two trains come face to face on the same line, the technology automatically takes over and applies sudden brakes.
- Additionally, the hooter activates by itself when approaching a level crossing which serves as a big boon to loco-pilots during fog conditions when visibility is low.
- Both the Shalimar-Chennai Coromandel Express and the Yeshwanthpur-Howrah Express were not fitted with KAVACH-TACS.

Research Design and Standards Organisation (RDSO)

- Research Design and Standards Organization (RDSO) is an ISO 9001 research and development organization under the Ministry of Railways of India.
- It functions as a technical adviser and consultant to the Railway Board, the Zonal Railways, the Railway Production Units, RITES and IRCON International in respect of design and standardization of railway equipment and problems related to railway construction, operation and maintenance.
- Indian Railways' Research Design & Standards Organization (RDSO) has recently become the nation's first institution to be declared as Standard Developing Organization (SDO) under the mission called "One Nation One Standard" on Bureau of Indian Standards.

4	INDIA AND GRAPHENE	
	– Graphene is the world's thinnest, strongest, and most conductive material of both electricity and heat. – Conductivity - conducts electricity better than copper. – Strength: It is 200 times stronger than steel but six times lighter. – Capability: It is almost perfectly transparent as it absorbs only 2% of light. It is impermeable to gases, even those as light as hydrogen and helium. – Potential: It has the potential to revolutionize electricity, conductivity, energy generation, batteries, sensors and more. – Also, when added to other materials, graphene even in small quantities produces composite materials with dramatically transformed qualities *Uses* – Graphene composites are used in aerospace, automotive, sports equipment and construction. – It is used for high-performance batteries and super-capacitors, touchscreens, and conductive inks. – Graphene-based sensors are used for environmental monitoring, healthcare and wearable devices. – Graphene oxide membranes are used for water purification and desalination. – Graphene-based masks were made during *Why 'graphene' is an important material?* – Graphene is important for defence and aerospace as well. – Its exceptional strength makes it promising material for armour and ballistic protection. – Graphene has the potential to absorb and dissipate electromagnetic waves, making it valuable for developing stealth coatings and materials that reduce radar signatures and electromagnetic interference. – Graphene is highly sensitive to environmental changes, which makes it an excellent candidate for sensing chemical and biological agents, explosives, radiation, and other hazardous substances. – The graphene-based materials can also protect us against chemical and biological attacks. – Better energy storage and electronics properties make graphene attractive in defence and aerospace as well as in civil and commercial applications. – China and Brazil are global leaders in the commercial production of graphene. India produces about one-twentieth compared to China and one-third compared to Brazil.	

Recent developments in India
- The Centre for Nano Science and Engineering at IISc Bangalore along with KAS Tech produced a graphene-based system several years ago.
- Tata Steel has succeeded in growing graphene (about 50 micrometers large domains) using annealingand extracting atomic carbon from steel surface.
- It has also mixed graphene with used plastic products to recycle them as new.
- India's niche is going to be innovation using graphene. It figured out how graphene oxide-based wrappers loaded with preservatives can increase the shelf life of fruits and vegetables.
- The IIT Roorkee-incubated Log 9 has patented a technology for graphene-based ultracapacitors, and the IIT Kanpur-incubated RF Nanocomposites has developed EMI shielding and stealth technology using graphene-based nanotubes.

5	TRANSFORMER, THE ML MODEL THAT POWERS CHATGPT	

The Transformer, the machine learning model that powers ChatGPT, has gained significant attention and is making headlines.

What is Machine Learning (ML)?
- Machine learning (ML), a subset of artificial intelligence, trains computers to perform tasks using structured data, language, audio, or images by presenting examples of inputs and their corresponding desired outputs.
- Unlike traditional computer programming that relies on explicit instructions, ML models learn to generate desired outputs by adjusting numerous parameters, often in the millions.
- This enables the model to generalize its knowledge and make predictions or generate responses based on new inputs.
- ML's ability to learn from data and adapt its behavior makes it a powerful tool for solving complex problems and handling diverse types of information.

What is 'attention'?
- Attention is a fundamental concept in machine learning that enables a model to determine the importance of different inputs.
- For example, in translation tasks, attention allows the model to select and weigh words from its memory bank, aiding in the decision of the next word to generate. Similarly, when describing an image, attention helps the model focus on relevant parts of the image while generating subsequent words.
- A similar observation applies to image captioning.

	– For an image of a "bird flying above water", the model is never told which region of the image corresponds to "bird" and which "water". – Instead, by training on several image-caption pairs with the word "bird", it discovers common patterns in the image to associate the flying thing with "bird". – One captivating aspect of attention-based models is their ability to discover meaningful patterns and relationships through extensive data analysis. By parsing large volumes of data, these models uncover valuable insights and learn intricate dependencies. – Transformers are attention models on steroids. They employ multiple attention layers within both the encoder and decoder components. – This architecture enables transformers to establish significant contextual understanding across input sentences or images in the encoder, and facilitate effective communication from the decoder to the encoder during tasks such as generating translated sentences or describing images. – Transformers take attention to new heights, allowing for enhanced performance and comprehensive learning in a wide range of machine learning applications.	
6	**NATIONAL QUANTUM MISSION**	
	The Union Cabinet cleared Rs 6,003 crore National Quantum Mission seeking to realise a host of frontier technologies related to quantum computing, quantum communication and quantum sensing that only a handful of countries possess. The new mission comes four years after the central government in December 2018 announced Rs 3,660 crore National Mission on Cyber-Physical Systems, which is being executed through 25 hubs. *National Quantum Mission* – Duration: Eight years – Verticals: The mission involving research institutions and industry will have four verticals – three on quantum computing, communication and sensing – a fourth one on developing novel materials and devices that would aid in the three core programmes – Aim: To accelerate quantum technology-led economic growth and nurture the ecosystem in the country. – The new mission targets developing intermediate scale quantum computers with 50-1000 physical qubits in eight years in various platforms like superconducting and photonic technology	

- Global race: India will be the seventh country to have a dedicated quantum mission after the US, Austria, Finland, France, Canada and China.
- All these countries are also at the R&D stage.

How Quantum technology can be a good 'solution'?

- Effective functioning:In modern day computing, information is relayed and stored in binary digits or bits, that is, 0 or 1. In quantum computing, information sharing, and storage is done in qubits, which exist as 0 or 1 or a combination of both.
- This allows for a quantum computer to perform a multitude of applications at the same time, at a much faster rate, surpassing the processing ability of a conventional computing system.
- Increased processing capabilities:Quantum computers will exponentially increase the processing capabilities of a modern-day computer and address impediments linked to combinatorics.
- Wide range of application: It has immense potential in a wide range of applications from ultra secure military communication to extra-precise MRI machines.
- Multiple benefits:Near-term and long-term quantum applications will:
  - ❖ augment AI solutions
  - ❖ improve financial forecasting
  - ❖ drastically reduce failures in the manufacturing sector
  - ❖ accentuate drug development
  - ❖ push for better cybersecurity paradigms

How this mission will give India a quantum leap?

- Valuable deliverables: Satellite-based secure quantum communications between ground stations over a range of 2000 km 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.
- Development of atomic systems: The mission will help develop magnetometers with high sensitivity in atomic systems and atomic clocks for precision timing, communications and navigation.
- Development of quantum materials: It will also support design and synthesis of quantum materials such as superconductors, novel semiconductor structures and topological materials for fabrication of quantum devices.
- Beneficial for different sectors: The mission would greatly benefit communication, health, financial and energy sectors as well as drug design, and space applications.

	– Boost to national priorities: It will 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).	
9	**FACIAL RECOGNITION TECHNOLOGY**	

	Right to Information (RTI) responses, reveals that the Delhi Police treats matches of above 80% similarity generated by its facial recognition technology (FRT) system as positive results.
	
	Why is the Delhi Police using facial recognition technology?
	  – The Delhi Police first started using FRT to trace and identify missing children as per a 2018 direction of the Delhi High Court in Sadhan Haldar vs NCT of Delhi.
	  – Delhi police later made use of this technology to investigate the anti-CAA protests in 2019.
	  – It has also used FRT specifically during the 2020 northeast Delhi riots, the 2021 Red Fort violence, and the 2022 Jahangirpuri riots.
	
	FRT
	  – Facial recognition is an algorithm-based technology that creates a digital map of the face by identifying and mapping an individual's facial features, which it then matches against the database to which it has access.
	  – It is a biometric technology that uses distinctive features of the face to identify and distinguish an individual.
	  – It has evolved in many ways- from looking at the 3D contours of a face to recognizing skin patterns.
	
	Why is the use of FRT harmful?
	  – Misidentification Due to Inaccuracy of The Technology:
	  – It can result in a false positive, where a person is misidentified as someone else, or a false negative where a person is not verified as themselves.
	  – One example of such "exclusion" is the failure of the biometric-based authentication under Aadhaar which has led to many people being excluded from receiving essential government services which in turn has led to starvation deaths.
	  – Mass Surveillance Due to Misuse of The Technology
	  – Violation of Internationally recognized best practices
	
	What does the right to Information Responses reveal?
	  – Lack of reasoning behind the 80% similarity as the threshold: The Delhi Police has revealed that matches above 80% similarity are treated as positive results while matches below 80% similarity are treated as false positive results which may require human intervention.	

	– It is unclear why 80% has been chosen as the threshold between positive and false positive. – Categorization of below 80% results: The categorization of below 80% results as false positive instead of negative shows that the Delhi Police may still further investigate below 80% results. – Thus, people who share familial facial features, such as in extended families or communities, could end up being targeted. – Overboard collection of Data: Delhi Police is matching the photographs/videos against photographs collected under Sections 3 and 4 of the Identification of Prisoners Act, 1920, which has now been replaced by the Criminal Procedure (Identification) Act, 2022. – It may result in a violation of internationally recognized best practices for the collection and processing of data. *Criminal Procedure (Identification) Act, 2022:* – This Act allows for wider categories of data to be collected from a wider section of people, i.e., "convicts and other persons for the purposes of identification and investigation of criminal matters". *Need for regulatory frameworks:* – The usefulness of facial recognition tech in countering terrorism can only increase in parallel with the sophistication levels of the tech itself, but this would also highlight the risks of data privacy in managing large-scale data collection.	
10	**OPEN-SOURCE TECHNOLOGY**	

	In the changing demand of socio-political and socio-economical dynamics, there is a dire need for reforms in the governance structure to be more accountable and responsive.
	New technology like open technology can push for significant governance reform, with the special characteristics of accountability, responsibility and answerability.
	What is meant by 'Openness' in technology?
	– Openness of technology refers to free availability of the source code to every user or developer for usage, modification and redistribution.
	– The concept of openness in technology involves two major pillars:
	    ❖ Digital Public Goods (DPGs)
	    ❖ Digital Public Infrastructure (DPI)
	– Both the pillars DPGs and DPIs are anchored in the idea of 'openness' and open source.
	– These are accessible and available to anyone who wishes to use them, modify them or build upon it.	

What are DPGs?

- Open-source software, open data, open AI models, open standards and open content that adhere to privacy and other applicable laws and best practices.
- It has the potential capacity to achieve Sustainable Development Goals (SDGs)
- DIVOC is one of the examples of Digital Public Goods used by India and other nations to provide vaccine certificates for COVID doses.

What are Digital Public Infrastructures (DPIs)?

- Open-source software, open data, open AI models, open standards and open content that adhere to privacy and other applicable laws and best practices,
- One example of DPI is OpenG2P, which digitized the cash transfer during the West African Ebola

Benefits of open source technology

- Free availability and accessibility: As compared to proprietary software open source doesn't have any vendor lock-in, i.e., no fee is charged for the use and modification of the technology.
- A community for developers: Any successful project would have a thriving community of developers to build suitable target-oriented software open-source software provides the platform to the desired developers.
- Secure software: Open source technology and software are vulnerable to the security breach, when such vulnerability is reported the team of developers gets the upper hand to resolve the issue, which makes it more secure and safe.
- Governance structure: Digital Public Goods and Digital Public infrastructure along with community engagement has the potential to democratize the governance structure of the nation. More accountable and responsive governance.
- Networked health care: Open source technology can bring a revolution in the health care sector in a geographically diversified country like India. Accessible and affordable healthcare services can be enabled for every citizen.
- Quality education: Emerging digital education can be fostered by open source technology.
- Service ecosystem: India is one of the largest service sector exporters in the world, availability of open source technology will help the Indian companies to hire developers and make their service route safer, secure and target-oriented.
- Digitization of payment: Open source technology has the potential capacity to be used in the digital India mission and make the payment system cashless.

Major steps to implement the technological reform
- Moving from words to action: To implement the process of Open source technology, accessible and affordable internet service plays a crucial role. The policy framers at the national and sub-national levels need to bridge the gap of the digital divide and penetrate the use of open source technology.
- Building deeper country capacity: Policy framers should focus on building up the infrastructure and frameworks for secure cyberspace to support the growth and penetration of open source technology and software.
- Leave no one behind: The objective of the implementation plan needs to be inclusive and democratic, which involves people's participation and development for all.

Open source approaches to technologies can help the government more efficiently develop a tailored solution to big and urgent challenges. Implementing GPGs to leverage DPIs can provide crucial interventions for emergencies and development. DPGs and DPIs when combined with community engagement can make the governance structure more transparent and accountable. Some major challenges lie ahead in the implementation process of the technology which needs to be catered to achieve the Sustainable Development Goals' 2030.

| 11 | NEW VPN RULES AND ITS IMPACT | |

India's cyber security watchdog Computer Emergency Response Team (CERT-In) had issued a new set of rules for the VPN companies to store personal data of the users.

Background
- In the era of globalized, liberalized and interconnectivity, internet plays the central role.
- Emergence of new age technologies, like, Artificial Intelligence, Internet of Things, Machine Learning and cloud computing etc, usage of cyber space and internet have increased.
- Recent pandemic and worldwide lockdown has increased the usage and importance of internet in various fields.
- Amidst strong pushback from various concerns, central government had told the companies to either comply with the rules or exit from India.

What is VPN?
- Virtual Private Network (VPN), a service that allows users to surf the internet anonymously by preventing the IP address from being tracked by websites, law enforcement agencies, cybercriminals and others.

- Every time a user connects to a VPN, an intermediary is created between the user's device and the destination website.
- Corporate employees are the most frequent VPN users, mainly for securely accessing company networks.

Major purposes for using VPN
- Secure encryption: A VPN connection hides the traffic of your data online and protects it from external access. Unencrypted data can be viewed by anyone who has access to the network and wants to see it. With VPN, cyber criminals cannot clear this data.
- Hiding where you are: VPN servers actually act as your proxy on the Internet. Because human location data comes from a server in another country, your location cannot be determined.
- Data privacy is managed: Most VPN services do not keep logs for your activities. Some providers, on the other hand, record your behaviour, but do not transmit this information to other people. This means that any potential record of your user behaviour is kept permanently hidden.
- Regional content access: Regional web content is not always available everywhere. Services and websites often contain content that can be accessed only in certain parts of the world.
- Protect data transfer: If you work remotely, you may need to access important files in your company network. For security reasons, this type of information requires a secure connection. To gain network access, a VPN connection is usually required.

What are the new sets of rules?
- VPN companies are advised to store the personal information of the users, like, name, email-id, phone number and IP address for a period of 5 years.
- Apart from VPN companies, new sets of rules have also mandated data centres, virtual service network providers and cloud service providers to record and maintain similar data in the form of KYC.
- Virtual asset service providers, virtual asset exchange providers and custodian wallet providers have the obligations to record same set of data for the same period of time along with financial transactional records.

Rationale behind the step
- Secured cyber space: In order to enhance the cyber security posture and ensure safe and trusted internet in the country government has initialized the new sets of rule.
- Investigative purpose: CERT-In, watchdog for the cyber-attacks has observed that non-availability of data hampers analysis and investigation.

– Internal security: Cyber space and internet usage are prone to cyber-attacks, threats and abuse. Cyber-space with VPN provides a safer platform to the extremist and terrorist organisations, creating a potential threat to the security of the nation.

How this will impact the users?

– Privacy Concern: Storing of data of the users breaches the privacy of the users, which is a fundamental right of every individual under article 21 of the Constitution of India.

– Freedom of information and internet: Right to freedom of information and internet are explicit right provided under the free speech and expression. New sets of rules curb the freedom of the individuals, impacting the ideals of democracy and modern political arena.

– Misuse and potential abuse: The stored information could be misused against the users. 'Broad' and 'overreaching' law opens the scope of potential abuse by cybercriminals and the states.

– Money laundering will be difficult.

– Bank fraud and scams will be reduced.

India has over 270 million VPN users, about 20% of the country's population, who use them to access company networks securely, remain anonymous, access geo-restricted content, stay safe on public Wi-Fi networks, and get around internet curbs, among other things. In the age of internet and cyberspace it becomes essential part of the state to provide a safe and secured cyber space and have an upper hand on tackling the internal security instances. At the same time, it is also important to ensure the privacy and basic rights of the citizen, thus, there requires a proportionate balance between national security and privacy of the individuals.

12	**DISRUPTIVE TECHNOLOGY**	
	Disruptive technology is an innovation that significantly alters the way that consumers, industries, or businesses operate. It displaces a well-established product or technology, creating a new industry or market. New technology can either be sustaining or disruptive. While sustaining technology depends on the incremental improvements in the already existing technology, disruptive technology is a completely new one. *Examples of Disruptive Technology* – Disruptive technologies evolved with time, a few years back the automobile, electricity service, and television were disruptive technologies. – However, the time is changing and so are they. Some of the examples which are included in disruptive technologies that are being used currently involve:	

Blockchain Technology
- Blockchain derives its name from the digital databases or ledgers where information is stored as "blocks" that are coupled together to form "chains".
- It offers a singular combination of permanent and tamper-evident record-keeping, real-time transaction transparency and auditability.
- An exact copy of the blockchain is available to each of the multiple computers or users who are joined together in a network.
- Any new information added or altered via a new block is to be vetted and approved by over half the total users.

Applications of Blockchain Technology
- Blockchain technology can facilitate innovations across a range of processes and applications requiring management, storage, retrieval and safety of vast and important information.
- These include - management of information pertaining to financial transactions (as in the case of cryptocurrencies), electoral voting, medical records, academic lessons, property ownership records and professional testimonials.

Indian Initiatives Related to Blockchain:
- Centre of Excellence (CoE): In 2020, the Union Government has CoE. It has been set up by the National Informatics Centre (NIC) - Objective: To provide Blockchain as a Service (BaaS) for efficient hosting of Blockchain network and allowing all stakeholders to benefit from shared learning, experiences and resources.
- Blockchain-as-a-Service (BaaS) is a third-party cloud-based infrastructure and management for companies building and operating blockchain apps.
- National Strategy on Blockchain: This strategy is recently brought out by the Ministry of Electronics and Information Technology (MeitY).
- It is the move in the direction towards enabling trusted digital platforms creating blockchain framework for the development of applications based on this technology.

Artificial Intelligence (AI):
- It describes the action of machines accomplishing tasks that have historically required human intelligence.
- It includes technologies like machine learning, pattern recognition, big data, neural networks, self algorithms, etc.
- AI involves complex things such as feeding a particular data into the machine and making it react as per the different situations.

- It is basically about creating self-learning patterns where the machine can give answers to the never answered questions like a human would ever do.
- AI technology helps in analyzing data and thus can improve the efficiency of systems like power management in cars, mobile devices, weather predictions, video and image analysis.

Indian Initiatives Related to AI

- The US-India AI Initiative: In 2021, the Indo-US Science and Technology Forum (IUSSTF) launched its flagship program, the US-India Artificial Intelligence Initiative - will bring together key stakeholders from India and the USA to foster AI innovation by sharing ideas and experiences, identifying new opportunities in research and development, and bilateral collaboration.
- Ministry of Corporate Affairs (MCA) 21 Version 3.0 - In 2021, The Ministry of Corporate Affairs (MCA) launched a new version of its portal, MCA 21, version 3.0 - will leverage the use of the latest technologies like data analytics, AI, and Machine Learning (ML), to simplify regulatory filings for companies.
- AI in Schools - As part of the NEP 2020, AI will now be a part of the Indian school curriculum.

5G Technology

- 5G is the 5th generation mobile network. It is a new global wireless standard after 1G, 2G, 3G, and 4G networks.
- It enables a new kind of network that is designed to connect virtually everyone and everything together including machines, objects, and devices.
- Internet speeds in the high-band spectrum of 5G has been tested to be as high as 20 Gbps (gigabits per second), while, in most cases, the maximum internet data speed in 4G has been recorded at 1 Gbps.
- In India, Satcom Industry Association-India (SIA) has voiced concerns over the Government's plan to include the Millimetre Wave (mm Wave) bands in the 5G spectrum auction.

Significance

- 5G technology would also bring positive changes in the governance of the country, ease of living and ease of doing business - would boost growth in every sector like agriculture, health, education, infrastructure and logistics - also increase convenience and create many employment opportunities.

Indian Initiatives Related to 5G Technology

- India's First 5G Testbed - Recently, Prime Minister inaugurated the country's first 5G testbed that will enable start-ups and industry

players to test their products locally, thereby reducing dependence on facilities abroad.
- Internet of Things (IoT)
- It is a computing concept that describes the idea of everyday physical objects being connected to the internet and being able to identify themselves to other devices.
- It is one of the fastest emerging technologies across the globe, providing enormous beneficial opportunities for society, industry, and consumers.

Application of IoT
- It is being used to create smart infrastructure in various verticals such as Power, Automotive, Safety & Surveillance, Remote Health Management, Agriculture, Smart Homes and Smart Cities, etc, using connected devices.
- Supplementary Technologies - IoT is benefitted from recent advances in several technologies such as sensors, communication technologies (Cellular and non-cellular), Artificial intelligence/ Machine Learning, Cloud / Edge computing etc.

Indian Initiatives related to IoT
- Smart City Project: In 2015, the Government of India formulated a Draft IoT Policy with a vision to develop connected and smart IoT based systems for our country's economy, society, environment and global needs - This Policy launched a Smart City project, with a plan of developing 100 smart cities in the country.
- Digital India Program: The launch of this program aims to transform the Indian society into a digitally empowered society and boost the IoT industry - The proposed smart cities shall consist of smart homes, smart parking, smartphone detection, smart transportation, smart roads and smart lighting.
- FutureSkill PRIME (FSP): In collaboration with NASSCOM, MeitY initiated FutureSkills PRIME program for re-skilling/ up-skilling of IT professionals which aims to create an ecosystem reskilling/upskilling ecosystem in ten emerging and futuristic technologies including IoT.

Drone Technology
- It is a layman terminology for Unmanned Aircraft (UA) Vehicle.
- Originally developed for the military and aerospace industries, drones have found their way into the mainstream because of the enhanced levels of safety and efficiency they bring.
- A drone's autonomy level can range from remotely piloted (a human controls its movements) to advanced autonomy, which means that it relies on a system of sensors and LIDAR detectors to calculate its movement.

Significance
- – Defence: Drone system can be used as a symmetric weapon against terrorist attacks.
- – Healthcare Delivery Purposes: Recently, the Ministry of Civil Aviation has approved a project with the Telangana government for using drone technology to deliver vaccines in remote areas.
- – Agriculture: In the agriculture sector, micronutrients can be spread with the help of drones.
- – Law Enforcement: Drones are also significant for the law enforcement agencies, the fire and emergency services wherever human intervention is not safe and the healthcare services.

Indian Initiatives Related to Drone Technology
- – SVAMITVA Scheme: This scheme is a collaborative effort of the Ministry of Panchayati Raj, State Panchayati Raj Departments, State Revenue Departments and Survey of India - It is a scheme for mapping the land parcels in rural inhabited areas using drone technology and a Continuously Operating Reference Station (CORS).
- – Draft Drone Rules, 2021: The Ministry of Civil Aviation has unveiled the Draft Drone Rules, 2021 based on "trust, self-certification and non-intrusive monitoring".
- – Hara Bhara Campaign: The idea of the campaign is to accelerate the mission of reforestation by planting one billion trees using drones by 2030 in the country - uses drones to disperse seed balls over thin, barren, and empty forest lands to turn them into lush green abodes of trees.
- – PLI for Drone Sector: It covers a wide variety of drone components, including airframe, propulsion systems, power systems, batteries, inertial measurement unit, flight control module, ground control station, communication systems, cameras, sensors, spraying systems, emergency recovery system, and trackers.

Genome Editing
- – Genome editing (also called gene editing) is a group of technologies that give scientists the ability to change an organism's Deoxy-Ribonucleic Acid (DNA).
- – These technologies allow genetic material to be added, removed, or altered at particular locations in the genome.

Indian Initiative related to Genome Editing
- – Genome Engineering/Editing Technologies Initiative (GETin): A fellowship program between Indian institutes and premier U.S. Universities, in significant areas of GETin, has been introduced in acknowledgement of the importance of strategies and techniques in

genome modification as a modern day essential tool for research & development (R&D).

3D Printing

- It is also known as additive manufacturing which uses materials such as plastics and metals to convert products envisaged on computer-aided design to real three-dimensional items.
- 3D printing is the opposite of subtractive manufacturing which is cutting out/hollowing out a piece of metal or plastic with, for instance, a milling machine.
- 3D printing traditionally has been used for prototyping. 3D printing has a lot of scope in making artificial limbs, stents, dental crowns, parts of automobiles and consumer goods, among others.

Indian Initiatives Related to 3D Printing

- National Strategy for Additive Manufacturing Policy: Recently, the Ministry of Electronics and Information Technology (MeitY) unveiled this Policy.
- The policy aims to increase India's share in global additive manufacturing to 5% within the next three years and add USD 1 billion to the gross domestic product.

Benefits of Disruptive Technology

- Innovation in Regular Activities: One of the key features of disruptive technology is its ability to offer consumers new and notable benefits. When this type of technology enters the marketplace, it changes the entire industry - by embracing disruptive technology, individuals and businesses alike can enjoy the benefits that the technology offers to their regular activities.
- Improves and Modifies Techniques: To provide solutions to the problems of the consumers, modern methods need to be adopted - modifies how a company evaluates its processes and how to adapt according to them, helps in the provision of better services, and brings about a modification in the industry.
- Growth of Startup Companies: Disruptive technology provides opportunities for startup companies to gain a significant foothold in existing industries - provides a unique chance for small startups to experience rapid growth and potentially outperform larger, more well-established companies.
- Business Expansion: When an established business willingly embraces disruptive technology, it enjoys prime opportunities for growth within its current industry or within a new industry created by the technology. This results in the economic growth of the country also - Companies that can smoothly incorporate disruptive technology in their existing line of products and services can help

existing customers transition into using the disruptive technology while also capturing new buyers with their entry into the fresh market.

- Leveraging India's IT Power: The Indian software industry is well-established, and plans to increase connectivity are well underway as part of 'Digital India' - would allow for the creation of additive manufacturing facilities in small towns and foster industrial development outside of major cities.

Challenges Regarding Disruptive Technology

- Ongoing Challenges: Developing countries like India are starting from a difficult position, because they are already grappling with the challenges of low human capital, ineffective institutions, and a difficult business environment.
- Trust and Ethical Questions: Disruptive Technology per se is not the problem, but there are ethical issues surrounding privacy, ownership and transparency which are related to these technologies that can become a cause of concern.
- Challenges in Adaptability: Disruptive innovations take time to prove in the complex market conditions and a significant time period is also consumed in penetrating the market. Disruptive innovations also have to be adaptive to the market environment.
- Untested & Time Consuming: New technology is typically untested and unrefined during its early stages and development can continue for years.
- Any innovative idea depending upon its utility and ability to meet the market needs has to undergo a gestation period. It takes a significant period for any innovative idea or a product or service to get established in the market.
- Redundancy of Prevalent Old Technology: New ideas or business models have got a tendency to disrupt the existing and established ideas/products/services/business models and this creates fierce competition in the market.
- This is very challenging for any new idea as the existing and established business may take any course to prevent them from being thrown out of the market.

Way Forward

- Favorable Environment: A policy framework for the next generation of technology and innovation should focus on creating an enabling environment for disruptive technologies to positively impact the economy, society, and environment, and reduce inequalities.
- Holistic Approach: Whole-of-economy or most-of-society approach should be followed, technology alone will not guarantee success. Policymakers must also account for local contexts and conditions

so that they can create social, political and economic ecosystems in which technology creates jobs and drives inclusive growth.
- Promotion of R&D Sector: There is a need to encourage the formation of product design centers so that the products are built to suit the Indian environment and consumers.
- Need for Government Support: There is a need for government support to provide incentives for distributed manufacturing in smaller towns, and for the IT industry to work on creating platforms and marketplaces that connect consumer demands, product designers and manufacturers in a seamless way.
- International Cooperation: Given that various governments have only recently established these types of disruptive technologies like AI, and in some cases are still formulating them, international cooperation is still very much a work in progress. in the setting of standards at the multilateral level.

This type of technology, if introduced, gives loads of notable benefits to both consumers as well as businesses. An entire industry is changed due to innovative technology, and that too in a positive manner. Thus, if the technology is embraced and used properly as the Internet, it can offer immense innovative benefits both to the consumers of the industry as well as the producers.

13	DARK NET	

- The darknet refers to encrypted networks on the Internet that are not indexed by search engines such as Google, Yahoo or Bing. It is a layer of the Internet accessible only by using special software like Tor (The Onion Router), or I2P (Invisible Internet Project).
- These are networks that are only available to a select group of people and not to the general Internet public, and only accessible via authorization, specific software and configurations.
- This includes harmless places such as academic databases and corporate sites, as well as those with shadier subjects such as black markets, fetish communities, and hacking and piracy.
- The terms "dark net" and "dark web" are occasionally used interchangeably, but with subtle differences in meaning. Dark net is a network built over the Internet whereas dark web refers to websites on a darknet.

Dark Net, Deep Web and Surface Web
- "Dark net" is commonly confused with "deep web." The deep web refers to unindexed sites which are unsearchable; in most cases, this is because those sites are protected by passwords.

- Part of the WWW (World Wide Web) which is not indexed by a search engine like Google is Deep Web and it about 500-600 times larger than the surface web.
- Surface Web -Also called the Visible Web, Indexed Web, Indexable Web or Lightnet -is that portion of the World Wide Web that is readily available to the general public and searchable with standard web search engines. It is the opposite of the deep web. It only constitutes 4-6% of the whole web.

Usefulness of DarkNet
- To avoid Censorship: Individuals within closed societies and facing extreme censorship can utilize the dark net to communicate with others outside of their society.
- Anonymity and Secrecy: Even individuals within open societies may have some interest in using the darknet, particularly as concerns about government snooping and data collection continue to grow worldwide.
- Useful for whistleblowers and journalists to maintain secrecy in communication and leaking and transferring information.

Concerns Regarding Darknet
- Facilitates Illegal Activities : A large portion of the activity which takes place on the dark net is illegal. The dark net offers a level of identity security that the surface net does not.
- Dark net is the virtual equivalent of a black market.
- Criminals looking to protect their identities in order to evade detection and capture are drawn to this aspect of the dark net. For that reason, it's unsurprising that a number of notable hacks and data breaches have been associated with the dark net in some way or another.
- The relative impermeability of dark net has made it a major haven for drug dealers, arms traffickers, child pornography collectors and other criminals involved in financial and physical crimes so much so that one can buy anything from tigers to hand grenades to any kind of narcotic substances, provided the potential buyer finds the right website on the dark net.
- One of the most famous examples of a dark network was the Silk Road marketplace. Silk Road was a website used for the buying and selling of a variety of illegal items, including recreational drugs and weapons. Although it was shut down by government authorities in 2013, it has spawned a number of copycat markets.
- Used by Activists and revolutionaries to organize themselves without fear of giving away their position to governments they oppose.

- Terrorists use dark net to provide information to fellow terrorists, to recruit and radicalize, to spread propaganda, raise funds, and to coordinate actions and attacks.
- Terrorists also use the dark net for illegal purchase of explosives and weapons, using virtual currencies like Bitcoin and other crypto-currencies.
- Security experts are claiming that hackers and fraudsters have started to offer access to SCADA and ICS systems via discussion forums on the dark web, potentially compromising vital infrastructure networks across the world.
- SCADA systems are used to run facilities like nuclear power stations, oil refineries and chemical plants, so if cyber-criminals gained access to major networks, then the consequences could be lethal.

Way forward

- Given the increased importance of cryptocurrencies in the financial world, it's possible that dark nets will become more of a feature for everyday Internet users in the future. In the meantime, they may also still provide criminals with a means of eluding capture, although true anonymity is never guaranteed, even when using encryption of the type found in these networks.
- Governments across the world should strengthen their Cybersecurity Framework to deal with the threats posed by dark net. They must cooperate with each other regarding securing the Cyberspaces worldwide through intelligence, information, technology and expertise sharing.
- India should invest enough in research and development and training and capacity building of personnel in the field of Cybersecurity.
- Kerala Police Department's initiative, Cyberdome, a premier facility dedicated to prevent cybercrime and mitigate cybersecurity threats to the State's critical information infrastructure, is a step in right direction which other concerned authorities across the nation can learn from.

| BIOTECHNOLOGY		
1	**MITOCHONDRIAL DONATION TREATMENT (MDT): A STEP TOWARDS PREVENTING INHERITED DISEASES**	

	A groundbreaking IVF procedure has been successfully performed in the United Kingdom, resulting in the birth of the first baby with genetic material from three persons, with the help of Mitochondrial donation treatment (MDT).
	
	 What is Mitochondrial Donation Treatment (MDT)
	   − Mitochondrial diseases affect 1 in 5,000 people globally and can cause severe health problems, including muscle weakness, organ failure, and neurological disorders.
	   − Mitochondrial donation treatment (MDT) is a medical procedure aimed at preventing inherited diseases caused by mutations in the mitochondrial DNA (mtDNA).
	   − The treatment involves replacing the faulty mitochondria in a woman's egg or embryo with healthy mitochondria from a donor.
	   − Inherited mutations in mtDNA can cause mitochondrial disease, which is incurable and can lead to severe health problems.
	   − Mitochondria are the powerhouse of the cell and are responsible for producing energy. They have their own DNA, separate from the nuclear DNA that determines an individual's physical traits.
	
	 How defects occur in Mitochondria?
	   − They have their own DNA, which is separate from the DNA in the cell's nucleus, and mutations in mitochondrial DNA can lead to a range of serious health conditions.
	   − Certain defects might occur impacting the way the mitochondria produces energy for the cells (especially in the 'energy-hungry' tissues of the brain, nerves, muscles, kidneys, heart, liver), and thereby impacting cell function.
	   − The diseases that arise out of such mitochondrial mutations are called mitochondrial diseases.
	   − Mitochondrial diseases are only passed on by the mother
	
	 How Does MDT Work?
	   − MDT involves the use of in vitro fertilization (IVF) to create an embryo with genetic material from three people: the mother, the father, and the mitochondrial donor. The process can be done in two ways:
	   − The genetic material from the donated egg comprises less than 1 percent of the child's genetics
	   − Pronuclear transfer: This involves transferring the nucleus of the mother's fertilized egg or embryo into the cytoplasm of a donor egg or embryo with healthy mitochondria. The resulting embryo has	

nuclear DNA from the mother and father and healthy mtDNA from the donor.

- Maternal spindle transfer: This involves transferring the nucleus of the mother's egg into a donor egg with healthy mitochondria before fertilization. The resulting embryo has nuclear DNA from the mother and father and healthy mtDNA from the donor.

How mitochondrial donation treatment works
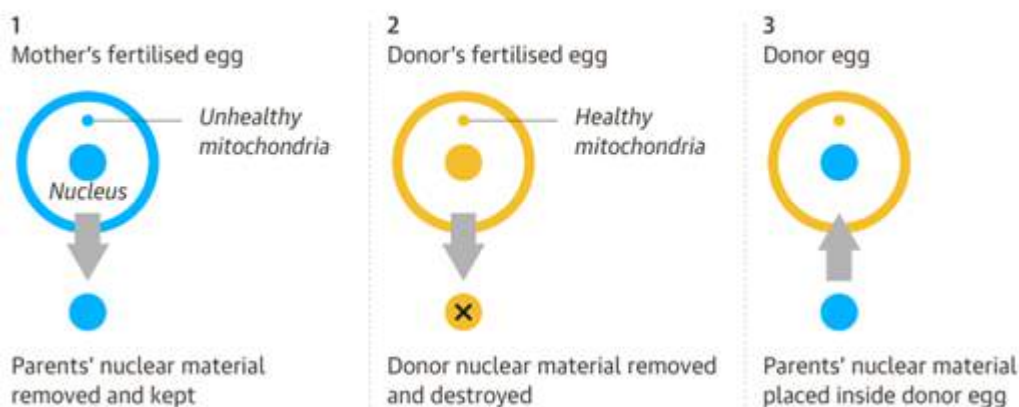
Legal Status of MDT
- The United Kingdom was the first country to legalize MDT in 2015.
- The law allows the procedure to be used in cases where there is a high risk of transmitting a severe mitochondrial disease. The first baby born using MDT in the UK was in 2016.
- Since then, a few other countries, including the United States, have also approved the use of MDT under strict regulations.

Status in India
- In India, the MDT procedure is not currently allowed.
- However, the Indian Council of Medical Research (ICMR) has issued draft guidelines for MDT and is seeking public comments.

What are the potential Benefits of MDT?
- MDT could prevent the transmission of mitochondrial disease to future generations and potentially eradicate it altogether.
- It could also provide families with a much-needed option to have a healthy child without passing on a debilitating genetic condition.

Ethical Concerns with MDT
- Questionable consequences of designer babies: One of the main ethical concerns with MDT is the creation of genetically modified babies. The procedure involves altering the genetic material of an embryo, which raises ethical questions about the creation of designer babies and the potential for unintended consequences.
- Exploitation of vulnerable: Another concern is that MDT could lead to the exploitation of vulnerable women who donate their eggs. It is essential to ensure that MDT is regulated and used only for medical purposes.

2	CARBON DATING METHOD - ISSUES AND SOLUTION	
	A new study shows a way to use calcium-41 the same way carbon-14 has been used in carbon-dating, but with several advantages. *What is Radiometric dating?* – Radiometric dating is a method used to determine the age of organic materials by measuring the decay of radioactive isotopes present in them. – Specifically, carbon-14 dating is a commonly used radiometric dating technique for estimating the age of once-living organisms. – When an organism is alive, it absorbs and loses carbon-14 atoms through various biological processes. – However, once the organism dies, the intake of carbon-14 ceases, and the existing carbon-14 begins to decay. – By comparing the relative abundance of carbon-14 in the remains of the organism with the expected amount, scientists can estimate the time of death. *What is the issue with this method?* – Carbon-14 has a half-life of 5,700 years, so the carbon dating technique can't determine the age of objects older than around 50,000 years. – A significant early issue with the method was to detect carbon-14 atoms, which occur once in around 10^{12} carbon atoms. – Calcium-41 is rarer, occurring once in around 10^{15} calcium atoms. – In the new study, researchers pitched a technique called atom-trap trace analysis (ATTA) as a solution. – ATTA is sensitive enough to spot these atoms; specific enough to not confuse them for other similar atoms; and fits on a tabletop. – In ATTA, a laser's frequency is tuned such that it imparts the same energy as required for an electron transition in calcium-41. – The electrons absorb and release this energy, revealing the presence of their atoms.	
3	GENOME SEQUENCING AND THE GENOME INDIA PROJECT	
	The Department of Biotechnology (DBT) recently updated about the exercise to sequence 10,000 Indian human genomes and create a database under the Centre-backed Genome India Project is about two-thirds complete. *What is the human genome?* – The human genome is the entire set of deoxyribonucleic acid (DNA) residing in the nucleus of every cell of each human body. – It carries the complete genetic information responsible for the development and functioning of the organism.	

	What is genome sequencing?	
	– While the sequence or order of base pairs is identical in all humans, there are differences in the genome of every human being that makes them unique.	

What is genome sequencing?
- While the sequence or order of base pairs is identical in all humans, there are differences in the genome of every human being that makes them unique.
- The process of deciphering the order of base pairs, to decode the genetic fingerprint of a human is called genome sequencing.

Important Projects
- Human Genome Project: In 1990, a group of scientists began to work on determining the whole sequence of the human genome under the Human Genome Project.
- The first results of the complete human genome sequence were given in 2003. However, some percentage of repetitive parts were yet to be sequenced.
- The Human Genome Project released the latest version of the complete human genome in 2023, with a 0.3% error margin.
- Genome India project: Genome India Project is a research initiative to gather samples, compile data, conduct research, and create a 'Indian reference genome' grid
- India's 1.3 billion-strong population consists of over 4,600 population groups,many of which are endogamous. Thus, the Indian population harbours distinct variations, with disease-causing mutations often amplified within some of these groups.
- Creating a database of Indian genomes allows researchers to learn about genetic variants unique to India's population groups and use that to customise drugs and therapies.

Application of genome sequencing
- Genome sequencing has been used to evaluate rare disorders, preconditions for disorders, even cancer from the viewpoint of genetics, rather than as diseases of certain organs.
- Nearly 10,000 diseases — including cystic fibrosis and thalassemia — are known to be the result of a single gene malfunctioning.

4	**"ORGANOID INTELLIGENCE" – REVOLUTIONARY BIOCOMPUTERS**	

Recently, researchers presented their ideas for "organoid intelligence," a potentially ground-breaking new field of study that aspires to develop Biocomputers.

Bio-computers and their functioning
- Researchers plans to produce "bio-computers" by fusing brain organoids with contemporary computing techniques.
- They intend to grow the organoids inside flexible frameworks attached with several electrodes, where they will be combined with machine learning (similar to the ones used to take EEG readings from the brain).

- These structures will be able to administer electrical stimuli to simulate sensory sensations as well as record the neuronal firing patterns.
- Then, using machine learning techniques, the response pattern of the neurons and their impact on human behaviour or biology will be analysed.

What is Organoid Intelligence (OI)?

- OI is an emerging multidisciplinary field working to develop biological computing using 3D cultures of human brain cells (brain organoids) and brain-machine interface technologies.
- It will be possible by scaling up current brain organoids into complex, durable 3D structures enriched with cells and genes associated with learning, and connecting these to next-generation input and output devices and AI/machine learning systems.

What are organoids?

- Organoids are stem cell-derived, microscopic, self-organized three-dimensional tissue cultures. Such cultures can be developed to mimic a much of an organ's intricacy.
- These are tiny organ-like structures that frequently resemble the embryonic phases of a developing tissue but lack the full functional maturity of human organs.

Opportunities of 'bio-computers'

- Biological basis of human cognition: stem cells from sufferers of cognitive or neurodegenerative problems can be used to create brain organoids.
- The biological underpinnings of human cognition, learning, and memory can be discovered by comparing the information on brain anatomy, connections, and signalling between "healthy" and "patient-derived" organoids.
- Drug development: They might aid in understanding the biology of and developing drugs for severe neurodegenerative and neurodevelopmental disorders including Parkinson's disease and microcephaly.

Are 'bio-computers' ready for commercial use?

- Smaller size: Today, brain organoids are around three millionths the size of a real human brain, with an average cell count of less than 100,000 and a diameter of less than 1 mm.
- Therefore, increasing the size of the brain organoid and adding non-neuronal cells involved in biological learning will both help the brain's computing capabilities.
- Microfluidic systems: microfluidic systems are not yet developed by the researchers, which help to transport oxygen and nutrients, and remove waste products.

- Advanced analytical techniques: Scientist have not yet developed the advanced analytical techniques (with help from machines) to correlate the structural and functional changes in the brain organoids to the various output variables.
- Long-term memory: The challenge in front of researchers is to develop long term memory, which they would achieve within 1-25 years.
- Ethical issues: There is no team to deal with the ethical issues arising from the bio-computers. Ethical guidelines have to be developed for the ethical use of bio-computers.

5	EXERCISE TARKASH AND CHEMICAL AND BIOLOGICAL WARFARE	

The National Security Guard (NSG) and US Special Operations Forces (SOF) conducted the joint exercise named TARKASH. This is the sixth edition of the exercise

Key-highlights of the Indo-US joint exercise
- Conducted between: India's National Security Guard (NSG) and US Special Operations Forces (SOF)
- Background: The exercise comes in the backdrop of Russian allegations against Ukrainein May last year that Kyiv had orchestrated a chemical attack in Kharkiv to blame Russia and get military aid from the West.
- Objective: The exercise for the first time included "Chemical, Biological, Radiological and Nuclear (CBRN) terror response" in its drill - objective was to rapidly neutralise the terrorists, rescue the hostages safely and deactivate the chemical weapons being carried by the terrorists. A drill to counter chemical and biological attacks by terrorists was also included.

Chemical, Biological, Radiological and Nuclear (CBRN) Weapons
- Today, chemical and biological warfare are being recognised as a looming threat to the world.
- These types of weapons have the ability to create both mass casualties as well as mass disruption of society.
- CBRN weapons are also classified as weapons of mass destruction.
- They have been used by States and terror elements in the past.
- The most recent use of CBRN in the form of a sarin gas attack was witnessed in Syria in 2017 when more than 100 people died.

Weapons of Mass Destruction (WMD)
- While there is no single, authoritative definition of a WMD in international law, the expression is usually understood to cover nuclear, biological, and chemical (NBC) weapons.
- According to the United States Department of Homeland Security, "A weapon of mass destruction is a nuclear, radiological, chemical,

biological, or other device that is intended to harm a large number of people."

International Treaties related to WMD

- The use of chemical, biological, and nuclear weapons is regulated by a number of international treaties and agreements.
- Among them are the:
  - ❖ Geneva Protocol, 1925, that banned the use of chemical and biological weapons
  - ❖ Biological Weapons Convention, 1972, and Chemical Weapons Convention, 1992, which put comprehensive bans on the biological and chemical weapons respectively.
  - ❖ India has signed and ratified both the 1972 and 1992 treaties.
  - ❖ There are very few non-signatory countries to these treaties, even though several countries have been accused of non-compliance.
  - ❖ The use and proliferation of nuclear weapons is regulated by treaties such as Nuclear Non-Proliferation Treaty (NPT) and the Comprehensive Test Ban Treaty (CTBT).

6	**NEW WHO REPORT - COLLABORATIVE ACTION TO REDUCE ANTIMICROBIAL RESISTANCE**	

WHO has recently released a report which provides for a strategic framework to advance a One Health response to AMR at the global, regional and country levels.

It is a joint effort by the:

- World Health Organization (WHO)
- Food and Agriculture Organisation (FAO)
- World Organisation for Animal Health (OIE)
- United Nations Environment Program (UNEP)

Goal of strategic framework:

- The goal of the strategic framework is to preserve antimicrobial efficacy and ensure sustainable and equitable access to antimicrobials for responsible and prudent use in human, animal and plant health, contributing to achieving the UN-mandated Sustainable Development Goals (SDGs).

Objectives

- Optimize the production and use of antimicrobials along the whole life cycle — from research and development to disposal.
- To decrease the incidence of infection in humans, animals and plants to reduce the development and spread of AMR.
- The overall impact to which the four organisations aim to contribute through their collaboration is for countries to have the

capacity to design and sustainably implement evidence-informed One Health responses to AMR.

What is Antimicrobial Resistance (AMR)?

- Antimicrobial Resistance (AMR) occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines making infections harder to treat and increasing the risk of disease spread, severe illness and death.
- Antimicrobial-resistant organisms are found in people, animals, food, plants and the environment (in water, soil and air).
- They can spread from person to person or between people and animals, including from food of animal origin.
- Multiple drug resistance (MDR) is antimicrobial resistance (AMR) shown by a species of microorganism to at least one antimicrobial drug in three or more antimicrobial categories.

Mains drivers of antimicrobial resistance

- misuse and overuse of antimicrobials
- lack of access to clean water, sanitation and hygiene (WASH) for both humans and animals
- poor infection and disease prevention and control in health-care facilities and farms
- poor access to quality, affordable medicines, vaccines and diagnostics
- lack of awareness and knowledge
- lack of enforcement of legislation

Major factors causing AMR in India

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

NUCLEAR TECHNOLOGY	

1	**Breakthrough in nuclear fusion energy**	

Researchers at the Lawrence Livermore National Laboratory in the U.S. have announced a major advance in the long-running quest to harness energy from nuclear fusion.

Key Features

- The researchers have for the first time produced more energy in a fusion reaction than was used to ignite it.
- They are referring to it as something called net energy gain.
- The researchers have used lasers to produce temperatures multiple times hotter than the center of the sun to create an extremely brief fusion reaction.

What is Nuclear Fusion?

- Nuclear fusion is the process whereby nuclei join together into one nucleus. The fusion of two atomic nuclei into one nucleus is not possible under standard temperature and pressure.
- It results in a subsequent release of huge amounts of energy.
- It is the opposite reaction of fission, where heavy isotopes are split apart.
- Harnessing fusion, the process that powers the Sun, could provide a limitless, clean energy source.
- In the sun, the extreme pressure produced by its immense gravity creates the conditions for fusion to happen.
- Fusion reactions take place in a state of matter called plasma. Plasma is a hot, charged gas made of positive ions and free-moving electrons that has unique properties distinct from solids, liquids, and gases.
- At high temperatures, electrons are ripped from an atom's nuclei and become a plasma or an ionized state of matter. Plasma is also known as the fourth state of matter.
- The Plasma is then controlled by humongous magnets.

Advantages of Nuclear Fusion

- In the future it may produce nearly limitless, carbon-free energy, displacing fossil fuels and other traditional energy sources.
- Fusion energy systems may help to tackle climate change and energy security.
- The net energy gain is of immense importance because fusion happens at such high temperatures and pressures that it is incredibly difficult to control.
- The fuel does not want to stay hot -- it wants to leak out and get cold - Containing it is an incredible challenge.

	Related Initiatives – International Thermonuclear Experimental Reactor (ITER) Assembly: It aims to build the world's largest tokamak to prove the feasibility of fusion as a large-scale and carbon-free source of energy. It is based in France. – China's Artificial Sun: The Experimental Advanced Superconducting Tokamak (EAST) device designed by China replicates the nuclear fusion process carried out by the sun. – ITER-India is a special project under Institute for Plasma Research. It is governed by the Empowered Board, which is chaired by the Secretary of, the Department of Atomic Energy (DAE).		
2	**INDIA'S POTENTIAL FOR NUCLEAR TECHNOLOGIES**		
	In its first visit in a Climatic event at COP 27 in Egypt, the International Atomic Energy Agency (IAEA) chief has spoken regarding the importance of Nuclear Technologies for the world to shift towards clean energy. He also highlighted India's potential for New Nuclear Technologies. (Baby steps towards Nuclear Building Nation) – India's nuclear energy self-sufficiency extended from uranium exploration and mining through fuel fabrication, heavy water production, reactor design and construction, to reprocessing and waste management. – The Atomic Energy Establishment was set up at Trombay, near Mumbai, in 1957 and renamed as Bhabha Atomic Research Centre (BARC) ten years later. – Plans for building the first Pressurized Heavy Water Reactor (PHWR) were finalized in 1964, and this prototype – Rajasthan 1, was built as a collaborative venture between Atomic Energy of Canada Ltd (AECL) and NPCIL. – The Indian Atomic Energy Commission (AEC) is the main policy bodyin the country for Nuclear energy exploration and research. – The Nuclear Power Corporation of India Ltd (NPCIL) is responsible for design, construction, commissioning and operation of thermal nuclear power plants. Its funding model is 70% equity and 30% debt – However, it is aiming to involve other public sector and private corporations in future nuclear power expansion, notably National Thermal Power Corporation (NTPC)which is largely government-owned. *The Strategy for Nuclear Energy developments in India* – Nuclear currently produces 25 per cent of the global clean energy. – India has a largely indigenous nuclear power programme.		

– The Indian government is committed to growing its nuclear power capacity as part of its massive infrastructure development programme.
– The government has set ambitious targets to grow nuclear capacity.
– Because India is outside the Nuclear Non-Proliferation Treaty due to its weapons programme, it was for 34 years largely excluded from trade in nuclear plant and materials, which hampered its development of civil nuclear energy until 2009.
– Due to earlier trade bans and lack of indigenous uranium, India has uniquely been developing a nuclear fuel cycle to exploit its reserves of thorium.
– Since 2010, a fundamental incompatibility between India's civil liability law and international conventions limits foreign technology provision.

Benefits
– Minimise carbon emissionin the long run.
– Essential to fulfil the Paris climate agreement
– Maintaining high rates of economic growth.
– Meeting long-term demands
– Diversification of energy options to attain energy security

Challenges
– Comparative costs of nuclear production are high as solar energy costs are decreasing, this difference is increasing further.
– Risks associated with radioactive wastes
– Threat of nuclear weapons

INTELLECTUAL PROPERTY RIGHTS

What are Intellectual Property Rights?
– Intellectual property rights (IPR) are the rights given to persons over the creations of their minds: inventions, literary and artistic works, and symbols, names and images used in commerce. They usually give the creator an exclusive right over the use of his/her creation for a certain period of time.
– These rights are outlined in Article 27 of the Universal Declaration of Human Rights, which provides for the right to benefit from the protection of moral and material interests resulting from authorship of scientific, literary or artistic productions.
– The importance of intellectual property was first recognized in the Paris Convention for the Protection of Industrial Property (1883) and the Berne Convention for the Protection of Literary and Artistic Works (1886). Both treaties are administered by the World Intellectual Property Organization (WIPO).

Intellectual property rights are customarily divided into two main areas:

– Copyright and rights related to copyright - The rights of authors of literary and artistic works (such as books and other writings, musical compositions, paintings, sculpture, computer programs and films) are protected by copyright, for a minimum period of 50 years after the death of the author.

– Industrial property - Industrial property can be divided into two main areas:

1. Protection of distinctive signs, in particular trademarks and geographical indications.
   ❖ Trademarks distinguish the goods or services of one undertaking from those of other undertakings.
   ❖ Geographical Indications (GIs) identify a good as originating in a place where a given characteristic of the good is essentially attributable to its geographical origin.
   ❖ The protection of such distinctive signs aims to stimulate and ensure fair competition and to protect consumers, by enabling them to make informed choices between various goods and services.

2. Industrial designs and trade secrets: Other types of industrial property are protected primarily to stimulate innovation, design and the creation of technology. In this category fall inventions (protected by patents), industrial designs and trade secrets.

What is the need of IPR?

– The progress and well-being of humanity rest on its capacity to create and invent new works in the areas of technology and culture.

– Encourages innovation: The legal protection of new creations encourages the commitment of additional resources for further innovation.

– Economic growth: The promotion and protection of intellectual property spurs economic growth, creates new jobs and industries, and enhances the quality and enjoyment of life.

– Safeguard the rights of creators: IPR is required to safeguard creators and other producers of their intellectual commodity, goods and services by granting them certain time-limited rights to control the use made of the manufactured goods.

– It promotes innovation and creativity and ensures ease of doing business.

– It facilitates the transfer of technology in the form of foreign direct investment, joint ventures and licensing.

India and IPR

– India is a member of the World Trade Organisation and committed to the Agreement on Trade Related Aspects of Intellectual Property (TRIPS Agreement).

- India is also a member of World Intellectual Property Organization, a body responsible for the promotion of the protection of intellectual property rights throughout the world.
- India is also a member of the following important WIPO-administered International Treaties and Conventions relating to IPRs.
- Marrakesh Treaty to facilitate Access to Published Works by Visually Impaired Persons and Persons with Print Disabilities.

National IPR Policy 2016

- The National Intellectual Property Rights (IPR) Policy 2016 was adopted in May 2016 as a vision document to guide future development of IPRs in the country.
- It's clarion call is "Creative India; Innovative India".
- It encompasses and brings to a single platform all IPRs, taking into account all inter-linkages and thus aims to create and exploit synergies between all forms of intellectual property (IP), concerned statutes and agencies.
- It sets in place an institutional mechanism for implementation, monitoring and review. It aims to incorporate and adapt global best practices to the Indian scenario.
- Department of Industrial Policy & Promotion (DIPP), Ministry of Commerce, Government of India, has been appointed as the nodal department to coordinate, guide and oversee the implementation and future development of IPRs in India.
- The 'Cell for IPR Promotion & Management (CIPAM)', setup under the aegis of DIPP, is to be the single point of reference for implementation of the objectives of the National IPR Policy.
- India's IPR regime is in compliance with the WTO's agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS).

Objectives

- IPR Awareness: Outreach and Promotion - To create public awareness about the economic, social and cultural benefits of IPRs among all sections of society.
- Generation of IPRs - To stimulate the generation of IPRs.
- Legal and Legislative Framework - To have strong and effective IPR laws, which balance the interests of rights owners with larger public interest.
- Administration and Management - To modernize and strengthen service-oriented IPR administration.
- Commercialization of IPRs - Get value for IPRs through commercialization.
- Enforcement and Adjudication - To strengthen the enforcement and adjudicatory mechanisms for combating IPR infringements.
- Human Capital Development - To strengthen and expand human resources, institutions and capacities for teaching, training, research and skill building in IPRs.

Achievements under new IPR policy

- Improvement in GII Ranking: India's rank in the Global Innovation Index (GII) issued by WIPO has improved from 81st in 2015 to 52nd place in 2019.
- Strengthening of institutional mechanism regarding IP protection and promotion.
- Clearing Backlog/ Reducing Pendency in IP applications: Augmentation of technical manpower by the government, has resulted in drastic reduction in pendency in IP applications.
- Automatic issuance of electronically generated patent and trademark certificates has also been introduced.
- Increase in Patent and trademark Filings: Patent filings have increased by nearly 7% in the first 8 months of 2018-19 vis-à-vis the corresponding period of 2017-18. Trademark filings have increased by nearly 28% in this duration.
- IP Process Re-engineering Patent Rules, 2003 have been amended to streamline processes and make them more user friendly. Revamped Trade Marks Rules have been notified in 2017.
- Creating IPR Awareness: IPR Awareness programs have been conducted in academic institutions, including rural schools through satellite communication, and for industry, police, customs and judiciary.
- Technology and Innovation Support Centres (TISCs): In conjunction with WIPO, TISCs have been established in various institutions across different states.

Issues in India's IPR regime

- Section 3(d) of the Indian Patent Act 1970 (as amended in 2005) does not allow patent to be granted to inventions involving new forms of a known substance unless it differs significantly in properties with regard to efficacy.
- This means that the Indian Patent Act does not allow evergreening of patents.
- This has been a cause of concern to the pharma companies. Section 3(d) was instrumental in the Indian Patent Office (IPO) rejecting the patent for Novartis' drug Glivec (imatinib mesylate).
- Issue of Compulsory licencing (CL): CL is problematic for foreign investors who bring technology as they are concerned about the misuse of CL to replicate their products. It has been impacting India-EU FTA negotiations.
- CL is the grant of permission by the government to entities to use, manufacture, import or sell a patented invention without the patent-owner's consent. Patents Act in India deals with CL.
- CL is permitted under the WTO's TRIPS (IPR) Agreement provided conditions such as 'national emergencies, other circumstances of extreme urgency and anti-competitive practices' are fulfilled.

- India continues to remain on the United States Trade Representative's (USTR's) 'Priority Watch List' for alleged violations of intellectual property rights (IPR).
- In its latest Special 301 report released by the United States Trade Representative (USTR), the US termed India as "one of the world's most challenging major economies" with respect to protection and enforcement of IP.
- Data Exclusivity: Foreign investors and MNCs allege that Indian law does not protect against unfair commercial use of test data or other data submitted to the government during the application for market approval of pharmaceutical or agro-chemical products. For this they demand a Data Exclusivity law.
- Enforcement of the Copyright act is weak, and piracy of copyrighted materials is widespread.

Way Forward

- Promoting an environment of innovations in schools. The academic curricula need to be rebooted.
- A proper resolution mechanism for resolving IPR related issues is needed.
- India will be unable to take full advantage of the transformative benefits of a strong IP system unless and until it addresses gaps in its IP laws and regulations.
- Success of India's flagship programmes - Make in India and Start up India - depends on the boost of innovation ecosystem with better IPR safeguardings.
- More awareness is needed about the creation, protection and enforcement of IPRs to encourage the Indian industry not only to innovate but also to protect and enforce their innovations.

India has made a number of changes in its IPR regime to increase efficiency and has cut down the time required to issue patents. The culture of innovation is taking centre stage in the country. India is well poised to focus on R&D. This has been reflected in its improved ranking in Global Innovation Index over the years.

Government's effort to strengthen National IPR policy, IP appellate tribunal, e-governance and commitment to abide by the TRIPS agreement of WTO in letter and spirit will help in improving perception of India globally.

An efficient and equitable intellectual property system can help all countries to realize intellectual property's potential as a catalyst for economic development and social & cultural well-being.

TOPICS AND POINTERS
2023- MAINS STUDY MODULE

OTHER AREAS		
1	**INDIA'S DEEP OCEAN MISSION**	

The National Institute of Ocean Technology is set to take an edge by undergoing a 6,000-metre dive into the Indian Ocean for a mission to explore marine biodiversity and potential of the seabed.

About Deep Ocean Missions

- Deep Ocean mission is the Government of India's mission to study the various aspects of ocean in an integrated framework.
- Objective: The focus of the mission will be on deep-sea mining, ocean climate change, underwater vehicles and underwater robotics related technologies.
- Nodal ministry - Ministry of Earth Science will be the nodal ministry implementing this multi-institutional ambitious mission.

Components of the mission

- Manned Submersible: A manned submersible will be developed to carry three peopleto a depth of 6,000 metres in the ocean with a suite of scientific sensors and tools - India's indigenous submersible, MATSYA-6000, will plunge into the bowels of the Indian Ocean
- Integrated mining system: An Integrated Mining Systemwill be also developed for mining polymetallic nodules at those depths in the central Indian Ocean.
- Desalination plants: Studies and detailed engineering design for offshore Ocean Thermal Energy Conversion (OTEC) powered desalination plants are envisaged in this proof of concept proposal.
- Ocean Climate Change Advisory Services: It entails developing a suite of observations and models to understand and provide future projections of important climate variables on seasonal to decadal time scales.
- Exploration and Conservation of Deep-sea Biodiversity: Bio-prospecting of deep sea flora and fauna including microbes and studies on sustainable utilization of deep sea bio-resources will be the main focus.

Significance

- Capabilities development: The 'Deep Ocean Mission' plan will enable India to develop capabilities to exploit resources in the Indian Ocean Basin.
- Minerals:The International Seabed Authority has allocated about 75, 0000 square kilometres in the Central Indian Ocean Basin (CIOB) to conduct exploratory mining. This will mean scouting polymetallic nodules that lie on the seabed. IN

- Climate Change:It will help in study Impact of climate change on ocean. This would help India to prepare for any disaster due to climate change.
- Technological advancements: It can also help us in innovating technologies from underwater vehicles to underwater robotics.
- In line with high seas treaty: United Nations passed this treaty – India too has committed to this – that seeks to protect 30% of the world's ocean by 2030. Deep sea mission in line with this treaty.

Similar government initiatives

- India-Norway Task Force on Blue Economy for Sustainable Development:
- It was inaugurated jointly by both the countries in 2020 to develop and follow up joint initiatives between the two countries.
- Sagarmala Project:
- The Sagarmala project is the strategic initiative for port-led development through the extensive use of IT-enabled services for the modernization of ports.

O-SMART

- India has an umbrella scheme by the name of O-SMART which aims at regulated use of oceans, marine resources for sustainable development.
- Integrated Coastal Zone Management - focuses on the conservation of coastal and marine resources, improving livelihood opportunities for coastal communities etc.

2	**CLICK CHEMISTRY & ITS APPLICATIONS**	

Recently, the Nobel Prize in chemistry, 2022 was awarded to scientists Carolyn R. Bertozzi, Morten Meldal and K. Barry Sharpless for their development of 'click chemistry' and 'bioorthogonal chemistry'.

About

- Click chemistry is a method for attaching a 'probe' or 'substrate' of interest to a specific biomolecule, a process called bio-conjugation.
- The possibility of attaching fluorophores and other reporter molecules has made click chemistry a very powerful tool for identifying, locating, and characterizing both old and new biomolecules.
- Fluorophores are microscopic molecules, which may be proteins, small organic compounds, or synthetic polymers that absorb light of specific wavelengths and emit light of longer wavelengths.

Bio-orthogonal Chemistry

- Bioorthogonal chemistry represents a class of high-yielding chemical reactions that proceed rapidly and selectively in biological

environments without side reactions towards endogenous functional groups.

What are its applications

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

Limitations

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

3	**TITAN TRAGEDY LESSONS FOR PROPOSED INDIAN SUBMERSIBLE DIVE**	
	- Scientists are preparing for a Deep See Dive with the Vehicle Matsya-6000 in late 2024 similar to the Titan submersible, which recently went missing. - The Matsya-6000 project under India's Deep Ocean Mission, scheduled for late 2024, aims to explore the Indian Ocean at a depth of about 6,000 meters. - In light of the recent incident of Titan Submersible, the safety systems employed for the crew will undergo reviews to ensure their effectiveness. *What are the Key Points of Titan Submersible?* - Titan submersible is operated by the privately owned U.S. company OceanGate that organizes underwater expeditions for both research and tourism. - It was built with "off-the-shelf" components, is lighter and more cost-efficient than other deep diving submersibles.	

- Titan is made of carbon fibre and titanium and weighs 10,432 kilograms.
- It is capable of going 4,000 metres undersea and moves as fast as three knots per hour (5.56 kph).
- Titan Submersible was travelling to see the wreckage of RMS (Royal Mail Ship) Titanic, which is nearly four thousand metres under water in the frigid North Atlantic Ocean.
- One hour and forty-five minutes into the journey, contact with Titan was lost.

Concerns
- The submersible's forward viewport was certified for 1,300 meters, but OceanGate aimed to reach 4,000 meters.
- The technology and components of the submersible may not have met rigorous safety standards. Insufficient hull testing raises the risk of failure and endangers occupants.
- The pressure vessel's combination of titanium and carbon fiber is unusual and raises concerns due to their different properties in deep diving situations.

What Happened to the Titan?
- The submersible "Titan" experienced a "catastrophic implosion," according to the U.S. Coast Guard. The five occupants on board are presumed to have died during the implosion.
- An implosion is the opposite of an explosion. In an explosion, the force acts outwards, but in an implosion the force acts inwards. When a submersible is deep in the ocean it experiences the force on its surface due to water pressure.

Key Points Related to Matsya-6000
- Matsya-6000 is an indigenous deep-sea dive submersible being developed by the National Institute of Ocean Technology (NIOT) in India. It is designed to explore the depths of the Indian Ocean at a depth of about 6,000 meters.
- The mission aims to send three Indian navigators to a point approximately 1,500 km away from Kanyakumari, India.

Objective
- The mission's primary objective is to support India's energy requirements and explore ocean resources.
- India aims to conduct exploratory mining for Polymetallic Nodules containing valuable resources such as copper, nickel, cobalt, and manganese.
- This endeavor aligns with the Indian government's Deep Ocean Mission, which aims to develop vehicles and technology for ocean scanning and mining.

Features of Submersible

- The submersible features a spherical titanium hull, which is crucial for withstanding the immense pressure at great depths.
- The titanium hull is manufactured by the Indian Space Research Organisation (ISRO), as no commercial fabricators in India were capable of producing such a hull.
- Two hemispheres of titanium alloy are fused to create a single hull, which serves as the primary barrier between the crew and the surrounding water columns.

Learning from Titan Incident

- The recent incident has highlighted the need for thorough safety evaluations and repeated testing.
- The inability to locate the submersible despite multiple communication systems onboard raises questions. Future submersibles may incorporate "black box" equivalents, similar to those found in aircraft, to aid in investigating the cause of such incidents.
- The choice of titanium for the submersible's enclosure, the utilization of syntactic foam, and the implementation of acoustic communication and tracking systems should be thoroughly evaluated.

4	RARE EARTH ELEMENTS (REE): WHY ARE THEY STRATEGICALLY IMPORTANT?	
	- Rare earth elements (REE) are a group of seventeen chemical elements that occur together in the periodic table, 15 lanthanides (Z=57 through 71), Scandium and Yttrium. - All are metals and have many similar properties which often cause them to be found together in geologic deposits. That is why they are also known as rare earth metals. - They are also referred to as "rare earth oxides" because many of them are sold as oxide compounds. - Samarium (Sm), scandium (Sc), terbium (Tb), thulium (Tm), ytterbium (Yb), yttrium (Y), cerium (Ce), dysprosium (Dy), erbium (Er), europium (Eu), gadolinium (Gd), holmium (Ho), lanthanum (La), lutetium (Lu), neodymium (Nd), praseodymium (Pr), promethium (Pm). *Are rare earth materials rare as a natural resource?* - They are not rare in quantity, in fact, some of them are very abundant in earth's crust for example cerium is more abundant than copper and lead. However, their extraction is very difficult. *Why are they called as rare earth minerals?* - They are so-called 'rare earth' because they were originally isolated in the 18th and 19th centuries as oxides from 'rare minerals'.	

Further, technologically it was difficult to extract them from their oxides forms until the 20th century. Therefore, the name they got in the 18th century is still stuck with them.

– They occur in many minerals but typically in concentrations too low to be refined in an economical manner.

What is the significance of Rare Earth Elements (REE)?

– They have distinctive electrical, metallurgical, catalytic, nuclear, magnetic and luminescent properties.

– They are strategically very important due to their use of emerging and diverse technologies which cater to the needs of current society.

– Its usage range from daily use (e.g., lighter flints, glass polishing mediums, car alternators) to high-end technology (lasers, magnets, batteries, fibre-optic telecommunication cables).

– Even futuristic technologies need these REMs (For example high-temperature superconductivity, safe storage and transport of hydrogen for a post-hydrocarbon economy, environmental global warming and energy efficiency issues).

– The global demand for REMs has increased significantly in line with their expansion into high-end technology, environment, and economic areas.

– They are extremely important for many modern technologies, including consumer electronics, computers, and networks, communications, clean energy, advanced transportation, health care, environmental mitigation, national defense etc.

– Due to their unique magnetic, luminescent, and electrochemical properties, they help in technologies perform with reduced weight, reduced emissions, and energy consumption; therefore give them greater efficiency, performance, miniaturization, speed, durability, and thermal stability.

– They are being used in anything and everything that comes out as an innovative product nowadays for example from I-phones to I-TV and many other devices that people use every day such as computer memory, DVDs, rechargeable batteries, cell phones, catalytic converters, magnets, fluorescent lighting and much more.

– These are used for air pollution control, illuminated screens on electronic devices, and the polishing of optical-quality glass.

Application	Example
Lightweight Magnets	Cars, Electronics, wind turbine, Speakers
Catalyst	Automotive catalyst, clean diesel, oil refining
Hybrid vehicles	Electric Motors, Generators, Hybrid Batteries
Polishing Powders	TV, computer screens, plasma, CRT, optical lenses
Glass additive	CRT, small optical lenses, phosphor, TV and computer
Ceramic	Military use

What is rare earth dilemma?
- The extraction of REMs is one of the most environmentally negative and toxic generating of all mining practices.
- Disproportionate rare earth mining has resulted into landslides, clogged rivers, environmental pollution emergencies and even major accidents and disasters, causing great damage to people's safety and health and the ecological environment.
- China produces tens of millions of tons of wastewater every year while extracting rare earth minerals.
- Therefore, it's a dilemma that is we really having better lifestyle using these materials in emerging technologies or we polluting our environment in the process too much!

Analysis of supply demand of REE
- Currently, China has control over 94% in producing and mining REMs and further china has very high natural reserves for these. As per some recent reports, China is even buying these reserve in others countries and regions to have a monopoly over production for a very long time. And due to these very reasons, it has become very critical metal for India since India is not having enough resources and it further suffers technological constraints in mining its own reserves of REEs.
- A study, conducted by the think-tank Council on Energy Environment and Water, identifies 12 minerals out of 49 that were evaluated as 'most critical' for India's manufacturing sector by 2030. These are beryllium, chromium, germanium, limestone, niobium, graphite, rare earth, rhenium, strontium, tantalum and zirconium. Other minerals like limestone and graphite, while currently abundantly available in India, are deemed 'critical' because extractable resources could be scarce in the future.
- For others, the report says, India is 100 percent import-dependent for seven out of 12 identified critical minerals and does not have any declared resources for them, except light rare earth (found along with monazite sands) and beryllium.

Future use of Rare Earth Metals
- The global demand for automobiles, consumer electronics, energy-efficient lighting, and catalysts is expected to rise rapidly over the next decade. REMs are critical raw material for future of these technologies/industries.
- Rare earth magnet demand is expected to increase due to the rise in demand for rechargeable batteries.
- New developments in medical technology are expected to increase the use of surgical lasers, magnetic resonance imaging, and positron emission tomography scintillation detectors.
- Future military and navy arsenals may utilize REMs for better efficiency and handling.

	DEFENCE	
1	**NEW AUTONOMOUS FLYING WING TECHNOLOGY DEMONSTRATOR**	
	Recently, Defence Research and Development Organisation (DRDO) carried out the maiden test flight of a new unmanned Aerial Vehicle, an Autonomous Flying Wing Technology Demonstrator. *Background* − Overdependence on the Soviet Union, brought about a change in India's approach to defenceindustrialisation from licence based production to production based on indigenous design. − From the mid-1980s, the government pumped resources into R&D to enable the DRDO to undertake high profile projects. − A significant beginning in defence indigenisation was made in 1983, when the government sanctioned the Integrated Guided Missile Development Programme (IGMDP) to develop five missile systems: ❖ Prithvi (surface-to-surface) ❖ Akash (surface-to-air) ❖ Trishul (the naval version of Prithvi) ❖ Nag (anti-tank) ❖ Agni Ballistic missiles with different ranges, i.e. Agni (1,2,3,4,5) − However, the indigenous efforts were not adequate to meet the requirements of the armed forces. This resulted in the shift of focus towards co-development and co-production in partnership with foreign companies. − A beginning was made in 1998, when India and Russia signed an inter-governmental agreement to jointly produce Brahmos supersonic cruise missile. − Apart from Russia, India has also partnered with other countries such as Israel and France for a number of projects. *What is Autonomous Flying Wing Technology Demonstrator?* − The Autonomous Flying Wing Technology Demonstrator is a precursor to an autonomous stealthy unmanned aerial combat vehicles (UCAV) being developed by the DRDO's Aeronautical Development Establishment (ADE), primarily for the Indian Air Force. − The UCAV will be capable of launching missiles and precision-guided munitions. − The unmanned aerial vehicle (UAV) is powered by a small turbofan engine. − It is a reduced sized autonomous aircraft. − The engine used is Russian TRDD-50Moriginally designed for cruise missiles.	

- Developed by: Assembled, designed and developed by Aeronautical Development Establishment (ADE), Bengaluru.
- The airframe, undercarriage and entire flight control and avionics systems used for the aircraft had been developed indigenously.

What is the need?
- To address the immediate requirement of the Armed Forces, India had procured UAVs from the US under an emergency procurement lease but government has adopted a no- import policy of UAVs.
- This has spurred the effort towards indigenization where DRDO and industry have demonstrated advanced capabilities.

Significance
- The flight marks a major breakthrough in developing autonomous technology demonstration under its unmanned combat aerial vehicle (UCAV) programme.
- Indigenization: It is a significant step towards self-reliance in such strategic defence technologies.
- This is the crucial step for the stealth wing flying test bed.
- SWiFT UAV is targeted to showcase the capability in developing stealth technology and high-speed landing technology.

What is Autonomous Flying Wing Technology?
- It's an Unmanned Combat Aerial Vehicle (UCAV) or a combat drone that is a flying wing type.
- It refers to a tailless fixed-wing aircraft that houses its payload and fuel in its main wings and does not have a defined fuselage-like structure found in conventional aircraft.
- The design has the potential to deliver high fuel efficiency and stability if executed with precision.

Applications
- Mapping of Landslide Affected Area
- Infested Crop Damage Assessment
- Large Scale Mapping
- Traffic Monitoring and Management
- Logistics support

Present developments in Defence sector
- INS Vikrant, also known as Indigenous Aircraft Carrier 1 (IAC-1), is the first aircraft carrier to be built in India for the Navy.
- Tejas aircraft: DRDO is not able to develop its indigenous Kaveri engine due to restricted access to high-end defence technology by countries such as USA, JAPAN etc.
- Project75:Indian Navy in 2017 initiated submarine programme called Project-75 (India), the "mother of all underwater defence deals" with France, Germany, Russia, Sweden, Spain and Japan to build six advanced stealth submarines.

	– Project 75 Submarines INS Kalvari, INS Khanderi, INS Vela, S53, S54 and S55are constructed by Mazagon Dock Limited and designed by French company DCNS in Mumbai. – Long-range artillery gun "Dhanush": first indigenous long-range artillery gun also called the "desi Bofors". – Arihant: first indigenous nuclear submarine was developed in association with BARC and DRDO. – The Pinaka Multi Barrel Rocket Launcher: was developed by armament Research Development Establishment (Pune). – Supersonic Cruise Missile BRAHMOS: is a Joint Venture between India and the Russian federation.	
2	**AIP: THE NAVAL TECHNOLOGY THAT INDIA CRAVES FOR**	
	One of five shortlisted Original Equipment Manufacturers (OEM) called Naval Group, earlier known as DCNS, for the Navy's P-75 India (P-75I) project to build six conventional submarines within the country, announced it would not bid for the project. *What is the P-75I project?* – In June 1999, the Cabinet Committee on Security approved a 30-year plan for the Navy to indigenously build and induct 24 submarines by 2030. – In the first phase, two lines of production were to be established — the first, P-75; the second, P-75I. Both lines producing six submarines each. – The contract for P-75 was signed in 2005 with the Naval Group, then known as DCNS, in partnership with Mazagon Dock Shipbuilders Ltd (MDL). – The first Kalvari Class (Scorpene Class) submarine under the project was commissioned in December 2017. – Another five submarines have been built since; the final one, Vagsheer, was launched last month, and will be commissioned by late 2023. – While P-75 deliveries were delayed, P-75I has seen long delays even before it has kicked off. – The first Request for Information was issued in 2008, then again in 2010, but the RFP was issued only in July 2021. – This will be India's first project under the Strategic Partnership Model — the government will give the contract to an Indian Strategic Partner (SP), which will partner with a foreign OEM to build AIP-powered submarines in the country. *What is the status of the project?* – The final bids — one each by the SP in partnership with an OEM — are yet to take place.	

- The project faces hurdles as the Naval Group has already announced it is pulling out, and sources said the Russian and Spanish companies might also not proceed with their bids.
- Among the concerns, as Naval Group said, is the requirement to demonstrate a sea-proven fuel cell AIP.
- While some manufacturers may have the technology, it may not have been proven at sea yet.
- Some analysts believe that while the RFP was clear about these conditions, it is possible that the OEMs were expecting certain concessions in the requirements eventually.
- Another problem for the OEMs is with respect to the transfer of technology, which is built into the process under the SP model.
- It is believed that the OEMs are unwilling to share all their expertise, especially the niche technologies that they have built.

Why does the Navy want AIP subs?

- Issuing the RFP last year, the government said it envisages indigenous construction of six modern conventional submarines with contemporary equipment, weapons & sensors including Fuel-Cell based AIP (Air Independent Propulsion Plant), advanced torpedoes, modern missiles and state of the art countermeasure systems.
- AIP is important for Indian Navy it has a force multiplier effect on lethality of a diesel electric submarine as it enhances the submerged endurance of the boat several folds.
- Fuel cell-based AIP has merits in performance compared to other technologies.
- AIP technology therefore allows a conventional submarine to remain submerged for much longer than ordinary diesel-electric submarines.
- All conventional submarines have to surface to run their generators that recharge the batteries that allow the boat to function under water.
- However, the more frequently a submarine surfaces, the higher the chances of it being detected. AIP allows a submarine to remain submerged for more than a fortnight, compared to two to three days for diesel-electric boats.
- While the six P-75 submarines are diesel-electric, they can be fitted with AIP technology later in their lives.
- India has been working to develop AIP technology indigenously as well.

What submarines does India have now?

- India has 16 conventional diesel-electric submarines, which are classified as SSKs.

	– After the last two Kalvari Class subs are commissioned under P-75, this number will go up to 18. – India also has two nuclear ballistic submarines, classified SSBN. – Of the 16 SSKs, four are of Shishumar Class, which were bought and then built in India in collaboration with the Germans starting 1980s: – 8 are Kilo Class or Sindhughosh Class submarines bought from Russia and – 4 are Kalvari Class built in India at MDL.	
3	**INDIA'S BALLISTIC MISSILE DEFENCE SYSTEM: WHY SHOULD WE NEED IT?**	

	– A ballistic missile/projectile is one which follows "ballistic trajectory".
	– The ballistic trajectory is the path followed by the projectile (missile) after thrust forces (propulsion) stop and the projectile are only acted upon by gravity and friction (drag forces).
	– A ballistic missile thus is one which is guided in the initial phase, i.e. lift off, while the rest of the trajectory is dependent on gravity and require minimal guidance.
	What are the advantages of Ballistic Missile?
	– The have very long range, as they travel above the atmosphere, experience less drag and use gravity and earth's rotation.
	– They are highly fuel efficient. Only fuel requirements are during lift-off phase and during course correction measures.
	– Multiple independent targetable re-entry vehicles (MIRV) capability can be achieved in ballistic missiles.
	– Due to fuel efficiency, their pay load carrying capacity is significantly more than cruise missiles.
	What's Ballistic Missile Defence (BMD) System?
	– A Ballistic Missile Defence system (BMD) is missile defence system that acts as a shield against ballistic missile attacks.
	– You may not that the purpose is defense (by intercepting a ballistic missile) and not attack/offense.
	– A ballistic missile can be intercepted in three phases:
	  ❖ Terminal phase: During the atmospheric descent phase.
	  ❖ Mid-course interception (in flight interception) – Most preferred interception.
	  ❖ Lift off phase– i.e. targeting at launch point- require advance radars.
	– Generally, a BMD is a two-tier automates system which has:
	  ❖ The advance radar system, Early warning system (Also called sensors system).	

❖ Integrated command and control center.

❖ Interceptor missile batteries- need to be agile, mobile and strategically located on land and sea.

India's Ballistic Missile Defence System

- India's BMD development began in 1999, after the Kargil war.

- The primary aim was to bolster India's defence against possible nuclear attack from Pakistan. It holds a place of prime importance especially when India follows 'No first use' policy.

- India seeks to deploy a functional 'iron dome' ballistic missile defence (BMD), incorporating both low-altitude and high-altitude interceptor missiles.

- India's BMD is primarily developed by DRDO with help of many public and private firms like BEL, Astra Microwave, L&T, etc.

India's BMD is being developed in 2 phase

- The first phase aims to develop a shield to intercept missile with a range up to 2000 km. 1st phase radar range is up to 600 km.

- The second phase will have intercept missile with 5000 km range. Radar range of this phase would be 1500 km.

Two- tiers of India's BMD

Prithvi Air Defence (PAD)

- Also referred as Pradyumna Ballistic Missile Interceptor.

- It's designed for High altitude interception (exo-atmospheric interception).

- Intercept missiles at altitudes between 50 – 80 km.

- The interceptor is Prithvi Defence Vehicle (PDV) which has two-stage, both with solid propellants.

Advanced Air Defence (AAD)

- Also called Ashwin Ballistic Missile Interceptor.

- It's endo-atmospheric interception system (for low altitude interception).

- Altitude of interception is range up to 30 km.

- It has single-stage solid fuelled missile.

Why should India need BMD?

- India follows 'No First Use policy'. A robust BMD provides an opportunity to the nation to strike back if a nuclear projectile is launched by an enemy state.

- In the past efforts have been made by radicalised non- state fractions in Pakistan to obtain Missile technology. BMD would shield from non-state actors initiated missile warfare and thus could avoid Mutual Destruction trap.

- India has hostile, nuclear states in its north. It's only practical for the nation to prepare in advance.

- China is developing new technologies to implement its Anti-Access/Area-Denial (A2/AD) strategy in the Western Pacific. It can impact mainland in Indian water. A robust BMD is a proactive measure to tackle China's A2/AD strategy.
- BMD reduces the incentive for the enemy state to launch a nuclear attack, Thus enhancing strategic stability.
- An indigenous system would reduce the import bill of defence systems from other nations.
- There are side benefits of BMD too, like better reconnaissance, detection, tracking and situation awareness.
- Technology developed for BMD can be used in other sectors, especially in space technology.

Apprehensions regarding BMD

- It may start the arms race with Pakistan investing in more powerful missiles to thwart BMD disturbing strategic balance.
- BMD is ineffective against Cruise missiles. Both China and Pakistan have cruise missile capable of delivering the nuclear payload.
- No BMD can have 100% success rate in the interception of the projectile (ballistic missile).
- BMD is a very costly affair. For example, U.S. Continental System is estimated to have cost around $100 bn from 2002 onwards.
- India has a wide and segregated geography. It creates a problem in protection of all critical centre and creation on land infrastructure for BMD in many areas.
- Even after interception there remain chances of damage, especially if the interception is done in the terminal phase of the ballistic missile.
- BMD testing is done in controlled atmosphere raising the question on its efficacy in war time.
- DRDO has been criticised for not releasing whole data related to BMD system. It evokes a sense of suspicion regarding BMD's capability.

In the fast changing geo-political scenario, strategic preparedness and self-reliance are the new currency of defence. BMD fulfills all such criteria and creates a protective shield which has not only physical but also the psychological effect on hostile nations. It bolsters India's NO FIRST USE policy by providing with the second strike capability. Though there are issues related to its cost, effectiveness, and extent; nevertheless with development in technology and support from Make in India, it has the capability to augment over a period of time. As for now, BMD is an idea whose time has come and will remain so for a long.