APPROACH – ANSWER: G. S. MAINS MOCK TEST - 1412 (2020)

1. What is proton therapy? Explain its advantages over conventional radiation therapy in cancer treatment and the limitations to its widespread adoption in India. (150 words) 10

Approach:

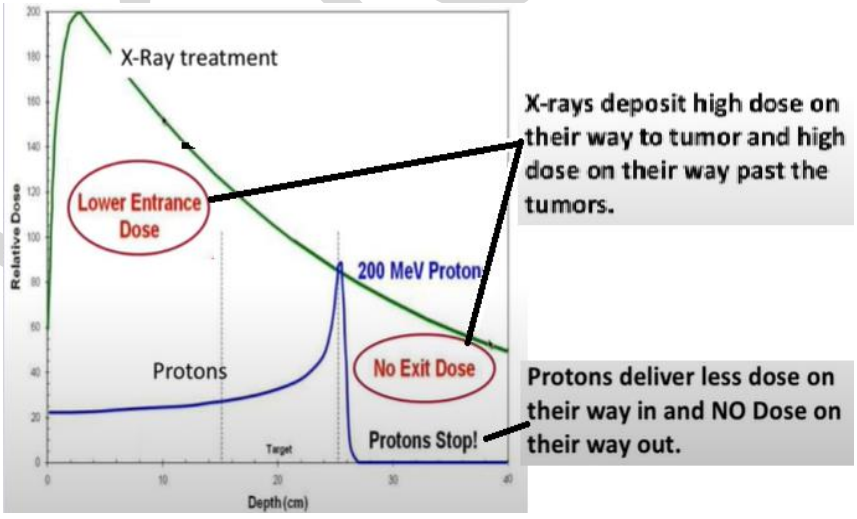
- Briefly define proton therapy and explain the technology employed in it.
- Mention its superiority or advantage over conventional radiation therapy.
- Mention the limitations to its widespread adoption in India.
- Conclude briefly with a way-forward.

Answer:

Proton therapy is a type of radiation therapy, which **uses protons rather than x-rays to treat cancer**. A machine called a cyclotron or synchrotron is used for increasing the speed of protons. **This high-speed movement of protons produces a form of powerful energy that pushes them to travel to the desired depth in the body and destroy cancer cells.** Recently, India became the 16th country in the world to offer proton therapy at Apollo Proton Cancer Centre, Chennai.

Advantages over conventional radiation therapy

- **No exit dose:** Standard radiation therapy utilises x-rays, which delivers radiation not only to the targeted tumour but even to the healthy tissues beyond. This exit dose is a cause of concern as the damage to the normal tissue or organs can affect the patient's quality of life post-treatment. In comparison, proton beams deposit the majority of the radiation dose directly in the tumour, without any exit dose.



- **Lesser sessions required:** A low dose of proton beam/ radiation is emanated at the targeted body surface that is followed by a sharp, powerful burst once it gets in contact with the tumour. This increases the chances that tumour cells targeted by the therapy will get destroyed in lesser sessions.
- **Efficacy of treatment:** Proton therapy can be even given to children with no harm in their growth. It can be used to treat recurrent tumours, even in patients who have already received

radiation. Further, the treatment can be delivered to the cancerous tumour from the most prominent angles, which wasn't possible in the conventional treatment.

- **Less Side effects:** Here the side effects such as fatigue, low blood counts, slight nausea during or the after treatment are reduced significantly**.** Thus, it also increases the long-term, progression-free survival rates for certain types of tumours.

Despite aforementioned advantages and the increasing cases of cancers in India, proton therapy faces certain challenges to its widespread adoption in India:

- These systems are highly **specialised, complex and expensive**. The high cost of establishing and operating proton therapy facilities has constrained the research and development necessary to maximize its clinical effectiveness.
- **Limited clinical data** available to prove its **applicability to common cancers** such as- breast, lungs etc.
- In proton beam therapy, no two machines are alike and the system at every centre needs **heavy customisation** for the efficient delivery of the therapy.

In view of above limitations, more research and clinical trials are needed to make this treatment more affordable and applicable to all types of cancers.

2. Explain the Raman effect and its applications with adequate examples. (150 words) 10

Approach:

- Explain the Raman Effect.
- Mention its application in different areas with examples.
- Conclude with the legacy of this discovery and its recognition.

Answer:

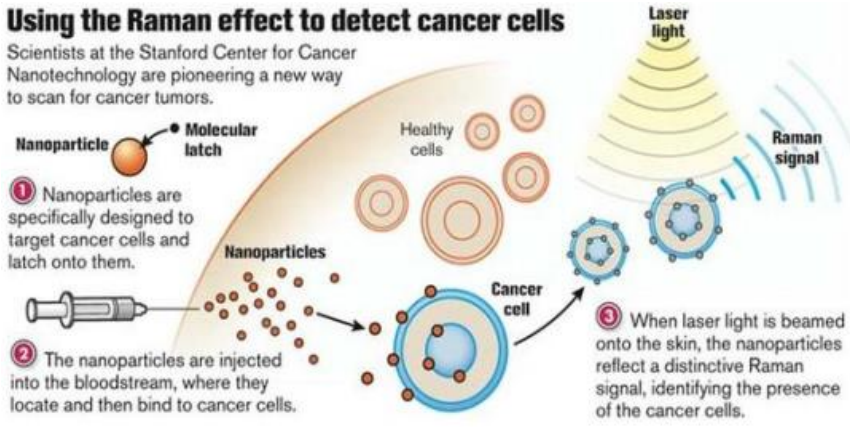
Raman Effect is the phenomenon of **inelastic scattering of light** as it passes through a medium. When monochromatic radiation or radiation of a very narrow frequency band is passed through a substance, a small amount of the radiation is scattered. The scattered beam consists almost entirely of the radiation of incident frequency (also known as *Rayleigh scattering*) but, in addition, certain discrete frequencies higher and lower than that of the incident beam are scattered. This phenomenon of scattering involving additional frequencies is called the **Raman scattering** or the **Raman Effect.**

The Raman Effect is a very weak effect where only one in a million of the scattered light particles, or photons, actually exhibit the change in frequency. Therefore a powerful laser source of visible or near-infrared monochromatic radiation is used to obtain **Raman spectra** with a suitable spectrometer.

Applications of Raman Effect:

Raman spectroscopy is based on Raman Effect, which has extensive applications, as the character of the scattered radiations enables us to obtain an insight into the ultimate structure of the scattering substance.

- It is a principal method of **non-destructive chemical analysis** for both organic and inorganic compounds. It can help in determining **molecular structures**, chemical bonding structures, characterise materials, crystalline orientation, structure of sample, in all phases of matter.
- It is used to monitor manufacturing processes in the **petrochemical** and **pharmaceutical** industries, such as identifying pharmaceutical chemicals, and analyse counterfeit drugs.
- It can identify pigments in old paintings and historical documents for **archaeological** preservation.



- Advances in Raman spectroscopy have enabled detection of different types of pathologies, **molecular diagnosis of cancer** etc.
- It is also used to **detect explosives** using lasers, analyse **nuclear waste material** from a safe distance.
- It is used for gemstone and **mineral identification**, analysing behaviour of minerals under extreme conditions.
- Surface-enhanced Raman spectroscopy is widely used for **studying surfaces** and reactions on surfaces.

The Raman Effect provided one of the most convincing evidence for **quantum theory** and **discrete energy levels**. In recognition of his work, Sir C. V. Raman was awarded with Nobel Prize in Physics in 1930. His birthday, 28th February is celebrated as the **National Science Day** in India.

3. Despite steps taken by India for the development and adoption of nanotechnology, much more needs to be done to ensure that its huge potential is fully leveraged. Discuss. (150 words) 10

Approach:

- Introduce by giving a brief account on nanotechnology and its potential in India.
- Briefly discuss the steps taken by India for the development and adoption of nanotechnology.
- Discuss the need of a multi-pronged approach to fully leverage its potential.
- Conclude appropriately.

Answer:

Nanotechnology is the development and use of techniques to study physical phenomena and develop new devices and material structures by manipulation of matter on an atomic, molecular, and supramolecular scale in the **physical size range of 1-100 nanometres** (nm).

Nanotechnology has huge potential for various fields in India like **Health and medicine** (Nanoscale diagnostic devices and implants), **Electronics** (use of Nanotetrapods to develop low cost electrodes for fuel cells), **Environment** (NanoCO_2 harvesters), **Defence** (Intelligence gathering can be done through nanosensors, nanotechnology enabled precision-guiding tools) etc.

In order to tap this potential, India has taken following **steps for the development and adoption of nanotechnology**.

- It began with the **Nanoscience & Technology Initiative** (2001 to 2006) to create the background and infrastructure for R&D in nano-science & technology.
- This was followed by the **Nanotechnology Initiative Programme** (2004) and **Nano Science and Technology Mission** (2006).
- **National Mission on Nano Science and Technology** (2007) was started as an '**umbrella capacity-building programme**' to promote basic research in nanotechnology, human resources development, infrastructure development and international collaboration. The Mission resulted in useful products like nanohydrogel based eye drops, pesticide removal technology for drinking water, nanosilver based antimicrobial textile coating, etc. and publication of over 23000 papers by Indian scientists.

However, India has been not able to **leverage the full potential** of nanotechnology and following steps need to be taken:

- **India needs to increase its spending on nanotechnology** research which, at present, is just a fraction of the research spending of countries like Japan, USA, China etc. **Long-term funding,** which can accommodate coherent research programmes with high-impact outcome is needed.
- The **number of PhDs** awarded in nanoscience and technology needs to be increased to meet the target set by the Ministry of Human Resource Development of producing 10,000 PhD students annually over the next decade.
- **Private sector** needs to be leveraged to contribute further to nanotechnology research.
- **Regulatory issues** arising out of the 'boundary-crossing' nature of nanotechnology need to be resolved. There is a need to have a **collaborative framework** so that various research centres throughout India work together to attain better results.
- A **streamlined ethical approach** that takes into account the potential benefits and risks of nanotechnology in consultation with all the stakeholders shall unlock the potential so limited by ethical consequences of nanotechnology.
- The linkages between the technology and commercial domains should be strengthened to **reduce the gap between basic research and application in nanotechnology**.

Nano technology holds great potential for India and a multi-pronged approach will ensure that this is fully leveraged. This will help India utilize its natural and human resources optimally and also help make India self-reliant in sectors like health and medicine, electronics, environment, defence etc.

4. Along with other measures, technological interventions are crucial in dealing with the Covid-19 pandemic and its after effects. Explain. (150 words) 10

Approach:

- Briefly explain the challenges posed by COVID-19.
- Explain how the technological interventions can help in dealing with the crisis and its after effects.
- Conclude on the basis of the above points.

Answer:

The chaos and panic created by COVID-19 infections has exposed the unpreparedness of the world towards handling of pandemics. Though several measures such as social distancing, lockdowns, face masks and sanitizers have been suggested to avoid the infection, technological interventions would be a crucial aspect of dealing with it and its after effects.

Technological interventions:

- **Artificial intelligence (AI):**
  - An **AI-enabled Fever Detection Cameras** can screen and identify those showing symptoms of fever.
  - **AI-enabled deep learning** can be useful in predicting and mapping the protein structure of the virus. It can help in future experimental work in developing therapeutics.
  - **Intelligent diagnosis** and quantitative evaluation of CT images of COVID-19 through image algorithms can help the doctor analyse the situation better.
  - Since doctors are overloaded with work, advice to patients can be given through a **customised chatbot.**
- **Robotics:**
  - **To curb contamination, robots can be used for taking vitals of the patients** and communicating with the medical team outside of the isolation area.
  - Drones can be useful for **delivering critical medical supplies, food, and other essential items**. They can also be used for **surveillance**, as well as to ensure that people are following safety guidelines.

- **Space technology**:
  - A **wearable GPS-tracking electronic device** can be used to track the movement of an infected person, as well as those put in isolation and quarantine.
  - **Heat mapping technologies** can be used for drawing up a containment plan.
- **3-D printing:** 3-D printing of ventilator valves, hygiene hooks or masks etc. can increase their overall production at a much cheaper rate.
- **Take home testing kits:** Innovation of such kits will allow users to collect samples at home and ship them to a lab. Such **self-test kits** will reduce the vulnerability of infection in healthcare professionals.
- **Information and communication technology:**
  - Government approved applications can provide correct information to people at a time when misinformation and panic is at a high. For instance, Aarogya Setu App.
  - ICT can help people stay connected during the lockdown. It can help in giving online classes to students, providing entertainment, and live conversation with government officials and health experts is also possible.
  - Telemedicine can help in reducing stress on already limited healthcare available in the country, especially in rural areas with fewer medical providers.
  - It can help in managing stress and other behavioural issues due to the lockdown.

The COVID 19 crisis has demonstrated that it is impossible for societies to ignore technological advancements as they are continuing to change everyday lives as well as business models. For long-term sustainable development of nations, it is important that the governments make full use of technological interventions to tackle the crisis.

5. Frugal Innovation, one of the most prominent contribution of India to the science and technology community across the world, comes with its own set of challenges. Elaborate.
(150 words) 10

Approach:

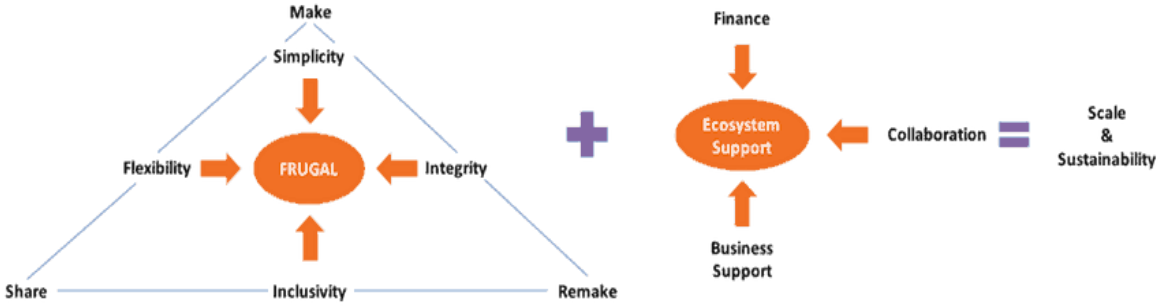
- Explain Frugal Innovation.
- Give examples of India's contribution in the form of frugal innovation to the world of science and technology.
- List the challenges involved in frugal innovation.
- Conclude on the basis of aforementioned arguments.

Answer:

Frugal innovation also referred to as **"reverse innovation" or "constraint based innovation"** is a distinctive approach to innovation, distinguished both by its means and its ends. It responds to limitations in resources, whether financial, material or institutional, and **turns these constraints into an advantage**; either by minimizing the use of resources or business models or reshaping them in newer ways that result in dramatically lower–cost products and services.

In the recent decades, India has become a hub for frugal innovation, creating high value products and services at extremely low cost.

- In 2009, BMVSS co–developed the **Jaipur Knee** made of ultra-low cost oil–filled nylon. It requires no tools and just under an hour to assemble.
- **Mitticool** has developed a natural refrigerator made from clay to store vegetables and fruits and also to cool water. It provides natural coolness without any electricity or any other form of energy.
- Priced at just over half the cost of its nearest rival, **Tata Nano** was the world's cheapest family car.
- Frugality in innovation marked India's credibility in high-tech ventures such as space missions. India's **Mars Orbiter Mission** was budgeted at a staggeringly cheap price of around $74million. In comparison, the cost of Nasa's Maven Mars mission was ten times as much.



By deriving more value from limited resources and finding creative ways to reuse existing resources, India has acquired the role of a pioneer for innovations that aim at combining affordability with excellence. However, frugality in innovation in India comes with its own set of **challenges**:

Structural Challenges:

- **Intellectual Property Regime**: Restrictive regime in India results in a lack of importance for Intellectual Property (IP) and its protection. This is a disincentive for global players to 'innovate in India'
- **Institutional Weakness**: Red-tapism, weak political institutions and corruption further discourage players to venture in businesses in India.

Operational Challenges:

- **Talent Pipeline:** Despite abundant labour supply, India lacks labour with adequate skills for innovation.
- **Weak logistics**: The weakness of distribution networks, inefficient transportation and handling systems adds to the challenges.

Economic Challenges:

- **Capital**: Despite the emergence of new networks of investors and venture funds in the recent years, there remains a big gap between the available capital and existing opportunities in India.

India's socio-economic conditions favour a culture of acceptance towards frugal innovation. It addresses the special requirements of the demanding and budget constrained consumers. It has certainly revived interest of the developed nations, by achieving frugality without compromising much on quality, performance levels, access and scalability.

6. What is Antimicrobial Resistance (AMR)? Examine the major contributing factors for prevalence of antibiotic resistance in India. What steps has the government taken to address this problem? (150 words) 10

Approach:

- Briefly explain Antimicrobial Resistance (AMR).
- Examine the major factors responsible for spread of antibiotic resistance in India.
- Discuss the initiatives taken by the government to check the spread of Antimicrobial Resistance in India.
- Conclude on the basis of the above points.

Answer:

Antimicrobial Resistance (AMR) is the ability of microbes to nullify the effects of antimicrobial drugs, resulting in these drugs becoming ineffective. When the microorganisms become resistant to most antimicrobials, they are often referred to as "superbugs". Antibiotic Resistance is of particular concern in developing nations including India, where the burden of infectious disease is high and spending on healthcare is low.

Factors which encourage development and spread of antibiotic resistance in India are:

- **Over-prescription of antibiotics:** Unethical commercial practices by doctors, pharmacists and pharmaceutical companies to promote the sale of antibiotics in large quantities.
- **Over-the-counter (OTC) access to antibiotics:** Easy access to over-the-counter antibiotics in medical stores leads to unnecessary and injudicious use of antibiotic dose.
- **Inadequate awareness:** There is **lack of knowledge/awareness** on the current revised guidelines and algorithms for antibiotic usage. Further, the patients do not finish the entire antibiotic course, due to which some of the bacteria causing the infection may survive and be further resistant to antibiotics.
- **Overuse of antibiotics in livestock and fish farming:** This is done for therapeutic purposes and growth promotion.
- **Untreated disposal of sewage into water bodies:** It amplifies the transfer of resistant genes to humans.

Various initiatives taken by government to check the spread of antibiotic resistance in India include:

- Adoption of **'Chennai Declaration on Antimicrobial Resistance (AMR)',** a set of recommendations, to promote antibiotic stewardship.
- The **National Programme on Containment of Antimicrobial Resistance** aims to establish laboratory based AMR surveillance, strengthen infection guidelines and promote rational use of antibiotics.
- India's **National Action Plan (NAP) for AMR** (2017-2021) was launched with the objectives to improve awareness, enhance surveillance measures, strengthen infection prevention and control, research and development and promote investments to control AMR. It also aims at intra and inter-sectoral coordination with a 'One Health approach'.
- The **'Red Line campaign'** was launched in 2016 to spread awareness and discourage the over-the-counter sale of antibiotics.
- The government has **capped the maximum levels of drugs** that can be used for growth promotion in meat and meat products.
- The Indian Council of Medical Research launched the **Antibiotic Stewardship Initiative** for controlled antimicrobial use in the hospitals.
- **Draft standards for antibiotic residues** in pharmaceutical industrial effluents were developed by the Central Pollution Control Board.

AMR is an increasing threat to global public health that requires action across all government sectors and society. Strong political commitment and support from the civil society, private sectors, and media are crucial in the fight against AMR.

7. Explaining how the 5G mobile communication technology works, discuss its differences with LTE. Discuss the challenges being faced in its rollout. (150 words) 10

Approach:

- Briefly explain what you understand about 5G and discuss how the technology works.
- Discuss some of the key differences between the LTE and 5G Networks.
- State the challenges being faced in its rollout.
- Conclude appropriately.

Answer:

5G is the successor to the fourth generation of cellular mobile communications (LTE-A & WiMax 2) that promises to deliver improved end user experience by offering new use cases through higher data rates, low latency, high reliability and enhanced coverage. Furthermore, it will ensure efficiency across energy consumption, spectrum & network usage.

5G networks use a system of cell sites that divide their territory into sectors and send encoded data through radio waves. Each cell site must be connected to a network backbone, whether through a wired or wireless backhaul connection. 5G networks use a type of encoding called Orthogonal

Frequency-Division Multiplexing (OFDM), which is similar to the encoding that 4G LTE uses. However, the new 5G NR (New Radio) will further enhance OFDM to deliver a much higher degree of flexibility, speed and scalability. 5G incorporates advanced wireless technology such as massive MIMO (multiple-input and multiple-output) i.e. use of multiple targeted beams to spotlight and follow users around a cell site.

Some of the key differences between the LTE and 5G networks are:

- **Capacity:** 5G will be able to boost capacity by four times over the current systems by leveraging wider bandwidths and advanced antenna technologies. Further, it can support a 100x increase in traffic capacity and network efficiency.
- **Speed:** 5G will deliver up to 20 Gigabits-per-second peak data rates and 100+ Megabits-per-second average data rates. It is expected to be nearly 100 times faster than 4G LTE network.
- **Spectrum support:** 5G will provide much more network capacity by supporting all spectrum types (licensed, shared, unlicensed) and bands (low, mid, high).
- **Frequency:** 5G will operate at **much higher frequencies** in the 30 GHz to 300 GHz range.
- **Latency:** 5G has **lower latency** LTE networks i.e**.** lag time in communications between devices and servers. Latency for 4G is around 20-30 milliseconds, but for 5G it will be below 10 milliseconds.
- **Device support:** 5G will support **more connected devices** than the LTE networks, using a wide range of deployment models and new ways to interconnect.

Challenges being faced in its rollout include:

- **5G technology is at a nascent stage** and research on its viability is still going on.
- A few Chinese corporations such as Huawei and ZTE Corporation dominate the 5G network. Their access to global data could potentially raise **economic and security threats.**
- Developing infrastructure and technology for 5G requires **high cost.** 5G deployment will also involve a heavy upfront investment with a long payback period.
- **Many of the devices will not be competent with 5G** and will require a fundamental change to their core communication architecture.
- Shifting to 5G technologies would require **massive up-gradation of the existing networks and antennae.**
- Telecom operators are still trying to fully monetize 4G services. Further, there is a need of a **reasonable spectrum pricing and swift allocation** of spectrum.

5G is seen as a likely game changer for India, with the potential to create an economic impact of more than US$1 trillion by 2035. The government should take definitive measures for its growth, such as push for 'Make in India' manufacturing for 5G equipment and handsets, public-private partnerships for broadband growth and penetration, indigenous technology advancements through R&D etc. India should also forge global partnerships in the development of 5G technology and become an active stakeholder.

8. Highlighting the significance of genome mapping in India, discuss the associated challenges with the Genome India Project. (150 words) 10

Approach:

- Introduce by giving the concept of genome mapping.
- Giving a brief introduction about the Genome India Project, highlighting the significance of genome mapping in India.
- Discuss the challenges associated with it.
- Conclude appropriately.

Answer:

A genome refers to the organism's **complete set of DNA, which includes all its genes**. In humans, each cell consists of 23 pairs of chromosomes and around 20,500 genes located on them. Some of the genes are lined up in a row on each chromosome, while others are lined up close to one another.

Genome mapping, therefore, essentially means figuring out the location of a specific gene on a particular region of the chromosome and also determining the location of and relative distances between other genes on that chromosome.

The **Genome India Project** inspired by the Human Genome Project (HGP 1990-2003), aims to build a grid of the Indian reference genome, to fully understand the type and nature of diseases and traits that comprise the diverse Indian population.

Significance of genome mapping in India:

- It can determine the role of individual genes and their ability to cause diseases which will help **assess genetic predisposition to a disease**, **diagnose heritable cancers**, and **develop tests to prevent adverse drug reactions**. For example, prenatal genetic testing to detect birth defects or genetic disorders.
- In **agriculture,** better understanding of the **genetic basis of susceptibility to diseases** may help to deter them genetically and reduce dependence on chemicals. Given the geographical and biological diversity in India, the project could provide information on the **interplay of species and genetic groups** thereby providing a **deeper understanding of ecology**.
- **Global science** would benefit as genome mapping in India would provide one of the most diverse gene pools for analysis.

However there are various challenges with the project such as:

- **Data storage and privacy**: There are concerns regarding anonymity and misuse of genetic data without informed consent in the absence of data privacy law in place in India.
- **Genetic stereotyping and stigmatization**: There is the potential of stereotyping of populations based on these genomic differences similar to caste identities.
- **Medical ethics**: Burdening people with mutation information can lead them to make lifestyle changes that are not necessary in routine conditions. For example, it can be misused to create designer babies.
- **Interpretational issues**: There are very few trained clinicians and genetic counsellors who could interpret the data in a meaningful manner and in the best interest of the patient.
- **Technological errors**: Even a single base pair false positive error can create a huge burden for the individual and community in terms of wrong diagnosis and unnecessary treatment as well as social stigmatization.

While mapping the genetic diversity of India would further scientific understanding of evolutions both from biological and sociological point of views, proper safeguards should be in place against any misuse of it.

9. What do you understand by 'soft robotics'? Highlight its possible applications. (150 words) 10

Approach:

- Explain the concept of soft robotics.
- Highlight its possible applications.
- Give a brief conclusion.

Answer:

Soft robotics is a subfield of robotics focused on **creating robots that act very similar to living organisms**, including the way they move and adapt to surroundings. Compared to standard robots, soft robots have certain specific characteristics. They have increased flexibility and thus capacity for movements, bringing robots closer to the structure of living organisms.

A soft robot is typically made of various types of rubber or silicone that increase the apparatus flexibility. Other substances include electro active polymer materials that can be used in soft robotics to create pseudo muscles that expand and contract in response to applied voltage.

Possible applications of soft robotics:

- **Healthcare treatments:** Over the past few years, soft robotics has been used for many different medical purposes like surgery, medical treatments, and diagnostics. For example,
  - **Edible robots** can be used to deliver medicine to different parts of the body. For example, researchers in Switzerland designed gelatine-based robots that humans and animals can ingest.
  - Since they can mimic the movement of living organisms, there is a possibility to develop more **life-like prosthetics** for those who have lost limbs or extremities.
  - In pandemics like **COVID 19,** these robots have been deployed for the potential use of delivering medications and food thus keeping medical staff safe, measuring vital signs etc.
- **Construction work:**
  - These types of robots have potential applications ranging from the **inspection and maintenance** of buildings to **search and rescue** missions.
- **Industrial process and exploration:**
  - The machinery produced incorporating soft robotics is capable of grasping and moving anything from delicate things such as tomatoes, eggs to frosted cakes quickly and precisely. This would further automate the **industrial processes handling delicate items**.
  - Their ability to **bio-mimic** enables deployment in hazardous situations minimizing the risk to human lives in an industrial setup.
  - They are developed to conduct soft manoeuvres unlike rigid robots which makes them a perfect candidate for deep sea or space exploration.

Soft robotics also address the problems of **wear and tear** that robots with hard structure face. With these potential applications, soft robotics is the future of robotics where varied application of it will be beneficial for the **society and scientific community**. India should also ramp up R&D in this subfield of robotics to ensure that it keeps up pace with the innovations in this area.

10. Examine the significance of GISAT-1 satellite, India's first earth imaging satellite in a geostationary orbit. (150 words) 10

Approach:

- Give a brief introduction of the GISAT-1 satellite and mention its significance.
- Write about the capabilities of the GISAT-1 satellite.
- Mention the constraints of GISTAT-1 satellite for India.
- Conclude appropriately.

Answer:

GISAT-1, is the first of the two geo imaging satellites (GISAT) which will provide near **real time observation of the Indian subcontinent, under cloud free condition**, at frequent intervals.

Significance of GISAT-1 operating from geostationary orbit

- **Wider coverage:** Other earth observation satellites operate from **low earth orbits** and therefore only cover smaller areas. Since GISAT-1 will be positioned in the **geosynchronous orbit**, it will give wider coverage of **earth and atmosphere.**
- **Better resolution:** It has **multi-spectral, multi-resolution imaging instrument**, which is capable of imaging full or part of the earth disk with higher resolution multispectral visible near infra-red (MX-VNIR), hyper-spectral visible near infra-red (HyS-VNIR), and hyper-spectral shortwave infrared (HyS-SWIR).
- **Complete Coverage of Indian subcontinent:** It will give coverage of the entire Indian subcontinent landmass and surrounding oceans. It will help Indian defense forces keep a constant eye on Indian border.
- **Wider application including Disaster Management:** Imagery from GISAT-1 will be utilized for a host of applications including crop monitoring at regional and national level, drought progression and assessment, ocean and coastal zone management, fog detection and warning, quick monitoring of natural disasters, pollution monitoring etc.

- **Space Defence and Monitoring:** The GISAT-1 serves a defensive purpose in a world where outer space, especially low earth orbit, is getting more competitive and gaining strategic importance. The GISAT-1 undercuts the risk of being blasted out of the sky since it operates at a height of 36,000 kilometres above the Earth's surface, putting it out of range of known anti-satellite weapons.

While GISAT type satellites are necessary, they are insufficient to meet the specifically defence-related challenges India faces. To identify and discriminate enemy targets, a very high resolution imagery is required. This will require a dedicated constellation of radar satellites as they are not subject to atmospheric interference.

Nevertheless, in the event ISRO is successful in launching the satellite, India will become only the seventh country to launch and operate a satellite of this kind. It will be an important milestone for India's space agency and its missions.

11. In the context of India, identify the issues faced by women in science to pursue higher studies or research. Also, discuss the measures needed and already in place to address these issues.
(250 words) 15

Approach:

- Introduce by highlighting the present status of women in science in India.
- Explain the challenges faced by women in science to pursue higher studies or research.
- Mention the measures taken and that needs to be taken by the government in this regard.
- Conclude briefly.

Answer:

In India, women's participation at higher levels of science or research is low. Only 15% of the Indian R&D workforce are women, while the global average is 30%. ISRO, the premiere research organisation, has only 8% women in its scientific and technical staff.

Issues faced by women in science to pursue higher studies or research:

- **Gender factors:** Gender responsibilities makes it less favourable for women to take up science. For example, some studies report tenure of female PhD candidates coincides with marriage and family commitments, which leads them to compromise at undergraduate or school level teaching assignments.
- **Economic factors**: Economic considerations affect the pursuit of a science degree as it is generally more expensive than arts or commerce degree. Moreover, women comprise less than 10% of the fellowships of India's science academies and awareness is less in vernacular languages that further affects their participation.
- **Fewer number of science colleges**: The number of institutions including women's colleges offering arts and commerce courses outnumber those offering science courses.
- **Bias in S&T fields**: As many as 81% of women in STEM courses in India felt a gender bias in performance evaluation. It has been noted that for same position and recognition, women have to work harder. It deters women from pursuing this field, causing a major leak at the postdoctoral level.

Measures undertaken to address the gender gap:

- **Knowledge Involvement in Research Advancement through Nurturing (KIRAN),** is an umbrella scheme, encompassing schemes like Women Technology Parks, Mobility Scheme etc. aimed to bring gender parity in S&T.
- **Women Scientist Scheme** encourages women with S&T qualifications to pursue research in science and engineering, to take up S&T-based internship followed by self-employment etc.
- **Partnership with other countries like INDO-US Fellowship for Women in STEM,** which provides opportunities to Indian women scientists, engineers and technologists to undertake collaborative research in premier institutions in the USA to enhance their capabilities.
- **BioCARE initiative** focuses on career development of employed/ unemployed women scientists' upto 55 years of age.

- **UDAAN,** aims to address the issue of lower enrolment ratio of girl students in science and engineering colleges.
- **Women Science Congress programme** aims to encourage more accomplished women scientists to participate, act as role models for budding women scientists and create a platform for networking and mentoring.

Measures still needed:

- **Strengthening science education in women's institutions**: All women institutions should provide the best platform to address many issues that concern women in pursuing higher studies.
- **Awareness of women accomplishments in science**: Successful women examples would act as an inspiration and make it easier for girls to pursue science and imagine a career in it.
- **More scholarships and programmes**: Such scholarships should be initiated which enable women to join at any time of their career. Corporate sector may be directed to earmark specific funds for women in S&T programmes.
- **Gender sensitization:** It would address gender issues with broader perspectives since they would bring the change in mindset in future at personal and professional fronts.

Gender equality in higher levels of science or research is not only vital to achieve the sustainable development goals, but it is also a critical element to create a flourishing culture of innovation in the enterprise. A diverse team with different perspectives and skill sets fuels a country's ability to innovate and stay competitive.

12. Highlighting the potential of supercomputing in helping solve some of the world's most pressing challenges, mention the initiatives taken by India in recent years to build its supercomputing power. Also, discuss some of the concerns around supercomputers.

(250 words) 15

Approach:

- Introduce by giving definition of supercomputing.
- Highlight its potential in helping solve some of the world's most pressing contemporary challenges.
- Enumerate the initiatives taken by India in recent years to build its supercomputing power.
- Mention a few concerns around supercomputers and conclude accordingly.

Answer:

Supercomputing refers to the processing of massively complex or data-laden problems using the concentrated computing resources of multiple computer systems working in parallel (i.e. a "supercomputer"). It involves a system working at the maximum potential performance of any computer, typically measured in Petaflops.

Supercomputers have the potential to support solutions for many of the world's most pressing contemporary challenges:

- **Weather forecasting**: The processing power of supercomputers can be utilised by climatologists to accurately predict not only the likelihood of rains, but also the paths and probability of cyclone strikes, thereby saving life and property.
- **Scientific research**: For example, researchers at CERN found the Higgs-Boson particle by analyzing the massive amounts of data generated by the Large Hadron Collider.
- **Medical research**: Supercomputers can conduct micromechanical simulations and aid medical research. For example, IBM is helping launch the COVID-19 High Performance Computing Consortium to help researchers everywhere better understand COVID-19, its treatments and potential cures.
- **Disaster preparedness**: For instance, it can aid in multiple and faster earthquake simulations, which can go a long way in helping cities plan for safer infrastructure.
- **Energy security**: It improves the accuracy of oil exploration and production companies in locating the reserves, thereby increasing oil's supply and meeting its soaring demand. Further, it

can be used to understand the elements critical to the development and design of much more efficient wind turbines and wind farms.

Considering its importance, India has taken many initiatives recently to build its supercomputing power:

- **National Supercomputing Mission** (NSM) was launched in 2015 by the Centre **for Development of Advanced Computing (C-DAC)** to empower our national academic and R&D institutions spread over the country by installing a vast supercomputing grid comprising more than 70 high-performance computing facilities. Recently **PARAM Shivay**, the first super computer designed & built under this scheme was launched.
- C-DAC **signed a contract with Atos** to supply the latter's BullSequana supercomputers.
- **Efforts are being made towards complete indigenisation** of supercomputers. At present, they are 60% indigenous. In the second phase of NSM, it is expected to increase with processors being developed by CDAC. Ultimately, complete indigenisation is being envisaged under the third phase of NSM.

Despite many positives, supercomputing could also lead to some concerns:

- **Data security and privacy:** These are some of the key concerns related to increased use of supercomputers in human life. Spectre and Meltdown – the hardware vulnerabilities that allow programmes to steal data – have brought these fears to the fore.
- **Predictive policing**: It could lead to racial profiling, biases against minorities etc. and lead to further incarceration.
- **Employment**: Supercomputing has the potential to cause significant job losses, due to promotion of automation along many levels.
- **Inequalities**: Risk of exacerbating the current racial, gender, and socioeconomic inequalities that are reflected in the technologies we create. These issues will compound much faster under the auspices of supercomputing.
- **Environmental impact**: These computers have high water and energy consumption which could be counter-productive to our commitment to sustainability.

The opportunities that supercomputing could bring to the world are immense. But so is our responsibility to wield them correctly and avoid the unintended consequences of innovation.

13. Discuss the key challenges that India faces in harnessing the full potential of Artificial Intelligence for its socio-economic development. (250 words) 15

Approach:

- Briefly define Artificial intelligence (AI).
- Mention its application in socio-economic development of India.
- Highlight the challenges faced by India to harness the full potential of AI.
- Conclude with a way forward.

Answer:

Artificial intelligence (AI) refers to the ability of a computer or a computer-enabled robotic system to process information and produce outcomes in a manner similar to the thought process of humans in learning, decision-making and solving problems.

Artificial Intelligence can play an important **role in socio-economic development** in India in following ways:

- **Health**: AI can be used for better, faster and more **precise diagnosis of diseases** in the human beings by mining patient data to form a hypothesis, which it then presents with a confidence scoring schema (e.g. IBM's Watson supercomputer).
- **Education**: AI can help teachers by automating the grading system and assess students and adapt to their needs, helping them work at their own pace.
- **Agriculture**: AI can provide real-time advisory based on satellite imagery, weather data, etc. to increase **farm yields** where the farm production levels are low.

- **Other applications**: AI's application in robotics can **help ageing population**, bring down **traffic accidents** and enable **effective disaster response**.

Despite the enormous opportunities presented by AI and its huge potential for socio-economic development, India has not been able to harness it due to:

- **Lack of private investment:** India lags behind most larger economies in terms of private investment in AI. The U.S. is far ahead, with investments worth $18 billion, followed by Europe ($2.6 billion) and Israel ($1.8 billion). While in India, this figure is just about $150 million.
- **Lack of State support:** Though, NITI Aayog has come up with a strategy document on AI, the government is yet to launch a dedicated national programme for AI in India. In 2018, the government of India set aside $480 million for investment into emerging technologies including AI. It pales in comparison to the $7 billion minimum that China has committed to invest in AI till 2030.
- **Paucity of human resources:** India suffers from the twin problems of poorly trained science graduates and the significant brain drain from the best institutions over the last several decades.
  - The 2018 India Skills Report found that only 45% of graduates are employable.
  - India also has a shortage of qualified faculty to teach AI courses.
- **Poor quality of internet access:** Though India has taken great strides in the internet penetration in the last few years, there has not been a corresponding increase in the quality of internet access. The development of future AI technologies is closely linked to 5G networks. India is not expected to begin rolling out 5G networks until 2020, and it may take up to five years to fully deploy.
- **Other factors:**
  - Lack of enabling data ecosystems, i.e. access to intelligent data.
  - Unattractive Intellectual Property regime to incentivise research and adoption of AI.
  - High resource cost and low awareness for adopting AI in business processes.
  - Unclear privacy, security and ethical regulations are a major concern as there is no formal regulation in place for anonymisation of data.

In addition to incentivising both public and private investment, India will have to create a cadre of technocrats and enable closer academia-industry linkages to harness AI's potential in socio-economic development of India. These challenges, if addressed in an expeditious manner, through collaborative efforts by relevant stakeholders with government playing a leading role could form the core to India's march towards leadership in AI.

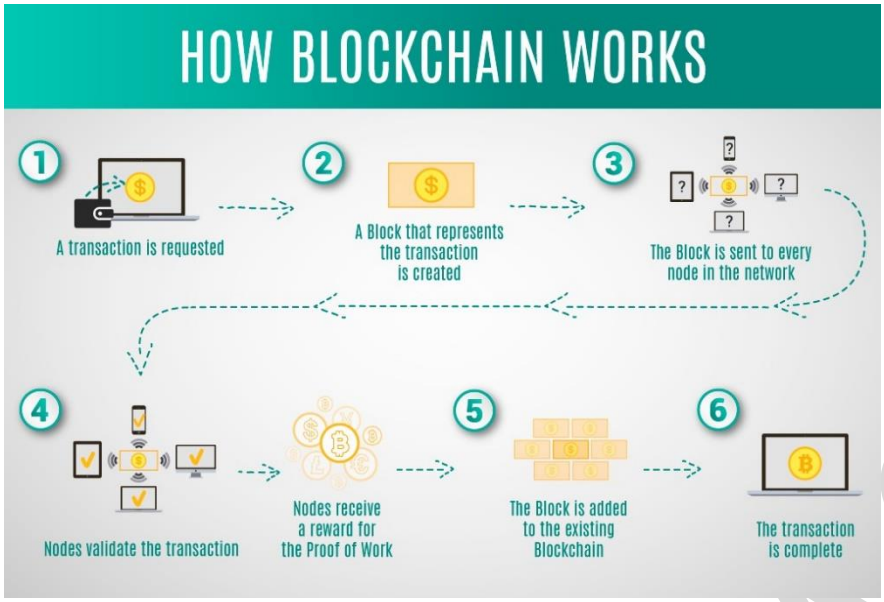
14. What is a blockchain and how does it work? Highlight its potential for various sectors in India. (250 words) 15

Approach:

- State what you understand by a blockchain and explain how it works.
- Mention its potential for various sectors in India.
- Mention some initiatives taken by India in this regard.
- Conclude with a way-forward.

Answer:

A blockchain is a digital, immutable, distributed ledger that chronologically records transactions in near real time. For each subsequent transaction to be added to the ledger, there should be a consensus among the network participants called **nodes**. The nodes are **linked using cryptography** wherein each successive block (transactional record) contains a cryptographic hash (a mathematical algorithm that maps arbitrary data into a unique string of text) of the previous block, a timestamp and transaction data. For a transaction to be valid, each block must refer to the hash of its preceding block. Thus, **a continuous mechanism of control regarding manipulation, errors, and data quality is created.**



If a hacker tries to attack the network and change information of any specific block, the hash attached to the block will also get modified and breach will be detected. Thus, blockchain technology **creates 'trust' in networks by introducing distributed verifiability, auditability, and consensus**.

The potential of blockchain for various sectors in India includes:

- **Governance:** Blockchain offers possibilities of addressing issues relating to improving governance such as securing citizens' data, efficiency in public service delivery etc.
- **Business:** Blockchain-powered smart contracts where every piece of information is recorded in a traceable and irreversible manner would enhance ease of doing business, augment the credibility, accuracy and efficiency of a contract and reduce the risk of frauds substantially.
- **Financial services:** Using a distributed ledger, banks can trade faster and cheaper as transactions can be done in minutes or even seconds. It results in a decline in banks operational costs.
- **Healthcare and pharmaceuticals:** Blockchain can provide a secure and reliable system to the health and pharma sector, which involves a lot of sensitive clinical data.
- **Insurance:** It could play a crucial part in health or agriculture insurance claims management by reducing the risk of insurance claim frauds.
- **Education:** It can transform 'record keeping' of degrees, certificates and diplomas and make credentials digital without the need for an intermediary to verify them.
- **Real estate:** Property deals are still carried out on paper making them prone to disputes. Application of blockchain technology can lead to transparency and traceability in the transactions.

Several **initiatives** are being taken in both public and private spheres in India to adopt the emerging technology. For instance, a consortium of eleven largest banks such as ICICI, Kotak Mahindra Bank, HDFC etc. have launched the first ever blockchain-linked loan system in the country. NITI Aayog, in its strategy paper, has identified key areas where blockchain can be used such as land records, pharmaceutical drug supply etc. It also stated that blockchain would help in improving ease of living by empowering citizens through features of transparency, decentralization and accountability. Further, National Power Training Institute is offering blockchain training in multiple cities across the country.

However, there are several **constraints** in its adoption such as absence of a regulatory framework, inadequate skilled workforce, limited awareness about the technology etc. In this regard, public-private collaboration could lead to faster and wider adoption of the technology in India. Further, a multi-pronged approach for adoption and development of blockchain technology can help in ensuring that its huge potential for India is fully leveraged.

15. In context of the potential and opportunities of Cyber Physical Systems, give a brief account of India's National Mission on Interdisciplinary Cyber-Physical Systems. (250 words) 15

Approach:

- Introduce by briefly explaining about Cyber Physical Systems (CPS) and its associated technologies.
- Discuss the potential and opportunities of CPS and its associated technologies.
- Give a brief account of the National Mission on Interdisciplinary Cyber-Physical Systems in this context.
- Conclude on the basis of the above points on a futuristic note.

Answer:

Cyber Physical Systems (CPS) are a new class of engineered systems that integrate computation and physical processes in a dynamic environment. Examples of CPS are Smart Grid Networks, Smart Transportation System, Enterprise Cloud Infrastructure, Utility Service Infrastructure for Smart Cities, etc. Its associated technologies include Artificial Intelligence (Al), Internet of Things (loT), Machine Learning (ML), Deep Learning (DP), Big Data Analytics, Robotics, Quantum Computing, Data Science & Predictive analytics etc.

Potential and Opportunities created by CPS and its associated technologies:

- **Enhanced security capabilities:** It can play a role in expediting design and delivery of trustworthy, adaptable and affordable systems, operations in cyberspace and autonomous systems to augment security operations.
- **Disaster Management:** CPS technologies including next generation public safety communications, sensor networks, and response robotics can dramatically increase the situational awareness of emergency responders and enable optimized response through all phases of disaster events.
- **Energy:** CPS can help in the creation of energy infrastructure, optimization and management of resources and facilities. It also allows consumers to control and manage their energy consumption patterns like smart meters.
- **Healthcare:** CPS correct-by-construction design methodologies are needed to design cost-effective, easy-to-certify, and safe products.
- **Transportation:** It can eliminate accidents caused by human error, Congestion control, traffic-based grid jams.
- **Agriculture:** It will play a key role in helping to increase efficiency throughout the value chain, improving environmental footprint and creating opportunities for a skilled and semi-skilled workforce.
- **Intelligent manufacturing:** CPS would assist the current trend of automation and data exchange in manufacturing technologies. It will help in monitoring physical processes, creating a virtual copy of the physical world and making decentralized decisions.

To harness the potential of CPS, the government has approved the launch of the **National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS)** in 2018. It does so in the following ways:

- It establishes 15 **Technology Innovation Hubs** (TIHs), which will be the nodal centres spearheading the activities in a specific domain. With leading-edge knowledge, competency and facilities, the hubs will attract potential and harness expertise available nationwide, thus fostering research innovation, world class technology and product development.
- **HRD and Skill Development**: Development of highly knowledgeable human resources with top-order skills including Graduate Internships, Postgraduate Fellowships, Faculty Fellowships, etc.
- **Innovation, Entrepreneurship and Start-up Ecosystem**
  - Enhance competencies, capacity building and training to nurture innovation and start-ups.
  - Support young and aspiring entrepreneurs for enabling translation of idea to prototype.
  - Initial funding assistance for student start-ups.
  - Create linkages with existing Technology Business Incubators (TBI) or create new TBI in Host Institute.

- **International Collaboration**
  - Leverage international alliances which can add value to the chosen domain.
  - Connect Indian research with global efforts in the proposed domain areas.
  - Participate in international projects and advanced facilities.
- It includes a strategic approach involving a suitable **mix of Academic, Industry and Government**.

It is estimated that CPS will create about 40,000 technology driven jobs in the short term and about 200,000 in long term. This Mission would act as an engine of growth that would benefit national initiatives related to Industry 4.0, SMART Cities, Sustainable Development Goals (SDGs) etc.

16. Explaining how quantum computers work, discuss the challenges that need to be addressed for the scalable development of this technology. Also, highlight significance of the recently launched National Mission on Quantum Technologies & Applications (NM-QTA). (250 words) 15

Approach:

- Explain the concept and working of Quantum Computers.
- Discuss the challenges in building and accessing them.
- Mention the significance of NM-QTA.
- Conclude in a futuristic manner.

Answer:

Quantum computing is a combination of **quantum mechanics, information theory** and **computer sciences**. A quantum computer is a machine, which takes advantage of some quantum mechanical phenomena such as superposition, entanglement and tunnelling to compute **at a much faster rate** than classical computers. Its basic unit to encode information is called **quantum bit** or a qubit.

A qubit can assume a continuum of values i.e. it can be a **1** or a **0** and it can be in a '**superposition'** of both a 1 and a 0 at the same time. Thousands of qubits can be '**entangled'** as well, so that an operation on one of them can determine the state of all others simultaneously. This provides an ability to do **numerous parallel calculations**.

In a **quantum processor**, superconducting qubits process the quantum information and send the computation outcomes back through the system via **microwave signals**. This processor is kept at a **very low temperature** and is also shielded from electromagnetic radiation.

Quantum computers are exceedingly difficult to engineer, build and program **due to following challenges**:

- **Reaching quantum state:** The method to convert large amounts of **classical data into quantum state** is yet to develop.
- **Fan-out challenge:** It means the mechanism to scale up the number of qubits within a quantum chip. As of now, multiple control wires or multiple lasers are required to create each qubit, which **makes the system huge**.
- **Loss of quantum coherence:** Vibrations, temperature fluctuations, electromagnetic waves and other interactions with the outside environment **can easily destroy the exotic quantum properties** of the computer.
- **Qubit quality:** Quantum gates cannot readily reject small errors/noise in the physical system. It can lead to wrong output.
- **Space constraint:** Complex algorithm required for error corrections, consume such a large number of qubits that relatively few qubits remain for actual computation.

The Government of India, in the Union Budget 2020 has announced a **National Mission on Quantum Technologies & Applications (NM-QTA)** with a total budget outlay of Rs 8000 Crore. It has following significance:

- Quantum technologies are expected to **disrupt the entire paradigm of computation**, **communication and encryption**, allowing India to secure its communications and financial transactions.

- Their applications will **boost domains** like aero-space engineering, numerical weather prediction, simulations, securing the communications & financial transactions, cyber security, advanced manufacturing, health, agriculture, education and other important sectors.
- The Mission shall **contribute to fundamental science, technology development, human and infrastructural resource generation, boost translational research, innovation and start-ups** to address issues concerning national priorities.
- It will help India to remain **competitive**, drive **societal progress**, generate employment, foster economic growth and to improve the **overall quality of life**.

In a technology-transformed geo-political world order, it is essential to keep pace with innovative and disruptive technologies. The mission mode towards development of quantum technology will bring India in the list of few countries with an edge in this emerging field.

17. How well India taps into the immense potential of its biotechnology sector depends largely on how it addresses the relevant policy and regulatory challenges. Discuss. (250 words) 15

Approach:

- Define biotechnology and give the status of Indian biotechnology sector.
- Discuss the potential of biotechnology sector for India.
- Discuss the policy and regulatory challenges in this sector.
- Mention steps need to be taken by the government.
- Conclude with a way forward.

Answer:

Biotechnology is defined as the **application of science and technology to living organisms** to alter living or non-living materials for the production of knowledge, goods and services. Indian biotechnology sector accounts for **2 percent** of the global biotech industry. It is expected to grow at 30.5 percent to reach the **$100 billion mark by 2025.**

Given the rich biodiversity, the traditional knowledge, various policy initiatives, and the emergence of private players, the sector has **huge potential for India**, which include:

- **Promote environmental conservation:** Use of bio-products such as microbial enzymes and microorganisms in food products, pharmaceuticals, textiles **provide an alternative to chemicals**, thereby addressing environmental hazards.
- **Ensure food security: Biological fortification** helps food crops withstand natural calamities, pest attack, and disease and also increase nutritional value. Therefore, it can help meet the food supply needs.
- **Enhanced agricultural productivity:** Application of **biofertilizers** and **biopesticides** promises high productivity; improved quality; and lower use of fertilizers, weedicides, and pesticides.
- **Advancement in healthcare:** Exploring new ways of treating a variety of human diseases, a revolution in drugs development, clinical trials using gene therapy.

Despite its immense potential, there are considerable **policy and regulatory challenges** facing the sector:

- **Multilayered regulatory structure and lack of coordination,** which leads to unnecessary delays or prevents new products from securing government approval.
- The **authorities** are plagued by a **lack of functional and financial autonomy**, poor infrastructure, and inadequate manpower to perform given regulatory and supervisory roles.
- The provisions under the legislations such as **Biological Diversity Act, 2002** have made it difficult for foreign companies to access India's biological resources, innovate and commercialize their research findings.
- **Politicized public opposition** about the negative effects of biotechnology based on misgivings have engendered political pressure to oppose advances.
- **Insufficient skilled human resources,** as despite India producing a large number of biotech graduates and postgraduates, most are not adequately skilled for employment.

- The **level of research** is comparatively low, as designing and testing new technological inventions requires more intensive, technically demanding research than traditional knowledge.

To navigate this complex policy landscape, India needs to craft a **more streamlined regulatory system** and take other concrete steps such as:

- **Strengthening the legal and financial system** and supporting the commercialization of biotech advances that will nurture innovation and growth while limiting regulatory hold-ups.
- Promoting an inclusive domestic dialogue to **bust the myths and promote awareness** about biotechnology norms and practices.
- **Providing a stable and open domestic ecosystem** for biotech innovations through research and development and skilled human resources.
- **Proactively dealing** with the new types of biological weapons, new ethical challenges, and other risks.

Further, addressing emerging critical issues arising from new innovations in the biotechnology space, such as big data analytics, apart from regulatory shortcomings and political hurdles may help India become a more competitive economic player and more influential international actor in this rapidly changing field.

18. Bring out the differences between bacteria and viruses. Also, explaining why antibiotics can work against bacteria but not viruses describe the general working of vaccines designed to attack certain viruses. (250 words) 15

Approach:

- Give a brief introduction of bacteria and virus.
- Discuss the main differences between infections caused by the two.
- Explain the reasons behind resistance shown by viruses to antibiotics.
- Discuss in brief how vaccines work against viruses.

Answer:

Bacteria and viruses are microbes that can have varied effects on the human body. Bacteria are prokaryotic living cells (i.e. without a distinct nucleus bounded by a nuclear envelope) that can either be harmful or beneficial to humans. However, viruses are microbes thought of to be lying in between living and non-living cells that need a host to survive. The main points of difference between the two are:

Characteristics	Bacteria	Viruses
Living Attributes	Bacteria are single-celled living organisms.	They are considered as organic structures rather than a living organism.
Host Dependence	Bacteria do not need a host organism for reproduction.	Viruses replicate only inside the host cell.
Size	Bacteria are larger, about 1000 nm in size.	Viruses are 10 to 100 times smaller than the smallest bacteria.
Cell Wall	Bacteria contain a cell wall.	Viruses have a protein coat called capsid and lack a cell wall.
Ribosomes	Ribosomes are present	Ribosomes are absent
Process of Reproduction	They are Prokaryotes i.e. their DNA is contained in an unenclosed nucleoid. Reproduction happens through binary fission and conjugation	They consist of either DNA or RNA surrounded by Capsid. They survive and reproduce by hijacking a host cell and using its ribosomes to make new viral proteins.
Cellular machinery	Bacteria possess cellular machinery.	Viruses lack cellular machinery
Infection	Most bacteria are beneficial in nature and only about 1% of them cause diseases. Their infection is localised in nature and can be treated with antibiotics.	Most viruses cause disease. They are usually quite specific about areas of the body that they infect e.g. liver, respiratory tract, blood etc. Their infection is systemic and cannot be treated by antibiotics. They require vaccination.

Antibiotics can be **successfully used against bacteria** since they work in the following ways:

- By **interfering with the construction of the bacterial cell wall** and weakening it. Antibodies and other immune system response cells can then penetrate the bacterial wall and destroy the bacterium.
- By **preventing the bacterial RNA from accurately reading the DNA**, thereby interfering with the functioning of ribosomes that hampers the reproduction of bacterial cells.
- Some of the antibiotics **attack the ribosomes effectively ending all reproduction process** of bacterial cells or leading to creation of weaker/defective bacterial cells.

Antibiotics do not work against viruses **because viruses lack a cell wall** and contain a **protective protein coat** around them. Besides, they **do not reproduce** on their own, but attach themselves to a healthy host cell for the same.

However, there are **anti-viral vaccines** that can disrupt the reproductive cycle of the virus. An antiviral vaccine typically contains a dead, weakened, or slightly **different version of the same virus** it protects against. This insertion then stimulates the immune system to produce antibodies with the right shape for the vaccine virus. These antibodies then eradicate the specific virus before it causes harm. The human immune system tends to remember the shapes of the antibodies that were effective. In the chance recurrence of an infection by the same virus, the immune system then quickly makes a number of **such 'effective' antibodies**, which destroy the virus before it has the chance to spread.

19. Comment on the significance of nuclear power for a country like India. In this context, also analyse the progress and challenges associated with three stage programme for nuclear power generation. (250 words) 15

Approach:

- Giving a brief introduction, bring out the significance of nuclear power for a country like India.
- Describe India's three-stage nuclear power generation programme.
- Briefly highlight the progress of this programme.
- Explain key challenges associated with it.
- Conclude with some suggestions.

Answer:

Nuclear energy provides a viable alternative to India's energy sector, which faces a series of problems such as bottlenecks in enhancing the supply of domestic coal, displacement caused by large hydroelectric projects, and the limited availability of cleaner fuels.

Nuclear power for a country like India has **huge significance in terms of:**

- **Energy security**: It can allow large scale generation of electricity to drive India's future energy demand, industrialisation and economic growth.
- **Less impact on climate**: Nuclear reactors **do not produce greenhouse gases** like power plants using coal and, therefore, can increase electricity generation without contributing to climate change.
- **Steady Supply**: Unlike solar and wind power sources, nuclear plants can operate when there is no sun or wind and are **not affected by fluctuations** in water availability like hydroelectric plants.
- **Economical:** Nuclear energy is a cheap source of energy. The average tariff of nuclear power in the year 2017-18 was Rs 3.55/kWh.

In this context, India's **three stage nuclear programmes** was formulated by Dr. Homi Bhabha to secure the country's long-term energy independence, via use of uranium and thorium reserves. The **three stages are:**

- **The First Stage (Pressurized Heavy Water Reactor):** It involves using natural uranium to fuel PHWR to produce electricity producing Plutonium 239 as a by-product.

- **The Second Stage (Fast Breeder Reactor, FBR):** This envisages the use of Pu-239 obtained from the first stage reactor operation, as the fuel core in fast breeder reactors (FBR). A blanket of U-238 surrounding the fuel core will undergo nuclear transmutation to produce fresh Pu-239 as more and more Pu-239 is consumed during the operation. Once a sufficient amount of Plutonium 239 is built up, thorium will be used in the reactor to produce Uranium 233 which will be crucial for the third stage.
- **Third stage (Advanced Heavy Water Reactor AHWR):** The main purpose of stage 3 is to achieve a sustainable nuclear fuel cycle using a combination of Uranium 233 and Thorium.

Presently, India has a **total installed nuclear capacity** of 6780 MW. After decades of operating Pressurized Heavy-Water-Reactors (PHWR), India is finally **ready to start the second stage**. Setting up Pu-239 fuelled fast Breeder Reactor of 500 MWe power generation (at Kalpakkam) is in an advanced stage of completion. Concurrently, it is proposed to use thorium-based fuel, along with a small feed of plutonium-based fuel in Advanced Heavy Water Reactors (AHWRs). The AHWRs are expected to shorten the period of reaching the stage of large-scale thorium utilization.

However, India is facing several challenges in this regard such as:

- India has rich reserves for Thorium but there is a **huge dependence on foreign countries for supply of Uranium** as the uranium deposits established in India are mostly of low-grade (less than 0.15per cent U).
- Despite being cost effective over the life cycle, the nuclear power plants **require most of their project cost upfront**, which demand large investments.
- Many communities in different parts of India have **opposed construction of nuclear plants** in their backyard, such as witnessed in the Jaitapur, Kudankulam and Mithi virdi protests.
- The **safe disposal** of nuclear waste, **regulatory delays** and insufficient **skilled workforce** are other major impediments faced by the sector.

Therefore, the government must address issues related to the pre-project activities such as land acquisition at new sites, clearances from various ministries especially the environment ministry. Also, establishing a **Nuclear Safety Regulatory Authority** would help assuage the fears of the local population.

20. Highlight the benefits of having an effective Intellectual Property Rights (IPR) regime. In this context, discuss the role of IPR Policy, 2016, in strengthening and making India's IPR regime more effective. (250 words) 15

Approach:

- Briefly mention the state of India's IPR regime.
- Highlight the benefits of having an effective IPR regime.
- Explain how the IPR Policy 2016 has strengthened and made India's IPR regime more effective.
- Conclude on the basis of above points.

Answer:

India has a well-established legislative, administrative and judicial framework to safeguard IPRs, that meets the international standards while utilizing the flexibilities provided in the international regime to address its developmental concerns. India has a TRIPS compliant, robust, equitable and dynamic IPR regime.

An effective IPR regime has following benefits:

- By providing a conducive environment for foreign investment, it is likely to **attract greater private investment** in research & development activities and produce more innovative output.
- It **balances the interests** of rights owners while catering to larger public interest. Also getting value for IPRs through commercialization becomes easier.
- It helps in **strengthening and expansion of human resources**, institutions and capacities.
- It will promote **more clinical trials and research** on biological therapies.
- It will attract **greater technology transfer** through international trade in goods and investments.

Recognizing the importance of innovation and creativity in the growth and development of a knowledge economy, India adopted the **National Intellectual Property Rights (IPR) Policy 2016**. It attempts to play an important role in strengthening and making IPR regime more effective as:

- In order to boost commercialization and value for IPs, the policy proposes a study to examine the feasibility of an **IPR exchange**. Such dedicated IP exchange could facilitate investment in IP driven industries by bringing together investors and IP owners/users. The government is in progress to develop such as an exchange under the Ministry of Science and Technology, through the National Research Development Corporation (NRDC).
- The policy urges the Government to explore the **possibility of expedited examination of patent applications** to promote manufacturing in India. The government has come up with the **Patent (Amendment) Rules** in 2018 and 2019 in this direction.
- It prioritises providing **financial support to the less empowered group of IP owners or creators**, such as farmers, weavers, artisans, craftsmen etc., through rural banks or co-operative banks.
- In order to expedite the adjudication of disputes, and ensure enforcement of IPR, the Policy suggests the setting up of **dedicated commercial courts** to deal with IP related matters. It also seeks to **promote Alternative Dispute Resolution** Mechanism for IP related disputes.
- To strengthen the enforcement of IPRs, the policy **proposes to enhance coordination among various agencies** of the government as well as non-government players and also **promote technology-based solutions for enforcement.** The government has launched the **IPR Enforcement Toolkit** in this direction.
- Various other measures proposed by the policy include criminalization of unauthorized copying of movies, encouraging Corporate Social Responsibility (CSR) funds into open innovation and expanding capacity building in IPR through training, teaching, research and skill building.

Therefore, the National IPR Policy, 2016 seeks to balance the goals of economic growth and social justice. The Cell for IPR Promotion and Management (**CIPAM**) under the Government of India, has also come up with **Model Guidelines on Implementation of IPR Policy for Academic Institutions**. To further strengthen the IPR regime, an active role needs to be played by the state governments.