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An Institute for Civil Services

IAS MAINS 2022

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CONTEMPORARY ISSUES *of* SCIENCE & TECHNOLOGY

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Contents

Digital public goods (DPGs) and Open Source Technology

The COVID-19 pandemic has shown the utility of technological solutions.

- Digital public goods (DPGs) and open source technology are prime examples of technological investments into 'open' tech that can help governments more quickly develop solutions to big and urgent challenges.

What are DPGs?

- DPGs are open source software, open data, open AI models, open standards and open content that adhere to privacy and other applicable laws and best practices, do no harm and help attain the SDGs.
- DPIs refer to societal scale digital systems with functions essential for public and private service delivery, including payment systems and data exchanges.
  - One example of a DPI is **OpenG2P,** which digitized cash transfers and was built during the West Africa Ebola crisis.

What is meant by 'Openness' in technology?

- Openness of technology refers to free availability of the source code to every user or developer for usage, modification and redistribution. Both Digital public goods (DPGs) and digital public infrastructure (DPI) are anchored in the idea of "openness" and open: source, i.e. each problem has to be solved only once. The solution is made free and accessible to anyone who wishes to use it, modify it or built upon it.

India's progress in DPGs

- India has emerged as a global leader in building population: scale digital public goods.
- **India Stack** for example is an ambitious project to build a unique digital infrastructure to help solve population: scale problems through creating a set of open APIs.
- The project has made presence: less (Aadhaar), paperless (eKYC, eSign, Digilocker), and cashless (UPI) services available for healthcare and urban governance.

Benefits of open source technology that India can derive	Disadvantages/Challenges
• Free availability and accessibility • A thriving community of developers to build suitable target: oriented software, open: source software provides the platform to the desired developers • Secure software • Potential to democratize the governance structure of the nation • More accountable and responsive governance • can bring a revolution in the health care sector in a geographically diversified country like India	• Constraints in technical capability • Persistent digital divide • Lack of fiscal space • Unintended exclusions • Risks to data and digital rights of citizens

⊙ Accessible and affordable healthcare services can be enabled for every citizen ⊙ Quality education ⊙ Enabling companies hire developers and make their service route safer, secure and target: oriented ⊙ Digitization of payment	

Conclusion:

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

India's leadership in digital public goods offers unique lessons and digital public solutions that can be adapted by countries worldwide. This is especially relevant for lower middle: income countries, which face similar challenges as India, including barriers to access, connectivity, and digital literacy.

3D Printing and Health Sector

Context:

3D printing is creating an enormous opportunity for the medical industry. Multiple sectors within the medical industry are benefiting from 3D printing, including orthopaedics and dental.

What is 3D Printing?

- Three: dimensional (3D) printing is a manufacturing method in which objects are made by fusing or depositing materials—such as plastic, metal, ceramics, powders, liquids, or even living cells—in layers to produce a 3D object from a digital file.
- This process is also referred to as **additive manufacturing (AM), rapid prototyping (RP), or solid free-form technology (SFF).**
- Some 3D printers are similar to traditional inkjet printers; however, the end product differs in that a 3D object is produced.

3D printing will be a $32bn industry by 2025, rising to over $60bn by 2030. The CAGR between 2018 and 2025 will be 16%, with software growing slightly faster than hardware, materials and services.

Key applications of 3D printing in healthcare

■ 3D: printed orthopaedic implants

- The technology enables medical professionals to create better- fitting, longer: lasting and higher-performing implants. Today, the technology can be used to make a wide range of implants, including spinal, hip, knee and skull implants.
- Electron Beam Melting (EBM) metal technology and Selective Laser Melting are used by orthopaedic manufacturers.

- Both technologies are optimized to work with biocompatible metals like titanium, and can produce many complex implants in one batch.

■ Patient-specific anatomical models

- Anatomical models are currently one of the most widely adopted applications of 3D printing in the medical industry.
- The accessibility of medical CAD/CAM software and lower: cost desktop 3D printers is increasing, enabling more hospitals to establish 3D printing labs.
- In such labs, medical professionals can produce high: accuracy 3D: printed models to assist in presurgical planning.
- 3D-printed anatomical models help surgeons evaluate better treatment decisions and plan their surgeries more accurately.
- By preparing for surgery using a 3D-printed model, surgeons can reduce the time a patient spends in the operating room. Ultimately, this leads to fewer complications and a better long: term outcome for the patient.

■ Enhanced surgical tools

- Another area where 3D printing is making an impact is personalised surgical tools. Surgical instruments, like forceps, hemostats, scalpel handles and clamps can be produced using 3D printers.
- Creating personalised surgical instruments offers many benefits. They facilitate faster and less traumatic procedures, increase a surgeon's dexterity and support better surgery outcomes.
- For such applications, 3D printing companies have developed biocompatible materials that can withstand sterilisation, including high: performance thermoplastics like Ultem, PEEK, nylon and also metals like stainless steel, nickel and titanium alloys.

■ Medical & Dental devices

- Medical and dental devices like prosthetics, braces, dentures, restorations and clear aligners can significantly benefit from 3D printing.
- Low-cost personalisation is a key benefit, driving the adoption of 3D printing for medical & dental devices. A 3D printer requires only a digital file to produce a device, which makes it possible to customise a design more easily and produce many different devices in one batch.
- With 3D printing, prosthetic limbs are becoming much more affordable and faster to produce. Increasingly, 3D printing is being used to create prostheses for children. Increasingly, 3D printing is being used to create prostheses for children.

New WHO report highlights collaborative action to reduce Antimicrobial resistance (AMR)

Context:

A strategic framework is published in a report in April 2022 to advance a One Health response to AMR at the global, regional and country levels is a joint effort by the World Health Organization (WHO), Food and Agriculture Organisation (FAO), World Organisation for Animal Health (OIE) and United Nations Environment Program (UNEP).

Antimicrobial Resistance (AMR)

- Antimicrobial Resistance (AMR) occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines making infections harder to treat and increasing the risk of disease spread, severe illness and death.
- Antimicrobial-resistant organisms are found in people, animals, food, plants and the environment (in water, soil and air).
- They can spread from person to person or between people and animals, including from food of animal origin.
- Multiple drug resistance (MDR) is antimicrobial resistance (AMR) shown by a species of microorganism to at least one antimicrobial drug in three or more antimicrobial categories.
- The main drivers of antimicrobial resistance include the misuse and overuse of antimicrobials; lack of access to clean water, sanitation and hygiene (WASH) for both humans and animals; poor infection and disease prevention and control in health: care facilities and farms; poor access to quality, affordable medicines, vaccines and diagnostics; lack of awareness and knowledge; and lack of enforcement of legislation.

Goal of strategic framework

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

Objectives of the framework are

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

The report defined three outcomes countries should have in place:

Policy and law support effective country-owned One Health AMR responses:

- Recognise AMR as a priority in the broader development agenda, acknowledging the need for capacity building to strengthen AMR: specific legislation, policy coherence and sector: specific research.

Systems and structures, including institutional capacities, are in place to support effective implementation of country: owned One Health AMR responses:

- National Action Plans on AMR and guidelines to be regularly updated including monitoring and surveillance of AMR and antimicrobial use (AMU).
- Access to good quality antimicrobials strengthened for all sectors.

Increased, sustained resourcing is in place for country: owned One Health AMR responses:

- Priority actions from national action plans on AMR mainstreamed into national plans and budgets
- The report also focuses on two intermediate outcomes that it considers interim steps, necessary for the achievement of the longer: term outcomes described above.
  - The first intermediate outcome relates to the support provided at country level

- The second is focused on the tripartite (WHO, OIE and FAO) and UNEP action at global and regional levels in support of countries' efforts.

Big Tech weaponizing internet amid conflict

Amid the continued "weaponization" of the internet by some Big Tech platforms during the ongoing Russia-Ukraine conflict brings back the focus on the sweeping powers of social media platforms, India is readying a new cybersecurity and data governance framework.

How Big Tech firms are weaponizing internet and why it is a troubling precedent

- Since the Russian action in Ukraine began on February 24, companies, countries, Big Tech platforms and intermediaries have announced a slew of sanctions which have either stopped or cut off services being provided by them to Russia and its citizens.
- Some of these measures include stoppage of payment services, refusal by intermediaries to operate in Russia and not allowing their citizens to post.
- Two phenomena are very visible: one is weaponisation of the internet of which we were aware of in some sense. The second is the phenomenon of the splinter-net. The internet is increasingly being splintered, driven by power of some Western countries.
- The actions by Big Tech companies and intermediaries also violate basic principles of net neutrality and basic idea of openness of internet as they have now become "gatekeepers".
- These platforms have now become dominant and in the event of a conflict between two sovereigns, they are being weaponised and there are no laws that would prevent this.
- The use of sanctions to cut off access to internet is disturbing. It is quite a troubling precedent.

What is splinter: net?

- The splinternet (also referred to as cyber: balkanization or internet balkanization) is a characterization of the Internet as splintering and dividing due to various factors, such as technology, commerce, politics, nationalism, religion, and divergent national interests.
- In this internet is controlled by autonomous political blocs or any other controlling power—such as tech or e-commerce companies, or countries with diverging national interests tied to nationalism or religion.
- In its original form, the internet transcended borders and allowed people unfettered access to virtually everything, while the splinternet limits citizens' access to data, forces businesses to keep data within borders, and even changes how they operate within a state.
- Splinternet is often defined as the balkanization of the net, as nations try to preserve their sovereign identities and economic interests.
- A fusion of the words "split" and "internet", the splinternet is a fragmented version of the world wide web with national identities.

Examples

- The Chinese government erected the "Great Firewall" for political reasons, and Russia has enacted the Sovereign Internet Law that allows it to partition itself from the rest of the Internet.
- US and Australia, discuss plans to create a similar firewall to block child pornography or weapon: making instructions.
- Russia has accelerated domestic online censorship amid Russia-Ukraine crisis.

- A Russian court banned Facebook and Instagram as "extremist" - part of efforts by Moscow to crack down on social media during the conflict in Ukraine.

Learning for India in dealing with Cyberspace

- These recent events strengthen India's case for
  - Data localization,
  - National champions,
  - Resilient internet network architecture,
  - Native open APIs (application programming interface) and
  - A strong cyber security command centre.
- It is validating our thinking in terms of a new digital law, the need for a data governance framework.
- We need to basically create a framework which will have the data protection law, a digital law and other cyber security statutes.
- Architecturally, we need to build the cyberspace jurisprudence rather than doing it piecemeal or in catch up mode.

Conclusion:

These Big Tech companies, which initially rallied on government support to become the behemoths that they are today, are now presiding over splinter-net and the balkanisation of internet by imposing sanctions on countries.

m: RNA technologies for Vaccine production

Context:

Researchers have developed a type of vaccine that uses a molecule called messenger RNA (mRNA) of the pathogen (say a virus) rather than part of an actual bacteria or virus.

About Messenger RNA (mRNA)

- Messenger RNA is a type of RNA that is necessary for protein translation in the ribosomes.
- For m: RNA vaccines, mRNA (messenger RNA) is placed inside a lipid (fat) membrane. This fatty cover both protects the mRNA when it first enters the body, and also helps it to get inside cells by fusing with the cell membrane.
- Once the mRNA is inside the cell, machinery inside the cell (in ribosomes) translates it into the antigen protein.
- This mRNA typically lasts a few days, but in that time sufficient antigen is made to stimulate an immune response.
- It is then naturally broken down and removed by the body.
- m-RNA vaccines work by introducing a piece of mRNA that corresponds to a viral protein, usually a small piece of a protein found on the virus's outer membrane. (Individuals who get an mRNA vaccine are not exposed to the virus, nor can they become infected by the vaccine)
- Using this mRNA blueprint, cells produce the viral protein. As part of a normal immune response, the immune system recognizes that the protein is foreign and produces specialized proteins called antibodies.
- Antibodies help protect the body against infection by recognizing individual viruses or other pathogens, attaching to them, and marking the pathogens for destruction.

- Once produced, antibodies remain in the body, even after the body has rid itself of the pathogen, so that the immune system can quickly respond if exposed again.
- Example: Moderna COVID: 19 vaccine, The Pfizer BioNTech, etc.

Risks of the mRNA Vaccine	Advantages
• Some mRNA: based vaccine platforms induce potent interferon type I responses, which have been associated not only with inflammation but also potentially with autoimmunity. • Thus, the identification of individuals at an increased risk of autoimmune reactions before mRNA vaccination may allow reasonable precautions to be taken. • The risks associated with mRNA strands that did not manage to pass into a human cell are considered to be low, as the fragile mRNA molecule should be quickly broken down inside the body once its drug delivery system has eroded.	• As mRNA vaccines are not constructed from an active pathogen (or even an inactivated pathogen), they are non: infectious. • RNA vaccines are not capable of combining with the human genetic code (DNA). • m: RNA from vaccines does not enter the nucleus and hence does not alter DNA. • mRNA vaccines can be produced faster, cheaper, and in a more standardized fashion which improves responsiveness to outbreaks.

Synthetic Biology

Context:

The Centre is working on a national policy on synthetic biology, an emerging science that deals with engineering life forms for a wide range of applications from making designer medicines to foods.

What is Synthetic Biology?

- Synthetic biology is the design and construction of new biological parts, devices, and systems, and the re-design of existing, natural biological systems for useful purposes.
- It has been described as a disruptive technology at the heart of the so: called Bioeconomy, capable of delivering new solutions to global healthcare, agriculture, manufacturing, and environmental challenges.
- Synthetic biology arose from four different intellectual agendas.
  - The first is the scientific idea that one practical test of understanding is an ability to reconstitute a functional system from its basic parts. Using synthetic biology, scientists are testing models of how biology works by building systems based on models and measuring differences between expectation and observation.
  - Second, the idea arose that, to some, biology is an extension of chemistry and thus synthetic biology is an extension of synthetic chemistry. Attempts to manipulate living systems at the molecular level will likely lead to a better understanding, and new types, of biological components and systems.
  - Third is the concept that natural living systems have evolved to continue to exist, rather than being optimized for human understanding and intention. By thoughtfully redesigning natural living systems it is possible to simultaneously test our current understanding, and may become possible to implement engineered systems that are easier to study and interact with.
  - Fourth, the idea emerged that biology can be used as a technology, and that biotechnology can be broadly redefined to include the engineering of integrated biological systems for the purposes of processing information, producing energy, manufacturing chemicals, and fabricating materials.

Applications of synthetic biology

- Redesigning organisms so that they produce a substance, such as a medicine or fuel, or gain a new ability, such as sensing something in the environment, are common goals of synthetic biology projects.
- Some examples of what scientists are producing with synthetic biology are:

Application in pharmaceuticals:

- For instance, researchers have been working on the synthetic manufacture of the antimalarial drug artemisinin, which is produced naturally in the sweet wormwood plant, a slow-growing species.
- Scientists have been trying to create new forms of bacteria that can destroy tumors.
- Department of Defense has experimented with the creation of biological computers, and other military scientists are trying to engineer proteins and gene products from scratch that will act as targeted vaccines or cures.

Application in Biofuels

- In the area of biofuels, scientists at numerous companies are trying to create microbes that can break down dense feedstocks to produce biofuels.
- Modify the genes of microbes to secrete oil. If successfully scaled up for commercial production, these organisms could serve as valuable sources of renewable energy.

Other Applications

- Microorganisms harnessed for bioremediation to clean pollutants from our water, soil and air.
- Rice modified to produce beta-carotene, a nutrient usually associated with carrots that prevents vitamin A deficiency.
- Yeast engineered to produce rose oil as an eco-friendly and sustainable substitute for real roses that perfumers use to make luxury scents.

Risk assessment of synthetic biology

- Synthetic biology is not without its risks. However, there is some debate as to whether synthetic biology represents categorically different risks from those posed by other forms of biological research and genetic engineering.
- Both genetically engineered and synthetic organisms are capable of reproducing, mutating, evolving, and spreading through the environment, which makes them riskier than hazardous chemicals.
- There is concern over so: called emergent properties, which could arise unexpectedly when genes with no natural lineage enter the environment and interact with one another.

Ethical and social implications

- Projects that propose to synthesize entire genomes raise important ethical questions about potential harms and benefits to society.
- Many of the ethical questions relevant to synthetic biology are similar to ethical discussions related to genome editing.
- Are humans crossing moral boundaries by redesigning organisms with synthetic biology techniques?
- If synthetic biology yields new treatments and cures for diseases, who in our society will have access to them?
- What are the environmental impacts of introducing modified organisms into the ecosystem?
- Such ethical questions have been the subject of research since the beginning of the Human Genome Project and will continue to be researched as technology evolves and changes.

- Most scientists, ethicists and policymakers agree that entire societies must discuss and weigh the potential harms and benefits of synthetic biology in order to answer these questions.

Way forward

Synthetic biology is seen as one of the top 10 breakthrough technologies as part of the new industrial revolution that are most likely to change the world.

The regulatory challenge is how to leverage its anticipated benefits while guarding against its potential risks. The laws and regulations framework governing traditional tools and products of biotechnology can be applicable to this relatively nascent field in some ways, but most often it fails to fully adapt to the evolving possibilities of synthetic biology.

Geospatial Sector of India

The Centre is currently in the process of finalizing the draft **National Geospatial Policy (NGP)** and the **Indian Satellite Navigation Policy (SATNAV Policy).** It has already implemented Guidelines for Geospatial Data (Guidelines for acquiring and producing geospatial data and geospatial data services, including maps) in 2021.

What is geo: spatial data?

- Geospatial data is data about objects, events, or phenomena that have a location on the surface of the earth. The location may be:

> India's geospatial economy is currently valued at Rs 38,972 crore and has potential to grow to Rs 63,100 crore at 12.8 per cent by 2025 end, according to India Geospatial Artha Report.

  - **static** in the short: term, like the location of a road, an earthquake event, malnutrition among children
  - **dynamic** like a moving vehicle or pedestrian, the spread of an infectious disease
- Geospatial data combines location information, attribute information (the characteristics of the object, event, or phenomena concerned), and often also temporal information or the time at which the location and attributes exist.
- Geo-spatial data usually involves information of public interest such as roads, localities, rail lines, water bodies, and public amenities.

Geospatial technology

- Geospatial technology is a term used to describe the range of modern tools contributing to the geographic mapping and analysis of the Earth and human societies.
- It enables to acquire data that is referenced to the earth and use it for analysis, modeling, simulations and visualization. It includes:
  - Geographic Information System (GIS)/Spatial Analytics
  - Global Navigation Satellite System (GNSS) & Positioning
  - Earth Observation
  - Scanning

GIS /Spatial Analytics

The use of GIS/Spatial Analytics by various industries is only expected to go up in a market driven by increasing global demand for geographically correlated information. GIS can primarily be categorized into three types:

- **Desktop GIS:** Software is installed onto and runs on a personal computer
- **Web/Cloud GIS:** A desktop or mobile application allows the user to connect with the GIS server on the Internet. Running GIS software on Cloud allows a user to leverage the flexibility of the Cloud environment for data capture, visualization, analysis and sharing
- **Mobile GIS:** Takes GIS technology out of the office and into the field on a mobile device like a smartphone or a tablet

GNSS & Positioning

GNSS or Global Navigation Satellite Systems has become such an integral part of our daily lives that it is almost impossible to do without them. Be it surveying, navigation or indoor positioning, GNSS is the backbone of it all.

Earth Observation

Earth Observation, or remote sensing from space to surface, includes technologies like satellites in space, aerial photography (manned as well as unmanned flying vehicles).

Scanning

The scanning market comprises of Laser, LiDAR, Radar and Point Cloud from images – non-contact technologies that can digitally capture the shape of physical objects.

3D laser scanners create "point clouds" of data from the surface of an object or data about the surroundings.

Liberalisation of sector

The recent liberalisation of geospatial data and services in the country have prompted good participation from private players.

The government has removed prerequisites such as getting licences or prior approvals as part of the liberalisation of geospatial data to promote Make-in-India solutions.

What are the issues in the sector?

- **Lack of demand:** There is the absence of a sizeable geospatial market in India. There is no demand for geospatial services and products on a scale linked to India's potential and size.
- **Lack of awareness:** This is mainly due to the lack of awareness among potential users in government and private.
- **Lack of manpower:** There is lack of skilled manpower across the entire pyramid.
- **Unavailability of data:** The unavailability of foundation data, especially at high-resolution, is also a constraint. The lack of clarity on data sharing and collaboration prevents co-creation and asset maximisation.

Conclusion:

There is a huge potential in the sector and it is set to go for a long time. However, the persistent issues remain to be addressed, otherwise the benefits of technology alone would not suffice.

Drone Technology in Agriculture

Drone technology has gotten most of the recognition in the industry because of its diversity and considered the future for the agrarian community. The military initially used them. However, other sectors quickly embraced unmanned aerial vehicles (UAVs) when they learned about its widespread applications.

Need of Agricultural transformation

- Agricultural transformation is a crucial aspect for every developing nation.
- Primarily because almost every country aspires to reach high-income status, and agricultural development is an important aspect contributing towards the same.
- Particularly in countries like India, where at least 60% of the population depends on agriculture as their primary source of income, sustainable development in this sector plays a pivotal role.

Drones in Agriculture

- Typically, drones include a navigation system, GPS, multiple sensors, high-quality cameras, programmable controllers, and tools for autonomous drones.
- Most farmers currently use satellite imagery as an introductory guide for farm management. Furnished with modern technology, unmanned aerial vehicles (UAVs) can get more precise data than satellites for precision agriculture. They then process the data captured into agri-tech software to produce beneficial knowledge.
- Data from agriculture drone takes place as in the following stages:
  - **Analyzing the area:** Establishing a boundary, analyzing the area, and then finally, uploading the technical GPS information into the drone's navigation system.
  - **Using Autonomous Drones:** Since UAVs are independent, they enter flight patterns into their already established system to collect required data.
  - **Uploading the data:** After capturing all the required data through sensors such as the multispectral sensor/RGB sensor, it is processed through numerous software for further analysis and interpretation.
  - **Output:** After collecting the data, they format it so that farmers can understand the data with no hassle, bringing them a step closer to precision farming.

Application

- **Irrigation Monitoring:** Drones, including hyper spectral, thermal, or multispectral sensors, recognize areas that are too dry or need improvement by the farmer. Drone survey helps improve water efficiency and disclose potential leaks in irrigation.
- **Crop Health Monitoring and Surveillance:** It is crucial to track the health of the vegetation and spot bacterial/fungal plagues in the early stages. Agriculture drones can see which plants reflect different amounts of green light and Near: infrared spectroscopy (NIRS) light. This data helps produce multispectral images to track crop health.
- **Crop Damage Assessment:** Agricultural drones detect field areas inflicted by weeds, infections, and pests. According to this data, the exact amounts of chemicals needed to fight these infestations are known, and this helps diminish the costs inflicted by the farmer.
- **Field Soil Analysis:** The drone survey allows farmers to obtain information about their land's soil conditions.

- **Planting: Drone startups in India have invented drone:** planting systems that allow drones to shoot pods, their seeds, and crucial nutrients into the soil. This technology doesn't only reduce costs by almost 85% but also increases consistency and efficiency.
- **Agricultural spraying:** Through drone crop spraying, human contact with such harmful chemicals is limited. Agri: drones can carry out this task much quicker than vehicles/airplanes. Drones with RGB sensors and multispectral sensors can precisely identify and treat problematic areas.
- **Livestock tracking:** The drone survey allows the farmers not to keep track of their crops only but also monitor the movements of their cattle. Thermal sensor technology helps find lost animals and detect an injury or sickness. Drones can carry out this function favorably.

Benefits

- **Enhanced Production -** The farmer can improve production capabilities through comprehensive irrigation planning, adequate monitoring of crop health, increased knowledge about soil health, and adaptation to environmental changes.
- **Greater safety of farmers -** It is safer and more convenient for farmers to use drones to spray pesticides in terrains challenging to reach, infected areas, taller crops, and power lines. It also helps farmers prevent spraying the crops, which leads to less pollution and chemicals in the soil.
- **Faster data for quick decision making -** Drone surveys back farmers with accurate data processing that encourages them to make quick and mindful decisions.
- **Less wastage of resources -** Agri: drones enables optimum usage of all resources such as fertilizer, water, seeds, and pesticides.
- **Useful for Insurance claims -** Farmers use the data captured through drones to claim crop insurance in case of any damages.

Human Cell Atlas

The Human Cell Atlas is a project to describe all cell types in the human body. The initiative was announced by a consortium after its inaugural meeting in London in October 2016.

- In October 2017, the Chan Zuckerberg's Initiative announced funding for 38 projects related to the Human Cell Atlas.
- By April 2018, the project included more than 480 researchers conducting 185 projects.
- In April 2018, the first data set from the project was released, representing 530,000 immune system cells collected from bone marrow and cord blood.

What is a Human Cell Atlas?

- The Human Cell Atlas will be catalogue of a cell based on several criteria, such as: cell type, its state, its location in the body, the transitions it undergoes, and the lineage of the cell.
- It will gather data from existing research, and integrate it with data collected in future research projects.
- Its scope is to categorize the 37 trillion cells of the human body to determine which genes in each cell expresses the sampling cells from all parts of the body.
- All aspects of the project will be made "available to the public for free", including software and results.
- Two main approaches to achieve this will be scRNAseq and spatially resolved methods.

- Many single-cell sequencing approaches exist and so the HCA has the opportunity to perform systematic comparisons as well as to develop novel methods.
- Single-cell sequencing data present unique computations challenges and rich areas for innovation.

The scRNA: seq technique

- Single cell RNA - Sequencing (scRNA - Seq) enables simple and robust access to the transcriptomes of thousands of single cells.
- ScRNA: seq can be used to define the molecular identities of a large number of cells at affordable costs and is a sufficiently mature and distributed technology to be available to a diverse range of laboratories worldwide.

What does it aim?

- The initiative can transform our understanding of the trillions of cells in the human body.
- Without maps of different cell types, their molecular features and location in the body, we cannot describe all their functions or understand the networks that direct their activities.
- The map can also help us understand how a disease emerged in a body and identify the precise place or cell where it arises.
- It will allow us to develop more precise diagnostics for patients and new treatments.

Important Initiatives

- **India's Project' MANAV':** The project named 'Manav' has been launched by the **Department of Biotechnology and Persistent Systems,** a biotechnology company.
  - This mega project will collate and integrate molecular information on human tissues and organs that currently lies hidden in research articles in an unstructured and disorganized form.
- **Human Genome project:** The Human Genome Project originally aimed to map the nucleotides contained in a human haploid reference genome (more than three billion).
  - The "genome" of any given individual is unique; mapping the "human genome" involved sequencing a small number of individuals and then assembling to get a complete sequence for each chromosome.
  - Therefore, the finished human genome is a mosaic, not representing any one individual. The utility of the project comes from the fact that the vast majority of the human genome is the same in all humans.
- **Human Protein Atlas (HPA):** It is a Swedish: based program started in 2003 with the aim to map all the human proteins in cells, tissues and organs using integration of various omics technologies, including antibody: based imaging, mass spectrometry: based proteomics, transcriptomics and systems biology.
- All the data in the knowledge resource is open access to allow scientists both in academia and industry to freely access the data for exploration of the human proteome.

Concerns

- **Lack of global equity**
- **Problem to scientists:** They may face premature restriction to specific technologies or approaches, which might limit innovation in a fast: moving field, implicit restriction of participation, based on available resources; and diversion of funding from other research directions.
- **Lack of non-governmental cooperation**

Conclusion:

The past quarter: century has many times showed the value of the scientific community joining together in collaborative efforts to generate and make freely available systematic information resources to accelerate scientific and medical progress in tens of thousands of laboratories around the world. The Human Cell Atlas builds on this rich tradition, extending it to the fundamental unit of biological organization: the cell. Many challenges will arise along the way, but we are confident that they can be met through scientific creativity and collaboration.

Space Debris

Context:

ISRO is building up its orbital debris tracking capability by deploying new radars and optical telescopes under the Network for Space Objects Tracking and Analysis (NETRA) project.

Background

- The launch of Sputnik on Oct. 4, 1957, marked the beginning of an intense space race that led to decades of rocket and satellite launches, which eventually resulted in a large amount of space debris.

What is Space Debris?

- Space debris is anything in orbit that is man-made and is no longer in use.
- It consists of old, inactive satellites; rocket stages; and other discarded hardware.
- Smaller pieces of space debris include fragments of vehicles that exploded or collided and bits of insulation and paint that have come off of space vehicles.

The Problem of Space Debris

- **Threatens satellite technology:** Space debris affects everyone especially since almost everything we do in our modern way of life uses satellite technology.
  - A one-centimeter: sized object is considered lethal if it hits a satellite and an object down to one millimeter can critically damage a satellite if it hits a critical component.
- **Addition to cost:** Space debris adds to the cost of operating satellites because if debris destroys a satellite, it may take years and hundreds of millions of dollars to restore that satellite's service.
- **Harmful for sensors:** Even tiny debris objects can inflict grave harm to critical sensors and spacecraft components.
- **Hazardous space flights:** In addition, the growth in space debris will make orbit operations and space flight more hazardous, difficult and more costly if frequent maneuvers are required to avoid debris.

How much is India responsible for?

- India still produces much less space junk than the top three polluters: Russia, the US, and China, according to ODPO data. Indian: made space debris, however, is on the rise - from 117 pieces in 2018 to 163 in 2019.

What is Network for Space Objects Tracking and Analysis (NETRA) project?

- Project NETRA is an early warning system in space to detect debris and other hazards to Indian satellites.
- ISRO SSA Control Centre, "NETRA", is now set up within the ISTRAC campus at Peenya, Bangalore. The project is estimated to cost of Rs. 400 crores.
- NETRA's eventual goal is to capture the GEO, or geostationary orbit, the scene at 36,000 km where communication satellites operate. Under NETRA, or Network for space object Tracking and Analysis, the ISRO plans to put up many observational facilities:
  - connected radars, telescopes
  - data processing units
  - a control centre
- They can, among others, spot, track and catalogue objects as small as 10 cm, up to a range of 3,400 km and equal to a space orbit of around 2,000 km.

India's race to quantum supremacy

Quantum computing is going to be the next great leap in technology, with the ability to solve problems beyond the reach of today's computers. Thus, it's important to analyze India's progress towards the new technology and address various gaps present.

What is Quantum technology?

- Quantum technology is a class of technology that works by using the principles of quantum mechanics (the physics of sub: atomic particles), including quantum entanglement and quantum superposition.
  - **Example:** Smartphone is a type of quantum technology – its semiconductors use quantum physics to work.
- A qubit (or quantum bit) is the quantum mechanical analogue of a classical bit. In classical computing the information is encoded in bits, where each bit can have the value zero or one. In quantum computing the information is encoded in qubits.

The global quantum supremacy race

- At present, quantum technology is in its nascent stage and will take a few years before it can be practically implemented.
- It is likely to have a value addition of US $5 billion to US $10 billion in the next three to five years. This figure is expected to reach US $450 billion in the next fifteen years.
- Given the scope and potential of this technology, governments, technology firms, and academia have been investing resources into achieving quantum supremacy or quantum advantage.
- **India, Canada, Germany, and France** have committed more than a billion dollars each towards its development. India formally joined the race to quantum computing by establishing the **National Mission for Quantum Technology and Applications (NM: QTA) in 2020.**

How Quantum technology can be a good 'solution'?

- **Effective functioning:** In modern day computing, information is relayed and stored in binary digits or bits, that is, 0 or 1. In quantum computing, information sharing, and storage is done in qubits,

which exist as 0 or 1 or a combination of both. This allows for a quantum computer to perform a multitude of applications at the same time, at a much faster rate, surpassing the processing ability of a conventional computing system.

- **Increased processing capabilities:** Quantum computers will exponentially increase the processing capabilities of a modern: day computer and address impediments linked to combinatorics.
- **Multiple benefits:** Near: term and long: term quantum applications will:
  - augment AI solutions
  - improve financial forecasting
  - drastically reduce failures in the manufacturing sector
  - accentuate drug development
  - push for better cybersecurity paradigms

What are the potential threats?

- **Threat to cyber infrastructure:** Quantum technology can put the present: day encryption at risk, which can pose a threat to a country's critical cyber infrastructure, thereby, putting its national security at stake.
- **Information leak:** Confidential military and strategic information can be decrypted easily once quantum computers and their applications become a reality.

Present gaps in India's approach	Required measures
• Loosely built quantum ecosystem • Metrics to assess the outcomes of India's quantum efforts are not clearly defined • Lack of capacity and skilled professionals.	• Renewed policies and governance • Proper financing • Powerful setup • Strength in hardware manufacturing • Working towards becoming the technology exporter • Research & development

Conclusion:

Currently there are various loopholes and policy gaps in India. With the persistent challenges, India is far behind to match pace with China and the US. Thus, India needs to identify the present challenges and work towards them. These will not only make India a competent contender in the global quantum race but also usher a new paradigm of technology policymaking in the country.

Geopolitics of Outer Space

Context:

It is in the interest of India's new strategies in outer space and also about the urgency of drafting new rules for the road to peace and stability in the atmosphere.

Space Geo: strategy

- The US traditionally held a foreign position in the commercial sector. Its military rivalry with Russia set a precedent in the security sector.

- The emergence of China as a major space force - both socially and militarily - reshapes astro politics.
- Significant expansion of China's spatial capabilities and China's desire for foreign domination has provided a new urgency for democratic powers to come together to protect their national interests and promote sustainable order in the upper atmosphere.

Importance for India

- Space has emerged as the **fourth possible arm** of the country's defense.
- With the **US, Russia and China** already seeking to become a Space Force, India will need to be properly equipped to deal with emerging security challenges.
- Space power has the power to use space while denying reliable use to any enemy.
- India already has a significant ability to use space. But it is the ability to deny the use of space to the opponent, understandably, is a small thing.
- Speaking of satellites, India has active satellite military satellites, compared to more than 40 civilians. Our first military satellite was launched in 2013 only.
- However, India has made some progress in the pursuit of space power.
- The newly commissioned Mission Shakti demonstrated India's ability to identify enemy satellites.
- The newly formed **DSA (space defense agency)** will be supported by the **Defense Space Research Organization (DSRO)** with the mandate to develop weapons to "degrade, disrupt, destroy or defraud an opponent's space".

Issues associated with Outdoor Space Geopolitics

- **Rising space warfare:** The war and the equipping of space are in stark contrast to the constructive commercial and scientific projects. Despite these realities, military development and space warfare projects in the air have been on the rise for the purpose of one country.
- **Atmospheric Disposal:** Satellite-destroyed satellites disperse into smaller pieces, then add to space debris. As countries introduce more and more satellites, each of which is a strategic or commercial asset, avoiding collisions could be a challenge in the future.
- **Demand for Space Mines:** This demand for space mines will create a new era of conflict and cooperation and lead to a new space race.
- **Moon Rush:** After the discovery of the water on the moon and the "Peaks of Eternal Light", the moon is moving faster towards the southern moon, it is a new phenomenon. For example:
  - **China's Chang'e 4** has softened down the Von Karman crater on the dark side of the southern polar region.
  - The **American lunar system** now aims to bring man back to the moon for the next ten years.
  - **NASA's** focus is on the southern poles and, if successful, will be the first personnel to reach the South Pole.
- **Jeff Bezos (owner of Amazon)** has launched a Blue Moon project that seeks to house men and women on the moon over the next few years.
  - **Atmospheric Awareness (SSA)** involves monitoring the movement of all objects - natural (meteorites) and man-made satellites - and tracking the weather.

Spatial Awareness (SSA)

- There are thousands of objects in Earth orbit that could be harmful to satellites.
- SSA refers to keeping track of things in their path and predicting where they will be at any given time.

Way Forward

- **Public: Private Partnerships:** India needs to structurally regulate the regulatory, commercial and scientific aspects of the space program.
- **Effective funding:** Funding for Space Research and development should be expanded and independent research institutes should be encouraged to work together.
- **Need for a Strong Regulatory Framework:** Delhi must also enact a strong regulatory framework to promote India's local work and protect its international interests.
- **Addressing challenges:** India should take into account the challenges that arise in the current space order, review some of its past political ideas about the external environment and participate in the development of new global systems that will strengthen the Context: of the Space Agreement.
- **Precise tracking of danger:** In order to effectively protect our spacecraft, India must have a reliable and accurate track record of celestial objects, from debris and spacecraft to celestial bodies.
- **Adoption of reliable capabilities:** For space defense to be effective, India must acquire minimum, reliable capabilities for a wide range of space, physical, technological and cyber weapons.

Deep Fakes

Context:

Today, as technology advances, it is becoming increasingly easier for anyone to produce **deep fakes and deep fakes** are becoming harder to detect using traditional techniques

What are Deep fakes?

- Deep Fakes are called so because they use **deep learning technology,** a branch of **Artificial intelligence** that applies neural network simulation to large data sets, to create fake videos.
- Using this technology, a person's head movements and expressions, etc are transferred onto some other person's video in such a way that it becomes difficult to tell that it is a deep fake unless one closely observes the source media file.
- Deep Fakes constitute **fake multi-media content —** often in the form of videos but also other media formats such as pictures or audio — created using powerful artificial intelligence tools.
- Deep Fake makes it possible to **synthesize media —** switch faces, lip: syncing, and puppeteers — mostly without consent. This creates a threat to internal security, political stability, and business disruption in a nation.

How are deep fakes detected currently?

Currently, deep fakes are identified manually or by software, using some identifiers like:

- Flicking, blur with bleeding color, etc. in poorly produced deep fake videos
- Unusual eye blinking pattern in deep fake videos
- Using markers known as "soft biometrics" of a person i.e., his/her eyebrow movements, lip movements, etc.

What are the threats posed by deep fakes?

- **Can lead to a new type of Warfare**
- **Can undermine Democracy:**

- Deep Fakes can be used to power false information about public policy, institutions, and politicians which can be exploited to change stories and manipulate beliefs.
- A high: quality deepfake can create false information that can cast a shadow on the legitimacy of the voting process and election results.
- Deep fakes can become an effective tool to induce polarization, amplify division in society, and suppress dissent.

- **Can be used for targeting women**
- **Can cause damage to personal reputation**
- **Can be used for financial and other frauds**

Genome editing and its medical application

- Genome editing (also called gene editing) is a group of technologies that give 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.
- Several approaches to genome editing have been developed.
  - A well: known one is called **CRISPR-Cas9,** which is short for clustered regularly interspaced short palindromic repeats and CRISPR: associated protein.
  - The CRISPR-Cas9 system has generated a lot of excitement in the scientific community because it is faster, cheaper, more accurate, and more efficient than other genome editing methods.

Categories of gene therapies

- There are two different categories of gene therapies

Germline therapies	Somatic therapies
• Germline therapies can alter many cell types but by definition they also change genes in reproductive cells (like sperm and eggs). • These changes would then be passed down from generation to generation. • Germline therapy could potentially prevent inheritance of diseases.	• Somatic therapies, on the other hand, target non: reproductive cells. • Changes made in these cells affect only the person who receives the gene therapy and do not pass on to future generations. • Somatic therapies could be used to slow or reverse the disease process.

Genome Editing Methods

Homologous recombination

- The earliest method scientists used to edit genomes in living cells was homologous recombination.
- Homologous recombination is the exchange (recombination) of genetic information between two similar (homologous) strands of DNA. Scientists began developing this technique in the late 1970s following observations that yeast, like other organisms, can carry out homologous recombination naturally.

Zinc: finger nucleases (ZFN)

- In the 1990s researchers started using zinc: finger nucleases (ZFN) to improve the specificity of genome editing and reduce off: target edits.

- The structures of ZFNs are engineered from naturally: occurring proteins that were discovered in eukaryotic organisms.
- Scientists can engineer these proteins to bind to specific DNA sequences in the genome and cut DNA.
- Once bound to their target DNA sequence, the ZFNs cut the genome at the specified location, allowing scientists to either delete the target DNA sequence or replace it with a new DNA sequence via homologous recombination.

Transcription activator-like effector nucleases (TALENs)

- In 2009, a new class of proteins called Transcription Activator-Like Effector Nucleases (TALENs) arrived to the genome editing scene.
- Similar to ZFNs, transcription activator-like effector nucleases (TALENs) are engineered from proteins found in nature and are capable of binding to specific DNA sequences.

Clustered regularly interspaced short palindromic repeats (CRISPR)

- CRISPR is a simple technology with little assembly required.
- CRISPR associated DNA sequences were first observed in bacteria in the early 1990s, but it was not until the 2000s that the scientific community understood its ability to recognize specific genome sequences and cut them via the Cas9 protein, a protein that works with CRISPR and that has DNA: cutting abilities.

Application in health care

- Genome editing is of great interest in the prevention and treatment of human diseases. Currently, most research on genome editing is done to understand diseases using cells and animal models.
- Scientists are still working to determine whether this approach is safe and effective for use in people.
- Its significance can be known from the following points:
  - **Identification:** It is being explored in research on a wide variety of diseases, including single: gene disorders such as cystic fibrosis, haemophilia, and sickle cell disease.
  - **Treating complex diseases:** It also holds promise for the treatment and prevention of more complex diseases, such as cancer, heart disease, mental illness, and human immunodeficiency virus (HIV) infection.
  - **Treating disorder:** India has a large burden of genetic disorders and unmet medical needs and gene therapy can prove to be a turning point in the treatment of such disorders.
  - **Crops and Livestock:** The technique of genome editing can also be used for increasing yield, introducing resistance to disease and pests, tolerance of different environmental conditions.
  - **Biomedicine:** Genome editing is also beneficial for pharmaceutical development, xenotransplantation, gene and cell-based therapies, control of insect-borne diseases.
  - **Reproduction:** It helps in preventing the inheritance of a disease trait.

Satellite Internet Services

Context:

India has launched projects such as **BharatNet, Digital India, Brand India and Startup India** to accelerate the growth of internet-based ecosystems. To provide **seamless connectivity** to the most remote parts of the country, the **Indian Space Association** is also pushing the Centre to provide subsidies to **satellite communication (Satcom)** providers through the **Universal Service Obligation Fund (USOF).**

What is Satellite Internet?

- **Satellite Internet** works similarly to satellite TV.
- It is a wireless connection spread across satellite dishes located both in space and on the Earth.
- It provides remote areas of the planet with easy access to communication networks to keep people connected and give access to up-to-date information and communication systems.

Satellite Internet service requires a five-part system-

- Internet-ready device
- Modem/router
- Satellite dish
- Satellite in space
- ground station known as Network Operations Center (NOC)

Why is it important?

- Not all places on the Earth are able to establish various types of **land-based internet connections** like **broadband, fiber optics, cable internet, etc.**
- In fact, satellite Internet remains the only option if one lives in a rural part of the country where **internet infrastructure is underdeveloped.**
- **Satellite Internet service** is available even in areas with **slow Digital Subscriber Line (DSL)** and where cable and fiber connections are unavailable or have limited reach.
- Satellite Internet service provides high-speed Internet access to areas where wired, fiber and cable options are inaccessible.
- Satellites are used to deliver broadband Internet services to hard-to-reach users in the under-served regions.

How does Satellite Internet work?

- With satellite connectivity, the internet is beamed from space. The signal is sent from a geostationary satellite to a dish installed on a property, which connects to a modem inside.
- The satellite that orbits the Earth communicates using radio waves.
- A communication network sends and receives data, beginning with the user's internet-enabled device like modem or satellite dish to a communication satellite in space then back to the Earth to ground stations called network operations centers.
- The data is transmitted back through the network to space and then back to the land-based satellite dish on the Earth to deliver data on devices.

Gaganyaan

Context:

The preparations for Gaganyaan, India's maiden human space mission, are complete and humans of Indian origin will go to space next year.

About

- The Gaganyaan Programme envisages undertaking the demonstration of human spaceflight to Low Earth Orbit (LEO) in the short-term and will lay the foundation for a sustained Indian human space exploration programme in the long run.

- The objective of Gaganyaan programme is to demonstrate indigenous capability to undertake human space flight mission to LEO.
- As part of this programme, two unmanned missions and one manned mission are approved by Government of India (GoI).

Benefits

The Human spaceflight programme has both tangible and intangible benefits for the nation, which includes:

- Progress towards a sustained and affordable human and robotic programme to explore the solar system and beyond.
- Advanced technology capability for undertaking human space exploration, sample return missions and scientific exploration.
- Future capability to actively collaborate in global space station development & to carry out scientific experiments of interest to the nation.
- Create a broad frame work for wider Academia – Industry partnership in taking up development activities for national development.
- Ample scope for employment generation and human resource development in advanced science and R&D activities.
- Unique opportunity to inspire and excite Indian youth and steer many students toward careers in science and technology towards challenging jobs that encourage knowledge, innovation and creativity.
- The programme will strengthen international partnerships and global security through the sharing of challenging and peaceful goals. Having a vibrant human spaceflight programme can be leveraged as a potent foreign policy tool.

Technology required

The major new technologies required for Gaganyaan programme are as follows:

- Human rated launch vehicle
- Crew escape systems
- Habitable orbital module
- Life support system
- Crew selection and training and associated crew management activities

Major collaborating agencies

Major collaborating partners for Gaganyaan include:

- Indian Armed Forces
- Defence Research Development organisation
- Indian maritime agencies - Indian Navy, Indian Coast Guard, Shipping Corporation of India, National institute of Oceanography, National Institute of Ocean Technology.
- Indian Meteorological Department
- CSIR Labs
- Academic institutes
- Industry partners

Future

- After the successful completion of Gaganyaan programme, the next step will focus towards achieving capability for a sustained human presence in space.
- Activities associated with Space station will be an extension of Gaganyaan Programme. The detailed proposals and modalities for space station will be worked out in future. The Indian space station will be a platform for conducting scientific and industrial research in myriad areas of fundamental, applied and engineering sciences.

Antimicrobial Resistance (AMR)

As per the new Global Research on Antimicrobial Resistance (Gram) report published in the Lancet, antimicrobial resistance has become a leading cause of death worldwide and is killing about 3,500 people every day.

Antimicrobial Resistance (AMR)

- Antimicrobials – including antibiotics, antivirals, antifungals and antiparasitics – are medicines used to prevent and treat infections in humans, animals and plants.
- Antimicrobial Resistance (AMR) occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines making infections harder to treat and increasing the risk of disease spread, severe illness and death.
- Antimicrobial: resistant organisms are found in people, animals, food, plants and the environment (in water, soil and air).
- They can spread from person to person or between people and animals, including from food of animal origin.
- **Multiple drug resistance (MDR)** is antimicrobial resistance (AMR) shown by a species of microorganism to at least one antimicrobial drug in three or more antimicrobial categories.
- The main drivers of antimicrobial resistance include the
  - Misuse and overuse of antimicrobials
  - lack of access to clean water, sanitation and hygiene (WASH) for both humans and animals
  - poor infection and disease prevention and control in health-care facilities and farms
  - poor access to quality, affordable medicines, vaccines and diagnostics
  - lack of awareness and knowledge
  - lack of enforcement of legislation

Why is antimicrobial resistance a global concern?

- It threatens our ability to treat common infections.
- The rapid global spread of multi: and pan-resistant bacteria (also known as "superbugs") that cause infections that are not treatable with existing antimicrobial medicines such as antibiotics.
- Antibiotics are becoming increasingly ineffective as drug-resistance spreads globally leading to more difficult to treat infections and death. New antibacterials are urgently needed – for example, to treat carbapenem: resistant gram-negative bacterial infections as identified in the WHO priority pathogen list. However, if people do not change the way antibiotics are used now, these new antibiotics will suffer the same fate as the current ones and become ineffective.

- The cost of AMR to national economies and their health systems is significant as it affects productivity of patients or their caretakers through prolonged hospital stays and the need for more expensive and intensive care.
- Without effective tools for the prevention and adequate treatment of drug: resistant infections and improved access to existing and new quality-assured antimicrobials, the number of people for whom treatment is failing or who die of infections will increase. Medical procedures, such as surgery, including caesarean sections or hip replacements, cancer chemotherapy, and organ transplantation, will become more risky.

Factors causing AMR

Major factors causing AMR in India are:

- **Inappropriate consumption of broad-spectrum (last resort) antibiotics**
- **Inappropriate antibiotic use among the general public** like Self-medication
- **Large proportion of sewage** is disposed of untreated into receiving water bodies, leading to gross contamination of rivers with antibiotic residues, antibiotic: resistant organisms.

Quantum Key Distribution (QKD)

Context:

Till end-2030, India is likely to see a hybrid computing: operating model that combines classical computing with emerging quantum computing.

What is Quantum key distribution (QKD)?

- Quantum key distribution (QKD) is a secure communication method for exchanging encryption keys only known between shared parties.
- The communication method uses properties found in quantum physics to exchange cryptographic keys in such a way that is provable and guarantees security.
- QKD enables two parties to produce and share a key that is then used to encrypt and decrypt messages.
- Specifically, QKD is the method of distributing the key, not the key itself or the messages it can enable users to send.

How does QKD work?

- QKD works by transmitting many light particles, or photons, over fiber optic cables between parties.
- Each photon has a random quantum state, and collectively, the photons sent make up a stream of ones and zeros. This stream of quantum states that make up ones and zeros are called qubits - - the equivalent of bits in a binary system.
- When a photon reaches its receiving end, it'll travel through a beam splitter, which forces the photon to randomly take one path or another into a photon collector.
- The receiver will then respond to the original sender with data regarding the sequence of the photons sent, and the sender will then compare that with the emitter, which would have sent each photon. Photons in the wrong beam collector are discarded, and what's left is a specific sequence of bits.
- This bit sequence can then be used as a key to encrypt data. Any errors and data leakage are removed during a phase of error correction and other post-processing steps.

- Delayed privacy amplification is another post: processing step that removes any information an eavesdropper might have gained about the final secret key.

Types of QKD

- There are many different types of QKD, but two main categories are:
  - **Prepare-and-measure protocols** focus on measuring unknown quantum states. This type of protocol can be used to detect eavesdropping, as well as how much data was potentially intercepted.
  - **Entanglement-based protocols** focus around quantum states in which two objects are linked together, forming a combined quantum state. The concept of entanglement means that measurement of one object thereby affects the other. In this method, if an eavesdropper accesses a previously trusted node and changes something, the other involved parties will know.

By implementing quantum entanglement or quantum superposition, just the process of trying to observe the photons will change the system, making an intrusion detectable.

Some examples of QKD protocols are the following:

- BB84
- Silberhorn
- Decoy state
- KMB09
- E91

Challenges of QKD

- Primarily, there are three prevailing challenges to QKD: the integration of QKD systems into current infrastructure, the distance in which photons can travel and the use of QKD in the first place.
- For now, it is currently difficult to implement an ideal infrastructure for QKD. QKD is perfectly secure in theory, but in practice, imperfections in tools like single photon detectors create many security vulnerabilities. It is important to keep security analysis in mind.
- Even though QKD is seen to be completely secure in theory, imperfect implementations of QKD open the potential to compromise security. Techniques for breaching QKD systems have been discovered in real-life applications because of these imperfections.

Traditional Medicine: Challenges & Opportunities

Context:

Ayurveda, India's traditional medicine, has been in practice for close to three millennia. Even today, this ancient system serves the health-care needs of millions of Indians

What is traditional medicine?

- The WHO describes traditional medicine as the **total sum of the "knowledge, skills and practices indigenous** and different cultures have used over time **to maintain health and prevent, diagnose and treat physical and mental illness".**
- According to WHO, its reach **encompasses ancient practices such as acupuncture, ayurvedic medicine and herbal mixtures** as well as modern medicines.

- Traditional medicine in India is often defined as including practices and therapies such as yoga, Ayurveda, Siddha that have been part of Indian tradition historically, as well as others such as homeopathy that became part of Indian tradition over the years.
  - **Ayurveda and yoga** are practised widely across the country;
  - the **Siddha system** is followed predominantly in Tamil Nadu and Kerala;
  - the **Sowa-Rigpa system** is practised mainly in Leh: Ladakh and Himalayan regions such as Sikkim, Arunachal Pradesh, Darjeeling, Lahaul & Spiti

How India is promoting 'traditional medicines'?

- For supporting traditional medicine in India, the first full: fledged department for **Indian Systems of Medicine and Homeophathy (ISM&H)** was created under **the Ministry of Health and Family Welfare, in 1995.**
- This department was, in November 2003, renamed as **Department of Ayurveda, Yoga and Nauropathy, Unant, Siddha and Homeopathy (AYUSH).**
- The current **National Health Policy** of India has proposed **functional linkages of AYUSH** at all levels of health systems, including **service delivery as well as work force.**

Need for Revival of traditional Medicines

- **In search of better alternative:** Variety, flexibility, easy availability, religious/social acceptance, relative low side effect and cost are the key factor for the need of revival of traditional medicine.
- **Increasing burden on modern medicines:** In 21st century, tremendous advances in healthcare sector coexist with inequities in accessibility, availability and affordability of the healthcare facilities in many parts of India.
- **Integration of Ayurvedic and others Indian traditional medicine in clinical practice** will helpful to promote the health of the people who are unable to access the modern medicine properly.
- **Rural reach:** A study in rural area of West Bengal shows that folk medicine play a key role to prevent common diseases likes small injuries, skin disease, fever, dehydration, diabetes, high BP, liver disease etc. in better way.
- In rural areas, indigenous medicine play significant role in primary healthcare for prevention/ management of common ailments.
- **Less side-effect:** the traditional medicines have less side effects with respect to modern allopathic medicines as they are made from natural substances.

Challenges faced by traditional medicine

- National health systems and strategies **do not yet fully integrate traditional medicine workers, accredited courses and health facilities.**
- The WHO has stressed the **need to conserve biodiversity and sustainability** as about 40% of approved pharmaceutical products today derive from natural substances.
  - For example, the discovery of aspirin drew on traditional medicine formulations using the bark of the willow tree.
  - The contraceptive pill was developed from the roots of wild yam plants and
  - child cancer treatments have been based on the rosy periwinkle
- The WHO has referred to **modernisation of the ways traditional medicine is being studied.**
  - Artificial intelligence is now used to map evidence and trends in traditional medicine.
  - Functional magnetic resonance imaging is used to study brain activity and the relaxation response that is part of some traditional medicine therapies such as meditation and yoga.

- The WHO has said **traditional medicine is also being extensively updated by mobile phone apps, online classes, and other technologies.**
  - The GCTM will serve as a hub for other countries, and build standards on traditional medicine practices and products.

Indian Antarctic Bill

The Union government introduced the Indian Antarctic Bill, 2022, that aims to lay down a set of rules to regulate a range of activities on territories in Antarctica where India has set up research stations. Following its first expedition to Antarctica in 1982, India has now established two standing research stations, Bharati and Maitri, at Antarctica

What does the Antarctic Bill envisage?

- **Regular Visits-** The Bill envisages regulating visits and activities to Antarctica as well as potential disputes that may arise among those present on the continent.
- **Prohibition without a permit-** If the Bill were to become law, private tours and expeditions to Antarctica would be prohibited without a permit or the written authorisation by a member country. A member country is one of the 54 signatories of the Antarctic Treaty signed in 1959 — India joined the Treaty System in 1983.
- **Antarctic fund-** The draft also directs the creation of a fund called the Antarctic fund that will be used for protecting the Antarctic environment.

Why was this Bill necessary?

- **Preserving the pristine environment-** There is growing concern over preserving the pristine Antarctic environment and ocean around Antarctica from exploitation of marine living resources and human presence in Antarctica.
- **Growing presence of Indian scientists-** The continuing and growing presence of Indian scientists in Antarctica warrants a domestic legislation on Antarctica consistent with its obligations as a member of the Antarctic Treaty.
- **Increasing Tourism-** India organises regular Antarctic expeditions and many persons from India visit Antarctica every year as tourists. In the future, the private ship and aviation industry will also start operations and promote tourism and fishing in Antarctica, which needs to be regulated.

What is the history of the Antarctic Treaty?

- **Formation-** The Antarctic Treaty came into force on June 23, 1961 after ratification by the 12 countries then active in Antarctic science.
- **Key Objective-** Its key objectives are to demilitarise Antarctica, to establish it as a zone free of nuclear tests and the disposal of radioactive waste, and to ensure that it is used for peaceful purposes only; to promote international scientific cooperation in Antarctica and to set aside disputes over territorial sovereignty.
- **Purpose-** These, together with the original Treaty, provide the rules which govern activities in the Antarctic. Collectively they are known as the Antarctic Treaty System (ATS).

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