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An Institute for Civil Services

INTERVIEW GUIDANCE SERIES

IAS 2023

CURRENT AFFAIRS & MAJOR DEBATES

of

SCIENCE & TECHNOLOGY

GS SCORE

An Institute for Civil Services

INTERVIEW GUIDANCE PROGRAMME 2023

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SCIENCE & TECHNOLOGY

1. INDIA & THE PROBLEM OF 'DEEPFAKE'

The problem statement

Deepfakes are fast becoming a problem and are used to spread misinformation online as India grapples with the treacherous costs of a rapidly evolving AI technology.

> The proliferation of online deepfake videos has surged by 550%, reaching a staggering 95,820, as revealed in the 2023

- **Meaning:** Deepfakes are digital media — video, audio, and images edited and manipulated using Artificial Intelligence (AI).
- **Why is it harmful?** Since they incorporate hyper-realistic digital falsification, they can potentially be used to damage reputations, fabricate evidence, and undermine trust in democratic institutions.
- **Challenges for India**: India lacks specific laws to address deepfakes and AI-related crimes, but provisions under several pieces of legislation under the IT Act could offer both civil and criminal relief.
- **Solution:** This problem requires a collaborative effort, one that involves open communication, rigorous risk assessment and proactive mitigation strategies.
- **International best practices**:
  - In October 2023, US President Joe Biden signed a far-reaching executive order on AI to manage its risks, ranging from national security to privacy. The Department of Commerce has been tasked with developing standards to label AI-generated content to enable easier detection — also known as **watermarking.**
  - States such as **California and Texas** have passed laws that criminalise the publishing and distribution of deepfake videos that intend to influence the outcome of elections.
  - In **Virginia**, the law imposes criminal penalties for the distribution of nonconsensual deepfake pornography.

2. ISRO'S STELLAR SUCCESS

- **Preface:** The Indian Space Research Organisation (ISRO) is basking in the success of Chandrayaan-3, its lunar mission, which executed a flawless soft landing on the lunar surface. Adding to this triumph, ISRO has now accomplished a precision deployment of Aditya, India's inaugural mission to the sun.

- **Mission:** India's moon mission, Chandrayaan-3, achieved the softest of landings for Vikram on the surface of the moon's near side (facing the earth), near the south pole.
- **Global Elite**: Mission makes India only the 4th nation after US, **Russia and China** to land on the moon.
- **Why South Pole?** Situated on the edge of the Aitken basin, the largest impact basin on the Moon, the lunar south pole offers a unique opportunity to study materials from the Moon's deep crust and mantle.
- **Why South Pole was challenging?**
  - The region has a difficult terrain, full of craters and deep trenches. It is also far from the equatorial region explored by previous lunar missions.
  - Some areas on the south pole are shrouded in darkness and have never received sunlight.
  - Temperatures are so cold there that they can plummet to as low as -230 degree Celsius. This rocky terrain, complete darkness and extremely cold weather make it more difficult for electronic instruments to function properly.
- **India's space capabilities and Global Influence**: Chandrayaan-3's lunar South Pole landing elevates India's global standing. India's success encourages Global South nations to overcome colonial legacies, emphasizing self-reliance. India's lunar research benefits developing countries, fostering international alliances.

3. INDIA'S SPACE SECTOR

The problem statement

The global space economy is estimated to be worth $440 billion and the Indian space economy is expected to reach **US$12.8466 billion by 2025**. The realisation of indigenous technology, infrastructure, systems, and the systematic deployment of services have helped India create a well-respected space programme. Indian space launch is expected to get a further boost due to the government's positive step towards the inclusion of private players in the Indian space ecosystem.

- **Preface:** India started its space journey seven decades back from a scratch and is today acknowledged as a leading space power. Indian space industry today is renowned across the globe for two things – reliability and economy.
- **New emerging arenas:** With increase in space exploration, various sectors like meteorology, energy, telecommunications, insurance, transport, maritime, aviation, urban development etc. have seen growth and increased efficiency.
- **Challenges:** Issues such insignificant budget allocations, lack of skilled human resource, delayed space policy (though geospatial guidelines was a very good step), environmental challenges (space debris), space security creates challenges for the growth.
  - Despite having the most accomplished space programme in the world, India's space sector represents about 2 percent to 4 percent of the global space economy.
- **Government's recent initiatives (the secret sauce of success):** The government began space sector reforms by regulating and authorising private businesses and start-ups to engage in space activities. India's own **GPS (IRNSS), Indian National Space Promotion and Authorization Center (IN-SPACe), Indian Space Association (ISpA)** also aims to enhance the sector.
- **Investors Clamour (privatisation):** Skyroot Aerospace, Pixxel, Dhruva Space, AgniKul Cosmos, SpaceKidz India, Aantriksh, Bellatrix Aerospace, Astrogate Labs, Kawa Space, Vellon Space, Blue Sky Analytics, and SatSure are among the Indian space tech businesses seeking to revolutionise the industry.

4. FLEX FUEL VEHICLE

- **Preface:** Toyota recently unveiled a prototype of the **Innova Hycross** with a flex-fuel hybrid powertrain, its first car in India with this option, and one that the Japanese carmaker claims is the **world's first BS6 Stage II-compliant flex-fuel vehicle.**
- **About:** A flex fuel, or flexible fuel, vehicle has an internal combustion engine (ICE), but unlike a regular petrol or diesel vehicle, this can run on more than one type of fuel, or even a mixture of fuels.
- **How flex fuel cars work?** Flex fuel vehicles have one fuel system, and most components are the same as those found in a conventional petrol-only car.
  - Some special ethanol-compatible components are required to adjust to the different chemical properties and energy content in ethanol or methanol, such as modifications to the fuel pump and fuel injection system.

Advantages of Flex-Fuel	Disadvantages of Flex-Fuel
◆ Cleaner Fuel ◆ Flexible Usage ◆ Sustainable Source ◆ Provides similar, and sometimes better, performance than pure petrol cars	◆ **Nationwide Adoption**: The greatest barrier to flex-fuel adoption is the infrastructure investment required to make the switch. ◆ **Increased Engine Wear**: While the engines will be designed to adjust to the blend of fuel used, the ethanol component in the flex-fuel will cause greater wear and stress on the engines. This might translate to higher maintenance costs during the time the technology matures and improves reliability. ◆ **Lower Mileage**: While ethanol burns cleaner, it also contains less energy than pure petrol.

5. RISKS AND ALTERNATIVES OF CHATGPT

- **Preface:** As the world of artificial intelligence (AI) evolves, new tools like OpenAI's ChatGPT have gained attention for their conversational capabilities.
- **About:** ChatGPT harnesses the immense power of GPT-3 and GPT-4, belonging to a new class of "gargantuan" and widely popular large language models used in various AI applications.
  - With ChatGPT, users can ask questions, generate text, draft emails, discuss code in different programming languages, translate natural language to code and more.
  - It stands out as a **high-quality conversational chatbot** that aims to provide coherent and context-aware responses.
- **Concerns**: These include security and data leakage, confidentiality and liability concerns, intellectual property complexities, compliance with open-source licenses, limitations on AI development, and uncertain privacy and compliance with international laws

6. SPACE DEBRIS

The problem statement

There are hundreds of millions of pieces of space debris hurtling in the space, ranging from pebble-size specks flying around the Earth at speeds of about 17,000 miles per hour to bus-sized satellites

and rocket remnants. Though the active satellites help communicate and understand the world, the chaotic, kinetic tangle of space junk in lower orbit is a big problem with no easy solution. And new space detritus is being created every day.

- **Meaning:** Space debris encompasses both natural meteoroid and artificial (human-made) orbital debris.
- **Frequency (the crowded field):** The world used to send about 80 to 100 satellites into orbit each year, but that number jumped above 1,000 in 2020, surpassed 2,000 in 2022, and more countries and companies are jumping into the satellite game every year.
  - The biggest contributor to the current space debris problem is explosions in orbit, caused by left-over energy – fuel and batteries – on-board spacecraft and rockets.
- **Threats:** The increasing amount of orbital debris is a growing danger to "all space vehicles". Environmental dangers include light pollution, deposition of hazardous levels of alumina into the upper atmosphere, solar radiation.
- **Responsibility:** Based on international law codified in treaties and conventions from 1967 to 1972, liability for damage and harmful interference falls squarely on the shoulders of states party to the treaty.
- **Initiatives taken to tackle the problem:** Inter-Agency Space Debris Coordination Committee, ELSA-d, Mission, ClearSpace-1 Mission (to be launched in 2025-26).
- **Ways to clean up:** Companies around the world have come up with novel solutions. These include removing dead satellites from orbit and dragging them back into the atmosphere, where they will burn up.

7. MILITARISATION OF SPACE AND A SLOW MOVEMENT TOWARDS WEAPONISATION OF SPACE

The problem statement

The militarization and weaponization of outer space have become contemporary challenges, impacting international relations and posing threats to global security. The concept of weaponizing outer space involves deploying weapons that can turn space into a battleground, affecting satellites and critical infrastructure.

- **Meaning:** Weaponization of space refers to the process of deploying weapons in outer space, transforming it into a potential theater of conflict. This includes the use of weapons to target satellites and other assets either in orbit or on Earth's surface.
- **Emerging Technologies and Applications: Anti-Satellite Weapons (ASAT):** ASAT weapons enable the destruction of satellites in **low earth orbit (LEO).** ASAT capabilities demonstrate the ability to shoot down satellites, affecting communication, navigation, and reconnaissance systems.
- **Benefits of Weaponization (from a military perspective):**
  - **Space Supremacy:** Nations seek space supremacy to gain strategic advantages in military operations.
  - **National Security:** Protecting space investments, including satellites, to ensure uninterrupted military communication and surveillance.
- **Challenges and Concerns:** Increased Risk of Conflict, destruction of critical infrastructure, arms race and militarization
- **Government Initiatives and Global Legal Framework:**

- **Outer Space Treaty (**1967): The treaty prohibits placing weapons of mass destruction in orbit and militarizing celestial bodies.
- **UN Resolution on Arms Race Prevention:** In 2020, India co-sponsored a UN resolution advocating for the prevention of weapons placement in outer space and promoting peaceful use.

8. LAUNCH VEHICLES: IMPORTANCE OF RE-USEABLE LAUNCH VEHICLES

The problem statement

Launch vehicles are crucial components of a nation's space program, enabling the transportation of payloads into space. India has made significant strides in the development of launch vehicles, showcasing technological advancements and achievements. One notable aspect is the emergence of reusable launch vehicles, which has revolutionized the economics of space exploration.

- **Meaning of Reusable Launch Vehicles:** RLVs are aerospace vehicles designed to be recovered, refurbished, and reused for multiple flights. Unlike traditional launch vehicles, RLVs aim to reduce costs by enabling multiple uses of the same vehicle.
- **Emerging Technology:** The evolution of RLVs represents a paradigm shift in space exploration. Key technologies include **hypersonic flight, autonomous landing, and powered cruise flight**.
- **Application:** The Reusable Launch Vehicle Technology Demonstrator (RLV-TD) serves as a flying test bed to evaluate various technologies. It aims to demonstrate hypersonic flight, autonomous landing, return flight experiment, and powered cruise flight. The ultimate goal is to scale up the RLV-TD to become the first stage of India's reusable two-stage orbital launch vehicle.
- **Benefits of Reusable Launch Vehicles:** Cost reduction, increased reliability and efficiency, more flexible and frequent launches
- **Challenges**: Technological complexity, infrastructure **and maintenance,** maintaining stringent safety standards adds complexity.
- **Government Initiatives:**
  - **RLV-TD Demonstration:** ISRO's RLV-TD, launched in 2016, marked a significant step in showcasing the feasibility of reusable technology. Subsequent initiatives aim to build upon the success of RLV-TD.
  - **International Collaboration:** Collaboration with international space agencies and organizations to share expertise and advancements in reusable launch technology. Participation in global forums for discussions on the benefits and challenges of reusable systems.

9. SPACE STATION MISSIONS: WHERE DOES INDIA STAND?

The problem statement

The concept of space stations has evolved as a natural progression in the pursuit of advanced space capabilities. India, through the **Indian Space Research Organisation (ISRO),** has expressed its commitment to constructing a space station, marking a significant milestone in its space exploration journey.

- **Meaning:** Space stations are habitable artificial satellites placed in orbit around the Earth, providing a platform for scientific research, technology experiments, and human activities in

space. The initiation of space station missions reflects a country's ability to safely transport and operate crewed missions in **Low Earth Orbit (LEO).**

- **Emerging Technology:** ISRO's focus on space station missions involves the development of technologies such as **orbital rendezvous and docking**, essential for linking separate units in space.
  - The **Gaganyaan programme** plays a pivotal role in advancing technologies related to human-rated rockets, crew training, and life support systems necessary for space station missions.
- **Application:** The **PS4-Orbital Platform (PS4-OP)** is a novel approach by ISRO to utilize the spent **PS4 stage** for **in-orbit scientific experiments** lasting one to six months.
  - This platform enables microgravity experiments, robotic armor technology demonstrations, rendezvous and docking experiments, and more.
  - The long-term goal is to scale up infrastructure for extended astronaut stays and experiments.
- **Benefits of Gaganyaan Programme for Space Station:** It helps in establishing Mature Capabilities. Gaganyaan's success is vital for scaling up payload capacity, achieving precise rendezvous, and docking capabilities required for space station missions.
- **Challenges:** Budgetary Constraints, complexity of space station project
- **Government Initiatives:**
  - **Public-Private Partnership:** ISRO can explore public-private partnership models to manage budgetary constraints.
  - **Upgrading GSLV Mark III, which** is critical for accommodating larger payloads required for space station missions.
- **Future of Space Stations:**
  - **Lagrange Points L-4 and L-5**, stable orbits between Earth and Moon, offer potential locations for future space stations.
  - **Artificial gravity** will become crucial for space colonies with larger populations.

SPACE EXPLORATION MISSIONS

10. ARTEMIS MISSION: TAKING HUMANS TO HITHERTO UNEXPLORED AREAS.

Problem Statement:

Human exploration beyond Earth poses significant challenges in terms of technology, sustainability, and international collaboration. The Artemis program emerges in response to the need for advanced space missions, aiming to address these challenges and establish a sustainable human presence on the Moon and beyond.

- **Meaning of Artemis Mission:** Artemis is **NASA's ambitious program** to return humans to the Moon. The mission goes beyond past achievements, aiming to land the first woman and the first person of color on the lunar surface, fostering inclusivity and diversity in space exploration.
- **Emerging Technology:** The Artemis program introduces **cutting-edge technologies** to enable human deep space exploration. Key technologies include the **Space Launch System (SLS)**

rocket, the Orion spacecraft, and advanced systems for navigation, communication, and life support. These technologies represent a leap forward in space exploration capabilities.

- **Human Lunar Exploration:** Artemis III focuses on landing astronauts on the Moon, conducting experiments, and collecting samples to deepen our understanding of lunar geology.
- **International Collaboration:** Artemis fosters collaboration by making Canada the second country to have an astronaut fly around the Moon during Artemis II.
- **Benefits of Artemis Mission:** Inclusivity in Space Exploration, Scientific Advancements, Technology Innovation, Inspiring students to enter the field (contributing to the growth of STEM fields).
- **Challenges: Budgetary Constraints, Technical Complexity**

11. SOLAR MYSTERIES AND SOLAR MISSIONS LIKE ADITYA- L1

Problem Statement:

Understanding the Sun has been a crucial aspect of human history, influencing ancient cultures and shaping our daily lives. In the early 21st century, advancements in technology have allowed for in-depth exploration of solar mysteries. **Aditya-L1,** India's first mission to study the Sun is all set to reach its destination, the **Lagrange Point 1 (L1)** in January 2024.

- **Mission Objectives:**
  - Study of Solar upper atmospheric (chromosphere and corona) dynamics.
  - Study of chromospheric and coronal heating, physics of the partially ionized plasma, initiation of the coronal mass ejections, and flares
- **Distance:** Hovering at **Lagrange point L1**, the spacecraft won't come any closer to the sun than 1% of the total distance between the Earth and the sun.
- **Benefits:** A better understanding of the:
  - magnetised solar atmosphere
  - impact of solar radiation on climate here on Earth
- **Why L1?** A satellite placed in the halo orbit around the L1 point has the major advantage of continuously viewing the Sun without any occultation/eclipses. This will provide a greater advantage of observing the solar activities and its effect on space weather in real time.

Payload

- Visible Emission Line Coronagraph(VELC)
- Solar Ultraviolet Imaging Telescope (SUIT)
- Solar Low Energy X-ray Spectrometer (SoLEXS)
- High Energy L1 Orbiting X-ray Spectrometer(HEL1OS)
- Aditya Solar wind Particle Experiment(ASPEX)
- Plasma Analyser Package For Aditya (PAPA)
- Advanced Tri-axial High Resolution Digital Magnetometers

Lagrange points are positions in space where gravitational forces create regions of enhanced attraction and repulsion.

- **Other Similar Missions:**
  - **NASA's Parker Solar Probe:** Traces energy and heat movement through the Sun's corona, part of NASA's 'Living With a Star' program.
  - **Solar Orbiter:** A joint ESA and NASA mission to collect data on the Sun's influence on the solar system's space environment.

12. VENUS MISSIONS LIKE SHUKRAYAAN: ITS RELATION WITH EVOLUTION OF EARTH

Problem Statement:

Venus, the second planet from the sun, has long fascinated scientists and space agencies worldwide. Missions like Shukrayaan by ISRO aim to unravel the mysteries of Venus, providing insights into the planet's evolution, atmospheric conditions, and its relevance to Earth's own history.

- **Meaning:** The exploration of Venus, through missions like Shukrayaan, holds significance in understanding the planetary evolution, especially as a reference for Earth's own development. Studying Venus aids in comprehending the diverse conditions that planets can undergo over time.
- **Emerging Technology:** Shukrayaan incorporates advanced technology, including a **synthetic aperture radar (SAR) payload**, to explore the Venusian surface and subsurface. The choice of a two-tonne satellite platform reflects ISRO's commitment to maximizing scientific instruments for a comprehensive study of Venus.
- **Objective:** To map Venus' surface and subsurface, study its atmospheric chemistry, and examine its interaction with solar wind.
- **Benefits:** Provides valuable data on Venus' geological features, atmospheric composition, and solar interactions. Offers insights into Earth's evolutionary history and contributing factors to habitability.
- **Challenges:** There is a thick atmosphere of sulphuric acid, high temperatures, and high pressure.
  - Venus' harsh environment poses a challenge to the longevity of orbiters. Overheating of electronics is a concern, necessitating the development of heat-resistant materials and electronics.
- **Government Initiatives:** Shukrayaan involves collaboration with Russia, France, Sweden, and Germany, showcasing global cooperation in planetary exploration.
- **Future Plans:** Upcoming missions by ESA (EnVision), NASA (DAVINCI+ and VERITAS), and ISRO's Shukrayaan reflect a coordinated effort for a comprehensive study of Venus in the early 2030s.
- **Venus and Earth's Evolutionary Connection:**
  - **Presence of Life:** The detection of phosphine in Venus' atmosphere raises questions about the possibility of microbial life. Studying Venus aids in understanding the potential habitability of planets.
  - **Past Water Presence:** Observations of granite-like rocks on Venus hint at past water presence, contributing to the understanding of Earth-like processes.
  - **Insights into Earth's Climate:** Venus serves as a model for climate change studies, offering lessons on how planetary climates can dramatically transform.
- **Future Plans for Venus Missions:**
  - **ESA's EnVision:** A revolutionary orbiter mission to provide a holistic view of Venus, targeting a launch in the early 2030s.
  - **NASA's DAVINCI+ and VERITAS:** Expected to launch in the 2028-2030 timeframe, these missions will complement EnVision, collectively providing the most comprehensive study of Venus to date.

DEFENCE TECHNOLOGY

13. HYPERSONIC MISSILES

As nations increasingly invest in the development of hypersonic missiles, there is a need to comprehensively assess the implications of these high-speed and highly maneuverable weapons. The evolving landscape raises concerns about arms race escalation, strategic stability, and the effectiveness of existing defense systems in countering this advanced weaponry.

- **Meaning:** Hypersonic missiles refer to missiles traveling at speeds exceeding **Mach 5, or five times the speed of sound.** They are different from ballistic missiles, which can also travel at hypersonic speeds (of at least Mach 5) but have set trajectories and limited maneuverability.

There are two main categories of hypersonic weapons:

- **Hypersonic glide vehicles** are launched from a rocket. The glide vehicle then separates from the rocket and "glides" at speeds of at least Mach 5 toward a target.
- **Hypersonic cruise missiles** are powered by high-speed, air-breathing engines.

- **Emerging Technology:** The core technology behind hypersonic missiles involves **advanced propulsion systems, typically scramjet engines, capable of sustaining high-speed flight in the upper atmosphere. Cutting-edge materials, aerodynamics, and guidance systems** contribute to the development of missiles that can maneuver dynamically, making them challenging to track and intercept.
- **Nations:** The **United States, Russia and China** are all developing hypersonic weapons.
- **Application:** Military superiority, precision strikes, deterrence strategy
- **Benefits:** Hypersonic missiles offer a rapid response capability, reducing decision-making time and enhancing military agility.
- **Challenges: Arms Race Concerns.** Hypersonic missiles' speed and maneuverability pose challenges for existing missile defense systems. Their unpredictability and quick-strike capabilities may disrupt traditional concepts of strategic stability.

14. WARSHIPS: PROJECT 15B, PROJECT 17A, PROJECT 28

Problem Statement:

The evolving geopolitical landscape, disruptions in global supply chains, and regional security challenges necessitate robust maritime capabilities for India. To address these issues, the Indian Navy initiated **Project 15B, Project 17A, and Project 28**. However, challenges such as emerging threats, technological advancements in naval warfare, and the need for strategic self-sufficiency persist.

- **Meaning:** These projects signify India's endeavor to bolster its naval strength, emphasizing indigenous design and construction. They aim to counter regional threats, particularly from China, and secure maritime interests. 'Aatmanirbharta' is not only a policy but a guiding principle in shaping the future of India's naval capabilities.
- Emerging Technology:
  - **Stealth Technology:** Projects 15B and 17A incorporate stealth design, including radar-absorbent coatings, reducing the vessels' detectability.

- **Use of Integrated Construction Methodology** in Project 17A optimizes hull block construction, enhancing efficiency and reducing construction timelines.
- **Use of indigenously developed steel (DMR 249A)** in Project 17A highlights advancements in material science.

- **Application:** These projects contribute to India's maritime security by countering potential threats and ensuring advanced stealth capabilities, gas turbine propulsion.
- **Benefits: Self-Reliance:** Projects 15B and 17A exemplify 'Aatmanirbhar Bharat,' with over 75% indigenous content, promoting self-reliance in warship design and construction.
- **Challenges:** Implementing and sustaining cutting-edge technologies require continuous research, development, and skilled manpower.
- **Future Plans: New Generation Corvettes (NGCs):** The introduction of NGCs, designed in-house by the Indian Navy, demonstrates a forward-looking approach to address evolving naval requirements.

15. IMPORTANCE OF DRONE TECHNOLOGY IN INDIAN AGRICULTURE

The problem statement

Digital technologies are finding increasing use in the agriculture, and farmers are increasingly becoming more informed, as various measures are taken to provide them ready access to technology and information. Technology in the sector plays a vital role to enhance productivity sustainably. Innovation mechanisms for technology transfer are required to bring relevant tools, knowledge and knowhow to farmers.

- **Meaning:** Drones are uncrewed aerial vehicles (also known as UAVs), which are used for surveillance in various industries. Till now, they were primarily used by companies working in industrial sectors. But now, drone technology is increasingly available for use in various sectors of agriculture as well.
- **Emerging technology:** Owing to the advancement in technology, especially in futuristic technologies like **artificial intelligence (AI), machine learning (ML)**, and others, today drones are widely used across various industries; enabling faster, better, and more cost-effective operations of various industries.
- **Application:** Irrigation Monitoring, Crop Health Monitoring and Surveillance, Crop Damage Assessment, Field Soil Analysis, Planting, Agricultural spraying, Livestock tracking.
- **Benefits:** Enhanced Production, Greater safety of farmers, Faster data for quick decision making, Less wastage of resources, Useful for Insurance claims.
- **Challenges:** The current state of India's farmers and commercial drone solutions pose particular challenges to fully utilising drones in agriculture.
  - **India faces challenges** due to weather dependency on drones, lack of proper internet connectivity across our arable farms, lack of knowledge and skill of the end users, and the potential for misuse.
- **Government initiatives**: AgriStack, Digital Agriculture Mission, Sub-Mission on Agricultural Mechanization (SMAM), Kisan Call Centres, Kisan Suvidha App, Agri Market App, Soil Health Card (SHC) Portal, etc.

16. POLICING IN THE METAVERSE

The problem statement

The Interpol launched the first-ever metaverse specifically designed for law enforcement agencies worldwide during its 90th General Assembly in Delhi.

- **Meaning:** The metaverse is a 3D version of the Internet and computing at large. The intent of the metaverse is to give users the power to create their own experiences and also to interact with others in these spaces, and even collaborate with each other.
- **Uses**: virtual concert, taking a trip online, and buying and trying on digital clothing, work-from-home shift.
- **Access:** For now, there is no one entrance or gateway into the metaverse, because the idea of a single metaverse is still theoretical.
- **India's position**: India currently ranks at the 5th position on the list of top nations driving the metaverse market.

17. 5G TECHNOLOGY & INDIA

The problem statement

The India Cellular and Electronics Association, has predicted that by the end of 2023, 75–80% of new smartphone launches will be 5G-enabled as India continues to roll out 5G in more than 50 cities and towns. The Indian government launched the 5G era on October 1, 2022. Since then, many private telecom players such as Jio, Bharti Airtel, and Voda-Idea have launched 5G telecom services in the country.

- **Meaning:** Precisely, 5G is the generation following 4G networks, which replaced all preceding ones. But on the technological side, it's far more complex than 4G.
- **Important features:** Ultra-low latency, super bandwidth per unit area, reliable connectivity, up to 100 percent coverage, capacity to connect more devices per unit
- **Benefits:** Faster connectivity, Socio-economic multiplier, Improving tech system of industries, Strengthened healthcare system, Support to new-age technologies.
- **Bottlenecks:** Obsolete technology, Low fiberisation footprint, Restricted range, Lack of finance
  - **How far have we come?** Unlike 3G or 4G rollouts, telcos this time are not entirely depending on global vendors for equipment and instead developing their own 5G tech. Emergence of platforms like O-RAN or Open-Radio Access Networks has helped Indian telcos to build their own 5G tech
- **Way forward:** Complete indigeneity in 5G infra and technology is still far-fetched for India. However, there is some progress on the tech front with 5G when compared with 3G or 4G.

18. INDIA'S GEOSPATIAL TECHNOLOGY

The problem Statement

The Indian geospatial industry is expected to experience a growth rate of 12.8 percent, reaching a valuation of INR 63,000 crore by 2025, and generating employment opportunities for over 1 million individuals, according to the **National Geospatial Policy.**

- **Meaning:** Geospatial data encompasses information in a dataset that includes details related to **location** (coordinates, addresses and spatial patterns). It include:
  - Geographic Information System (GIS)/Spatial Analytics
  - Global Navigation Satellite System (GNSS) & Positioning
  - Earth Observation
  - Scanning
- **Utilization & Application:** Data acquiring & utilization, informed decisions for resources, intelligent maps and models.
- **Issues in the sector:** Lack of access to reliable and up-to-date geospatial data. Data collection, integration, and maintenance require significant resources and expertise.
- **Required measures:** Bridging the digital divide and ensuring equitable access to technology infrastructure is crucial for enabling the widespread adoption of geospatial technology in policy and decision-making.

BIOTECHNOLOGY

19. CRISPR & ITS ROLE IN CHANGING THE WORLD (10 YEARS OF CRISPR)

The problem Statement

Over the last 10 years, India's geospatial economy is growing larger and larger. It is expected to cross Rs 63,000 crore by 2025 and achieve a more than 10 per cent growth rate.

- **Meaning:** CRISPR is short for Clustered Regularly Interspaced Short Palindromic Repeats, which is a reference to the clustered and repetitive sequences of DNA found in bacteria, whose natural mechanism to fight some viral diseases is replicated in this gene-editing tool.
  - It is simple, and still far more accurate — and it does not involve the introduction of any new gene from the outside. Its mechanism is often compared to the 'cut-copy-paste', or 'find-replace' functionalities in common computer programs.
- **Potential of CRISPER-gene editing technology:** It open ups the possibility of 'correcting' genetic information. It is a permanent cure to genetic disorders and cure to deformities due to abnormalities in gene sequences
- **Role in changing the world:** This gene-editing tool has revolutionized biology research, making it easier to study disease and faster to discover drugs. The technology is also significantly impacting the development of crops, foods, and industrial fermentation processes.
- **Government intervention:** Government's approved a five-year project to develop this technology to cure sickle cell anaemia
- **What's next for CRISPR?** With its potential already demonstrated in research applications, the next big milestone for CRISPR will be to prove it is safe and effective as a treatment. But there are still many other applications underway.
- **Ethical dilemma:** Because of CRISPR's power to induce dramatic changes in an individual, scientists, including the main developer Doudna, have been warning of the potential for misuse of the technology.

20. STEM CELLS THERAPY AS A REGENERATIVE MEDICINE

Problem Statement:

The Delhi High Court in August 2023 permitted two children with **autism spectrum disorder (ASD)** to undergo **stem cell therapy** for treatment of their condition. Stem cell therapy, a promising field in **regenerative medicine**, grapples with ethical, scientific, and practical challenges. The destruction of **blastocysts**, unknown long-term effects, and potential misuse raise concerns.

- **Meaning:** Stem-cell therapy is the use of stem cells to treat or prevent a disease or condition. The regenerative properties of stem cells make them extremely valuable in medicine. This is why stem cell treatments are also termed as regenerative medicine.

> Stem cells are the body's raw materials — cells from which all other cells with specialized functions are generated.

- **Emerging Technology:**
  - **Mesenchymal Stem-Cell Therapy:** Mumbai's experimental use of mesenchymal stem-cell therapy showcases the evolving technology's potential in tissue repair.
  - **Therapeutic Cloning:** Advances in therapeutic cloning contribute to a better understanding of human cell growth and open avenues for treatment.
- **Stem Cell Research Guidelines:** The development of National Guidelines for Stem Cell Research in 2013 in India reflects the emerging focus on ethical and scientific norms.
- **Benefits:** Stem cell therapy offers regenerative capabilities, potentially revolutionizing treatments for various diseases (Alzheimer's, cancer, and diabetes) and injuries. It enables ethical drug testing without direct experimentation on animals or humans.
- **Challenges:** Ethical concerns, unknown long-term effects, adult stem cells' limitations to differentiate into specific cell types.

21. GENETIC ENGINEERING: ISSUES AND CHALLENGES

Problem Statement:

Genetic engineering, the alteration of an organism's DNA, presents a spectrum of challenges encompassing ethical dilemmas, environmental impacts, and economic considerations. The capacity to modify genes poses questions about ethical boundaries, potential ecological consequences, and issues of ownership and access. Striking a balance between scientific progress and ethical responsibility is crucial for the responsible development of genetic engineering technologies.

- **Meaning:** Genetic engineering involves manipulating an organism's DNA, ranging from single base pair changes to introducing foreign DNA. This technology is utilized to enhance or modify the characteristics of organisms, from plants to animals, for various purposes, including agriculture and medicine.
- **Emerging Technology:**
  - **Precision Gene Editing:** Advanced gene-editing tools like CRISPR-Cas9 enable precise modifications, allowing scientists to target specific genes with unprecedented accuracy.
  - **Synthetic Biology:** The emergence of synthetic biology involves designing and constructing new biological entities, opening possibilities for creating organisms with novel functionalities.

- **Gene Therapy:** In the medical field, gene therapy applications aim to treat or prevent diseases by correcting or replacing faulty genes.

- **Application:** Genetic engineering is applied to **create crops** with enhanced nutritional value, tolerance to **environmental stress, and resistance to pests**. The therapy is applied for **treating genetic disorders**. **It** is also explored for environmental purposes, such as bioremediation and creating organisms for sustainable resource utilization.
- **Benefits:** Improved Crop Varieties, Potential Medical Breakthroughs, Precision in Trait Selection
- **Challenges:** The potential for "designer babies" and tampering with human DNA raises ethical questions. The altered organisms' impact on ecosystems and biodiversity, coupled with the potential creation of unintended harmful traits, poses environmental challenges. It also introduces concerns about **ownership, pricing, and accessibility.**

22. BASE EDITING TECHNIQUE FOR CANCER TREATMENT

Problem Statement:

Cancer, specifically **T-cell leukemia**, poses a significant challenge in the medical field, requiring innovative and targeted approaches for effective treatment. The conventional methods have limitations in precision and may not adequately address the underlying genetic mutations responsible for malignancy. There is a need for advanced techniques that can directly address genetic anomalies associated with cancer cells while minimizing collateral damage to healthy tissues.

- **Meaning:** Base Editing, a newer genome editing approach, offers a means to directly modify the genetic code in cellular DNA or RNA without causing double-stranded DNA breaks. In the context of cancer treatment, it aims to correct specific genetic mutations in T-cells associated with leukemia, potentially providing a more targeted and efficient therapeutic solution.
- **Application:** The primary application of base editing for cancer treatment involves the targeted modification of genetic sequences in T-cells. By directly addressing the genetic abnormalities leading to malignancy, base editing aims to restore the normal functioning of T-cells, contributing to the elimination of cancerous cells while preserving the overall immune system.
- Benefits:
  - **Precision Medicine:** Base editing offers a highly precise approach, allowing for the correction of specific genetic mutations associated with cancer, minimizing off-target effects.
  - **Minimized Collateral Damage:** By avoiding double-stranded DNA breaks, base editing reduces the risk of introducing undesired editing byproducts, contributing to a more controlled and targeted therapeutic intervention.
  - **Enhanced Treatment Efficacy:** Targeted modifications in T-cells, such as altering the targeting mechanism and removing specific chemical markings, contribute to an enhanced and tailored treatment strategy for T-cell leukemia.
  - **Challenges:** Safety considerations regarding unintended consequences of base editing, potential off-target effects, and the overall impact on the patient's health need careful evaluation.

23. GENETICALLY MODIFIED ORGANISMS: HOW THEY ARE DIFFERENTIATED THE OUTCOMES OF GENOME EDITING

Problem Statement:

The advent of **genetically modified organisms (GMOs)** and **genome editing technologies** in agriculture has sparked widespread debate and misinformation. Distinguishing between the outcomes

of traditional genetic modification and genome editing is crucial for informed decision-making and regulatory frameworks.

- **Meaning:**
  - **Genetically modified organisms (GMOs)** involve the introduction of foreign genetic material into a host organism to achieve specific traits.
  - **Genome editing**, a form of genetic engineering, alters the genetic material without introducing foreign genes.
- **Utilized Techniques:** Genome editing, encompassing techniques like **CRISPR-Cas9**, represents a cutting-edge technology in genetic engineering. Unlike traditional GMOs, genome editing aims to modify specific DNA sequences without incorporating foreign genes. This precision allows for targeted improvements in crops, animals, and microbes, presenting a more controlled and efficient approach to genetic modification.
- **Application:**

Genetically Modified Organisms (GMOs)	Genome Editing
◆ Involve the introduction of foreign genetic material into a host organism to confer specific traits, such as pest resistance or enhanced nutritional content. ◆ Examples include BT Cotton, where genes from the soil bacterium Bacillus Thuringiensis (BT) are inserted into cotton plants to naturally combat pests.	◆ Alters the genetic material without introducing foreign genes, focusing on precise modifications of existing DNA sequences. ◆ Aims to generate variants with improved yields, resistance to stress, and other desirable traits without the ethical concerns associated with foreign genetic material.

- **Benefits:**
  - **Precision and Control:** Genome editing offers a high level of precision in modifying specific DNA sequences, allowing for controlled improvements without introducing foreign genes.
  - **Targeted Agricultural Advancements:** Both GMOs and genome editing aim to enhance crops for better yields, resistance to pests, and adaptability to environmental conditions, contributing to food security.

24. RECOMBINANT VACCINES

Problem Statement:

Developing effective vaccines against intracellular pathogens that cause chronic infections poses a significant challenge in traditional vaccine strategies. The need for eliciting robust cell-mediated immunity, especially against pathogens with the potential for lifelong infections, requires innovative approaches.

- **Meaning:** Recombinant vaccines, produced through recombinant DNA technology, offer a promising solution to challenges in vaccine development. These vaccines involve incorporating the DNA encoding specific antigens into bacterial or mammalian cells, expressing and purifying the antigens, and utilizing them to stimulate immune responses.
- **Emerging Technology:** Recombinant vaccine technology encompasses recombinant protein vaccines, DNA vaccines, and live recombinant vaccines using viral or bacterial vectors. The innovation lies in the use of highly purified recombinant proteins, **virus-like particles (VLPs),** and DNA plasmids to elicit targeted immune responses.

- **Application:**
  - **Recombinant Protein Vaccines:**
    - Highly purified antigens expressed in bacterial or mammalian cells, offering a controlled and scalable approach to vaccine development.
    - Virus-like particles (VLPs) as a form of recombinant protein vaccine, known for high immunogenicity.
  - **DNA Vaccines:** Administration of **naked DNA plasmids** directly into muscles to provoke immune responses and confer protection against pathogens.
  - **Live Recombinant Vaccines:** Utilization of genetically modified viral or bacterial vectors as vaccines against specific pathogens, providing a safer alternative to live attenuated vaccines.
- **Benefits:** Increased immunogenicity, leading to improved immune responses. Simplifies the purification process, ensures scalability, and provides a more controlled approach to antigen production.
- **Challenges:** Developing vaccines that elicit significant cell-mediated immunity against intracellular pathogens causing chronic infections remains a challenge. Safety concerns with live attenuated vaccines, including potential virulence in susceptible hosts and the risk of attenuation reversal.

25. GENE THERAPY

Problem Statement:

Gene therapy, a groundbreaking approach to treat or cure diseases by introducing, removing, or altering genetic material in a patient's cells, presents several challenges. These challenges include ethical concerns, high costs, experimental nature, potential dangers, and the need for robust regulation. Striking a balance between innovation and safety while addressing ethical and accessibility issues is crucial for the responsible advancement of gene therapy.

- **Meaning:** Gene therapy involves manipulating a patient's genetic material to replace faulty genes, deactivate malfunctioning genes, or introduce new genes. The technique aims to cure diseases or enhance the body's ability to fight them. With multiple mechanisms, including gene replacement, inactivation, and introduction, gene therapy is a transformative approach in modern medicine.
- **Benefits:** Offers potential cures, especially for diseases with no effective medications. Provides lasting symptom relief, potentially improving the quality of life.
  - **Generational Impact:** Removes faulty genes from the parental line, preventing their transfer to future generations.
  - **Advancing Technology:** Harnesses rapid technological advances, with ongoing improvements and increased FDA approvals.
- **Challenges:** Cost Barrier, lacks guarantees of success, and uncertainties persist, persistence of ethical dilemmas, increased infection risks.

NANOTECHNOLOGY

26. THREATS POSED BY NANOMATERIALS: THEIR HEALTH AND ENVIRONMENTAL CONCERNS

Problem Statement:

The advent of nanotechnologies and nanomaterials, while holding significant promise for improving our quality of life, poses potential threats to health and the environment. The challenge lies in

understanding the distinctive properties of nanomaterials and their implications for toxicity, exposure pathways, and environmental impact. Insufficient knowledge, expensive processes, and a lack of comprehensive assessment methods hinder the safe integration of nanotechnologies into various applications.

- **Meaning:** Nanotechnologies involve the manipulation of materials at the nanoscale (millionths of a millimeter). Nanomaterials, particles of nanometer size, have unique properties that distinguish them from conventional materials. The challenge is to comprehend these differences and their potential effects on health and the environment.
- **Emerging Technology:** Nanotechnology utilizes nanomaterials with properties distinct from conventional materials. The technology is emerging across various fields, including medicine (nanomedicine), offering novel solutions and applications.
- **Application:**
  - **Nanomedicine:** Nanoparticles are employed in medicine for targeted drug delivery and diagnostic purposes.
  - **Environmental Sensing:** Nano-sensors can be used for environmental monitoring and detection of pollutants.
  - **Materials Science:** Nanomaterials enhance the properties of materials, impacting industries such as electronics, textiles, and construction.
- **Challenges:**
  - **Toxicity Concerns:** Lack of understanding of the toxic effects of nanoparticles on human health and the environment.
  - **Limited Knowledge on Biochemical Impacts:** Inadequate knowledge about how nanoparticles affect biochemical pathways in the human body.
  - **Expensive Processes:** The cost of processes and treatments involving nanomaterials poses economic challenges.
  - **Diversity of Impact Data:** Difficulty in drawing conclusions on environmental risks due to the diverse impact data and nanomaterials.
  - **Insufficient Data on Environmental Hazards:** Limited information on the hazards of nanoparticles in soils and sediments.
  - **Lack of Comprehensive Models:** Scarcity of models describing the release, distribution, and exposure of nanomaterials in complex environments.

27. QUANTUM COMPUTING

Problem Statement:

The Union Cabinet cleared Rs 6,003 crore **National Quantum Mission** seeking to realise a host of frontier technologies related to quantum computing, quantum communication and quantum sensing that only a handful of countries possess.

- **Meaning:** Quantum technology is a class of technology that works by using the principles of quantum mechanics (the physics of sub-atomic particles), including quantum entanglement and quantum superposition.
  - **Example-**Smartphone is a type of quantum technology – its semiconductors use quantum physics to work.
- **Global race**: India will be the seventh country to have a dedicated quantum mission after the US, Austria, Finland, France, Canada and China. All these countries are also at the R&D stage.

- **Application:**
  - **Cryptography:** Quantum computers can potentially break existing cryptographic algorithms, prompting the development of more secure alternatives.
  - **Simulation:** Quantum computers enable the simulation of complex systems like chemical reactions, facilitating advancements in materials science and drug discovery.
  - **Optimization:** Quantum computing addresses optimization problems crucial in logistics, finance, and transportation, offering faster and more efficient solutions.
  - **Machine Learning:** Quantum computers enhance machine learning algorithms, leading to quicker and more accurate predictions.
  - **Quantum Chemistry:** Quantum computers contribute to the study and design of materials and drugs, offering breakthroughs in medicine and energy.
  - **Financial Modeling:** Quantum computers simulate financial markets, optimizing investment portfolios and risk management.
  - **Weather Forecasting:** Quantum computing improves weather forecasting models, enhancing prediction accuracy and disaster preparedness.
- **Benefits:**
  - **Unprecedented Computing Power:** Quantum parallelism enables the processing of multiple calculations simultaneously, surpassing classical computing capabilities.
  - **Revolutionary Applications:** Quantum computing has the potential to revolutionize cryptography, simulation, optimization, machine learning, quantum chemistry, financial modeling, and weather forecasting.
  - **Scientific Advancements:** Quantum computers facilitate breakthroughs in scientific research, particularly in materials science, drug discovery, and complex system simulation.
- **Challenges:**
  - **Stability and Error Correction:** Quantum computers face challenges related to maintaining stability and implementing effective error correction mechanisms due to the delicate nature of quantum states.
  - **Scalability:** Scaling quantum computers to handle more qubits while maintaining coherence poses a significant challenge.
  - **Decoherence:** Quantum systems are susceptible to decoherence, leading to the loss of quantum information and affecting computation accuracy.
  - **Limited Qubits:** Building quantum computers with a sufficient number of qubits for practical applications remains a challenge.
- **Future Plans:**
  - **Error Correction Advances:** Invest in research to advance error correction techniques, enhancing the stability and accuracy of quantum computers.
  - **Increased Qubit Count:** Focus on developing scalable quantum computing systems with an increased number of qubits to tackle more complex problems.
  - **Algorithmic Improvements:** Work on refining quantum algorithms for improved efficiency and applicability across various domains.
  - **Global Collaboration:** Encourage international collaboration among researchers, industries, and governments to collectively address challenges and accelerate quantum computing development.
  - **Educational Initiatives:** Promote educational initiatives to train a skilled workforce in quantum computing, fostering innovation and addressing the shortage of experts in the field.

28. BIOPIRACY

Problem Statement

Pat Mooney, the founder of the ETC Group, an organisation that works to protect the world's most vulnerable people from the socioeconomic and environmental impacts of new technologies, coined the term "biopiracy" in the early 1990s to describe the theft or misappropriation of genetic resources and traditional knowledge through the intellectual property system.

- **Famous cases relating to Bio-Piracy**
  - **Neem Patent Case** – A fungicidal product derived from the Neem tree (Azadirachta Indica) was patented in the US which in reality was public knowledge in India. On opposition from India on grounds of novelty, it was revoked by the European Patent Office in the year 2000.
  - **Turmeric Patent Case** – An attempt by the University of Mississippi Medical Center, Mississippi to patent Turmeric for its healing properties was opposed by India on grounds of lack of novelty being a traditional knowledge of India. Ancient medical texts were cited by the Indian government to oppose this patent.
  - **Basmati Patent Case** – A US company named Rice Tec obtained a patent on Basmati-like rice by crossing an Indian variety with an American one and claimed rights on Basmati-like rice grown in the Western hemisphere. Basmati rice was traditionally grown in India and therefore the USPTO struck down large sections of the Basmati patent due to lack of Novelty.
  - **Colgate Case** – Colgate has been accused of stealing India's 1000-year-old traditional toothpaste recipe using ingredients like clove oil, spearmint, black pepper, etc. Attempts are still going on to stop the production by Indian activists.
  - **Yoga Patent Case** – Bikram Choudhary, a US-based Yoga teacher applied to get his method of teaching yoga patented. India is preparing to oppose this and other similar Yoga Patents granted by the United States Patent Office (USPTO).
- **Effects of Biopiracy**
  - Biopiracy poses a threat to many of the indigenous communities whose livelihoods depend on the natural resources available in their area.
  - Unfair usurpation of traditional knowledge and indigenous resources by a patent holder will give them ill-earned profit.
  - On the other hand, the indigenous people will not gain any compensation and will also have to compromise on their generational knowledge.
  - Other than forsaking their generational knowledge the farmers or communities may also have to compromise their livelihood
  - Unjust and unethical exploitation by claiming such patents translates into the disturbance of a well-established judicial system.
- **Impact on Biodiversity** Biopiracy is often extended to claiming rights over the biodiversity of a particular region. Such activities have a significant impact on biodiversity- it leads to the depletion of the endemic biodiversity and also exploit the communities that safeguard the biodiversity of an area. Biopiracy can also lead to the extinction of endemic species.

29. INCREASING ADOPTION OF AI (DELHI POLICE'S USE OF FACIAL RECOGNITION TECHNOLOGY)

The problem Statement

AI adoption has become a main focus in the technology business. The field of artificial intelligence (AI) has come a long way since its creation in the 1950s, with numerous new programs being introduced in

recent decades. In the most recent development, India has been elected as the new chair of the Global Partnership on Artificial Intelligence (GPAI) for 2022-23.

- **Meaning:** Simply put, Artificial Intelligence (AI) is the simulation of human intelligence demonstrated by machines.
- **India's interest in GPAI:** India must have a seat on the table so that we can become part of conversations and negotiations with regard to the development of ethical and responsible AI.
- **Application:** The specific applications of AI are natural language processing, machine learning and vision, expert systems, and speech recognition.
- **Factors in India responsible for AI flourishment**: India is an IT powerhouse and the second-largest online market in the world.
  - **What brought AI intro mainstream?** Increased technological investments, more internet penetration and the improvement in the overall digital infrastructure have prompted the massive inclusion of AI in mainstream operations.
- **Way forward**: The 4th Industrial Revolution is almost here, and artificial intelligence is undoubtedly an essential part of it.

30. DATA PRIVACY

The problem Statement

The Indian government released a draft version of a much-awaited data protection regulation earlier this month. It is the fourth draft of the bill since it was first proposed in July 2018.
Regulations in the draft aim to form a comprehensive legal framework to regulate the online space, including legislation on data privacy, cybersecurity, telecom regulations and harnessing non-personal data to boost innovation. The proposed legislation is called the Digital Personal Data Protection Bill (DPDP). It aims to secure personal data, while also guaranteeing user consent. The long-delayed bill needs the approval of parliament before becoming law.

- **Storage of personal data:** The draft law requires the data fiduciary (data controller) to ensure that personal data maintained is accurate and to use appropriate organisational and technical measures to comply with the law.
  - Personal data breach is any unauthorised processing or accidental disclosure, use, alteration, or destruction of personal data that compromises its confidentiality, integrity, or availability.
- **Significance of data privacy:** If items like financial data, healthcare information, and other personal consumer or user data get into the wrong hands, it can create a dangerous situation (risk for fraud and identity theft).
  - It is important because in order for individuals to be willing to engage online, they have to trust that their personal data will be handled with care.
- **Data Privacy vs Data Security:** Data privacy focuses on the manner in which an entity protects data when sharing with third parties. Data Security concentrates on keeping data safe from attacks from hackers.
- **Global standards:** The EU's landmark General Data Protection Regulation (GDPR) has substantially influenced legislation in nearly 160 countries. It is clearly focused on privacy and requires individuals to give explicit consent before their data can be processed.

NOBLE PRIZE

31. NOBEL PRIZE IN CHEMISTRY

For the discovery and synthesis of **quantum dots,** Moungi G. Bawendi, Louis E. Brus, and Alexei I. Ekimov have been given the Nobel Prize in Chemistry 2023. These nanoparticles have numerous uses in industries like electronics, cutting-edge surgery, and quantum computing.

Quantum Dots

- Quantum dots are **tiny particles**, in the range of a few nanometers.
- Quantum dots are bringing the greatest benefit to humankind. Researchers believe that in the future they could contribute to **flexible electronics, tiny sensors, thinner solar cells and encrypted quantum communication** – so we have just started exploring the potential of these tiny particles.

32. NOBEL PRIZE IN PHYSICS

The Nobel Prize 2023 in Physics has been jointly awarded to **Pierre Agostini, Ferenc Krausz, and Anne L'Huillier** "for experimental methods that generate attosecond pulses of light for the study of electron dynamics in matter."

- **Applications:**
- These short pulses can be applied to test the internal processes and **events of matter**.
- The pulses can be utilised to push molecules that can be used in medical diagnostics such as the early detection of diseases like **lung cancer**.

33. NOBEL PRIZE IN PHYSIOLOGY OR MEDICINE

Katalin Kariko and Drew Weissman have shared the Nobel Prize in Physiology or Medicine, 2023 for their "discoveries regarding nucleoside base modification that enabled the development of effective mRNA vaccines against COVID-19."

mRNA COVID Vaccine

Vaccines before the pandemic

- Producing protein-, vector-, or whole virus- was time consuming as they require large-scale cell culture.

Vaccines after the COVID-19 pandemic: mRNA vaccines

- The basis for these vaccines is messenger RNA, or mRNA. The messenger RNA molecules that instruct the body's cells to produce certain proteins are used in mRNA vaccines.
- In this instance, the mRNA is coded to instruct the cells to produce the **spike protein** of the SARS-CoV-2 coronavirus, which causes Covid-19 because it enables the virus to enter cells, where it then begins to replicate.
  - The immune system is subsequently expected to respond by producing antibodies to combat it.
  - These antibodies will remain in the blood and fight the real virus if and when it infects the human body.