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SCIENCE & TECHNOLOGY

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SUCCESS IS A PRACTICE





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IT, COMPUTER, ROBOTICS

1. INTERNET OF THINGS (IOT)

Context: The Internet of Things (IoT) viz. a mesh or network of smart devices has evolved considerably over the last 30 years. Its adoption in different fields is a super hit. In a recent development, IoT based devices were installed to ensure drinking water supply in Bihar.

About Internet of things (IoT)

The Internet of Things (IoT) is a network of physical objects that are fitted with sensors, software and other technologies. Connected to the Internet, these 'things' are able to exchange real time data with other connected devices and systems over networks. These connected devices combine with automated systems to gather IoT data that can be analysed to assist with tasks or learn how to improve a process.

- Healthcare: Patients can be monitored in real-time using IoT.
- **Public Sector:** Government authorities can notify people of a city of outages or interruptions in the supply of water or electricity. Parking spaces can be well maintained using data obtained by optical or infrared sensors.
- **Manufacturing:** Manufacturers can deploy IoT to monitor the manufacturing processes and avoid any irregularities. The quality of the products can also be confirmed using IoT.
- **Automobiles:** IoT can be implemented to supervise the production of automobiles. Even after the car has been sold, the IoT can enhance the user experience on the road (kind of like what Tesla does).
- **Retail:** Retailers can benefit a lot if they implement IoT. They can use IoT to optimize the supply chain, reduce operational costs and improve customer experience. They can use smart shelves to notify them if they run out of products, for instance.
- **Transportations and logistics:** Transport vehicles can be equipped with IoT sensors to tell drivers the optimal driving route according to weather, road condition, and traffic. This can save a lot of costs.
- **Wearables:** Smart wearables like smartwatches can track everything from calories burned to heartbeat rate and blood oxygen levels.
- Smart homes: Smart homes are the most popular application of IoT. Smart surveillance systems, smart air conditioners, smart lighting systems, smart speaker systems, and smart fridges are some features of smart homes.

How IoT incfluences teh market dynamics?

- **Social Media for authenticity:** consumers are connected to businesses and each other more than before. With the evolution of technology the consumers can search about the product, ask sales question, take review from other consumers of the product and buy the best quality services. They can also voice their opinions on various social media apps about their experience.
- **Online Opinions:** Discussion forums like Quora, WikiAnswers, StackExchange, Facebook Questions, Reddit, Twitter, Instagram and even LinkedIn Answers (oriented around professionals) are helpful in gauging your audience's views. With a sense of participation consumer gets the confidence to be more involved and active in the activities of the market.
- **Buying habits:** e-commerce being accessible on hand and secure payment gateways has caused a multiplier effect in the buying habits of consumers.

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• Enhanced competition: with more services and products accessible on the fingertips of consumers, the scope of perfection has narrowed down. This aspect pushes the manufacturers to produce products of good quality thus inducing a healthy competition in the market.

Role is IoT in modern world:

- **Agriculture:** In agriculture, IoT systems are used for **'precision farming'**. Sensors are deployed to constantly monitor different variables like soil moisture, temperature, irrigation, nutrients, fertilizers, etc. Using the data from these sensors allows farmers to take quick decisions for enhancing crop yield. It is improving the crop-growing processes through insights from the compiled data.
- **Healthcare:** Wearable devices like smart watches and patient monitoring devices can provide doctors with real-time data about a patient's vital information such as blood pressure, heart rate, etc. The data from these IoT devices can allow doctors to detect potential diseases early on and start treatment before the patients suffer any ill health effects.
- **Logistics and transport:** Lastly, IoT in logistics and transport has already become deeply integrated. When you order online, you can track the exact location and status of your order through the shopping app. This is made possible through IoT integration allowing for real-time tracking. The use of IoT systems in supply chain and inventory management also removes many inefficiencies and fast-forwards the process.
- **Manufacturing:** Manufacturing is another industry where IoT can be used. It effectively cut down costs and optimizes the manufacturing process. Using automated machines in an IoT system that can effectively communicate with one another to ensure the manufacturing process is carried on without any glitches. If any issues do arise, they can be quickly identified and dealt with using data insights.

	Advantages of IoT:		Disadvantages of IoT:
0	Better decision making: With added sensors, the devices with advanced technology are able to collect a large amount of data on many different areas and process it with in turn helps in taking better decisions. This helps boost productivity and efficiency because IoT empowers your team to take a proactive approach.	0	Security issues: IoT systems are interconnected and communicate over networks. So, the system offers little control despite any security measures, and it can lead to various kinds of network attacks.
0	Increases efficiency: As well as saving time for the device owner, it can also result in cost savings. The IoT system encourages machine to machine (M2M) communication resulting in increased long term efficiency for both the company and user.	0	Privacy concern: The IoT system provides critical personal data in full detail without the user's active participation.
Θ	Smarter healthcare: Smart wears such as smart watches as well as other wearables that monitor our health conditions on a real-time basis are quite common in the present day. So if some medical urgency is needed such devices can initiate the necessary actions like alerting the family members, calling an ambulance, etc.	٥	Increased unemployment: Unskilled workers or even the skilled ones are at a highrisk of losing their jobs, leading to high unemployment rates. Smart surveillance cameras, robots, smart ironing systems, smart washing machines, and other facilities are replacing the humans who would earlier do these works.
٥	Disaster management: IoT aids in predicting the environmental conditions with absolute accuracy and helps us to evacuate the humans inhabiting the disaster-prone area as quickly as possible.	٥	The complexity of the system: The designing, developing, maintaining, and enabling the extensive technology to IoT system is quite complicated.
ø	Helps in businesses: IoT allows companies to automate processes and save money on labor. It also reduces waste and improves service delivery, making it less expensive to manufacture and deliver goods and providing transparency into customer transactions.	Θ	High chances of the entire system getting corrupted: If there is a bug in the system, it is possible that every connected device will become corrupted.

• Lack of international standardizations: As there is no international standard of compatibility for IoT, it is problematic for devices from different manufacturers to communicate with each other.
• High dependency on the internet: They rely heavily on the internet and cannot function effectively without it.
• Reduced mental and physical activity: Overuse of the internet and technology makes people ignorant because they rely on smart devices instead of doing physical work, causing them to become lethargic and inactive.

In essence, IoT creates a large ecosystem of connected networks and machines. All work together to share data, optimize processes and ensure that the users have the relevant data for critical decision-making.

Practice Question

Q. The Internet of Things (IoT) has emerged as a significant technological advancement with the potential to revolutionize various aspects of human life. Discuss the concept of IoT, its key features, and its applications in different sectors.

2. DRONE TECHNOLOGY

Context: Drone technology in India is redefining traditional systems in almost every industrial sector. Statements by the Civil Aviation Ministry in India suggest that the Indian drone industry will reach a turnover of Rs. 15,000 Crore by 2026.

Major areas getting impacted by drone technology include:

Role of drone technology in Agriculture:

- **Spraying Applications for Crops:** Drone technology incorporates ultrasonic, light detection, and grounding lasers, allowing farmers to spray crops five times faster than conventional crop spraying methods. With advanced topographical scanning, agricultural drones dispense the optimal amount of liquid to ensure uniform crop coverage and prevent waste.
- **Plant Irrigation:** With sensors such as thermal and multispectral varieties, drone technology analyzes and pinpoints dehydrated crops and measures the density, heat signature, and overall health of the field to provide farmers and producers with a comprehensive picture.

About Drones

- Drones, also referred to as unmanned aerial vehicles (UAVs), refers to any aerial vehicle that developed for the military receives remote commands from a pilot or relies on software for autonomous flight.
- Drones can also be configured to carry small packages, which include communication devices and cameras.
- They can fly uninterrupted for an hour and have a maximum range of 60 miles, which enables them to reach isolated areas quickly.
- Originally developed from the military and aerospace industries, drones have found their way into the mainstream because of the enhanced levels of safety and efficiency they bring.

• **Crop monitoring:** Precise photography allows modern drone technology to enable agricultural producers to monitor crops in a cost-effective and riskfree manner. Any problematic crop regions or areas needing improvement are readily visible twentyfour hours a day, seven days a week.

• **Evaluation of Crop Health:** Agricultural drones utilize visible and infrared light sources to identify plants reflecting the types of light that indicate disease and other health issues.

- Agricultural Planting: Drone farming technology enables drone-powered planting techniques that can reduce planting costs by up to 85 percent.
- **Evaluations of Fields and Soil:** Drones are crucial in the modern agricultural industry because they provide real-time, three-dimensional, and ultra-precise measurements of:
 - ► soil health
 - planting patterns
 - vital information regarding optimal irrigation and nitrogen requirements

Drone aircraft is helpful in all facets of agriculture, including performing critical analyses and scans to detect bacteria, fungi, problem areas requiring irrigation, and more.

Role of drone technology in Manufacturing Sector:

- **Inventory monitoring and picking in warehouses:** As drones can employ built-in sensors to cover large areas, they can be used for inventory monitoring in large areas like steel plants or construction sites.
- **Intra-logistics:** Drones can be used to transport materials or parts from the warehouse to the assembly belt of the production center on the shop floor.
- Asset management and planning: By using drones to scan factory infrastructure, 3D digital models can be developed that can trigger preventive maintenance. This can be used to improve factory and production flow planning, as well as for training purposes.

Role of drone technology in services sector:

- **Medical services:** Drones can be used to transfer organs from donor to patient, often between 4-36 hours depending on the organ type. Drones can make organ delivery faster, safer, and more cost-effective.
- **Disinfecting and Sanitizing:** Sanitizing convention centers, entertainment, or sports venues with safe disinfectants becomes easy with drones.
- **Hospitality Services:** Drones are revolutionizing the hospitality industry, streamlining and automating many of the services traditionally provided by hotel staff.
- Administration: Drones are incredibly useful in managing traffic during rush hours or crowded events. With a drone overhead, authorities can immediately assess the situation, and then radio to the traffic light authorities to better manage the flow.
 - ► For example: it is proposed that the drone technology will be used for traffic management on expressways, in providing medicines in remote areas, in fire rescue operations, in geo mapping and in agriculture and disaster management in UP.
- **Smart Policing**: The concept of smart policing has outlined the systematic changes to transform the Indian Police to be more efficient, modern, accountable, and reliable and trained, with the aid of advanced technology.
- **Disaster Management:** During the course of disaster drones can help in various operations such as search and rescue, Delivering Emergency Infrastructures and Supplies such as essential medicines and food, assess structural damage, extinguish wildfires to contain the real time situation.
- **Climate:** Drones can be used for predicting weather conditions, storm and hurricane tracking and prediction, long-term data gathering for climate change research.

Role of drone technology in for environmental monitoring and conservation:

- Securing Protected Forests, Oceans and Endangered Animals: Drone Cameras being used in many industries for several natural resources to mass-produce their commercial products to supply rising demands. Fishing companies overfish in our oceans and seas. Such activity leads to abuse and polluted water resources. Some lumber companies perform illegal logging discreetly, resulting in deforestation and wildlife habitat destruction.
- **Reversing Deforestation through Drone Seed Planting:** Hiring humans to guard forests is undeniably too costly, time-consuming, and risky. Instead of deploying people, Drones are the perfect substitute as it can scan a wide range of areas efficiently in just one charge. Drone cameras can detect people who try trespassing for logging or animal trafficking in the forest. It can also help detect heat signatures from possible forest fires.



- Drone monitoring capabilities and real-time data gathering about the wilderness, ocean resources, flora, and fauna are critical in preserving them.
- With many poachers, illegal loggers, and traffickers of endangered animals, monitoring the forests, seas, and lands entails efficient technological innovation.

Role of drone technology in generating employment:

- **Supply chain:** Drones have the capability to quickly transport goods from one location to another and offer a cost-effective alternative to traditional distribution methods creating new jobs that require specialized skills in programming and maintenance.
- **Gig Economy:** The ability to quickly deliver products and services has been a major benefit of drones in the gig economy. With the increased use of drones, more jobs are available related to their operation and maintenance. This has allowed many people to take advantage of the gig economy and gain additional income.
- **Maintenance:** Drone technology requires pilots, engineers and technicians. It is expected that the drone technology in India will create around 1 lakh drone pilot jobs by 2024.

Government initiatives to promote drone industry:

- **The new Drone Policy 2021:** The policy allows citizens to own drones and use them for non-commercial and personal purposes. Drone pilots no more need a training certificate to fly a nano-drone. They can fly drones anywhere outside the restricted zones near airports.
- **Drone Shakti:** In the budget 2022, Finance Minister Ms. Nirmala Sitaraman introduced the Drone Shatki scheme to boost startups and leverage them to facilitate growth in the drone sector. Startups are encouraged to provide Drone-as-a-Service. Citizens can rent drones and use them in many ways like taking videos and photos.
- **Kisan Drones:** Farmers can use drones to monitor crops and spray the correct amount of pesticides and fertilizers uniformly over their crops. Thus, they can grow crops of export quality with less effort. Moreover, farmers can be spared from constant exposure to hazardous chemicals.
- **PLI Scheme for drones:** The scheme aims to fulfill the vision of 'Atmanirbhar Bharat' by financially aiding the Indian drone industry. The PLI scheme will allocate an amount of INR 120 crore for drones and drone components spread across a period of three financial years. The benefits from this scheme will act as a catalyst to sustain and boost small drone manufacturers, eventually helping them scale up.

Drone manufacturing is a sunrise sector, poised for exponential growth, driven by the realization of multiple use cases across various sectors. India finds itself to be at a critical juncture in the evolutionary timeline of drone technology, wherein we have a time-critical window of three years to understand and develop drone manufacturing to emerge as the drone manufacturing hub of the world by 2030.

Practice question

Q. Bringing out the various applications of drone technology, discuss how AI is revolutionizing this technology?

3. SUPERCOMPUTERS

Context: India is developing an Arm-based **high-performance computing (HPC)** processor to power its first exascale supercomputer, which is expected to be ready next year.

What is a supercomputer?

- Supercomputer is the fastest computer in the world that can process a significant amount of data in a very short span of time.
- The computing performance of a supercomputer is measured very high as compared to a general purpose computer which is measured in **FLOPS (floating point operations per second) which** implies that a supercomputer can perform trillion of calculations per second.
- Supercomputing in India began in 1980; **PARAM-SIDDHI** AI is the fastest supercomputer in India and 63rd in the world.



Features of supercomputers:

- Supercomputers can be used by more than one person at the same time.
- Supercomputer is used to calculate complex calculations in very short time which is not done with the help of a simple computer.
- Supercomputer has more than one processor and for processing, parallel processing is used, so there processing speed is very high.
- Supercomputer had enormous in size and uses maximum electricity. They were installed in air conditioned room to maintain its cooling.
- Supercomputer can be used in the scientific institutions, research institutions, development firms, and medical institutions for complex data or research. This is not possible with a simple computer.

Applications of supercomputers:

- Scientific research: In this field, scientists use a supercomputer to analyse solar systems, satellites and other nuclear research areas.
- **Data mining:** Large corporations often use specialised computers to extract useful information from data storage warehouses or a cloud system. For instance, life insurance companies use supercomputers to reduce their actuarial risks.
- **Weather forecasting:** The forecasting power of supercomputers helps a climatologist predict the likelihood of rain or snowfall in the neighbourhood. It can also predict the actual path of hurricanes and cyclones and their probability of striking.
- **Intelligence agencies:** Government intelligence agencies use supercomputers to monitor communication between private citizens and fraudsters. These agencies primarily need the numerical processing power of supercomputers to encrypt cell phones, emails and satellite transmission.
- **Military and defence:** Supercomputing provides military and defence departments with the ability to perform virtual testing of nuclear explosions and weapon ballistics.
- **Automobile:** Using supercomputers, an automobile company can help people buy vehicles because before purchasing a vehicle, customers can test the simulation environment created by supercomputers.
- **Smog control system:** Many scientists and climatologists use supercomputers in the laboratory for predicting fog and other pollution and smog levels in a particular region.

Performance of India in developing supercomputers:

- India launched the national supercomputing mission to enhance the research capacities and capabilities in the country by connecting them to form a Supercomputing grid, with **National Knowledge Network (NKN)** as the backbone. The NSM is setting up a grid of supercomputing facilities in academic and research institutions across the country.
- PARAM Shivay, the first supercomputer assembled indigenously, was installed in IIT (BHU), followed by **PARAM Shakti, PARAM Brahma, PARAM Yukti, PARAM Sanganak.**
- India plans to indigenously develop 60 supercomputers over the next three years, Under **National Supercomputing mission (NSM).** India has lagged behind in the race of building supercomputers despite being a leader in the IT enabled services (ITES). Hence, National Supercomputing Mission is a step in the right direction.

India is fast emerging a leader in high power computing with the National Super Computing Mission (NSM) boosting it to meet the increasing computational demands of academia, researchers, MSMEs, and startups in areas like oil exploration, flood prediction as well as genomics and drug discovery. It is really necessary for a country like India to invest in expensive technology like supercomputers to solve complex scientific problems which have real-life implications.

Practice question:

Q. What is India's National Supercomputing Mission? Analyse the performance of India in developing supercomputers while discussing their applications.

4. UTILITY OF ROBOTS

Context: A study revealed that 85% of Indian business leaders would prefer robots to make their decisions.



Overview:

A robot is a type of automated machine that can execute specific tasks with little or no human intervention and with speed and precision. The field of robotics, which deals with robot design, engineering and operation, has advanced remarkably in the last 50 years. Robots are used in multiple areas, especially where they can alleviate strenuous tasks or complete missions that are dangerous for a human to undertake.

Robots operating in environments which are unsafe for humans:

- **Industrial Welding:** Welding is a very important part of all kinds of heavy manufacturing environments. Unfortunately, a single moment of inattention can spell disaster for a human welder. With robots, the hazard is eliminated noise, intense heat, and toxic fumes are no problem.
- **Underwater Exploration:** Even divers with modern equipment and years of experience can succumb to various hazards of the deep, including sea predators and pressure sickness. Undersea exploration robot is capable of rudimentary planning in unpredictable environments.
- **Deep Space Exploration:** Government agencies and private companies are testing new ideas for space exploration as bigger, more ambitious journeys become possible. In 2011, the Robonaut 2 became the first humanoid robot to make it to the International Space Station. Hence, robots are of great use in solving the mysteries of the universe.
- **Disaster Response:** Robots have been tested for a wide range of emergency response applications, including dealing with wildfires, floods, and other situations.

With time, robots are sure to enter more and more situations that would be potentially lethal to humans. With ever-improving maneuverability and adaptability, robots make the perfect partner for any kind of exploration or risk-intensive rescue mission.

Robots undertaking tasks pioneering in Nature:

- Robots for agriculture: The United Nations estimates that the world population will reach 10 billion by 2050; this will cause demand for agricultural products to rise by over 30%. Agricultural robots, underpinned by GNSS, SatEO and Satcom technologies, are poised to be at the centre of the third agricultural revolution; not by displacing farmers, but by increasing the farmer's added value while maximising yield and optimising the use of natural resources.
- **Robots for infrastructure monitoring:** Structural health monitoring (SHM) is an essential component in civil engineering for safety and integrity of civil structures such as buildings, bridges, power plants, off-shore structures and tunnels. State-of-the-art sensing, automation and robotic technologies can greatly facilitate construction automation of infrastructure systems.
- **Robotics in the transport sector:** Flanked by **radio transmitters,** vision cameras, magnetometers, LiDAR, lasers, equipped with digital maps, navigation systems and fitted sensors to identify obstacles, robots can drive independently to a destination and calculate their exact position and route.
- **Robotics for social care:** Robots and autonomous systems, together with **AI**, connected data and digital infrastructure can have the potential to revolutionize the way in which social and medical care is delivered, for the elderly and disabled people.

The robotics industry is filled with an admirable promise of progress that science fiction could once only dream about. From the deepest depths of our oceans to thousands of miles in outer space, robots will be found performing tasks that humans couldn't dream of achieving alone.

5. GENERATIVE ARTIFICIAL INTELLIGENCE

Context: World leaders, during the **G7 Summit** held in Hiroshima, Japan, in May this year, emphasized the urgent need to assess the impact of **generative artificial intelligence (AI)**.

What is Generative Artificial Intelligence?

Generative AI refers to a category of **artificial intelligence (AI)** algorithms that generate new outputs based on the data they have been trained on. Unlike traditional AI systems that are designed to recognize patterns and make predictions, generative AI creates new content in the form of images, text, audio, and more.



Applications of Generative Artificial Intelligence:

- **Images:** Generative AI can create new images based on existing ones, such as creating a new portrait based on a person's face or a new landscape based on existing scenery.
- **Text:** Generative AI can be used to write news articles, poetry, and even scripts. It can also be used to translate text from one language to another.
- Audio: Generative AI can generate new music tracks, sound effects, and even voice acting.
- **Drug Discovery in Health Care:** In the health care and medical fields, drug discovery plays a major role in treating illnesses and supporting treatment programs. With generative AI, researchers can find new drugs and test their efficacy in much less time than it used to take.
- **Fraud Detection in Banking:** Generative AI has plenty of applications in the banking and financial services industry. The industry is well-known for being on the cutting edge of innovation, so it's no surprise that more banks will invest in generative AI-powered solutions like **ChatGPT**.
- **Entertainment:** ChatGPT, Dall-E and other tools are already employed in generating conceptual art to guide scenario and environment development and are expected to be used to generate full environments in the future. Generative AI tools are also taking up background music generation for games.
- **Location services** This involves converting satellite images to map views. This can be a huge step towards venturing into unexplored geographic locations.
- Security services at Airports/ Country Borders Generative AI can create front-on photos from photos taken at different angles and vice versa for face verification or face identification system.

Ethical issues arising out of Generative Artificial Intelligence:

- **Distribution of harmful content:** Generative AI, particularly machine learning approaches such as deep fakes, can be used to generate synthetic media, such as images, videos, and audio. Such AI generated content can be difficult or impossible to distinguish from real media, posing serious ethical implications.
- **Copyright and legal exposure:** Popular generative AI tools are trained on massive image and text databases from multiple sources, including the internet. When these tools create images or generate lines of code, the data's source could be unknown, which can be problematic for a bank handling financial transactions or pharmaceutical company relying on a formula for a complex molecule in a drug.
- **Truthfulness & Accuracy:** Generative AI uses machine learning to infer information, which brings the potential inaccuracy problem to acknowledge. Also, pre-trained large language models like ChatGPT are not dynamic in terms of keeping up with new information.
- Sensitive information disclosure: Generative AI is democratizing AI capabilities and making them more accessible. For example: This combination of democratization and accessibility, could potentially lead to a medical researcher inadvertently disclosing sensitive patient information or a consumer brand unwittingly exposing its product strategy to a third party.
- **Malware** / **social engineering:** Generative AI can be misused to create convincing and realisticsounding social engineering attacks, such as phishing emails or phone calls. These attacks could be designed to trick individuals into revealing sensitive information, such as login credentials or financial information, or to convince them to download malware.
- **Education:** In the educational context, generative AI could be misused by generating false or misleading information that is presented as fact. This could lead to students being misinformed or misled. Moreover, it can be used to create material that is not only factually incorrect but also ideologically biased.

For Example: Students can use generative AI tools like **ChatGPT** for preparing their homework on a wide variety of topics.

Issues

• Lack of explainability and interpretability: Many generative AI systems group facts together probabilistically, going back to the way AI has learned to associate data elements with one another. But these details aren't always revealed when using applications like ChatGPT. Consequently, data trustworthiness is called into question.

Ethical Issues

• **Risk of Unemployment:** There is a risk that generative AI could contribute to unemployment in certain situations. This could happen if generative AI automates tasks or processes previously performed



by humans, leading to the displacement of human workers. **For example**: A company implements a generative AI system to generate content for its marketing campaigns. Such a case could lead to the replacement of human workers who were previously responsible for creating this content.

 Like other forms of AI, generative AI can influence a number of ethical issues surrounding data privacy, security, policies and workforces. Generative AI technology can also potentially produce a series of new business risks like misinformation, plagiarism, copyright infringements and harmful content. Overall proper legislations are to be made in order to reap the benefits off this disrupting technology.

Practice Question:

Q. What do you understand by generative artificial intelligence? Do you think disruptive technologies like generative artificial intelligence poses a threat to the labor force? Provide a suitable argument.

6. NATIONAL QUANTUM MISSION

Context: National Quantum Mission received cabinet approval at a total cost of about Rs. 6000 crores.

About the Mission

- **Aim:** To seed, nurture and scale up scientific and industrial R&D and create a vibrant & innovative ecosystem in Quantum Technology (QT).
- **Implementing agency:** It will be implemented by the Department of Science & Technology (DST) under the Ministry of Science & Technology.
- Mission duration: From 2023 to 2031.
- Targets:
 - Developing intermediate-scale quantum computers with 50-1000 physical qubits (refer image) in 8 years.
 - Satellite-based secure quantum communications between ground stations over a range of 2000 kilometers within India and with other countries.
 - ► Also, inter-city quantum key distribution over 2000 km.

Key aspects of the mission

- **Quantum Computing:** Advancing quantum computing capabilities for solving complex problems and enhancing computational efficiency.
- **Quantum Communication:** Developing secure and high-speed quantum communication networks to safeguard sensitive information.
- **Quantum Sensing:** Utilizing quantum principles for ultra-precise measurements in fields such as navigation, imaging, and environmental monitoring.
- **Quantum Metrology:** Enhancing measurement accuracy by exploiting quantum properties, leading to advancements in metrology and standards.
- **Quantum Materials and Devices:** Investigating and harnessing the unique properties of quantum materials to develop advanced devices for diverse applications.

Knowing the terms

- **Quantum technology:** It 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.
- **Quantum entanglement**: It is when two atoms are connected, or entangled, despite being separated. If you change the properties of one of them, the other changes instantly.
 - ➤ For example, you can have two entangled atoms with clockwise and anticlockwise 'spins'. One atom is sent with the encryption key and if an eavesdropper intercepts the transmission, this causes a change in the 'spin' of the atom, affecting the overall quantum state of the system and resulting in the detection of the eavesdropping attempt.

• Quantum superposition: It is the theory that sub-atomic particles exist in multiple states simultaneously. It's the crux of the Schrodinger's Cat thought experiment - a cat, a flask of poison and a radioactive source are in a sealed box. If a Geiger counter detects radioactivity, it shatters the flask, releasing the poison and killing the cat. Since the radioactivity detection is a statistical process, the cat can be both alive and dead while the box is sealed, with the outcome only confirmed when you open the box and observe the cat to be in one state or the other.

Significance of the Mission

- **Technological advancement:** NQM can take the Technology Development ecosystem in the country to a globally competitive level.
- Help various disciplines: The Mission would greatly benefit various sectors, including communication, health, finance, and energy with applications in drug design, space, banking, security, etc.
- **Research and Development:** It will help establish a research ecosystem in and around quantum technology.
- **Global leader:** India can take an early advantage in developing the technology and harnessing the benefits. o Currently, only six other countries the United States, Finland, Austria, China, Canada, and France are working in the field of developing quantum technology on a large scale.
- **National Security:** It will aid national security in areas such as optimized intelligence collection, encryption, stealth technology, communications etc.

Applications of quantum computing:

- **Diagnosis:** Quantum technologies could be used to provide faster, more accurate diagnostics with a variety of applications. High-resolution MRI machines will provide greater levels of detail and also aid clinicians with screening for diseases.
- **Treatment:** Targeted treatments, such as radiotherapy, depend upon the ability to rapidly model and simulate complex scenarios to deliver the optimal treatment. Quantum computers would enable therapists to run more simulations in less time, helping to minimise radiation damage to healthy tissue.
- Automated, high-frequency trading: One potential application for quantum technologies is algorithmic trading the use of complex algorithms to automatically trigger share dealings based on a wide variety of market variables. The advantages, especially for high-volume transactions, are significant.
- **Fraud detection:** Like diagnostics in healthcare, fraud detection is reliant upon pattern recognition. Quantum computers could deliver a significant improvement in machine learning capabilities; dramatically reducing the time taken to train a neural network and improving the detection rate.
- **Big Data Analytics:** Quantum computers will have the ability to aggregate and analyse huge volumes of consumer data, from a wide variety of sources. Big data analytics will allow commerce and government to precisely target individual consumers, or voters, with communications tailored to their preferences; helping to influence consumer spending and the outcome of elections.
- **More Accurate Weather Forecasts:** With so many variables to consider, accurate weather forecasts are difficult to produce. Machine learning using quantum computers will result in improved pattern recognition, making it easier to predict extreme weather events and potentially saving thousands of lives a year.
- **Increase Supply Chain Efficiency:** Improved data analysis and modelling will enable a wide range of industries to optimise workflows associated with transport, logistics and supply-chain management. The calculation and recalculation of optimal routes could impact on applications as diverse as traffic management, fleet operations, air traffic control, freight and distribution.

Challenges:

- **Expensive:** Quantum computers are extremely expensive. The materials used to create them can be costly, and many researchers believe that these costs may never be recovered.
- **Difficult to program:** Quantum computing is extremely difficult to program and control- it requires a high-level understanding of complex quantum principles.
- **Sensitive:** When it comes to interference from the outside world, such as temperature variations, magnetic fields, and vibrations, quantum technology is extremely sensitive.
- **Framework:** A disruption in current computer architectures is another possible drawback of quantum computing.

- **Proper functioning:** Its reliance on entanglement and superposition, according to many experts, makes it susceptible to assault by hackers who are familiar with the technology.
- Ethical and Societal Implications: Quantum technology raises ethical, legal, and societal considerations. The development and application of quantum technologies, such as quantum computing and cryptography, may have significant societal implications, including data privacy, cybersecurity, and societal disruption. Addressing these concerns and establishing ethical frameworks and guidelines is a challenge.
- **Funding and Resource Allocation:** Adequate funding is critical for the success of the National Quantum Mission. Securing sustained funding and effective resource allocation, both from government sources and private investments, is a challenge.

The National Quantum Mission offers a tremendous opportunity for India to contribute significantly in this area with many factors and conditions in its favour such as a large and young talent pool and a rapidly accelerating infrastructure for high-tech R&D. However, it will require dedicated teamwork with smart and efficient execution from all the stakeholders. An optimal mix of basic, applied and translational R&D, with a continuous and effective evaluation programme, is needed to keep India relevant in this highly critical area of science and technology and set the stage for taking a leadership position in the 21st century.

Practice Question:

Q. Discuss why India needs to harvest Quantum Technology for strategic as well as economic development. Analyse the role of National quantum mission in achieving the foresaid objectives.

7. BHARAT 6G MISSION

Context: India released **"Bharat 6G Vision"** document which eyes **6G services** rollout by 2030 and launched the **6G research and development test bed.**

About Bharat 6G Mission:

- 6G is the next phase of wireless technology, incorporating novel approaches like edge computing and artificial intelligence to help make a completely new type of internet.
- 6G is the sixth generation of wireless technology. A 6G network follows up on 4G and 5G, using higher frequency bands and agile, cloud-based networking technology to deliver record-breaking speeds and microsecond latency.
- The vision for 6G is built on the desire to create a seamless reality where the digital and physical worlds as we know them today have merged. This merged reality of the future will provide new ways of meeting and interacting with other people, new possibilities to work from anywhere and new ways to experience faraway places and cultures.
- By delivering ever-present intelligent communication, 6G will contribute to the creation of a more human-friendly, sustainable and efficient society.

Bharat 6G Mission - Objectives

- Facilitate and finance Research and Development, design and development of 6G technologies by Indian Startups/Companies/Research bodies/Universities;
- Enable India to become a leading global supplier of IP, products and solutions of affordable 6G telecom solutions;
- Deploy 6G technologies to act as a powerful force multiplier for **India@2030**;
- Enable inclusive and significant enhancement in the quality of living experience of citizens in India and across the world.

About the Bharat 6G Vision document:

- Bharat 6G vision document is prepared by the **Technology Innovation Group on 6G** (TIG-6G) that was constituted in 2021 by Department of Telecommunications (DoT) under Ministry of Communications.
 - TIG-6G has members from various Ministries/Departments, research and development institutions, academia, standardization bodies, Telecom Service Providers and industry to develop a roadmap and action plans for 6G in India.

- Vision document which aims to design, develop and deploy 6G network technologies that provide ubiquitous intelligent and secure connectivity for high quality living experience for the world.
- India will launch a 6G Mission that holistically combines all associated technologies, supported by an adequate financial backup.

Bharat 6G Vision Statement:

"Design, develop and deploy 6G network technologies that provide ubiquitous, intelligent and secure connectivity for high quality living experience for the world.

Bharat 6G mission will be divided into two phases:

- **Phase 1 (2023-2025):** The ideation phase to understand the inherent potential and risk associated with the pathways ahead and test proof-of concept implementations.
- **Phase 2 (2025-2030):** Dedicated to conceptualizing and delivering potential technology solutions to serve India and the global community.

An apex body is to be constituted to oversee the Mission and approve the budget for the Mission split into two phases and lay down the Phase-wise objectives.

Recommendations of taskforces to enable Bharat 6G Mission:

- **Innovative funding mechanisms:** To support industry, start-ups, academia, and national laboratories to undertake R&D.
- **Solutions through start-ups:** To address key verticals such as transport, water, power grid and renewables, healthcare, education, digital twins and smart cities.
- **Shared use of spectrum:** Particularly in the higher frequency bands where the propagation is more akin to that of light.
- **Rationalisation of congested spectrum bands:** Adoption of captive networks for Industry 4.0 and enterprise use cases in hitherto less used bands.
- **Participation and contribution to global standards forums:** To ensure interoperability and global reach of our innovation.
- **Fiber-broadband:** To every home and integrated dense wireless and optical network, with wireless communications primarily serving mobile users.
- **New multi-sensor man-machine interfaces and devices:** Leveraging edge cloud computing resources and AI to deliver tactile Internet, ambience awareness and realistic 3D experiences.
- **Others:** Space-Terrestrial Integration for ubiquitous coverage; combined communication and sensing in (Sub-) Terahertz bands.

Significance of Bharat 6 G mission:

- **Faster Internet Speeds:** 6G is projected to offer internet speeds of up to 1 terabyte per second, which is about 100 times faster than 5G.
- **Lower Latency:** 6G is expected to have ultra-low latency, meaning there will be a very little delay in data transmission. This will enable smooth interactions, especially for applications that require real-time response, such as autonomous vehicles and remote surgeries.
- **Improved Connectivity:** 6G is expected to provide more reliable and secure connectivity, especially in remote and rural areas where internet access is currently limited.
- **New Applications:** 6G is projected to enable new applications such as seamless virtual and augmented reality, ubiquitous sensing, and machine learning-based communication systems.
- **Economic Development:** 6G is expected to boost economic development by enabling innovation in various industries such as healthcare, transportation, and manufacturing. It may also slow down rural migration to cities and metro-led urbanization.

Challenges associated with 6G Technology:

- **Technical Complexity:** 6G technology is expected to be much more complex than its predecessor, with a large number of components and subsystems. This complexity could make the development and implementation of 6G more challenging.
- **Infrastructure Deployment:** To deliver on the promise of 6G, significant investments will be required in terms of infrastructure development. This could pose challenges in terms of financing, regulation, and deployment.



- **Spectrum Allocation:** The availability of spectrum is crucial for the development and deployment of 6G technology. However, the spectrum is a finite resource, and allocating sufficient spectrum for 6G could be a challenge, particularly given the demands of other emerging technologies.
- **Security:** As with any new technology, 6G is likely to face security challenges. The high speeds and large amounts of data transmitted over 6G networks could make them vulnerable to cyber-attacks. Ensuring the security of 6G networks will be crucial to their success.
- **Standardization:** Developing standards for 6G will be essential to ensure interoperability and compatibility across different networks and devices. However, the process of developing and agreeing on standards can be time-consuming and complex, and disagreements among stakeholders could delay the rollout of the 6G technology.

Practice Questions:

Q. Critically analyze the potential impact of 6G technology on India's digital infrastructure and economy, taking into consideration the Bharat 6G Vision document and the roles of various stakeholders such as the government, industry, and academia.





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2

SPACE TECHNOLOGIES

1. NASA'S ARTEMIS MISSION

Context: NASA has embarked on a mission called **Artemis** that involves a multistage plan to send astronauts to the moon and beyond.

What are the Artemis missions?

The Artemis missions are increasingly complex endeavors that lay the foundation for sustainable human and robotic exploration of Earth's only natural satellite, the **Moon**.

Mission includes:

- **Artemis I**, an uncrewed test flight of the Orion spacecraft, launched on the Space Launch System (SLS) rocket on November 16, 2022.
- Artemis II, the first-ever crewed test flight of the Orion spacecraft, targeted to launch no earlier than November 2024.
- **Artemis III**, currently targeted for no earlier than 2025, will fly astronauts to the Moon. The mission will land humans on the lunar surface.

During later missions, astronauts will dock Orion to the Lunar Gateway, a small space station to which Canada is contributing a smart robotic system, **Canadarm3**. The Gateway is critical to sustainable lunar exploration and will serve as a model for future missions to Mars. From the Gateway, astronauts will be able to venture to the lunar surface.

Objectives of NASA's Artemis Mission:

- Enable scientific discovery: NASA's Artemis aims to find water and other resources that will support long-term space exploration. Along the way, the agency expects to learn more about the moon, Earth and the universe.
- **Economic opportunities:** The space economy is already a \$400 billion industry and on the way to \$1 trillion. Artemis mission will create new opportunities in the space especially on moon.
- **Inspire upcoming generations:** The mission also aims to inspire the young generations to study science by unveiling the fascinating mysteries of the universe and creating a sense of curiosity in young minds.

NASA's Artemis Mission will help prepare for human landing on Mars:

- The primary focus of Artemis missions from a space radiation perspective is developing the capability to accurately monitor the deep space radiation environment and its effect on the human body. This information will help NASA to design countermeasures and protections for astronauts when they go on farther missions to Mars.
- The research gathered through Artemis mission aims to examine the risks astronauts will encounter on long missions far from Earth. Additionally, the studies will provide insight into how humans adapt or respond to those risks, and how to develop effective ways to counter any negative effects while they are on Mars.
- When medical issues arise on Mars, crews will need to deal with them quickly and competently. On trips to Mars, communication delays will require astronauts to address health events themselves using

automated technology. NASA will help advance Mars missions by testing in-flight medical capabilities that enable the crew to function with more independence from Earth.

• The gravity on Mars is about one-third that of Earth's while that of moon is one-sixth. Astronauts landing on the Moon will have to adapt to the gravity of the lunar surface. During Artemis missions, researchers will be able to verify whether crew members can perform activities inside and outside of their spacecraft without ground support which will further help in understanding the adaptability of human body in such strained conditions.

The Artemis mission to lunar landscape will be revolutionize our knowledge about the universe and its origin. The mission is a stepping stone to discover the insights of Mars and encourage the upcoming generations to engage more in scientific discoveries.

Practice question

Q. Discuss the objectives of NASA's Artemis Mission. How will this Mission help prepare for human landing on Mars?

2. GAGANYAAN:

Context: Indian Space Research Organisation (ISRO), along with the Indian Navy, has conducted an important trial for the **Gaganyaan**, **Indian Human Spaceflight Programme (IHSP)**.

About the development:

- They carried out initial recovery trials of the Crew Module in the Navy's **Water Survival Test Facility** (WSTF) in Kochi.
- A **Crew Module Recovery Model (CMRM),** that simulates the mass, center of gravity, outer dimensions, and externals of the actual Crew Module at touchdown, was used for the trials.
- ISRO's recent operation form the initial recovery trials of Crew Module in a closed pool.
- The crew module will be the habitable part of the Gaganyaan spacecraft that will have pressurisation and life support systems for the crew members.
- In contrast, the service module will be an unpressurised structure containing the propulsion system, power systems, and avionics to support the crew module during the mission.

Overview:

- It is ISRO's first manned space mission which envisages demonstration of human spaceflight capability by launching crew of 3 members to an orbit of 300-400 km for a 3 days mission.
- It will bring them back safely to earth, by landing in Indian sea waters.
- Mission includes three space flights: two unmanned 'Abort missions' to test for crew safety, followed by the manned space journey.
- First trial (uncrewed flight) for Gaganyaan is being planned by the end of 2023 or early 2024.
- This will be followed by sending Vyom Mitra, a humanoid and then with the crew onboard.
- It will take off on a **Launch Vehicle Mark-III (LVM 3 rocket)** previously known as **GSLV Mk III** which is capable of launching four-tonne satellites in the **Geosynchronous Transfer Orbit (GTO)**.
- Mission will make India 4th country to have human spaceflight capability after US, Russia and China.

Significance of Gaganyaan

- **India's aim of Self-reliance:** It will help India in achieving self-reliance, in line with the vision of Atma Nirbhar Bharat and also boost the capacity development in launching satellites under the Make in India Initiative. It will reduce India's dependence on foreign cooperation in this direction.
- **R&D and robotic programme:** It will also enhance the research and development (R&D) at science and technology levels especially in the space sector. It is in line with India's progress towards a sustained and affordable human and robotic programme to explore the solar system and beyond.
- Focus on regional needs: Gaganyaan will focus on regional needs because one International Space Station (ISS) may not be enough to cater to global requirements.
- **Strengthening international partnerships:** The programme will strengthen international partnerships and global security through the sharing of challenging and peaceful goals.



Challenges in carrying out Man Made Missions:

- **Hostile environment:** Gaganyaan has to create an atmosphere like Earth inside a small volume and ensure that is adequate supply of oxygen, removal of carbon dioxide and comfortable temperature and humidity levels are maintained throughout the mission.
- **Gravity field:** Transitioning from one gravity field to another has impact on the physical bodies. It affects hand- eye and head-eye coordination.
- **Isolation:** Due to isolation, one may encounter depression, fatigue, sleep disorder and psychiatric disorders.
- **Radiation:** In space stations, astronauts receive over ten times the radiation than what people are subjected to on Earth. Radiation exposure may increase the risk of cancer. It can also damage the central nervous system.
- **Budgetary constraints:** These missions require exorbitantly huge investment as they are highly technology intensive.

What are the Other Upcoming Missions?

- **Shukrayaan Venus Mission (for 2023):** The Shukrayaan orbiter will be the ISRO's first mission to Venus, and it will spend four years studying the planet.
- L-1 Aditya Solar (2022-2023): It is the first scientific mission of India to study the Sun.
 - After AstroSat, which was launched in 2015, this would be ISRO's second space-based astronomy mission.
- **Chandrayaan-3 Mission(for 2022-23):** The Chandrayaan-3 mission, which is a follow-up to the Chandrayaan-2 mission, entails "a variety of processes, including configuration finalization, subsystems realization, integration, spacecraft level comprehensive testing, and a number of special tests to evaluate system performance on Earth."

Practice questions:

Q. Why is Gaganyaan mission significant for India? Discuss the features as well as challenges associated with the mission.

3. INDIA'S REMOTE SENSING PROGRAM

Context: Indian Space Research Organisation (ISRO), which has the **world's largest constellation of remote-sensing satellites** and has sent two missions to the Moon and one to the Mars, is ready to help Oman in its space research programme.

About India's Remote Sensing Program:

- India's remote sensing program was developed with the idea of applying space technologies for the benefit of human kind and the development of the country, the program under the **Indian Space Research Organization (ISRO)** started off in 1988 with the IRS-1A, the first of the series of indigenous state-of-art operating remote sensing satellites.
- India demonstrated the ability of remote sensing for societal application by detecting coconut root-wilt disease from a helicopter mounted multispectral camera in 1970.

Components of the program:

The program involved the development of three principal capabilities:

- The first was to design, build and launch satellites to a sun synchronous orbit.
- The second was to establish and operate ground stations for spacecraft control, data transfer along with data processing and archival.
- The third was to use the data obtained for various applications on the ground.

Significance of India's remote sensing program for benefit of humankind and development of the country:

• Pre-harvest **crop acreage and production estimates (CAPE)** for wheat, rapeseed and mustard, Sorghum, rice, cotton and sunflower for large part of the country.

- Monitoring of seasonal drought conditions over the country based on satellite derived vegetation index.
- Near real time flood damage assessment in all the major flood prove river basins using optical and microwave data.
- Current land-use/land-cover mapping for entire country towards agro-climatic zonal planning.
- Forest cover monitoring on a biennial basis to assess and detect changes
- Mapping of saline/alkaline soils for the entire country.
- Coastal land-use mapping for all maritime states of the country.
- Sea surface temperature (SST) retrieval and its applications including fisheries.
- Methodology development for retrieval of winds, waves, bathymetry, sea mounts, internal waves, ocean circulation etc., from ERS-1 microwave data.
- Applications of microwave SAR data for soil moisture assessment and crop identification.
- Geosphere Biosphere studies on carbon cycle in oceans, macro vegetation dynamics, forest biodiversity, forest eco dynamics etc.

Success of India in achieving the foresaid objective:

- Enhancing agriculture productivity: Satellite remote sensing has provided timely inputs towards achieving food security through sustainable agriculture.
- Water security: The remote sensing data in conjunction with sufficient ground truth information provides information on the geology, geomorphology, structural pattern and recharge conditions which ultimately define the groundwater regime.
- **Towards improving livelihood:** One of the major applications of satellite remote sensing is in delineating the potential fishing zones (PFZ). The technique developed for the PFZ forecast (up to 2–3 days in advance), which combines chlorophyll information.
- **Building natural resources assets:** Timely and reliable information on spatial distribution, intra and inter annual changes in cropping systems, forest cover, surface water bodies and snow cover is a pre-requisite for land use planning, and is a valuable input to global change studies and climatological models. India's remote sensing programe has tried to address all these issues by providing timely information.
- **Disaster resilience**: The **Disaster Management Support (DMS) Programme** of ISRO commits to providing timely support and services from aero-space systems, both imaging and communications, for strengthening the resolves of disaster management in the country. These include creation of digital data base for facilitating hazard zonation, damage assessment, etc., monitoring of major natural disasters using satellite and aerial data; development of appropriate techniques and tools for decision support, establishing satellite based reliable communication network.
- **Reaching the unreached:** VRCs are envisaged as the single window delivery mechanism for a variety of space-enabled services and deliverables such as telemedicine; tele-education; information on natural resources for planning and development at local level; interactive advisories on agriculture, fisheries, and land and water resources management; livestock management; interactive vocational training towards skill improvement, alternate livelihood; e-governance services; weather information, etc. The programme has enabled the inclusion of the marginalized.

India has achieved a viable, self-reliant remote sensing programme with the establishment of expertise and self-sufficiency in operationalisation of the Indian Remote Sensing Satellite series, establishment of a well-knit infrastructure for reception, processing, dissemination, analysis and interpretation of remote sensing data which has been of immense significance for the mankind.

Practice question:

Q. Discuss the significance of India's remote sensing program in development and protection of the country.

4. ROLE OF PRIVATE SECTOR IN SPACE PROGRAMMES

Context:

The **new space policy** opens up the Indian space sector, providing a place for the private sector to play an active role in augmenting the development and competitiveness of the Indian space program.



Overview:

The global space economy is currently valued at about USD 360 billion. Despite being one among a few **spacefaring nations** in the world, India accounts for only about 2% of the space economy. Over the last 2 decades, the private sector has played an increasingly important role in other spacefaring countries within the global space economy like **SpaceX**, **Blue Origin**. In India however, players within the private space industry have been limited to being vendors or suppliers to the government's space program.

Reasons why India's space programmes lacks private sector participation:

- Limited to components and subsystems: Indian players have generally been unable to compete in satellite-based services and ground-based systems segments, as they have mainly been suppliers of components and subsystems.
- **Resource crunch:** Indian companies do not have the resources or the technology to undertake independent space projects or provide space-based services.
- **Traditional model of functioning:** ISRO works on the traditional vendor-supplier model, most intellectual property is owned by the organisation; this has hindered the technological advancements of Indian companies.
- **Skilled labour:** as we have entered the space arena in later stages we lack technological advances to skill our workforce for the space sector.
- **Investment:** due to the nature of industry being capital intensive and un-assured returns, the sector lacks proper investment which is imperative to drive growth.
- Absence of coherent policy: The absence of a comprehensive policy framework for private sector participation in space in India has created uncertainties regarding investment and technology transfer.

India contributed 2.1% to the global space industry economy in 2020, amounting to US\$ 9.6 billion, with a contribution of 0.4% to the country's gross domestic product (GDP).

Significance of private sector in growth of Indian space Industry:

The significance of the space industry in enabling services and applications across several industries, such as media and entertainment, weather forecasting, disaster management, agriculture, geological and oceanographic studies, navigation, broadband services, and remote sensing, demonstrates the importance of the sector.

- **Reduction in cost:** Participation of private sector and start-ups in the space sector have an advantage in terms of low-cost operations.
- **Technology and innovation:** Participation of the private sector will give rise to new innovations and technology.
- **Investment and capacity development:** Private sector facilitates investments in technology development and acquisition, capacity-building and space exploration, including planetary exploration.
- **Harvesting talent pool:** India has a huge talent pool and is searching for opportunities. So, participation of private entities in the space sector helps to harvest a sizable talent pool available outside ISRO.
- **Transparency and accountability:** Expanding the number of stakeholders with participation of private entities will ensure more transparency and better accountability and regulatory practices.
- **Competitiveness:** With low cost, innovation and better talent pool in India's space will make it more competitive with respect to globally reputed, private space industry.
- **Fill communication infrastructure deficit:** The vast amount of potential and resources available with the private sector will help the space industry to grow and fill in the communication infrastructure deficit by looking beyond the traditional modes of internet delivery and look for space-based solutions.

Initiatives to promote space sector among young minds:

• YUva VIgyani KAryakram (YUVIKA-2022): YUVIKA is a two weeks residential programme organized at five ISRO centres which includes teaching and practical exposure to students in the 9th standard. 153 nos. of students from 36 states/UTs participated in the programme.

- UNNATI (Unispace Nano Satellite Assembly & Training by ISRO): UNNATI is a capacity building programme, it is a training on combination of theoretical course work and hands-on training on assembly, integration and testing of nano satellites for the foreign participants. ISRO had trained 60 participants from 33 countries in two batches and third batch training is in progress.
- **Space Tutor Space Tutor:** is a collaborative programme between ISRO and NGOs/Start-ups/Institutions involved in promoting space education & STEM activities. 56 space tutors are registered across the country.
- Atal Tinkering Labs (ATL): ISRO has adopted 100 Atal Tinkering labs established by Atal Innovation Mission, Niti Aayog across the country to promote space education in the schools. Two interactive sessions were organized with these schools for extending the mentorship.

Role of Government-owned Commercial Organisations in fostering private sector participation:

- **IN-SPACe:** In-SPACe will be responsible for regulating and permitting private sector activities in the sector. It will appoint its own directorates for security, legal, promotion (of activities) and monitoring purposes. The organisation will also be responsible for promoting private industries by creating an amiable regulatory ecosystem and ensuring seamless transfer of technological knowhow from ISRO to the private players.
- **NSIL:** It is the commercial arm of ISRO and primarily responsible for enabling Indian industries to take up high-tech, space-related activities. It is also responsible for promotion and commercialisation of products and services in the space industry. In addition, the NSIL will soon take over a large share of ISRO's responsibilities—operational launch vehicles, satellites and commercial activities—that will be executed in the form of industry consortia.
- Antrix Corporation Limited: Was incorporated as a marketing arm of ISRO; it handles ISRO's commercial deals for satellites and launch vehicles with foreign customers.
- **Space communication Policy 2020:** The policy aspires to address the nation's expanding needs for space-based communications and the creation of pertinent technologies for self-sustenance in the fields of commercial, secure, and societal communications.
- **The Indian Space Association (ISpA):** To make India self-sufficient, technologically advanced, and a major player in the global space arena, it will engage in policy advocacy, engage, and operate with all stakeholders, and act as a catalyst for accelerating the exchange of knowledge, information, and technology of space-related domains amongst all stakeholders of the entire Indian Space ecosystem, including the government and its agencies.

It is essential to provide a favourable policy environment to encourage private sector investment. These regulations should aim to create an environment that will support and empower entrepreneurs and SMEs to create internationally scalable, end-to-end products and services. Also, there is a need to develop competency, such as an academic emphasis on system development, or companies are spending a lot of money training employees in systems engineering.

Practice Question;

Q. State the significance of private sector investment in growth of Indian space industry. Also mention the reasons why India's space program lacks private sector investment.

5. INDIAN SPACE POLICY – 2023

Context: The Indian Space Research Organisation (ISRO) formally published Indian Space Policy, 2023.

Key Highlights of the Policy

The Indian Space Policy 2023 is a comprehensive set of guidelines that outlines the roles and responsibilities of different entities in the Indian space sector.

• **Research & Development:** The policy aims to keep India at the cutting edge of space research and development. ISRO, the Indian Space Research Organisation, has been tasked with focusing on applied research, technology development, and human spaceflight capabilities.



- Efficient collaboration between public and private sector: The policy outlines a strong emphasis on sharing technologies, products, processes, and best practices with New Generation Entities (NGEs) and Government companies.
- **Privatising:** The policy 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.
- This initiative promises to empower researchers, industries, and the general public with valuable information for various applications. In contrast, 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. Additionally, the policy emphasizes the development of a collaborative framework for scientific research in multidisciplinary domains related to human space activities.
- **Celestial Prospecting and In-situ Resource Utilization:** ISRO is set to undertake studies and missions focused on in-situ resource utilization, celestial prospecting, and other aspects of extra-terrestrial habitability. This forward-looking approach will help India pave the way for future space exploration and utilization of resources beyond Earth.

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): IN-SPACe will serve as the interface between ISRO and non-governmental entities.
- **Department of Space:** The Department of Space (DOS) will oversee the implementation of the **Indian Space Policy-2023**, ensuring that stakeholders are suitably empowered to carry out their respective functions.
- From international cooperation to sustainable space operations, DOS will play a pivotal role in the successful execution of the policy.

What are the expected benefits of the new policy?

- Enhancing the Indian space economy: The Policy is 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.

Practice question:

Q. Discuss how ISRO is gearing up For India's space programe. However, there are many opportunities and challenges in the new space age that needs to be addressed.

6. NATIONAL GEOSPATIAL POLICY

Context: The Ministry of Science and Technology has notified a citizen centric National Geospatial Policy (NGP) 2022, to strengthen the Geospatial sector to support national development.

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What is Geospatial Data?

- Geospatial data are descriptions of events or occurrences with a location on or near the surface of the earth.
- This location can be static relating to earthquakes, vegetation, etc., or dynamic a person walking on the road, a package being tracked, etc.

Vision of National Geospatial Policy:

- **Global leader:** To make India a World Leader in Global Geospatial space with the best in the class ecosystem for innovation.
- **Integrated Policy:** To develop a coherent national framework in the country and leverage it to move towards a digital economy and improve services to citizens.
- **Better utilization of data:** To enable easy availability of valuable Geospatial data collected utilizing public funds, to businesses and the general public.
- **Encouraging participation of the private sector:** To have a thriving Geospatial industry in the country involving private enterprise.

Institutional framework

- The **Geospatial Data Promotion and Development Committee (GDPDC)** shall be constituted at the national level as the apex body for formulating and implementing appropriate guidelines, strategies, and programs.
 - The **GDPDC**, a **17-member body** to be headed by a person of repute from industry, government, or academia.
 - GDPDC would replace and subsume the functions and powers of National Spatial Data Committee (NSDC) and Geospatial Data Promotion and Development Committee.
- **Role of Department of Science & Technology (DST):** It shall continue to be the nodal Department of the Government and GDPDC shall make suitable recommendations to DST.

Geospatial Data Infrastructure

- GDPDC will adopt and develop **Data Themes** related to **14 global geospatial data themes** recognized by United Nations Statistics Division. It will also develop Sectoral Geospatial Data Themes for various sectors like Environment, Forest, etc.
- National Geospatial Data Registry (NGDR): It will act as a common set of registers of data sets and services accessible by all stakeholders.
- **Unified Geospatial Interface (UGI):** It will operationalize to provide consumer-oriented products, applications, services, and solutions using the Geospatial data.
- **Survey of India (SoI):** It shall be the agency responsible for developing and operating the NGDR and the UGI in collaboration with **BISAG-N**, other institutions, and the private sector, under the guidance and supervision of **GDPDC**.
- **Mapping infrastructure:** This Policy shall replace the National Map Policy, 2005. Government to collaborate with private and other agencies for improving Geospatial information delivery.
- **Geospatial Education and Skill Development:** National Institute for Geo-informatics Science and Technology (NIGST), Indian Institute of Remote Sensing (IIRS), and/or any suitable institute(s), public or private, will be developed into Centre(s) of Excellence for Geospatial Science & Technology.
- **Geospatial Enterprise:** An enabling ecosystem will be provided for industry, academia, and research with ease of doing business and proactively engaging them in various spheres of the Geospatial domain.
- An advisory body named as **Geospatial Industrial Development Board (GIDB)** will be constituted under GDPDC for advancing the growth of the Indian Geospatial entities.

Significance of National Geospatial Policy:

- The focus of the National Geospatial Policy is to make geospatial technology and data agents of transformation for achieving sustainable development goals, bringing efficiency in all sectors of the economy and instilling accountability and transparency at all levels of governance.
- **Atmanirbhar Bharat:** The Policy recognizes the importance of locally available and locally relevant Maps and Geospatial Data in improved planning and management of resources and better serve the specific needs of the Indian population.

- **IGIF:** The National Geospatial Policy seeks to draw on international best practices, such as work by the **United Nations Global Geospatial Information Management (UN-GGIM) Committee of Experts** and the **Integrated Geospatial Information Framework (IGIF)**, to strengthen national-level spatial information management arrangements across our country.
- The Policy seeks to create a conducive business atmosphere and facilitate ease of doing business for a prosperous geospatial sector economy by enhancing the effectiveness of the policies and their implementation.
- The Policy will support innovation, creation, and incubation of ideas and start-up initiatives in the Geospatial Sector that will enable leapfrogging of outdated technologies and processes, bridging the geospatial digital divide and capitalizing on the opportunities due to continually evolving Technology.
- The National Geospatial Policy will encourage open-source software, open data, and platforms.

The Geospatial sector in India, however, has not realized its true potential and registered around 15% per annum growth whereas it has the potential to grow annually at 25% and more. The National Geospatial Policy aims to provide an enabling environment in which the Indian Industry can flourish and minimize its dependence on foreign data and products, thereby contributing to an Atmanirbhar Bharat.

Practice question:

Q. State how geospatial technology has applications in almost every domain of the economy? Also discuss how the National geospatial policy, 2022 will ensure an Atmanirbhar economy?

7. JAMES WEBB SPACE TELESCOPE

Context: James Webb Space Telescope has provided a glimpse of the early universe in a new image to the astronomers.

Overview about the news:

- Telescope captured an image of a galaxy cluster called **MACS0647**, as well as distant galaxy **MACS0647**-JD.
- The distant galaxy is visible because of a certain type of observational phenomenon called **gravitational lensing**.

A **gravitational lens** can occur when a huge amount of matter, like a cluster of galaxies, creates a gravitational field that distorts and magnifies the light from distant galaxies that are behind it but in the same line of sight. The effect is like looking through a giant **magnifying glass**. It allows researchers to study the details of early galaxies too far away to be seen with current technology and telescopes.

About James Webb Space Telescope:

- Also called **JWST or Webb**, it is NASA's largest and **most powerful** space science telescope.
- Formerly known as the **"Next Generation Space Telescope"** (NGST), JWST is more powerful than its predecessors.
- It will be able to see further into space to discover distant planets in far-off galaxies.
- It is an international collaboration between NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA).
- The multipurpose observatory launched in December 2021 on an Ariane 5 rocket from Europe's Spaceport in French Guiana on the north-eastern coast of South America.

Objectives of the Webb space telescope:

- Search for the galaxies that formed the very beginning after the **Big Bang**.
- Determine the evolution of galaxies from their earlier formation until now.
- Observe the stages of the formation of stars until the formation of planetary systems.
- Measure the physical and chemical properties of planetary systems and investigate the potential for life in such systems.

Features of James Webb telescope:

• Vision: Webb views the universe in infrared. It is a zone on electromagnetic spectrum with slightly longer wavelengths than visible light. It will be the only infrared-specialized telescope in space that can see long distances.

- **Mirrors:** Its primary mirror is 6.5 metres in diameter, bigger than any mirror previously launched into space. The size heightens the sensitivity of the telescope, larger the mirror area collecting light, more details it can capture of a star or galaxy.
- **Location/Orbit:** It will not be in orbit around Earth but will orbit Sun, 1.5 million kilometers away from the Earth at second Lagrange point or L2.
- L2 lets telescope stay in line with Earth as it moves around Sun. This allows satellite's large sunshield to protect telescope from light and heat.
- **Major elements:** Webb's instruments are contained within the Integrated Science Instrument Module (ISIM) which is one of three major elements that comprise JWST. The others are **Optical Telescope Element (OTE)** and **Spacecraft Element (Spacecraft Bus and Sunshield)**.
- **Main instruments:** The ISIM is the heart of Telescope, called main payload. It houses the four main instruments that will detect light from distant stars and galaxies, and planets orbiting other stars.

Hubble Space telescope:

- NASA has called the Webb telescope the successor of Hubble.
- The **Hubble Space Telescope** was launched into low Earth orbit in 1990 and has made more than 1.4 million observations, including tracking interstellar objects, capturing a comet colliding with Jupiter, and discovering moons around Pluto.
- Hubble has captured galaxies merging, probed supermassive black holes, and has helped scientists understand the history of the universe.

Key differences between Hubble and James Webb Telescope:

	Dimension	Hubble telescope	James Webb Telescope
1.	Size	The instruments on Hubble mainly focus on the ultraviolet and visible parts of the spectrum. It could observe only a small range in the infrared from 0.8 to 2.5 microns.	Webb Space Telescope has four scientific instruments to observe primarily in the infrared range and provide coverage from 0.6 to 28 microns
2.	Size	Hubble's mirror was much smaller, about 2.4 meters in diameter hence it covered a lesser field of view.	Webb's primary mirror has a diameter of 6.5 meters which will have a larger field of view.
3.	Orbit	Hubble orbits around the Earth at an altitude of about 570 km.	Webb will orbit the sun at about 1.5 million kilometres away from Earth.
4.	Area of Study	Webb's near- and mid-infrared instruments will help study the first formed galaxies, exoplanets, and birth of stars.	Webb's near- and mid-infrared instruments will help study the first formed galaxies, exoplanets, and birth of stars.

Webb has been designed to answer outstanding questions about the Universe and to make breakthrough discoveries in all fields of astronomy. It will have a unique and profound role in transforming our understanding of astrophysics and origins of galaxies, stars, and planetary systems.

Practice Question:

Q. Why is James Webb Telescope considered to be a milestone in space exploration? Discuss how the mission will benefit the human race while stating the goals and objective of the mission?

8. LIGO-INDIA PROJECT

Context:

text: The government has given the final go-ahead to **India's Laser Interferometer Gravitational-Wave Observatory, or LIGO, project**, clearing the way for the construction of the country's biggest scientific facility that will join the ongoing global project to probe the universe by detecting and studying gravitational waves.

What is LIGO-India?

 LIGO-India will be an advanced gravitational-wave observatory to be located in India as part of a worldwide network.

Brief about LIGO

- LIGO is a **network of laboratories**, spread around the world, designed to detect gravitational waves produced by the movement of large celestial objects like stars and planets.
- These ripples were first postulated in **Albert Einstein's General Theory of Relativity** that encapsulates our current understanding of how gravitation works.
- In **2015**, LIGO made history by detecting gravitational waves for the first time.
- Background: LIGO-India had received the government's in-principle approval in February 2016. Since then, the project reached several milestones towards selecting and acquiring a site and building the observatory.
- **Collaboration**: It is envisaged as a collaborative project between a consortium of Indian research institutions and the **LIGO Laboratory in the USA**, along with its international partners.
 - The United States will provide key components for the lab worth USD 80 million, which amounts to Rs 560 crore.
- **Built by:** The LIGO-India project will be built by the Department of Atomic Energy and the Department of Science and Technology, with a memorandum of understanding (MoU) with the National Science Foundation, the US, along with several national and international research and academic institutions.
- Location: Hingoli district of Maharashtra, about 450 km east of Mumbai

Gravitational waves

- Gravitational waves are 'ripples' in space-time caused by some of the most violent and energetic processes in the Universe.
- Gravitational waves are invisible.
- They travel at the speed of light (1,86,000 miles per second). Gravitational waves squeeze and stretch anything in their path as they pass by.
- Albert Einstein predicted the existence of gravitational waves in 1916 in his general theory of relativity.
- General theory of relativity concludes that objects of mass warp the very fabric of space-time.
- Most powerful gravitational waves are created when objects move at very high speeds.
- LIGO-India will be an **extremely sensitive interferometer** capable of sensing **gravitational waves** generated during the **merger of massive astrophysical objects** such as **black holes, and neutron stars**.
- The observatory comprises **two 4-km-long vacuum chambers**, built perpendicular to each other. **Highly reflective mirrors** are placed at the end of the vacuum chambers.
- **Fifth node:** LIGO India would be the **fifth node** of this international network of gravitational wave observatories. Currently, there are following operational gravitational wave observatories around the world-
 - ▶ two in the United States (Hanford and Livingston)
 - ▶ one in Italy (Virgo)
 - one in Japan (Kagra)

Practice questions:

Q. Briefly explain the Laser Interferometer Gravitational-Wave Observatory (LIGO). How will the establishment of LIGO-India contribute to advancing India's scientific capabilities?

9. SPACE TOURISM

Context: Indian Space Research Organisation (ISRO) is planning space tourism by 2030.

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What is space tourism?

Space tourism, intends to give tourists the opportunity to experience space flight for fun, work, or other purposes by putting them in the position of astronauts.

Various companies like Blue Origin, virgin galactic and Elon Musk's SpaceX have already entered the space tourism industry.

Overview:

- The objective of India's maiden human spaceflight programme **Gaganyaan** is demonstration of human spaceflight capability to **Low Earth Orbit**, which is a precursor to future Space Tourism Programme.
- ISRO has carried out a few feasibility studies for a sub-orbital space tourism mission.

Pros

- **Job creation:** Commercial space tourism has the potential to boost the economy by creating jobs and encouraging investment.
- Advances in research: Spending more time in space could help solve some of the most baffling mysteries about the universe.
- **Opportunity to experience space:** At Space Perspective, we want to enable more people than ever before to go to space to gaze into the unknown and imagine what could be, and to look down at Earth and gain a new perspective on home.
- **Economic Impact:** the market size of space tourism was USD \$598 million in 2021 and it is expected that the market for space tourism would reach multi-million dollar levels in the next 10 years.

Cons

- **Expensive:** Many people point out that the hefty price tag is one major downside to today's space travel. At hundreds of thousands of dollars per ticket, only the wealthiest travelers can afford a seat on a future spaceflight.
- It may be bad for the environment: Scientists also worry that space travel could damage the planet and contribute to climate change. One study found that the carbon released by 1,000 private suborbital flights per year would increase the temperature over the poles by 1 degree Celsius and reduce polar sea ice levels by 5% each year.
- **Space debris:** Space tourism and satellite deployment have contributed to a significant amount of space debris orbiting Earth, which poses risks to future space missions and the safety of spacecraft.
- Lack of responsibility and regulation: The space tourism industry is relatively new, and there are insufficient regulations to ensure the safety of passengers and the environment.

Future of space tourism:

- Need to formulate laws and legislations that shall regulate issues of space tourism including the regulation of private players.
- Need for habitable structure apart from international space station
- Future of space tourism has the ability to positively impact many socioeconomic factors on Earth including creating jobs, educating citizens about space and fostering further innovation in the space economy.
- Need for environmental regulation to reduce the climatic damage from this fast-growing industry

10. CONTROLLED RE-ENTRY OF THE SATELLITE:

Context: ISRO successfully carried out controlled re-entry experiment of decommissioned **Megha-Tropiques-1 (MT-1) satellite.**

About

- MT-1 was launched by ISRO and French space agency for carrying out tropical weather and climate studies.
- Controlled re-entries involve deorbiting (large satellites/rocket bodies) to very low altitudes to ensure impact occurs within a targeted safe zone.
- UN/IADC (Inter-Agency Space Debris Coordination Committee) space debris mitigation guidelines recommend deorbiting a LEO (Low Earth Orbit) object at its End Of Life:

- Through controlled re-entry to a safe impact zone. By bringing it to an orbit where orbital lifetime is less than 25 years.
- Space debris encompasses both natural (meteoroid) and artificial (man-made) particles.
 - > Much of the debris is in LEO, though some debris can be found in geostationary orbit.
 - > LEO is normally at an altitude of less than 1000 km but could be as low as 160 km above Earth.

Initiatives taken by ISRO for space debris mitigation:

- **ISRO System for Safe and Sustainable Space Operations Management (IS4OM)** for tracking and monitoring space objects.
- Project NETRA: To provide first-hand information on the status of debris.





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3

HEALTH

1. ONE HEALTH APPROACH

Context: Four multilateral agencies have launched a **One Health Joint Plan of Action** (2022-2026).

One Health is a collaborative, multi-sectoral, and transdisciplinary approach — working at the local, regional, national, and global levels — with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment.

One Health is a collaborative, multi-sectoral, and transdisciplinary approach — working at the local, regional, national, and global levels — with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment.

- One Health calls for a holistic, integrated and systems-based approach that recognizes the interconnection between the health of humans, animals, plants and the environment.
- It mobilizes multiple sectors, disciplines and communities to work together to foster well-being and tackle threats to health and ecosystems.
- At the same time, the approach aims at addressing the collective need for clean water, energy and air, safe and nutritious food, taking action on climate change, and contributing to sustainable development.
- It is the primary approach for addressing the complex health challenges facing our society, such as ecosystem degradation, food system failures, infectious diseases and antimicrobial resistance (AMR).

About One Health Joint Plan of Action (2022-2026):

Launched as collaborative approach between:

- United Nations (UN) Food and Agriculture Organization (FAO),
- UN Environment Programme (UNEP),
- World Health Organziation (WHO)
- World Organisation for Animal Health.

The plan is valid from 2022-2026 and is aimed at mitigating the health challenges at global, regional, and country levels.

It will create a framework and integrate systems and capacity to collectively better prevent, predict, detect and respond to health threats to all living beings as well as the environment.

Action tracks highlighted in Plan of Action:

- Enhancing one health capacities to strengthen health systems.
- Reducing the risks from emerging and re-emerging zoonotic epidemics and pandemics.
- Controlling and eliminating endemic zoonotic, neglected tropical and vector borne diseases.
- Strengthening the assessment, management and communication of food safety risks.
- Curbing the silent risk of anti-microbial resistance.
- Integrating the environment into one health.



What are common One Health issues?

One Health issues include emerging, re-emerging, and endemic zoonotic diseases, neglected tropical diseases, vector-borne diseases, antimicrobial resistance, food safety and food security, environmental contamination, climate change and other health threats shared by people, animals, and the environment. For example:

- Antibimicrobial-resistant germs can quickly spread through communities, the food supply, healthcare facilities, and the environment (soil, water), making it harder to treat certain infections in animals and people.
- Vector-borne diseases are on the rise with warmer temperatures and expanded mosquito and tick habitats.
- **Diseases in food animals** can threaten supplies, livelihoods, and economies.
- The **human-animal bond** can help improve mental well-being.
- **Contamination of water** used for drinking, recreation, and more can make people and animals sick.

Even the fields of **chronic disease**, mental health, injury, occupational health, and non-communicable diseases can benefit from a One Health approach involving collaboration across disciplines and sectors.

Need for one health approach:

- **Tackle Emerging infectious diseases**: 75% of Emerging infectious diseases and almost all recent pandemics are zoonotic in nature ("Disease X" as highlighted by WHO).
- **Extension of Human activities:** Human activities like encroachment into natural habitats and altering them to extract resources, expansion of human populations into new geographic areas.
- **Growing threat of antimicrobial resistance:** Emergence and spread of antibiotic resistant pathogens is on the rise due to irrational use of antibiotics in humans and animals, contaminated environments, and ineffective infection control policies.
- **Climate change:** These factors are reinforcing the above trend by increasing pressure on land use and food systems and providing new, potentially more suitable, conditions for pathogens and diseases to develop and spread.

Global initiatives in line with one health approach:

- **The Pilanesberg Resolution, 2001:** It was targeted at multilateral and bilateral donors and governmental authorities to consider potential wildlife health impacts in development projects.
- **One World-One Health:** Introduced by The Wildlife Conservation Society (WCS) in 2007 along with 12 recommendations (Manhattan Principles) that focused on establishing a more holistic approach to preventing epidemic disease and maintaining ecosystem integrity.
- **National Framework for One Health, 2021** by FAO guides towards overcoming the systemic barriers to implement the One Health approach.

Steps taken to implement one health approach in India:

- **Institutional collaboration:** Institutes like Indian Council of Medical Research (ICMR) and Indian Council of Agricultural Research (ICAR) have collaborated for joint research priorities, to control disease outbreaks.
- One Health Support Unit (OHSU) initiated by the Department of Animal Husbandry and Dairying (DAHD), to develop a national One Health Framework.
- Under it, the pilot project are being implemented in states like Uttarakhand and Karnataka.
- National Mission on Biodiversity and Human Well-being (NMBHWB): It explicitly links biodiversity to human health by integrating biodiversity, ecosystem services, climate change, agriculture, health, bio-economy and capacity-building in the realm of biodiversity science.
- **One Health' project:** Launched by department of Biotechnology, It envisages carrying out surveillance of important bacterial, viral and parasitic infections of zoonotic as well as trans boundary pathogens in India, including the North-eastern part of the country.

Possible outcomes of one health approach:

• Prevent outbreaks of zoonotic disease in animals and people.

- Improve food safety and security.
- Reduce antibimicrobial-resistant infections and improve human and animal health.
- Protect global health security.
- Protect biodiversity and conservation.

By promoting collaboration across all sectors, a One Health approach can achieve the best health outcomes for people, animals, and plants in a shared environment.

Practice question:

Q. Mention the relevance of "one health approach" in today's world. Highlight the steps and initiatives taken in India to implement one health approach.

2. MEDICAL BIOTECHNOLOGY

Context: The biotechnology industry has seen remarkable growth and progress over the past few years.

About Medical Biotechnology:

- Medical biotechnology is a branch of medicine that uses living cells and cell materials to research and then produce pharmaceutical and diagnosing products.
- These products help treat and prevent diseases.
- The Indian Biotechnology has witnessed a manifold increase in valuation in the past ten years, with COVID-19 giving the industry a much-needed push.
- India is poised as one of the leading destinations for bio innovation and bio manufacturing, and hence is identified as a sunrise sector.

Medical Biotechnology providing avenues for technological growth while saving lives:

- **Recombinant DNA Technology**: It is combining **DNA molecules** from two different species and then inserting that **new DNA** into a host organism. That host organism will produce new genetic combinations for medicine, agriculture, and industry. The genetically modified products are able to perform better than the regular medicine or produce. **Recombinant agriculture** is able to be more pest resistant or weather resistant; recombinant medicine like insulin is able to better work with bodies, etc.
- Medical utility: The ability of therapeutics and vaccines to treat and prevent diseases has been well documented. Biotechnology has been central to these advances, progressively offering the ability to make more complicated medicines and vaccines, opening up the treatment and prevention of a broader set of diseases.
 - Accurate diagnostic: Biotechnology has the potential to provide the platforms needed for rapid identification of biological threats, development of potential cures and global manufacturing of the solutions.
- **Stem Cell Research:** Biotechnology plays a big part in supporting stem cell research, which supports the exploration of growing stem cells in a lab setting or in vitro. This could help in situations where patients may be suffering from a disease or disorder where implanting stem cells could help restore their vitality and give them a new lease on life.
- **Agriculture:** Biotechnology can be used to create genetically modified crops for combating hunger and malnutrition. Modern biotechnology techniques can be used to add, delete, or edit specific genes to produce a desired variety that withstand natural calamities, pests, and diseases lessen the need to use pesticides and insecticides.
- **Environment:** Biotechnology has the potential to help mitigate pollution by using microbes and their byproducts, instead of chemical methods, to treat solid, liquid, and gaseous wastes. For example, some bacterial enzymes can digest the raw material used to produce single-use bottles for beverages.
- **Dairy/Animal Biotechnology:** Apart from enhancing the quality and quantity of milk, meat, and other animal products like wool produced through the use of recombinant DNA technology, therapeutic proteins/drugs can also be made to be produced in animal products.

Reasons why India is considered a land of opportunities in the field of biotechnology:

- **Growing market:** India is among the Top 12 destinations for biotechnology worldwide and 3rd largest destination for biotechnology in Asia Pacific. India is poised as one of the leading destinations for bio innovation and bio manufacturing, and hence is identified as a sunrise sector.
- **Biggest supplier:** India is one of the biggest suppliers of low-cost drugs and vaccines in the world. India also leads in biosimilars, with the greatest number of biosimilars approved in the domestic market.
- **Largest producer:** With nearly 55% of Indian terrain under agriculture and allied activities, India is one of largest producer of BT-Cotton and has the 5th Largest Area of Organic Agriculture Land Globally.
- **Waste disposal:** The application of biotechnology to industrial processes is transforming manufacturing and waste disposal across the country.
- **Research ecosystem:** India offers a strong capability in contract manufacturing, research and clinical trials, and is home to the most US FDA approved plants globally outside of the US.
- **Entrepreneurship:** India has more than 5300 biotech startups, which are estimated to reach 10000 by 2025.
- **Relaxed Investment norms:** The government of India has allowed 100% FDI under the automatic route in the biotech startups which will foster a sense of innovation in the country.

From the Ebola vaccine to mapping human DNA to agricultural impacts, medical biotechnology is making huge advancements and helping millions of people with India taking a lead in the field. Valued at \$ 80.12 Bn in 2022, the Indian Biotechnology Industry is targeted to reach \$ 150 Bn by 2025 and \$ 300 Bn by 2030.

Initiatives taken by government to address the issue of Tuberclosis:

- National Strategic Plan for Tuberculosis Elimination 2017-2025
- National Tuberculosis Elimination Program (NTEP)- Centrally Sponsored Scheme
- TB Harega Desh Jeetega Campaign
- Bacillus Calmette–Guérin (BCG) vaccine included in the Indradhanush program.
- **National TB Elimination Programme** to meet the goal of ending the TB epidemic by 2025 the country, five years ahead of the Sustainable Development Goals (SDG) for 2030
- **Two vaccines VPM (Vaccine Projekt Management) 1002 and MIP (Mycobacterium Indicus Pranii)** have been developed and are under Phase-3 clinical trial.
- Ni-kshay Poshan Yojana: It provides Rs 500 support through direct benefit transfer to the patients.
- **'Dare2eraD TB' campaign-** data-driven research to eradicate TB in the year 2022 while citing the goal to achieve TB Mukt Bharat by 2025.

If we look at the broader spectrum of biotechnology and its implications in the treatment of TB, it has played a critical role in TB control in India and across the globe. Biotechnology-based diagnostic tests, drug development, and vaccine development are revolutionizing TB control and providing new hope in the fight against this deadly disease. We can accelerate progress towards the goal of TB elimination by continuing to invest in biotechnology-based research and development.

Practice Question:

Q. Discuss how medical biotechnology is providing avenues for technological growth while saving lives. Highlight the reasons as to why India is considered to be a land for opportunities in the field of biotechnology.

3. TRANS FAT

Context: Five billion people unprotected from trans fats leading to heart disease.

What are trans fats?

• Trans fat are a type of unsaturated fats that has been modified through a process called hydrogenation.

- Trans fats are made when liquid oils are turned into solid fats, like shortening or margarine. These are called partially-hydrogenated oils (PHOs). This process changes the structure of the fat, making it more stable and solid at room temperature.
- Trans fats are often found in processed foods like baked goods, fried foods and snack foods. Like saturated fats, trans fats can raise levels of cholesterol and increase risk of heart disease.

Reasons why trans fats are harmful

- Trans fats raise your LDL (bad) cholesterol.
- They lower your HDL (good) cholesterol.
- High LDL along with low HDL levels can cause cholesterol to build up in your arteries (blood vessels). This increases your risk for heart disease and stroke.
- Many high-fat foods such as baked goods and fried foods have a lot of trans fat. Their regular consumption affects you overall health.
- Consuming a lot of fat can lead to unwanted weight gain. Excess weight increases the risk for diabetes, heart disease, and other health problems.

Actions taken to combat Trans-fats in India:

- **PFA Act, 1954:** Prevention of Food Adulteration (PFA) rules were introduced under PFA Act, 1954. According to these rules, it was mandatory for food products containing hydrogenated vegetable oils or bakery shortening to declare on their label "hydrogenated vegetable fats or bakery shortening used contains trans-fats".
- Amendment to Food Safety Standards Regulations, 2011:Under this regulationthe limit of trans fats in margarine, bakery shortening, inter esterified vegetable oils and Vanaspati was set to "not more than 10% by weight" which was further reduced to "not more than 5% by weight" in the year 2015.
- India@75: As a commemoration of the 75th year of Indian Independence, FSSAI had launched a campaign called India@75: Freedom from Trans-fats. The campaign is set to align with the global target of eliminating Trans fats completely from India by 2022.
- Heart Attack Rewind: The first mass media campaign of its kind supported FSSAI's global target of eliminating trans-fat in India by the year 2022, a year ahead of the global target by the World Health Organization (WHO) for complete elimination of trans fat.

Complete elimination of trans-fats from our food supply chain, though a hard challenge is a proven means to minimizing cardiovascular deaths and requires dedication of an entire generation to achieve the end. While increasing the longevity on one hand, it has the capacity to improve the workforce by minimizing the healthcare requirements-both physically and financially. Science-based policies and regulatory compliances to check the food industry participation in a multipronged approach from FSSAI will be a huge contributor to meet this goal.

Practice Question:

Q. What are Trans fats? Discuss the reasons why Trans fats are considered harmful. Mention the initiatives taken by the government to combat trans fats in India.

4. PRET (PREPAREDNESS AND RESILIENCE FOR EMERGING THREATS) INITIATIVE:

Context: World Health Organisation (WHO) has launched Preparedness and Resilience For Emerging Threats (PRET) Initiative.

About PRET Initiative:

- PRET is an innovative approach to improving disease pandemic preparedness.
- It recognizes that the same systems, capacities, knowledge, and tools can be leveraged and applied for groups of pathogens based on their mode of transmission (respiratory, vector-borne, foodborne etc.).
- It incorporates the latest tools and approaches for shared learning and collective action established during the COVID-19 pandemic and other recent public health emergencies.
- It places the principles of equity, inclusivity, and coherence at the forefront.



- PRET provides a platform for national, regional and global stakeholders to collaborate to strengthen preparedness.
- PRET operate under the aegis of the International Health Regulations (IHR).
- IHR 2005 is a legally binding agreement of 196 States Parties, including all 194 Member States of WHO to build the capability to detect and report potential public health emergencies worldwide.
- IHR sets out the core capacities that countries need to be able to detect and respond effectively.
- WHO plays the coordinating role in IHR implementation and, together with its partners, helps countries to build capacities.
- IHR require that all countries have the ability to Detect; Assess; Report; and Respond.

Systems and capacity:

PRET recognizes that there are **3 tiers of systems and capacities** relevant for pandemic preparedness those that are:

- cross-cutting for all or multi-hazards,
- Relevant for groups of pathogens (respiratory, arboviruses etc.),
- are specific to a pathogen

Technical actions:

- The technical actions in PRET are mapped to the IHR core capacities, grouped according to five subsystems for health emergency preparedness, response and resilience (HEPR).
- HEPR under WHO is a learning channel brings together resources for WHO, national counterparts and partners to outline the process of developing national investment plans to apply for additional resources, including Pandemic Fund resources.

Practice Question:

Q. Discuss the role of Preparedness and Resilience for Emerging Threats (PRET) in improving pandemic preparedness. Mention how COVID-19 has served to be an eye opening event in this regard.





DEFENSE TECHNOLOGIES

1. SPACE TECHNOLOGY AND INDIAN ARMED FORCES

Context: Absence of a space force huge gap in India's security cover, must be filled on priority as adversaries like Pakistan and China can impact India's space capabilities through **jamming**, **lazing**, **hacking**, **or spoofing**.

About:

- Armed forces, tasked with maintaining peace and security at and within Indian borders. Indian Armed Forces also conduct search and rescue operations during natural calamities and disasters playing a humanitarian role in peacetime.
- Space technology plays an essential role in augmenting the capacity of the Armed Forces to fulfill its objectives.
- It boosts India's defense preparedness by aiding in **reconnaissance**, weather tracking, communication, and **navigation** among others.

Space technology augmenting the capabilities of Indian armed forces:

- **Border management**: India has deployed military satellite **RISAT** which can help trace any unusual activity in the border terrains and transmit the information to ground sources to address the situation.
- **Navigation**: From target location to guiding weapons systems. There are two main systems: the US military's global positioning system or GPS, The **Indian Regional Navigation Satellite System** (NavIC), is an autonomous regional satellite navigation system that provides accurate real-time positioning and timing services. It covers India and a region extending 1,500 km around it.
- **Telecommunications (telecoms): GSAT 7 and GSAT 7A** enable the exchange of information, for example between the 'front-line' and strategic commanders, so decisions can be based on up-to-date intelligence.
- **Multi band communication:** India has Geosynchronous Satellite (GSAT) 7 in a Geosynchronous Transfer Orbit since 2013 to meet the Indian Navy's multi-band communication requirements over the whole of the Indian Ocean region.
- **Early warning**: Infrared satellite sensors can spot missile launches by detecting their hot plumes. However, the technology to track missiles along their trajectory, from space, is in its early stages.
 - ► Surveillance: India has an Electromagnetic Intelligence Gathering Satellite or *EMISAT* which is equipped with an Electronic Intelligence (ELINT) package called Kautilya that allows the collection of information on ground-based radar as also electronic surveillance across India.
- **Meteorology**: India is a country with vast and rugged terrains, especially on its borders. Advanced information about the climate and weather conditions can help the military be better prepared to guard the borders, especially during the time of war.
- **Situational awareness: EMISAT satellite** enhances the situational awareness of the Indian Armed Forces by providing information about the **hostile radars**.

In March 2019, India conducted an Anti-Satellite Test to demonstrate its capability to shoot down satellites in space. The test helped India develop deterrence capability against adversaries who may want to attack Indian satellites to cripple systems in times of war.



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the Indian industry and start-ups the government has launched **Mission DefSpace** which will promote indigenization of military products. The undebatable conclusion is that India must strive to keep space peaceful but at the same time gear up for military confrontation in space so as to affirm its ambition of becoming a global power.

Practice question:

Q. Advancement in Space technology will help the defence sector in harnessing its unrealized potential. Discuss.

2. DEFENCE INDIGENIZATION

Context: India has been making progress with its self-reliance project or the **Atmanirbhar Bharat** (AB) initiative that was launched in May 2020. This flagship undertaking has shown signs of incremental progress in the defence sector.

Overview:

- As India inches to achieve its rightful strategic autonomy, it needs to do much more in planting the seeds for a commercially viable and technologically robust indigenous defence industrial base along with promotion of developing defence equipment in India.
- **Defence indigenisation** has remained the inner calling of a nation, which has the third largest Army, is the eighth largest military spender and has emerged as the largest importer of weapon systems and platforms in the world.
- Even when defence products are manufactured domestically, there is a large import component. This factor reflects that Make in India itself is not sufficient for an evolving sector like defence, thus there is a need to promote indigenization for holistic development of the sector. All these factors make the Indian defence market one of the most attractive globally and provides an immense opportunity for both domestic and foreign players in the defence sector.

The facts

- India has the **third largest Army**, the **fourth largest Air force** and the **seventh largest Navy** in the world.
- India is among the **top 10 countries in the world in terms of military expenditure** and **world's largest arms importer**.
- India allocates about **1.8% of its GDP towards defence spending**, of which 40% is allocated to capital acquisitions and only about 30% of India's equipment is manufactured in India, mainly by public sector undertakings.

A country like India with its immense potential and strategic location requires being self-reliant, hence it is important to pursue the idea of indigenisation for:

- **Self-defence:** The presence of hostile neighbours like China and Pakistan makes it improbable for India to boost its self-defence and preparedness.
- **Strategic advantage:** Self-reliance will make India's geopolitical stance strategically stronger as a net security provider.
- **Technological advancement**: Advancement in the defence technology sector will automatically boost other industries hence catapulting the economy further ahead.
- **Economic drain:** India spends around 3% of GDP on defence and 60% of that is spent on imports. This leads to an immense economic drain.
- **Employment:** Defence manufacturing will need the support of numerous other industries which generate employment opportunities.

Progress in defence indigenization:

- **INS Vikrant:** India's first indigenous aircraft carrier 1 (IAC 1).
- Tejas aircraft: DRDO is trying to develop an indigenous Kaveri engine for the aircraft.

- **Project 75:** Indian navy's submarine program dealt with France, Germany, Russia, Sweden, Spain, and Japan to build six advanced stealth submarines. INS Kalvari, INS Khanderi, INS vela are constructed by Mazagaon Dock Ltd in Mumbai.
- **"Dhanush**", first indigenous Long-range artillery gun.
- Arihant: India's first indigenous nuclear submarine by BARC and DRDO
- Agni V: The ICBM (intercontinental ballistic missile)
- The **Pinaka** multi-barrel rocket launcher was developed by RDE, Pune.
- Supersonic cruise missile **Brahmos** was developed by a joint venture with Russia.
- **Arjun tank:** the third-generation main battle tank developed DRDO and produced by Indian Ordnance Factories.

Issues related to defence indigenization:

- Lack of an institutional capacity and capability to take different policies aimed at indigenisation of defence to its logical conclusion.
- **Dispute Settlement body:** There is an urgent need for a permanent arbitration committee which can settle disputes expeditiously.

In the USA, the **procurement agency DARPA** has a permanent arbitration committee which resolves such issues amicably and their decision is final.

- Infrastructural deficit increases India's logistics costs thus reducing the country's cost competitiveness and efficiency.
- Land acquisition issues restrict entry of new players in the defence manufacturing and production.
- Policy dilemma offset requirements under the DPP are not helping it achieve its goal. (Offsets are a portion of a contracted price with a foreign supplier that must be re-invested in the Indian defence sector, or against which the government can purchase technology.

The requirement for domestic production of defence equipment is more than for any other sector because it will not only save precious foreign exchange but will address the national security concerns. 'Make in India' policy aims at facilitating investments and fostering innovations for the manufacturing sector in India and stands imperative for indigenization of defence technology.

Practice Question:

Q. Discuss the need for defence indigenization while highlighting the progress in the said arena. Also mention the initiatives taken by government to promote defence indigenization.



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BIOTECHNOLOGY, NANOTECHNOLOGY, INTELLECTUAL PROPERTY RIGHTS

1. GENOME EDITING VS. GENOME TECHNOLOGY

Context: The government of India has been taking initiatives regarding developing **CRISPR Cas9 technology** since 2017 that will not just enable editing parts of the genome of DNA sequence, but will also make it affordable.

Overview:

- Genome editing (also called gene editing) is a group of technologies that give scientists the ability to change an organism's DNA.
- These technologies allow genetic material to be added, removed, or altered at particular locations in the genome. Genome editing is of great interest in the prevention and treatment of human diseases.
- Although, it is being said that rampant deployment of this technology may pose marginal risk to the economy, human health and the environment.

Difference between genome editing technology and GM Technology:

- **Genetically modified organisms (GMO)** involves modification of the genetic material of the host by introduction of a foreign genetic material.
- In the case of agriculture, soil bacteria is the best mining source for such genes which are then inserted into the host genome using genetic engineering.
 - ➤ For example, in case of cotton, introduction of genes cry1Ac and cry2Ab mined from the soil bacterium Bacillus Thuringiensis (BT) allow the native cotton plant to generate endotoxins to fight pink bollworm naturally.
- The basic difference between genome editing and genetic engineering is that while the former does not involve the introduction of foreign genetic material, the latter does.
- In the case of agriculture, both the techniques aim to generate variants which are better yielding and more resistant to biotic and abiotic stress.
- Before the advent of genetic engineering, such variety improvement was done through selective breeding which involved carefully crossing plants with specific traits to produce the desired trait in the offspring.

Risks posed by gene editing:

- Gene-edited organisms are prone to unintended and unexpected effects at the molecular level. These could pose a threat to human health and the environment if commercialized without comprehensive mandatory safety assessment and oversight.
- Gene drives, designed to drive a particular trait through the entire population of a species, could have far-reaching and unpredictable negative consequences for organisms and the environment.
- The prevalence of herbicide-tolerant gene-edited plant proposals implies that gene editing applications will further entrench a chemical-intensive approach to agriculture.
- Gene flow can reduce the differences between populations and decrease diversity within a population, thus broadly impacting biodiversity.

- Gene introgression into wild relatives may also pose more direct risks, depending on the introduced trait.
- Invasiveness of gene-edited animals in special cases involving traits increasing their fitness (ability to survive, reproduce, feed and persist in ecosystems) could theoretically pose risks to ecosystems should they escape or be deployed in unmanaged situations.

Introduction of gene-editing technologies will have far-reaching implications for agrifood and social systems in terms of its potential for improving and securing production of food. Introduction of gene-editing technologies will have far-reaching implications for agrifood and social systems in terms of its potential for improving and securing production of food.

Practice Question:

Q. Highlight the difference between genome editing and GM technology. Discuss the risks posed by gene editing to agriculture.

2. NANOTECHNOLOGY

Context: India to usher in revolution in global fertiliser space with nano technology.

About

Nanotechnology is the study and application of extremely small things (1 to 100 nanometers) and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering. Nanotechnology has the potential to play a significant role in environmental protection and sustainability by enabling new and improved methods for monitoring, cleaning up, and mitigating environmental pollutants.

Environmental application of Nanotechnology:

- **Generating less pollution during the manufacture of materials**: One example of this is how researchers have demonstrated that the use of **silver Nano clusters** as catalysts can significantly reduce the polluting byproducts generated in the process used to manufacture propylene oxide which is used to produce common materials such as plastics, paint, detergents and brake fluid.
- **Production of solar cells at a competitive cost:** Researcher have demonstrated that an array of silicon nanowires embedded in a polymer results in low cost but high efficiency solar cells. This, or other efforts using nanotechnology to improve solar cells, may result in solar cells that generate electricity as cost effectively as coal or oil.
- **Increasing the electricity generated by windmills:** Epoxy containing **carbon nanotubes** is being used to make windmill blades. The resulting blades are stronger and lower weight and therefore the amount of electricity generated by each windmill is greater.
- **Cleaning groundwater:** Researchers have shown that iron nanoparticles can be effective in cleaning up organic solvents that are polluting groundwater. The iron nanoparticles disperse throughout the body of water and decompose the organic solvent in place. This method can be more effective and cost significantly less than treatment methods that require the water to be pumped out of the ground.
- **Cleaning up oil spills:** Using **photocatalytic copper tungsten oxide** nanoparticles to break down oil into biodegradable compounds. The nanoparticles are in a grid that provides high surface area for the reaction, is activated by sunlight and can work in water, making them useful for cleaning up oil spills.
- **Reducing the cost of fuel cells:** Changing the spacing of platinum atoms used in a fuel cell increases the catalytic ability of the platinum. This allows the fuel cell to function with about 80% less platinum, significantly reducing the cost of the fuel cell.
- **Storing hydrogen for fuel cell powered cars:** Using graphene layers to increase the binding energy of hydrogen to the graphene surface in a fuel tank results in a higher amount of hydrogen storage and a lighter weight fuel tank. This could help in the development of practical hydrogen-fueled cars.

Healthcare applications of nanotechnology:

• **Treatment of cancer:** Commercial applications have adapted gold nanoparticles as probes for the detection of targeted sequences of nucleic acids, and gold nanoparticles are also being clinically investigated as potential treatments for cancer and other diseases.



- Low cost and high speed: The design and engineering of advanced solid-state nanopore materials could allow for the development of novel gene sequencing technologies that enable single-molecule detection at low cost and high speed
- **Regenerative medicines:** Research in the use of nanotechnology for regenerative medicine spans several application areas, including bone and neural tissue engineering.
- Vaccine Efficiency: Nanomedicine researchers are looking at ways that nanotechnology can improve vaccines, including vaccine delivery without the use of needles.

Energy Applications of Nanotechnology:

- **Enhanced efficiency:** Nanotechnology is improving the efficiency of fuel production from raw petroleum materials through better catalysis. It is also enabling reduced fuel consumption in vehicles and power plants through higher-efficiency combustion and decreased friction.
- **Oil and gas industry:** Nanotechnology is also being applied to oil and gas extraction through, for example, the use of nanotechnology-enabled gas lift valves in offshore operations or the use of nanoparticles to detect microscopic down-well oil pipeline fractures.
- **Pollution control:** Researchers are investigating carbon nanotube "scrubbers" and membranes to separate carbon dioxide from power plant exhaust.
- **Reduces power loss:** Researchers are developing wires containing carbon nanotubes that will have much lower resistance than the high-tension wires currently used in the electric grid, thus reducing transmission power loss.
- **Renewable energy:** Nanotechnology can be incorporated into solar panels to convert sunlight to electricity more efficiently, promising inexpensive solar power in the future. Nanostructured solar cells could be cheaper to manufacture and easier to install, since they can use print-like manufacturing processes and can be made in flexible rolls rather than discrete panels.
- **Longer electric charge:** Nanotechnology is already being used to develop many new kinds of batteries that are quicker-charging, more efficient, lighter weight, have a higher power density, and hold electrical charge longer.

Initiatives taken by the government for the promotion of Nano technology research and innovation:

Research and work on nanotechnology in India started in 2001 with the formation of the Nano Science and Technology Initiative with initial funding of Rs. 60 crores.

- Nano Mission:
 - ► It is an umbrella programme aims for the overall development of research in the field of nanotechnology and to make use of its applied potential for economic development.
 - It strives to promote basic research through funding to individual or group of scientists and create centres for excellence for promoting skills and education in this field.
- UNNATI Program (UNispace Nanosatellite Assembly & Training by ISRO):
 - > UNNATI is a capacity building programme on nanosatellite development.
 - The Programme provides opportunities to the participants from developing countries to strengthen their capabilities in assembling, integrating and testing of nanosatellites.
 - ▶ It is an ISRO initiative to commemorate the 50th anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE+50).
- Nanotechnology regulatory board was set up to regulate industrial nano products.
- **Nano technology institutes** like Indian Institute of Nano sciences at Bangalore,Mumbai,Kolkata were set up to promote the environment of innovation.
- **Nano technology initiatives program** were promoted by Department of Information technology and for nano electronic products.
- **Department of Science and Tech-Nanomission (nano-biotechnology activities)** through DBT, ICMR, and CoE in Nanoelectronics by MeitY support nanoscience, nanotechnology, nanobiotechnology, and nanoelectronics activities.
- Eighteen **sophisticated analytical instruments facilities** (SAIFs) established by DST across India play a major role in the advanced characterization and synthesis of nanomaterials for various applications.

- The Center of Excellence in Nanoscience and Nanotechnology established byDST Nanomission helps research and PG students in various thrust areas.
- **Thematic Units of Excellence (TUEs)** for various areas of nanoscience and nanotechnology play a major role in product-based research to support nanotechnology.

One possible means of bridging the gap between India's abundant, varied natural resources and her everincreasing requirements like clean water, food and rapid, low cost diagnostic machinery is the use of nanotechnology. Self reliance in nanotechnology can make good use of the natural and human resources India has and also help make India self reliant in sectors like defence and anti-terrorism.

Practice Question:

Q. Discuss the applications of nanotechnology while highlighting the risk the technology poses to the environment. Mention the key initiatives taken by the government for promotion of nanotechnology research and innovation.

3. INDIAN BIOLOGICAL DATA CENTRE

Context: Indian Biological Data Center (IBDC) was inaugurated at Faridabad, Haryana.

What is Biological Data?

The data that are collected from biological world are called biological data. For example, DNA sequence data, population data, genetical data, ecological data etc.

What is Biological database?

- Biological databases act as repository of biological information for utilization by researchers. The biological database is a collection of "entry" which is the unit of the data.
- Each entry includes nucleotide sequence data, protein sequence and 3D structure data, the biological nature such as gene function and other property of the sequence etc. and the information of submitters, references, source organisms.
- Biological databases are coherent, consistent and designed for a specific purpose to store a set of clearly defined data in an organized manner.
- The contents of database can easily be accessed, managed and updated. The contents of database can be analyzed with the help of defined algorithm.

About Indian Biological data center:

- IBDC is the **first national repository** for life science data in India.
- It is envisaged to emerge as a major data repository for all life science data emerging from India. Also, as per the Biotech-PRIDE guidelines, released last year, IBDC is mandated to archive all life science data generated from publicly funded research in India.
- It is being established at Regional Centre of Biotechnology (RCB), Faridabad in collaboration with National Informatics Centre (NIC).
- The digitised data will be stored on a four petabyte supercomputer called 'Brahm'.
- It is supported by Department of Biotechnology (DBT).
- IBDC is committed to the spirit of data sharing as per FAIR (Findable, Accessible, Interoperable and Reusable) principle.
- FAIR Data Principles, published 2016, are a set of guiding principles proposed by a consortium of scientists and organizations to support the reusability of digital assets.
- The database also contains most of the 2.6 lakh Sars-Cov-2 genomes sequenced by the Indian Sars-CoV-2 Genomic Consortium (INSACOG).
- Under IBDC, currently, two sections have been developed. These include:
- Indian Nucleotide Data Archive (INDA) shall archive nucleotide sequence data generated from publicly funded research projects in India and provide internationally accepted data accession numbers. The digitised genetic makeup of humans, plants, animals, and microbes.
- Indian Nucleotide Data Archive Controlled Access (INDA-CA).

• IBDC would have majorly two data access types i.e. Open access/time-release access and Restricted access.

Significance of Indian biological data center:

- **Improved understanding of genetic diseases:** Genome data management allows for the identification of genetic mutations and variants associated with various diseases, which can lead to improved diagnosis, treatment, and prevention strategies.
- **Enhanced drug discovery:** It can help identify new drug targets and facilitate drug discovery and development by providing a better understanding of the underlying genetic mechanisms of disease.
- **Personalized medicine:** Data repository can enable personalized medicine by providing a more comprehensive understanding of an individual's genetic makeup, which can help tailor treatment plans to their specific needs.
- **Improved agricultural productivity:** IBDC can help identify genetic markers associated with desirable traits in crops and livestock, which can improve breeding programs and increase agricultural productivity.
- **Evolutionary research:** It can facilitate research into the evolutionary relationships between species, providing insights into the history of life on Earth.
- **Studying zoonotic diseases:** The database currently stores the genomic sequences of crops such as rice, onion, tomatoes. With genomes of humans, animals, and microbes present in the same database, it will also help researchers in studying zoonotic diseases.
- **Research for vaccines:** The database will store the 25,000 sequences of mycobacterium tuberculosis. This will help in understanding the spread of multi-drug and extremely drug resistant TB, and aid the search for targets for new therapies and vaccines

Disadvantages of Indian biological data center:

- **Privacy concerns:** A centralized repository raises privacy concerns, as genetic information is highly personal and sensitive.
- **Ethical concerns:** It raises ethical concerns related to issues such as genetic discrimination and the potential for misuse of genetic information.
- **Data quality:** relies on accurate and reliable data and data quality issues such as errors or inconsistencies can affect the accuracy and usefulness of the data.
- **Computational challenges:** management of genome data requires powerful computing resources and specialized software tools to process and analyze large datasets, which can be expensive and time-consuming.
- **Standardization challenges:** Accumulation of Genome data involves a diverse array of data types and formats, which can make standardization and integration of data challenging.

Practice question:

Q. Indian biological data bank will reduce the dependency of Indian researchers and agencies on the western world. In the light of the above statement, discuss the significance of Indigenous data bank center.

4. CLONING

About:China has successfully cloned a wild Arctic wolf for the first time in the world. The Arctic
wolf (white wolf or polar wolf) is native to the High Arctic tundra of Canada's Queen
Elizabeth Islands.

About cloning:

Cloning is a technique scientists use to make exact genetic copies of living things. Genes, cells, tissues, and even whole animals can all be cloned.

- The copied material, which has the same genetic makeup as the original, is referred to as a clone.
- Despite having the same genetic material clones do not always look identical. This is because the environment also plays a role in deciding the physical feature of an organism.

• To clone a gene, researchers take DNA from a living creature and insert it into a carrier like bacteria or yeast. Every time that carrier reproduces, a new copy of the gene is made.

Do you know?

- Some clones already exist in nature. Single-celled organisms like bacteria make exact copies of themselves each time they reproduce.
- In humans, identical twins are similar to clones. They share almost the exact same genes. Identical twins are created when a fertilized egg splits in two.

Applications of cloning

- Animals can be cloned to have gene mutations that help scientists study diseases.
- Livestock can be cloned to produce more dairy products.
- Recreating extinct species to conduct studies and impacts.
- Cloned embryo could produce stem cells that can be used to fix damaged organs like spinal cord, insulinmaking cells to treat diabetes, etc.

Intellectual Property Rights

Context: Women in India face unique challenges in protecting their intellectual property rights.

What are intellectual property rights?

Intellectual property (IP) pertains to any original creation of the human intellect such as artistic, literary, technical, or scientific creation. IPR provide certain exclusive rights to the inventors or creators of that property, in order to enable them to reap commercial benefits from their creative efforts or reputation.

Role of IPR in encouraging innovation and rewarding entrepreneurs:

- Intellectual property serves as the foundation of innovation in our economy. Government-granted rights incentivize discovery and creativity by providing creators with an opportunity to profit from the value of their innovative work.
- The creative work is made public so that others may build on and benefit from the work of the original creator thus fostering an environment and push for innovation.
- Laws protecting intellectual property also reduce the transaction costs between inventors and industry by providing information about the quality of the invention without jeopardizing the ownership of the idea.
- For the entrepreneur, intellectual property in the form of patents, trademarks, and copyrights can be especially valuable. Patents, for example, have been shown to increase firm productivity and, more immediately, a firm's market value.
- The revenues generated from commercially successful patent-protected technologies make it possible to finance further technological research and development (R&D), thereby improving the chances of even better innovations in the future.
- Patents recognize and reward inventors for their commercially-successful inventions. With a patent, an entrepreneur or small business knows there is a good chance that they will get a return on the time, effort and money they invested in developing a technology.

Success of India in fostering creativity and stimulating a strong IPR system:

India has made a significant progress in developing an IPR regime, which is proving to be successful in protecting the rights of the innovators and creators. India formulated the National Intellectual Property Rights (IPR) policy in 2016. The main object of this policy is "Creative India; Innovative India" It helps in setting up an institutional mechanism for reviewing, assessing and implementing all forms of IP.

Development in the field of IPR over years:

• Introduction of the National IPR Policy: India announced its first National IPR policy in 2016, which aimed to strengthen the country's intellectual property regime and promote innovation and economic growth. This initiative has been effective in improving India's ranking by 41 points in the Global Innovation Index from 81st position in 2015-16 to 40th position in 2021-2022.



- **Digitalising IP Registration and Prosecution:** The Indian government has taken several steps to make the IP registration process more efficient. On the recommendations given by the Parliamentary Standing Committee in their 161st Report, the Controller General of Patents, Designs and Trademark (CGPDTM) took active steps to streamline the IPR filing system in India, which has led to a spur in the inflow of the FDI. As a result, there has been a significant increase in the patent filings.
- **SIPP (Start-Ups Intellectual Property Protection) Scheme:** The Indian Government has launched the Start-Ups Intellectual Property Protection (SIPP) Scheme to provide legal and financial support to start-ups for filing and prosecution of their patents, trademarks and designs. This Scheme has been effective in encouraging start-ups to protect their IP.
- Introduction of IPR toolkits for proper enforcement: DPIIT had launched an IPR enforcement toolkit in association with the Federation of Indian Chambers of Commerce and Industry to help the police in handling IP crimes, particularly counterfeiting and piracy. DPIIT has also created a Trade secret toolkit which has been made in order to guide Indian businesses especially MSMEs and start-ups regarding protection of their trade secrets.
- **Ministry of Education's Innovation Cell:** The Ministry of Education's Innovation Cell have also taken steps to foster innovation and promote IP literacy and awareness in classrooms across the country. By encouraging students to develop innovative ideas and teaching them about the importance of protecting their IP. The Innovation Cell is helping create a new generation of innovators and entrepreneurs.

Practice Question:

Q. Analyse the role of IPR in encouraging innovation and rewarding entrepreneurs. Discuss the development of IPR regime over years in India.



GSSCORE

6

MISCELLANEOUS

1. HYDROGEN FUEL CELL VEHICLE (HFCV) VS BATTERY ELECTRIC VEHICLE (BEV)

Context: The Automotive Research Association of India (ARAI) has organised a one-day seminar on Hydrogen as a Carbon Neutral Fuel for internal combustion engines (ICE) at its Kothrud campus in Pune.

What is hydrogen fuel cell vehicle?

Hydrogen fuel cell generate electricity without any combustion. Instead, they combine hydrogen (stored in a tank) and oxygen (from the air) in an electrochemical reaction, producing electricity, heat and water vapour. Hydrogen fuel cell electric vehicle are more efficient than conventional internal combustion engine and battery electric vehicles as they produce no tailpipe emissions—they only emit water vapor and warm air.

What is battery electric vehicle?

Battery electric vehicles (BEV) and hydrogen fuel-cell vehicles (FCV) are both electric vehicles. BEVs get their electricity from batteries that have to be plugged in and recharged. Fuel-cell vehicles make their own electricity on board from hydrogen stored in tanks. They have to be refilled at a hydrogen station.

Overview:

Most fuel cell electric vehicles (FCEVs) are powered by hydrogen (H2) and considered zero-emission vehicles (ZEVs). FCEVs are like battery electric vehicles (BEVs) in that they are both electric vehicles (EVs) that use an electric motor instead of an internal combustion engine to power the wheels. However, while BEVs run on batteries that are plugged in to recharge, FCEVs produce their electricity onboard. Hydrogen can be used as fuel in a variety of fuel cell electric applications to generate power, **emitting only water and heat as byproducts**. The conversion of hydrogen to electricity emits no pollutants that affect public health and minimizes greenhouse gases (GHG) that contribute to climate change.

Advantages of hydrogen fuel cell electric vehicle over battery electric vehicle:

- **Availability:** Earth has approximately 88 million tonnes of lithium, but only one-quarter is economically viable to mine as reserves.
- **Flexible energy source:** Hydrogen fuel cells provide an inherently clean source of energy, with no adverse environmental impact during operation as the byproducts are simply heat and water. Unlike biofuel or hydropower, hydrogen doesn't require large areas of land to produce. Lithium-ion batteries contain metals such as cobalt, nickel, and manganese, which are toxic and can contaminate water supplies and ecosystems if they leach out of landfills.
- **High energy efficiency:** Hydrogen fuel cell technology provides a high-density source of energy with good energy efficiency. Hydrogen has the highest energy content of any common fuel by weight. High pressure gaseous and liquid hydrogen have around three times the gravimetric energy density of diesel and LNG and a similar volumetric energy density to natural gas.
- **Highly Efficient:** Hydrogen fuel cells are more efficient than many other energy sources, including many green energy solutions. This fuel efficiency allows for the production of more energy per pound of fuel.



- **Reduces Carbon Footprint:** With almost no emissions, hydrogen fuel cells do not release greenhouse gases, which means they do not have a carbon footprint while in use. Electric cars are moved by lithium batteries and their production entails high CO2 emissions.
- **Fast charging:** The charge time for hydrogen fuel cell power units is extremely rapid, similar to that for conventional internal combustion engine (ICE) vehicles and markedly quicker in comparison to battery powered electric vehicles. Where electric vehicles require between 30 minutes and several hours to charge, hydrogen fuel cells can be recharged in less than five minutes.
- **Long Usage Times:** Hydrogen fuel cells offer greater efficiencies with regard to usage times. A hydrogen vehicle has the same range as those that use fossil fuels (around 300 miles). This is superior to that currently offered by electric vehicles (EVs), which are increasingly being developed with fuel cell power units as 'range-extenders'. Hydrogen fuel cells are also not significantly impacted by the outside temperature and do not deteriorate in cold weather, unlike EVs. This advantage is increased further when coupled with the short charging times.

Disadvantages of hydrogen fuel cell electric vehicle over battery electric vehicle:

- **Transportation and storage:** The biggest problem associated with the use of hydrogen as a fuel is its transportation and storage. Regardless of the element's state of aggregation gaseous or liquid there are always losses during transportation and there is a need for additional consumption of electricity, for example, for compression or liquefaction of hydrogen.
- **Flammable in nature:** Hydrogen is flammable and therefore dangerous if not properly stored or handled. Hydrogen has to be highly compressed for road use. This adds yet more complexity, and any distribution network for hydrogen has to handle this high-pressure gas.
- **Gaps in infrastructure:** Battery-electric vehicles have the significant advantage of building on an already extensive electric grid infrastructure, which means that virtually every electric outlet in the world can function as a charging station. On the other hand, fuel cell electric vehicles face the challenge of developing an entirely new infrastructure from ground up.
- **Cost efficiency:** The cost for a unit of power from hydrogen fuel cells is currently greater than other energy sources, including solar panels. This may change as technology advances, but currently this cost is a barrier to widespread use of hydrogen even though it is more efficient once produced. This expense also impacts costs further down the line, such as with the price of hydrogen operated vehicles, making widespread adoption unlikely at the moment.

Whereas solar energy can be used to generate electricity which in turn can be used to power the electric vehicles.

• **Cost of Raw Materials:** Precious metals such as platinum and iridium are typically required as catalysts in fuel cells and some types of water electrolyser, which means that the initial cost of fuel cells (and electrolysers) can be high. This high cost has deterred some from investing in hydrogen fuel cell technology.

Lithium which is used in manufacturing of batteries in EV is widely available and becoming accessible due to technological advancements.

Challenges for India to develop a FCEV ecosystem:

- It is quite challenging to integrate renewables in the electric grid beyond a point without technological intervention. Higher penetration might result in the **duck curve phenomenon**, first observed in California, USA.
- The cost of green hydrogen production is much higher than what is produced from fossil fuels. Decreasing renewables prices and economies of scale promise to make green hydrogen economical going forward, but much work remains.
- Hydrogen can be produced by a variety of process and has use in various sectors, making its sourcing and supply chain complicated when compared to oil and gas. Moreover, as discussed above, transporting and storing hydrogen remain a big challenge and will require massive investment in infrastructure upgrades.
- Traditionally, hydrogen has seen minimal policy support from the governments. Policy push has been towards other technology options and end uses, even when hydrogen can make a much bigger impact. Lastly, standards around hydrogen use either don't exist or haven't been updated.

Since the Paris Agreement in 2015, decarborization has taken center-stage. Transportation is a vital sector from a decarbonization perspective, contributing 24% of direct CO2 emission from fuel combustion.

With India holding the G20 presidency for 2023 and its continued commitment to the **National Green Hydrogen Mission**, the stage is set for India's energy transition journey and hydrogen fuel cell electric vehicles will be a crucial intermediate step in the transition strategy.

Practice Question:

Q. How are hydrogen fuel vehicles different from battery electric vehicle? Highlight the challenges associated with development of fuel cell electric vehicle ecosystem.

2. FLEX FUEL VEHICLES

Context: Ministry of Road Transport & Highways has launched first of its kind pilot project on **Flexi-Fuel Strong Hybrid Electric Vehicles (FFV-SHEV)** in India which would run on 100% petrol as well as 20 to 100% blended ethanol and electric power.

What are flex fuel vehicles?

- Like traditional vehicles, flex fuel vehicles have an internal combustion engine, but instead of regular petrol, it can run on blended fuel petrol with ethanol or methanol.
- The ethanol mix can vary between 20% and 85%.
- The vehicle has additional sensors and different programming of the engine control module to assess the blend of the fuel and adjust accordingly.
- Unlike electric hybrid vehicles, no bulky parts need to be added to the basic gasoline vehicle architecture

Flex Fuel, also known as **E85**, is a fuel mixture made of gasoline and between 51-83 percent ethanol. E85 can only be used in Flex Fuel vehicles that have been specifically designed to use this type of fuel.

Significance of FFV:

- **Less polluting:** According to the US department of energy, they have lower overall greenhouse gas emissions, between 40-108%, depending on the feedstock used to produce them.
- Manage glut in sugar production: India suffers from a glut in sugar production of 6 million tonnes and in sugar season 2020-21, about 2.4 million tonne was diverted to produce 302 liters of ethanol for blending.
- **Burning facility:** Possibly the greatest advantage is that the flex fuel vehicle has been designed to burn whatever proportion of mixture is in its combustion chamber.
 - ▶ Electronic sensors gauge the blend, while microprocessors adjust the fuel injection and timing.
- Reduce import bill: as they reduce the dependence on crude oil.
- **Benefits farm community:** wide uptake of ethanol or methanol as a fuel may create additional revenue stream for farmers and aid in increasing farm income.
- Uses Waste Materials For Production: Under the government's 'waste-to-wealth' program, using waste products like straw, sugarcane, bamboo and waste grains makes the raw material abundant and cheap for producing bioethanol sustainable for the long-term.
- Helps Reduce Dependence On Crude Oil & Provides Cushion Against Oil, Currency Fluctuations: The 20% ethanol blend in petrol will help us cut our crude oil imports. Thus, it'll provide at least some cushion against the high USD-INR exchange rates and volatile crude oil prices.

Challenges associated with Flex fuel vehicles:

- **Issues with ethanol:** Constant supply must be ensured. However, since this largely comes from sugarcane in India, which is a water-guzzling crop, any drought could have an impact on blending rates.
- Less vis-à-vis environmental benefits: The benefit for the environment is less as compared to battery EVs or hydrogen fuel cell vehicles of the future.
- Less Mileage: While ethanol raises a vehicle's octane level, it contains less energy. It will take 1.5 times more to provide the same energy levels.



- The report by Ministry of Petroleum and Natural Gas mentioned that E20 blending will result in drop in fuel efficiency by nearly 6-7% in 4 wheelers calibrated to E10.
- **Resource Scarcity:** NITI Aayog in a report mentioned that over 90% of ethanol in India came from sugarcane alone, and other food crop like maize. o While availability of sufficient feedstock on a sustainable basis is challenge.
- **Ethanol Is More Hygroscopic Than Petrol:** Ethanol attracts moisture far more easily than petrol. So, using E20 flex fuel and leaving the car unused for long periods of time can result in corrosion of the fuel tank, fuel pipe and other parts of the fuel system.
- **Doesn't Drastically Lower Ownership Costs:** While we're counting on the flex fuel to cost about the same as diesel does today, it won't help you save enough cash during the ownership costs. The maintenance costs will also remain similar to that of a petrol car. In this category, electric vehicles hugely outperform all other alternative and traditional fuel vehicles with their drastically lower fuel and maintenance costs.

Overall, with the move towards higher ethanol blends, flex fuel will add a new dimension to the automobile industry's energy mix, which is set to change significantly from the contemporary times. There has to be value preposition for the customers to come to flex fuel. Fiscal incentives like tax incentives on flex fuel would be crucial for consumer interest and adoption.

Practice Questions:

Q. What is flex fuel? State the significance of flex fuel vehicle in green model of development. What are the challenges associated with the implementation of flex fuel vehicle infrastructure in India?

3. RARE EARTH ELEMENTS:

Context: Hyderabad-based National Geophysical Research Institute has found large deposits of 15 Rare Earth Elements (REE) in Andhra Pradesh's Anantapur district.

What are rare earth metals?

- Rare Earths are a group of 15 elements in the periodic table known as the Lanthanide series. Chemically, rare earths are strong reducing agents.
- Their compounds are generally ionic and they display high melting and boiling points.
- Rare earths are relatively soft when in their metallic state while those with a higher atomic number tend to be harder.
- Rare earths react with other metallic and non-metallic elements to form compounds each of which has specific chemical behaviours.
- This makes them indispensable and non-replaceable in many electronic, optical, magnetic, and catalytic applications.
- Rare earth compounds are commonly fluorescent under ultraviolet light, which can assist in their identification. Rare earths also react with water or diluted acid to produce hydrogen gas.

Applications of rare earth metals:

- New technology:"Rare-earth elements (REEs) are used as components in high technology devices, including smart phones, digital cameras, computer hard disks, fluorescent and light-emitting-diode (LED) lights, flat screen televisions, computer monitors, and electronic displays. Large quantities of some REEs are used in clean energy and defense technologies."
- In lights : "Specific REEs are used individually or in combination to make phosphors—substances that emit luminescence—for many types of ray tubes and flat panel displays, in screens that range in size from smart phone displays to stadium scoreboards.
- **Glass:** Some REEs are used in fluorescent and LED lighting. Yttrium, europium, and terbium phosphors are the red-green-blue phosphors used in many light bulbs, panels, and televisions. The glass industry is the largest consumer of REE raw materials, using them for glass polishing and as additives that provide color and special optical properties.
- **Screens:** Lanthanum makes up as much as 50 percent of digital camera lenses, including cell phone cameras."

- As catalysts: "Lanthanum-based catalysts are used to refine petroleum. Cerium-based catalysts are used in automotive catalytic converters"
- **In magnets:** "Magnets that employ REEs are rapidly growing in application. Neodymium-iron-boron magnets are the strongest magnets known, useful when space and weight are limiting factors. Rareearth magnets are used in computer hard disks and CD–ROM and DVD disk drives. The spindle of a disk drive attains high stability in its spinning motion when driven by a rare-earth magnet. These magnets are also used in a variety of conventional automotive subsystems, such as power steering, electric windows, power seats, and audio speakers."
- In batteries: "Nickel-metal hydride batteries are built with lanthanum-based alloys as anodes. These battery types, when used in hybrid electric cars, contain significant amounts of lanthanum, requiring as much as 10 to 15 kilograms per electric vehicle."
- In steel alloys: "Cerium, lanthanum, neodymium, and praseodymium, commonly in the form of a mixed oxide known as mischmetal, are used in steel making to remove impurities and in the production of special alloys."

Red Mud

- Scientists from **Institute of Minerals and Materials Technology**, Bhubaneswar, have estimated the quantity of REEs that can be recovered from **Red Mud**.
- Red Mud is a toxic byproduct of aluminium extraction from bauxite ore using Bayer process.
- Red Mud contains REEs, there are two strategies to recover REEs from red mud: extract only REEs or extract all metals (such as iron, titanium, and sodium) including REEs.

Practice question:

Q. Why rare earth metals are strategically important? Do you think concentration of rare earth metals can prove to be disastrous during times of war and disturbances?

4. LITHIUM DEPOSITS

Context: Months after India's first lithium reserves of 5.9 million tonnes were discovered in Jammu and Kashmir, the Geological Survey of India (GSI) has found another reserve of the crucial mineral in Degana in Rajasthan's Nagaur district.

It is believed that these reserves are much bigger in quantity than the one found in the Union Territory and can meet 80% of the total country's demand.

Previously, in India, lithium reserves have been reported from Karnataka's Mandya district.

Significance of Lithium finding

- **Reduce import dependency:** Currently, India does not have its own lithium resources and is dependent on imports.
- In FY2022, India imported lithium and lithium ion worth almost ₽14,000 crore, which is likely to increase going forward.
- India presently imports lithium from Hong Kong, China, USA, Australia and Argentina.
- **Boost to manufacturing and exports:** Manufacturing of rechargeable Lithium based batteries for multiple purposes and self-reliance.

A World Bank study suggests that the demand for critical metals such as lithium (Li) and cobalt is expected to rise by nearly 500% by 2050.

- **Transformation of Mobility:** It will strengthen India's National Mission on Transformative Mobility and Battery Storage for transitioning towards Electric Vehicles and green mobility.
- **Fulfilment of Net Zero Emission Goal by 2070:** Lithium being a key component of lithium-ion batteries used in EVs, harnessing solar power, wind energy etc.
- **Strengthening of critical mineral supply chain for emerging technologies:** Lithium reserves and processing is highly concentrated and India's find will significantly strengthen its supply chain.



► Although, China does not hold a lot of lithium reserve, it controls over half the global lithium processing and almost 75% of cell components and battery cell production in the world.

Where does India get its lithium from?

- In 2021-22, India's lithium imports were \$22.15 million. Hong Kong, China and the US were the top three sources.
- Lithium-ion batteries are used in wind turbines, solar panels, and electric vehicles, all of which are crucial in a green economy.
- China currently controls 77% of the global lithium-ion battery manufacturing capacity and is home to six of the world's 10 manufacturing companies.
- As India embarks on this new journey, it could learn from the experiences of South American countries, especially the 'lithium triangle' of Bolivia, Chile, and Argentina, which contain roughly half the world's known Li.
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Risks associated with lithium mining:

- **High risk in ecologically sensitive Himalayas**: Recent Joshimath subsidence shows fragility of the region and longterm issues with activities like mining.
- Environmental pollution: Open-pit-mining, refining, and waste disposal from Lithium extraction processes substantially degrades the environment, including depletion and contamination of waterways and groundwater, biodiversity, and considerable air pollution.
- **Stress on Water Resources:** Extracting lithium from its ore is highly water-intensive, taking about 2.2 million litres of water for one tonne of lithium.
- **CO2 Emissions:** The lithium production process involves heating the ore at a high temperature that can only be costeffective by burning fossil fuels. It could mean emission of 15 tonnes of CO2 for every tonne of lithium.

Practice questions:

Q. The discovery of lithium deposits in India may have substantial effects on India's security as well as economic development. Analyze.







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