GS3: Science & Technology

June 2025

Prepared together by:

Madhav Agarwal (https://t.me/madhavagrawalair16)

Ratnesh Agrrwal (Insta: https://www.instagram.com/ratnesh13/)

About Us

Madhav Agarwal and Ratnesh Agrawal *— two friends, one mission, and a bond forged through shared dreams. From school classrooms to college corridors, their journey was always side by side. United by a common goal of cracking the UPSC, they spent over 300 hours on video calls — dissecting concepts, solving doubts, and building the notes that would become the backbone of their preparation.*

Madhav went on to secure AIR 211 in CSE-2023 and then soared to ***AIR 16 in CSE-2024****. Now set to join the* ***Indian Administrative Service****, he is living proof that quiet determination, when sustained with laser focus, can turn even the toughest dreams into destiny.*

Ratnesh, who reached the ***UPSC interview stage in CSE-2023****, chose a different but equally powerful path. With the same intensity and sharp thinking that marked his preparation, he stepped into the world of real estate. Today, he's a* ***dynamic builder in Indore*** *— shaping skylines and lives with a vision rooted in public purpose and entrepreneurial fire.*

These notes are a result of their shared struggle, deep friendship, and uncompromising pursuit of excellence — a ***gift to future aspirants****, from two dreamers who refused to settle for average, each leaving a mark in his own way.*

Index

Note: These notes are the result of a group effort over the past few years. You'll find pink (or other coloured) highlights at the start of many topics—these usually mark key terms, definitions, quotes, etc., based on our memory cues at the time. While most content is updated, some sections—especially in **GS3**—may contain older material, so do cross-check and update where needed. Don't get confused by the highlights; use what's useful and feel free to build your own notes from them.

To assist with updates, we've added a **Current Affairs & Value Addition** section at the end of the notes. It can help you **enrich your answers** and also serves as a reference on how to make concise, effective short notes. In, S&Tech apart from static content you should focus more on current affairs.

GS-3 Science & Technology

Syllabus

Science and Technology- developments and their applications and effects in everyday life. Achievements of Indians in science & technology; indigenization of technology and developing new technology. Awareness in the fields of IT, Space, Computers, robotics, nano-technology, bio-technology and issues relating to intellectual property rights

---

PYQs Categorised As Per Syllabus

1. Achievements of Indians, Indigenization
    a. **Plan of Action:** 5-10 famous names of scientists keeping in mind points of syllabus such as in space (ques in 1981), IT, etc. nobel laureates, bharat ratna
    b. Dr. M. S. Swaminathan - agricultural science
    c. Sir M. Visvesvaraya - water engineering
    d. 2018: Bose-Einstein Statistics
2. IT and Computers
    a. 2015: Digital Indian Programme: How it can help to improve farm productivity and income? Steps taken?
        i. Cover various angles where S&T in general can impact agriculture
    b. 2015: Advantage and security implications of cloud hosting of servers vis-a-vis in-house machine-based hosting
        i. Arihant
        ii. GS Score PDF
    c. 2013: Digital signature: Features, Uses, Authetication, process
    d. 2013: 3D printing technology: Advantages and disadvantages
    e. IT Sector: SWOT Analysis
        i. Threats: Telangana loan apps blackmailing, Blue whale game,
    f. Artificial intelligence: Current scenario, prospects (Also read abt Mach learning, etc.)
    g. Basic of optical fiber and other developments in telecomm

h. Super Computer and Quantum technology (8000 crore mission in Budget 2020)
    i. Uses: Secure comm, fast computers, sensors, etc. Concept of entanglement can be used to transmit a msg with high level of secrecy
    ii. The NM-QTA (8000 cr mission) is still in processing stage; D/o ST conducted a programme called QuEST to explore QT and engage with reasearchers

3. Space & Defence
    a. **PoA:** Develop framework of space advancement (incl inter-planetary) on humankind, PESTEL, new possibilities that have opened,
    b. Benefits of India's own space station(2019)
    c. Need for IRNSS, advantages; Meaningn of 'Standard Positioning Systems' and 'Protection Positioning Systems' in the GPS era(2018(GS1),2015,2008)
        i. GS Score PDF
    d. New Mars Mission by NASA, other players(2012)- Juno mission(GS1)
        i. Find common dimensions of any space missionGERD
    e. Manned space mission: Prospects, Causes for less dev., status(2017)
    f. Different types of satellites (incl remote sensing) and their uses in Indian context (incl socio-economic)
    g. India's missile development programme, why defence tech not as successful to space tech (DRDO vs ISRO)
    h. Significant milestones of Indian Space research(2016)
        i. 1963: First rocket launch; First Satellite in 1975
        ii. 2009: Lunar mission showed possibility of water on moon
        iii. 2014: Mars mission - Only country to reach mars in 1st try; Cost effective
        iv. 2017: PSLV launched 104 satellites on a single mission (prev record Russia 37 satellites)
        v. 100% successful foreign satellites launches using PSLV rockets
        vi. Charges just 60% of fees charged by other foreign players
        vii. Planned future mission - mention names
    i. 2016: Discuss India's achievements in the field of Space Science and Technology. How the application of this technology has helped India in its socio-economic development?

4. Robotics
    a. 2015: Challenges posed by Robots? Areas of prohibitive labour? Initiatives taken and needed?
        i. Robotics is the field of Science and Technology that deals with the design, manufacture, and applications of robots and using computers for their manipulation and processing
        ii. Robot means self – labour.

iii. Deploying robotic inventions in the area of **prohibitive labour** like manual scavenging, sewage treatment, underground mining, rescue relief and rehab in times of disaster, at battle-sites to reduce casualties, etc

iv. The **lump of labor fallacy** is the assumption that there is a fixed amount of work to be done. If this were true, new jobs could not be generated, just redistributed. Those who believe the **fallacy** have often felt threatened by new technology or the entrance of new people into the **labor** force.

v. Examples:

1. Muntra - India's first Unmanned Tank developed by DRDO
2. Vyommitra - dev by ISRO
3. On average, each newly installed robot displaces 1.6 manufacturing workers IFR Report
4. BRABO Robot used by Tata Motors
5. Mitra Robot by Invento Robotics

5. Nano-technology
   a. Basics, Uses in India, Govt. efforts, Status (2016)
   b. 2016: Why is nanotechnology one of the key technologies of the 21st century? Describe the salient features of Indian Government's Mission on Nanoscience and Technology and the scope of its application in the development process of the country.
   c. 2020: What do you understand by nanotechnology and how is it helping in health sector?
6. Bio-technology (General write up- applications,types,govt)
   a. 2019: Improving the living standards of farmers (eg: bio fertilizers)
   b. 1991: Achievements in realm of biotechnology in India
   c. 2018: General benefit for India? Impacts on **'bio'**-pharma? (Difference with bio-tech)
   d. 2017-Stem cell therapy: merits and demerits; advantages over other treatment? Various genetic diseases
   e. MDR-TB: What? Measures for containment, Implications of spread
   f. Genetics: Basics, Uses, Merits/ Demerits; Projects at GOI and Global level; Uses of DNA Technology (eg: DNA fingerprinting)
      i. DNA Bill(current)
   g. `Biological clean-up methods`
   h. `Trans Fat: Meaning? Implications on human2016 health`
7. IPR and Its Related Issues
   a. 2015: Protecting traditional knowledge of medicine from patenting; TKDL: Pros & cons of making it under open source licensing
   b. IPR in global discourse; Role of TRIPS; Steps taken to confirm to TRIPS? Concerns of India towards new IPR discussions
   c. Meaning of Copyrights, Patents and Trade Secrets

   d. What stimulates innovation?
   e. Indian Patent Law 1970; Section 3d Analyse? SC Judgement? Pros and cons?
8. Renewable and Alternative Energy Sources (Cover both cover economic potential & science angle)
   a. 2013: Run-of river hydroelectricity project? Differences?
   b. Status & prospects of non-conventional sources of energy relevant for India
   c. Renewable energy as a viable option for India? Pros and cons
   d. Alternative fuels for transport: Characteristics, advantages and disadvantages (eg: hydrogen, green charcoal also in news)
   e. Additional Topic: Waste to Energy - Techniques, potential, efforts, challenges
   f. *Biogas technology? Uses? Govt. measures?*
   g. *Integrated Rural Energy System*
9. Miscellaneous
   a. R&D Theme
      i. 2012: Globalization of R&D and impact of development; One Illustaion wrt to Health, IT
      ii. Need to re orient science education and scientific research; Imp areas that need reorientation
      iii. 2014: Career in S&T is not attractive and universities becoming consumer-oriented - Critically comment
   b. Antimicrobial resistance: Causes? Mechanisms for monitoring and control (take example of MDR-TB)(2014)
      i. MDR-TB: What? Measures for containment, Implications of spread
   c. 2020: How is science interwoven deeply with our lives? What are the striking changes in agriculture triggered off by the science-based technologies?
      i. Analyse various technology for agr
   d. 2020: COVID-19 pandemic has caused unprecedented devastation worldwide. However, technological advancements are being availed readily to win over the crisis. Give an account of how technology was sought to aid management to the pandemic.
      i. IT- Arogya setu
      ii. Space- Location of patients
      iii. Robotics- patient care
      iv. Nano-technology-
      v. Biotech- Vaccines
10. Nuclear Energy
   a. 2018: With growing energy needs should India keep on expanding its nuclear energy programme? Discuss the facts and fears associated with nuclear energy

i. Current Status of % of NT
ii. Stats showing growing needs

b. 2016: Give an account of the growth and development of nuclear science and technology in India. What is the advantage of fast breeder reactor programme in India?
c. Indian Nuclear Programme: Phases, milestones, 3 staged process
d. Civilian, econmic and defence needs fulfilled by nuclear programme
e. Fission vs Fusion
f. *Nuclear medicine and its uses*

11. Prelims
    a. leukaemia, Thallessemia, damaged cornea

Robotics

2015: Challenges posed by Robots? Areas of prohibitive labour? Initiatives taken and needed?

- Robotics is the field of Science and Technology that deals with the design, manufacture, and applications of robots and using computers for their manipulation and processing
- Robot means self – labour. India has only three robots for every 10,000 workers as per IFR report
- **Applications**
    - Space
        - Tackling constraints of manned missions using humanoid eg: Vyomamitra (ISRO)
        - Assist humans in space eg: Robotic hands to lift heavy objects
        - Rovers can move and collect samples
    - Military:
        - Muntra - India's first Unmanned Tank developed by DRDO used to detect mines
        - Drones
        - Robots can reduce casualties in conflict situations (dealing with Guriella warfare LWE)
        - Intelligence gathering
    - Industry
        - Used for good delivery to remote areas
        - Automotive industry (largest adopter of robotics in India) - BRABO Robot used by Tata Motors
        - Using robots for education, legal ad vice
    - Agriculture

        - Using robots for regular works such as spraying fertilizers, Agribot – an agricultural robot to work on fields.
        - Prevent attacks of wild animals
        - Monitor crops using drones
    - Health-
        - Corona care eg: KARMI Bot
        - AIIMS- Robotic surgery on patient (easy procedure, lesser incision, less pain & blood loss)
        - Elderly care
        - Self care- personal robots to tackle mental heath issues
    - Prohibitive Labour
        - Bandicoot robot for Manual scavneging
        - Mining robots (Exploration work by going beneath the earth)
        - Monotonous work
        - Disaster management- use where humans cant go for relief & response
    - Cultural Preservation & Sports
        - Robotic leather puppet preserving the 'Tholpavakkoothu' at Kerela's museum
        - Bhavina Patel credited her paralympic medal to the TT Robot that improved her game (brought by her using TOPS Scheme by SAI)
- **Challenges posed by Robots**
    - Negates Gandhi emphasis on doing manual labour for developing humility
    - Personal dependence on robots- neglects human cooperation- increase mental health issues
    - Increase electricity usage- carbon foorprint inc
    - Fears of AI induced Robots- control the controller
    - On average, each newly installed robot displaces 1.6 manufacturing workers International Federation of Robotics Report
- **However**
    - The lump of labor fallacy is the assumption that there is a fixed amount of work to be done. If this were true, new jobs could not be generated, just redistributed. Those who believe the fallacy have often felt threatened by new technology or the entrance of new people into the labor force.
    - Need for prohibitive sectors(MS,pandemics,mining,nuclear radiation etc)
    - As per ILO Future of Work Report 2019 said robotics will create jobs but those who lose jobs will be least equipped (thus there is need for skill enhancement, social protection, people at the centre of economic & social policy)
- **Impediments to Robotic industry in India**
    - High importance dependence

- Lack of financial incentives such that GST + customs on import is very high
- High cost of deployment

Renewable and Alternative Energy Sources

2013: Run-of river hydroelectricity project? Differences?

https://www.drishtiias.com/daily-updates/daily-news-analysis/arun-3-hydro-project

Run-of-the-river Project

- Run-of-the-river hydroelectric projects are hydroelectric systems that harvest the energy from flowing water to generate electricity.
- The primary difference between this type of hydroelectric generation compared to others is that run-of-the-river primarily uses the natural flow rate of water to generate power—instead of the power of water falling from a height.
- For a run-of-the-river system to be possible in a given location, there needs to betwo specific geographical features:
  - A substantial flow rate, either from rainfall or a melting snowpack.
  - There must be enough of a tilt to the river to speed the water up significantly.
  - The Arun-3 Hydro Electric project (900 MW) is a run-of-river located on Arun River in Eastern Nepal made with Indian investement help.
- **Features and differences with large hydro projects**
  - These are less expensive to build and can be built over a shorter period of time.
  - They have a smaller environmental footprint when compared to dams with large amounts of water storage.
  - However, the output from run-of-the-river system is significantly lower than large scale hydro projects, which increases the cost per kWh as compared to Dam based hydroelectric generation.
  - The manipulation of river flows can cause a significant number of environmental impacts affecting the aquatic ecosystem.

Alternative Fuels for Transport

Characteristics, advantages and disadvantages (eg: hydrogen, green charcoal also in news)

Introduction

- India is heavily dependent on fossil fuels for its energy requirements and therefore, needs to identify renewable fuel sources which would help reduce import of petroleum crude.
    - Alternative fuel should reach the remotest corners so that the poorest of the poor can be provided fuel at an affordable price.
- The only non-renewable solid fuel that is still controlling the world's energy sector is coal, in view of the restricted utilisation of nuclear energy. The replacement of liquid fuel is a near difficult task in the coming several decades. So the world is slowly towards the use of hydrogen as the replacement of liquid fuels.

Types of Alternative Fuels

1. **Ethanol:** Primarily alcohol is produced from fermentation of sugars found in crops like corn, barley, sugarcane bagasse, wheat. etc. It is blended with gasoline to increase octane level and improve emission quality
2. **Natural Gas:** Derived while extracting crude oil (about 6.2% of the entire energy consumption)
3. **LPG:** The other name is propane; Byproduct of crude oil refining and natural gas processing. It is widely used as cooking gas and a popular alternative fuel
4. **Biodiesel:** it is one of the fuels whose source is always renewable, It can be produced from vegetable oils or animal fats/oils. Vehicle engines can be converted to run by pure biodiesel and it is also blended with petroleum diesel to run in modified engines also.
5. **Methanol:** is formed due to hydrogenation of carbon monoxide; CO2 generated from burning methanol can again be captured and converted to methanol (perpetual recycling of C02)
6. **Electricity:** Electricity can be used as a transportation alternative fuel for battery-powered electric and fuel-cell vehicles
7. **Hydrogen:** U can be mixed with natural gas to create an alternative fuel which can be used in some types of internal combustion engines. Hydrogen is the fuel for fuel-cell vehicles and is produced by the petrochemical reaction.

Waste to Energy

Techniques, potential, efforts, challenges

Waste-to-Energy (WtE) or Energy-from-Waste (EfW) is a form of energy recovery and the process of generating energy in the form of electricity and/or heat by processing

of waste into a fuel source. Waste to energy generates clean, reliable energy from a renewable fuel source

A modern, properly run waste-to-energy plant sorts material before burning it and can co-exist with recycling.A few plants use gasification, but most combust the waste directly because it is a mature, efficient technology.

Typically, about 50 tonnes of Refuse Derived Fuel generate 1 MW of power

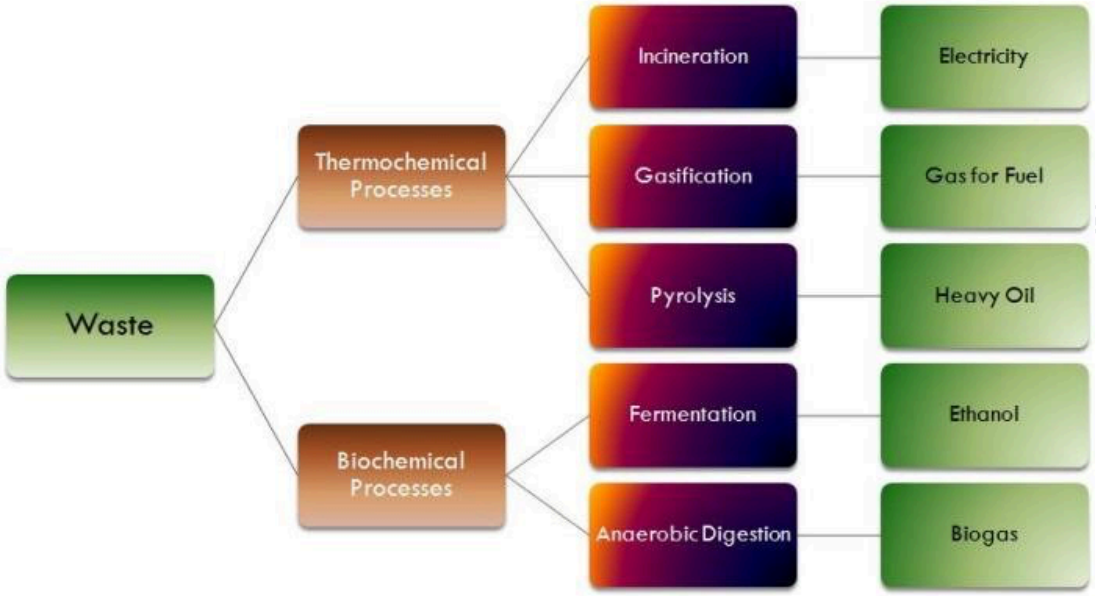
Benefits of wastes to energy plants:

1. In terms of volume, usually waste-to-energy plants incinerate 80 to 90 percent of waste, thus helping large cities from choking due to unmanageable waste.
2. Most wastes that are generated find their way into land and water bodies without proper treatment, causing severe water and air pollution.
3. Reducing dependence on fossil fuels, the combustion of which is a major contributor to GHG emissions
4. Residue ash is clean enough to be used for other purpose eg: raw materials for for road construction
5. Metals that may be burned are collected from the bottom of the furnace and sold to foundries
6. It is carbon-negative – processing waste into biofuel releases considerably less carbon and methane into the air than having waste decay away in landfills or the lake

Challenges faced in installing Waste-to-Energy plants:

1. Technology suppliers are international organisations who struggle with the change in quality and nature of waste generated in Indian cities. A few plants in India have stopped operations for this reason.
2. Waste-to-Energy is still a new concept in India. Most of the proven and commercial technologies in respect of urban wastes are required to be imported.
3. The costs of the projects are high as critical equipment for a project is required to be imported.
4. In view of low level of compliance of Solid Waste Management Rules, 2016 by the Municipal Corporations/ Urban Local Bodies, segregated municipal solid waste is generally not available at the plant site, which leads to non-availability of waste-to-energy plants.
5. Lack of financial resources with Municipal Corporations/Urban Local Bodies.

6. Tariff at which the power is purchased by such plants across the country is around Rs.7-8 KwH which is higher than the Rs.3-4 per KwH generated through coal and other means.



Pyrolysis is defined as a process of temperature decomposition of organic material in the absence of oxygen - syngas is produced

Incineration : Combustion of organic substances contained in waste materials. Heat → Steam → Turbines

Fermentation: changes in organic substrates through the action of enzymes

Anaerobic digestion: digestion in the absence of oxygen

Gasification: Conversion of waste into gases eg: Biogas

Conclusion:

Urban local bodies (ULBs) should invest in preparing an action plan on waste management in accordance with the Solid Waste Management (SWM) rules, 2016 within a time-bound approach and promote and adopt the key elements of waste hierarchy as refuse, reduce, reuse, recycle and recover.

This will not only improve effectiveness of Waste To Energy's, but will also ensure protection and improvement of our environment as envisaged in Article 51 A(g) of our Constitution.

Measures taken: Setting up of Compressed biogas (CBG) plant has been brought under PSL norms

Biogas Technology

Uses? Govt. measures?

Wood as fuel - contains a very less amount of carbon plus major amount of impurities such as sulphur, chlorine, silicon and water decrease its efficiency as a fuel- results in the production of a large amount of smoke and ash.

But when wood is converted to charcoal by removing volatile impurities and water- get an excellent fuel with higher efficiency and low production of smoke.

Similar observations can be noted for biomass.

Cow dung cakes are used as fuel- large amount of smoke and ash is generated.

Biomass - modify for getting a better fuel (bio gas)

What is Biogas?

Biogas refers to a mixture of gases produced by the anaerobic decomposition of organic matter such as agricultural waste, municipal waste, plant residue, food waste etc. Biogas consists of methane, carbon dioxide along with the small amount of hydrogen sulphide, and moisture.

What is a Biogas Plant?

After a few days anaerobic decomposition of orgainic waste, the organic matter completely decomposes to generate gases like methane, carbon dioxide, hydrogen and hydrogen sulphide. These gases are then drawn through pipes from the storage tank above the digester and distributed.

Advantages of Biogas

- Non-polluting: Biogas burns without smoke; hence no harmful gas such as CO2, CO, NO2, and SO2 are evolved.
- Reduces Landfills: The slurry produced after the production of biogas is used as manure in fields. The method of disposal is safe and efficient and hence no space is wasted in the form of landfills.
- Cheaper technology: Biogas plants require very little installation cost and become self-sufficient in a span of 3-4 months.
- Generates employment: in rural areas.eg IFS
- Renewable source of energy: As dependent on the generation of waste which is an endless process.

Disadvantages of Biogas

- Not efficient enough on a large scale: Since it is difficult to enhance the efficiency of biogas, it is not economically viable to use biogas on a large scale
- Contains impurities: It contains many impurities which are difficult to be controlled even after rounds of purification. Biogas when compressed, to be used as fuel, proves to be highly corrosive to the container
- Unstable and hazardous: When methane comes in contact with oxygen it reacts violently to produce carbon dioxide. The highly inflammable nature of methane makes it prone to explosions

Govt measures

- PMJIVAN
    - promoting Second Generation (2G) Biofuels Technology(primarily ethanol) moving away from food crops used in First Generation(1G) to feedstocks, nonfood crops agricultural residues or waste.
- National Biogas and Organic manure programme.
    - setting up of Family Type Biogas Plants mainly for rural and semi-urban/households
- Gobar-dhan scheme- collected organic wastes from rural villages and then converting biodegradable waste into compressed biogas (CBG)
    - Also help in estb community-based CBG plants in rural areas
    - Promoting Second Generation (2G) Biofuels Technology' and increase farmers income

BIOFUELS		
GENERATION	CHARACTERISTICS	REMARKS
FIRST	Produced from food crops like maize, corn, sugar cane, rapeseed, palm, and soybean into ethanol and biodiesel, using a similar process to that used in beer and wine-making.	Impose significant costs on food security by demanding a share of staple crops, traditionally used solely for food and feed. Resulting in a conflict between fuel and food security. At the same time, lift the price of staple crops
SECOND	Produced from non-food crops and organic agricultural waste, which contain cellulose.	Grasses like switchgrass, non-edible oil seeds like Jatropha, castor seed can be transformed into biofuels.
THIRD	Derived from algae. Also known as green hydrocarbons	The list of fuels that can be derived from algae includes: Bio-diesel, Ethanol, and Jet-fuel.
FOURTH	Produce sustainable energy as well as capture and store CO_2 by converting biomass materials, which have absorbed CO_2 while growing, into fuel.	At all stages of production, the CO2 is captured using various processes. Rather than simply being carbon neutral, the fourth generation biofuel production is carbon negative, since it 'locks' away more carbon than it produces and also lowers CO_2 emissions by substituting fossil fuels.

Examples of biofuels include ethanol (often made from corn in the United States and sugarcane in Brazil), biodiesel(sourced from vegetable oils and liquid animal fats), green diesel (derived from algae and other plant sources), and biogas(methane derived from animal manure and other digested organic material)

Nuclear Energy

- Stats:
  - Currently account for 2% of energy requirement (Current 7 GW → 275 GW by 2052)
- India's Stand on different Nuclear Treaties
  - Nuclear Non-Proliferation Treaty (NPT): Signed in 1968; Requires countries to give up any present or future plans to build nuclear weapons in return for access to peaceful uses of nuclear energy. 3 main

objectives are non-proliferation, disarmament and peaceful use of nuclear tech. India's stand is follows:
    - 5 states are permitted to possess nuclear weapons while other have to remain non-nuclear weapon states - India rather wants complete disarmament
    - Act as restriction on India's political autonomy and foreign policy choices
- Comprehensive Test Ban Treaty (CTBT): intends to ban all nuclear explosions - everywhere, by everyone. Opened for signature in 1996. The Treaty will enter into force after all 44 States listed in Annex 2 to the Treaty will ratify it. India's stand is follows:
    - US rejected India's demand to present a schedule for eliminating its nuclear stockpile
    - India believes that the universal and complete nuclear disarmament should be the end goal not a mean
    - Treaty is vague on the ban of laboratory testing of nuclear weapons
- Nuclear Suppliers Group (NSG): Formed after 1974 Pokhran Test. It's a group of nuclear supplier countries that seek to contribute to the non-proliferation of nuclear weapons through the implementation of two sets of Guidelines for nuclear exports and nuclear-related exports. A non-NPT state cannot become a member of NSG which keeps India out of the group
- Though India is not a member of NPT and NSG, its track-record in observing the provisions of either body, is impeccable. NSG was able to **grant a waiver** to India in 2008 on the basis of its past performance, now it should have no objection to admitting the country as a member

2018: With growing energy needs should India keep on expanding its nuclear energy programme? Discuss the facts and fears associated with nuclear energy

- Stats showing growing needs: Indian energy demand grows at 4% annually, and is expected to increase from 700 million tonnes of oil equivalent (MTOE) in 2010 to 1,500 MTOE by 2030. In this, nuclear energy comes out as a clean source of energy for future
- Need to expand nuclear energy program(merits)
    - Import dependence and increasing and CAD due to fossil fuel import; (target to reduce bill 10% by 2022)
    - Environmentally friendly nature of nuclear tech allows to pursure UNFCCC goals- reduce GHG

    - Strategic partnership among nations eg: US relation improved after Indo-US nuclear agreement
    - Continous supply of energy (as not dependent on weather unlike sun/wind)- Nuclear power plants run 24 hours a day, 7 days a week.
    - Achieve energy security
    - National security - can be diverted in case of war
- Apprehension/Challenges
    - Depended on Bilateral relations- Raw material supply dependent on US 123 agreement.
    - Anti-nuclear protests: Following the 2011 Fukushima nuclear disaster in Japan, populations around proposed Indian Nuclear power plant sites have launched protests. E.g. Protests in Jaitapur protests and Mithi Virdi.
    - Threat from increasing disasters make coastal nuclear plants vulnerable to cyclones (2011 Fukushima)
    - Reactor's safety: Nuclear reactors are unsafe; Chernobyl disaster resulted in a huge death toll.
    - Nuclear waste: Radioactive radiation, need highly precision nuclear waste mgmt system
    - Fear of being used for making nuclear bombs: Reprocessing spent fuel gives rise to plutonium which is likely to be used in bombs
    - Uranium contamination in groundwater from aquifers in 16 Indian states (due to mining of uranium)
    - Reactor's cost: cost at least billion dollars to be built
    - Cyber security - challanges of getting hacked by non state actor
- Issues in implementation
    - Land acquisition -NPP's like kudankulam in Tamil Nadu and Kovvada in Andhra Pradesh have met with several delays due to the land acquisition related challenges.
    - Future challanges in sustainable mining of monazite sands for thorium in kerela
    - Manpower issues , technology

2016: Give an account of the growth and development of nuclear science and technology in India. What is the advantage of fast breeder reactor programme in India?

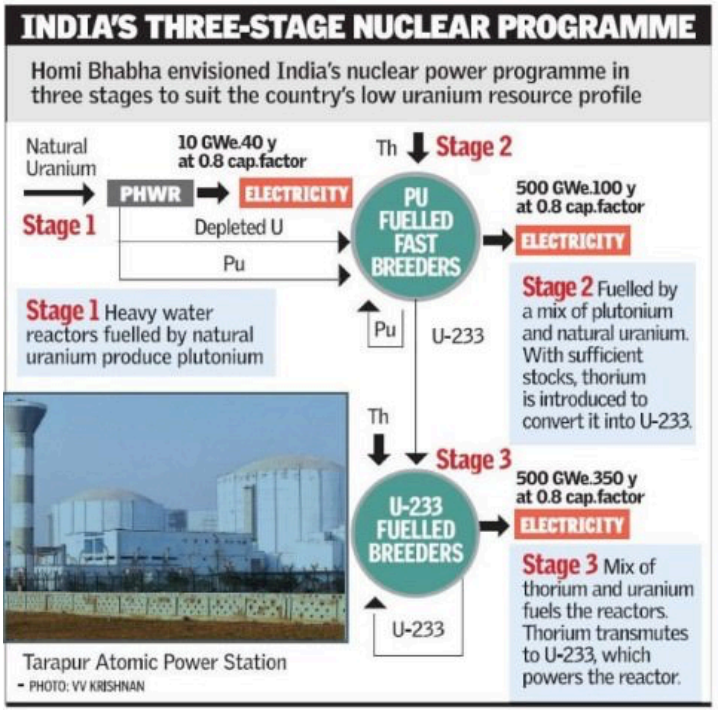
Milestones covered below in next answer

- The advantage with a breeder reactor is that it generates more fissile material than it consumes
- This technology does not contribute to air pollution, except during mining and processing of Uranium ore.

- Breeder reactors use a small core, which is important to sustain chain reactions.
- Besides, they do not even need moderators for slowing down neutrons, as they use fast neutrons.

Indian Nuclear Programme: Phases, milestones, 3 staged process

- Milestones of Indian Program:
  - 1948: Atomic Energy Commission to explore raw material
  - 1969: 1st Boiling water reactor at Tarapur (collab with USA)
  - 1974: Operation Smiling Buddha
  - Nuclear aparthied- indigenous driven nuclear prog
  - 1998: Pokhran Tests → No-first-use policy
  - 2013: Achieved second stage in Kundakulam
- Raw material status-India lack of uranium-only 2% of world- focused on recycling of spent fuell and utilisation of thorium(32% of world reserves)
- Uranium Reserves: 70k tonnes (of which 99% is Ur 238 and balance Ur 233); Thorium Reserves: 360k tonnes
- Institutional- Bhabha atomic research centre(BARC)- for Nuclear R&D, Nuclear power corp of India(operate N power stations), Dept of Atomic energy(overall cord), Uranium corp of India(exploratory body)



1st stage: Use domestic and imported uranium(easy supply after US agreement)

Ur 238 + n -------> Pu 239

2nd stage: (Akshay Patra)

Pu 239 + depeleted Ur -------> Pu 239

Blanket of thorium -------> Ur 233

3rd stage:

Ur 233 + thorium -------> Ur 233

In FBRs, plutonium-239 undergoes fission to produce energy, while the uranium-238 present in the fuel transmutes to additional plutonium-239. Furthermore, once a sufficient amount of plutonium-239 is built up, thorium will be used in the reactor, to produce Uranium-233. This uranium is crucial for the third stage

Civilian, economic and defence needs fulfilled by nuclear programme (Applications)

- Medicine
  - Nuclear medicine- cure cancer(Bhabhatron by BARC for cancer reatment),tumours,clotting through radioactive substance, detect diseases (using radio tracers and spcl cameras)
  - Radiology- trace tumour,cancer,detect TB
  - Pharmacology- study of metabolism of drugs before actual use
  - Radio sterlization of products frequently used in surgery
- Industry
  - In construction industry- review of materials used, pipes
  - Used as fuel space exploration
  - Used in desalinisation plants
  - Material analysis
  - Determine flow rates in oil & gas exploration
- Agriculture
  - Food preservation: foods are exposed to gamma rays to get rid of microbes eg: Presently fruits like Mango and Pomegranate and vegetable like onions and garlic are being irradiated for shelf life extension.
  - Plant breeding: BARC has developed more than 1800 new crop varities through mutation; DAE has developed 42 varieties in oilseeds
  - Subsidy is granted to radiation processing plants under SAMPADA scheme
- Archaelogy
  - Geoplogical event dating- radiocarbon dating

- Weopon
    - Now I become death- Gita

Nuclear medicine and its uses

Nuclear medicine is the medical specialty, which utilizes the nuclear properties of radioactive nuclides for diagnostic evaluation and / or physiological conditions of the body and provides therapy with unsealed radioactive sources.

Fission vs Fusion

Nuclear fission is the splitting of a nucleus into smaller particles, releasing a high amount of energy	Nuclear fusion is the combination of two smaller atoms to create a large atom releasing energy
Not common in nature	Common in stars such as sun
May require high-speed neutrons	Require high temperature and high pressure conditions
Produce a high energy	Reactions of light nuclei produce a very high energy; reactions of heavy nuclei may not release energy
Examples: neutron bombardment of Uranium-235 and radioactive decay in unstable isotopes	Examples: fusion between Deuterium and Tritium

---

IPR and its Related Issues

- Basics:
    - Invention(novelty) vs Innovation (on existing product)- Invention key to patenting, innovation patenting - need standard criteria to grant patent

- IPR are the rights given to persons over the creations of their minds eg: inventions, literary and artistic works, and symbols, etc.
- IPR aims to create an environment where creativity and innovation can foster
- Also recognised under the Article 27 of Universal Decl. of HR

- **Merits of India's IPR regime**
  - Sec 3(d) of Patent Act: Prevents evergreening of patent unless their is significant improvement- help in public health emergecy - generic drugs for domestic and export
  - Complulsory licensing- ensures that drug is not very expensive, available to most people(eg Bayer's drug- 2.8 Lakh per month vs 8800 per month (Natco)-kidney cancer drug- got CL
    - WTO Doha round- each nation sov to grant CL for public health need
  - Oxford university vs Rameshwari photocopy case- Delhi HC- As mentioned in exception to copyright regime for study material, HC allowed photcopying portion for wider knowledge to people- help poor students
  - Novartis case
- **Issues in India's patent regime**
  - Sect 84 of Patent Act: Compulsory licensing is a seen as an impediment to innovation by innovators
    - Compulsory licensing: -ves: Promotes grey markets; No comprehensive definition of 'national emergency' (As per the Indian Patents Act, 1970, a compulsory license can be granted for the patents after the expiry of three years of grant of patent)
    - Issues to India- Issues in granting smooth CL- litigations
  - Poor enforcement of IPR promoting culture of piracy
  - India continues to remain on the USTR's Special 301 Report 'Priority Watch List' for alleged violations of IPR
  - IPR policy recommends scientist to cover all discoveries into IP- hampers frugal innovation over them due to free flow of knowledge
    - Poor quality of patent issue- eg in China after their IPR policy
    - Learn from Jagdish Chandra Bose who advocated for open system of knowledge
  - Developed nations want TRIPS(+) (which will be outside WTO); They want data exclusivity (protection of clinical test data so that that generic drug dev have to conduct their own trials again)
- **Measure taken**
  - National Innovation Policy
    - Creating robust national innovation system, India-specific focus on inclusive growth,promote scientific temper,Linking research and action, promote STEM careers

- National IPR Policy 2016 (admin by DIPP)
  - Aims to promote IP, set up institutions for imp,mom,review and incorporate global best practices
  - 7 objectives of IPR Policy- IPR Awareness, Generation of IPR's, Legal laws to balance IPR and public interest, Modern Administration of IPR, Commercialisation of IPR, Enforcement and Adjudication, Human capital dev
  - Benefits:
    - Fin support to less empowered for IPR protection eg farmer,weavers,artisans
    - Bring down window time of registration to one month
    - Tax benefits, simplify laws, stable IPR regime to domestic and foreign
- Intellectual property Appellate board
  - Hear appeals against Registrar under TM,GI,patents.
  - Tribunal with global impact
- International Agreements
  - TRIPS: TRIPS Agreement btw WTO members - introduced global minimum standards (national laws, dispute stellement,grant of rights to owners etc) for protecting and enforcing nearly all forms of intellectual property rights (IPR), including those for patents wef 1995
  - WIPO: Specialised agency of UN
    - Responsible for promotion/protection of IPR whole world-admin of IPR treaties
    - Objectives
      - Increase capacity of developing C in patent creation, their ability to acquire foreign patents and technology
      - Under TRIP- gives legislative, human resource, institutional advise
- **Success**:
  - India's rank in the Global Innovation Index (GII) issued by WIPO has improved from 81st in 2015 to 52nd place in 2019.
  - Increase in Patent and trademark Filings; Increase in IPR Awareness through 'IPR Nani' Scheme
  - India made CoWIN platform open-source (ie no IPR attached) - so that it can serve global good

Probable Question: India & South Africa submitted a joint petition to WTO for requesting temporary suspension of TRIPS (for COVID-19 treatment)

Benefits of Patents: Moral and natural right to claim over their inventions; Utalitarian premise that exclusive licenses promote invetions; People must be allowed to bear the fruits of their labour

Refuting above objections: During COVID-19, the pvt. organisation could earn patent only after basic research of efficacy was conducted by various public run institutions and hospitals; Research is driven only for diseases that affect developed world (leading Tropical diseases); Patents are seen as the only means to promote innovation which is not true

Other solutions: Replacing patents with patent prizes (as advocated by Josesph Stiglitz)

2019: Protecting traditional knowledge of medicine from patenting; 2015: TKDL: Pros & cons of making it under open source licensing

- Legislative Framework:
    - Biological Diversity Act 2002: Provision for fair and equitable sharing of the benefits of genetic resources (role of local level committees part of 3 tier structure)
    - Forest Rights Act 2006: provides for community rights over forest resources
    - GI Act 1999: right to the holders of the traditional knowledge associated with a particular geographical area
- International Cooperation:
    - Under Nagoya Protocol of CBD
    - Agreements have been signed with various international patent offices to prevent the grant of invalid patents
- Policy Measures:
    - TKDL Initiative
    - National AYUSH Mission conducted to bring awareness of our traditional knowledge
    - Research Centres and National Institutes have been created across India in the fields of Ayurveda, Unani, Homoeopathy, Siddha
    - People register of Bio-Diversity- compile tradional knowledge which has passed through oral-oral route iin generations
    - CSIR files objection at Int patent office- eg when yoga method patent filed in US

TKDL Initiative

- The Traditional Knowledge Digital Library (TKDL) is an Indian digital knowledge repository of the traditional knowledge. It was setup in 2001 and is a collaboration between CSIR and M/o AYUSH
- Prevent misappropriation of tradional knowledge by foreigners (eg medicinal uses of neem and turmeric) through bio-piracy by listing it in international patent list
- Available in five languages: English, German, French, Japanese and Spanish- knowledge of ayurveda,unani,siddha etc
- Intends to act as a bridge between information recorded in ancient Sanskrit and patent examiners abroad
- Pros of open source:
    - Prevent invalid patent, save legal costs
    - Protection to traditional knowledge
    -
- Cons of open source:
    - Lawyers can work around the existing info given in the database to secure their patent
    - Might be used to earn corporate profits w/o giving due credit and references

IPR in global discourse; Role of TRIPS; Steps taken to confirm to TRIPS? Concerns of India towards new IPR discussions

Copyrights, Patents and Trade Secrets

2014: Meaning of Copyrights, Patents and Trade Secrets

- Copyrights: Protection of original creative expressions like literary works, artistic works, dramatic works. musical, etc; Covered under The Copyright Act, 1957
    - Valid for life time of the author + 60 years after his/her death; No symbolic representation to show registration
    - Automatically comes into effect but application for copyright can help in legal disputes
    - Eg: Copyright of books, or songs, or films
- Patent: Protection of inventions that are novel, original and has industrial utility; Covered under The Patents Act, 1970

    - Validity for 20 years; No symbolic representation(like TM sign) to show registration.
    - Patent Act ammendemt 2005- emphasis on indigenous manufacuring of medicine, prevent ever greening, pre-grant and post-grant opposition avenues.
    - Eg: Patent taken for newly invented COVID vaccine
- Trademark: Protection of unique name that makes a brand distinct from other. Can include name, slogans, logo, shape, colour etc. Covered under Trade Marks Act, 1999
    - Validity for 10 years can be made perpetual by renewing the trademark every 10 years; Symbol of ® is used when registered; While registration process is on ™ is used
    - Eg: Trademark of Haldiram Bhujiya
- Trade Secret: Confidential information of a business entity which provides a competitive edge over its rival business. Trade secret could be commercial information or information pertaining to industrial manufacturing process.
    - For instance, Pepsi Co's formula for producing Pepsi is considered a trade secret.
    - In India, no specific law governs trade secrets, but it is accorded protection by the Courts through interpretation of natural law, principles of equity and common law, and the Contract Act.
- Geographical Indications: It is a sign used on agricultural or natural or manufactured goods when they originate or are manufactured in a particular region of a country.
    - Specific quality, characteristic or reputation of the product is essentially attributable to that origin.
    - Governed by The Geographical Indications of Goods (Registration & Protection) Act, 1999
    - eg: Darjeeling Tea, Kadaknath Chicken (MP)
- Design: Consists of the creation of a shape, composition of pattern or color, or combination of pattern and color in three-dimensional form containing aesthetic value.
    - Eg: Design of Apple Iphone; Designs in India are governed by The Designs Act 2000

What stimulates innovation?

Indian Patent Law 1970; Section 3d Analyse? SC Judgement? Pros and cons?

- Section 3(d) of the Indian Patent Act 1970 (as amended in 2005) does not allow patent to be granted to inventions involving new forms of a known substance unless it differs significantly in properties with regard to efficacy.
    - This means that the Indian Patent Act does not allow evergreening of patents.
    - This has been a cause of concern to the pharma companies. Section 3(d) was instrumental in the Indian Patent Office (IPO) rejecting the patent for Novartis drug Glivec

---

R&D, Miscellaneous Topics

- **Background**
    - Investments in R&D are key inputs in economic growth. The impact of this is proven on productivity, exports, employment and capital formation.
    - In the decades following independence, this choice of self-reliance had placed India ahead of most developing countries. However India did not modernize these industries and missed the third industrial revolution. The private sector stayed content with near-monopoly conditions in non-core sectors (Bombay Plan)
    - Post NEP 1991, focus shifted to importing cheaper R&D to fuel indigenous efforts. However, there was inadequate absorption of these imported technologies
    - India's gross domestic expenditure on R&D (GERD) stands at 0.7% of GDP (compared to Brazil 1.3, China 2.1)
    - India: Top exporter of IT products, 'Pharmacy of the world',
    - India is at the 48th position in the list of top 50 innovative countries as per Global Innovation Index 2020 (Rank 52 in 2019) - shown a consistent improvement in its innovation ranking
- **Data from R&D Statistics and Indicators 2019-20 by D/o ST**
    - The number of researchers per million population has doubled since 2000. It has increased to 255 in 2017 from 110 in 2000
    - Women participation in extramural R&D projects has increased significantly to 24% in 2016-17 from 13% in 2000-01
    - According to WIPO, India's Patent Office stands at the 7th position among the top 10 Patent Filing Offices in the world
    - India's investment in R&D has shown a consistent increasing trend over the years. However remained between around 0.6% to 0.7%

- **Challenges**
  - Government expenditure, almost entirely the Central Government, is the driving force of R&D in India which is in contrast to the advanced countries where the private sector is the dominant and driving force of R&D spend
    - Government's participation in R&D in the other countries ranged from seven percent in U.K. to 38 % in Mexico, as against India's 55%
  - India only 0.7% comp to China 2%(pvt sector only 0.2%)
  - Shortcomings of the Indian university system has been the focus on basic research rather than application research- disconnect btw academia and imp lab
  - Weak IPR regime - ineffective, inadequate - backlog of almost 2 lakh patents pending examination
  - Though number of journals are increasing - they are not so impactful (not highly citited)
  - Global unfair competition practised by China (to counter that we need push towards R&D)
- **Measures taken**
  - Emphasis on collaborative R&D by CPSEs and IITs/Universities to work on market oriented research
  - Weighted deduction provisions available in Income Tax Act for inhouse and R&D contributions
  - Make in India
  - National Knowledge Network by M/o HRD
  - Atal Innovation Mission by NITI Aayog: to promote the culture of innovation, R&D in India
  - National Research Foundation - to coordinate research funding in India
  - Draft National Science Technology and Innovation Policy, 2020
  - Draft Scientific Social Responsibility
  - Promotion of one person companies can promote startups which inturn fuel innovation
  - Collaboration in international projects such as Large Hadron Collider
  - Draft STIP (new policy) 2020: Aims to double GERD, no of FTE researchers, pvt sector contribution to GERD; Also aims for "one nation, one subscription" solution
- **Way Forward**
  - Need for greater participation of State Governments and the private sector in overall R&D spending
  - Need for a hawk eye like focus - as done by China rose from 276 patents in 1999 to global leader in 2019
  - Learn from global models such as that of Singapore, South Korea who spend 3-5% on R&D along with 4-6% on education & skill development

    - EAC-PM recommended:
        - R&D exp must reach at least 2% of GDP by 2022
        - minimum percentage of turnover of medium and large enterprises be invested in R&D
        - creating 30 dedicated R&D Exports Hub
        - Mandate ministries at centre to allocate a certain percentage of their budget for research and innovation
    - CPSEs of the petroleum and power sector are the biggest spenders in R&D. Other need to follow suit
    - Address the data gaps in compiling R&D data so that it could reflect India's true rank globally
    - **Economis Survey** said India's business sector needs to rise to the occasion and significantly ramp up its gross expenditure on R&D to a level commensurate to India's status as the fifth largest economy. This requires boosting business sector contribution to total GERD from 37 per cent currently, to close to 68 per cent — the average business contribution in GERD of other top 10 economies
    - Need to learn from US Senate which approved $170bn+ innovation bill (mainly to surging economic threat from rival China)
- **Conclusion**: Higher investments in R&D and education are the key areas to become *'atmanirbhar'* and should be the focus of our policymakers

Antimicrobial Resistance

Causes? Mechanisms for monitoring and control (take example of MDR-TB)(2014)

MDR-TB: What? Measures for containment, Implications of spread

- AMR happens when microorganisms (such as bacteria, fungi, viruses, and parasites) change when they are exposed to antimicrobial drugs(called superbugs after becoming AMR)
- AMR occurs naturally over time along as well as other man made reasons; However due to below mentioned reasons are accelerating the same
- ICMR Study found antobiotic resistant organisms in digestive tracts of 2 out of 3 healthy persons it tested
- India is one of the top users of antibiotics.

Reasons for AMR

- Inappropriate use of medicines: Overuse, underuse and misuse
- Lack of quality medicine: Weak drug quality assurance systems leading to poor quality medicines
- Animal Husbandry: Sub-therapeutic doses of antibiotics are used in animal-rearing for promoting growth- transfer AMR bacteria from animal to humans

- Poor infection prevention and control: Hospitalised patients are one of the main reservoirs of resistant microorganisms
- Contamination around hospitals releases active antimicrobials into env due to inappropriate disposal
- Inappropriate usage in agriculture
- Weak surveillance systems: It impairs the ability to detect emergence of resistance and take prompt actions.

Why is AMR a concern?

- New resistance mechanisms are emerging and spreading globally,
- A growing list of infections such as pneumonia, TB, blood poisoning and gonorrhea are becoming harder, and sometimes impossible, to treat as antibiotics become less effective.
- Medical procedures and major surgery become very high risk.
- AMR increases the cost of health care with lengthier stays in hospitals and more intensive care required.
- AMR is putting the gains of the Millennium Development Goals at risk and endangers achievement of the Sustainable Development Goals.

Govt steps

- National Anti-Microbial Resistance Research and Surveillance Network to strengthen the surveillance of AMR by compilation of National Data of AMR at different levels of Health Care.
- National Action Plan to combat Antimicrobial Resistance
- Red Line Campaign' for antibiotics packaging to curb their over-the-counter sale

WHO Steps

- Global Antimicrobial Resistance Surveillance System (GLASS): supports a standardized approach to the collection, analysis and sharing of data related to antimicrobial resistance at a global level.
- AWaRE tool: aimed at guiding policy-makers and health workers to use antibiotics safely and more effectively.
- One health approach- to tackle zoonotic diseases by tackling them holistically
- WHO Recommendation(Way forward)
    - Individual: Only use antibiotics when prescribed, Never share or use leftover antibiotics
    - Policy Makers: robust national action plan to tackle AMR, Make information available on its impact
    - Health Profesionals/Industry: Talk to your patients about how to take antibiotics correctly, Invest in research and development of new antibiotics

    - Agriculture: use alternatives to antibiotics when available, Only give antibiotics to animals under veterinary supervision
    - Policy alignment is also needed much beyond the health system. Solutions in clinical medicine must be integrated with improved surveillance of AMR in agriculture, animal health and the environment. This means that AMR must no longer be the remit solely of the health sector, but needs engagement from a wide range of stakeholders, representing agriculture, trade and the environment with solutions that balance their often-competing interests.
    - International alignment and coordination are para mount in both policymaking and its implementation. Indeed, recent papers have proposed using the Paris Agreement *as a blueprint* for developing a similar global approach to tackling AMR.

2020: How is science interwoven deeply with our lives? What are the striking changes in agriculture triggered off by the science-based technologies?

Analyse various technology for agri

2020: COVID-19 pandemic has caused unprecedented devastation worldwide. However, technological advancements are being availed readily to win over the crisis. Give an account of how technology was sought to aid management to the pandemic.

- IT- Arogya setu, making heat maps, crowd management, info dessimination about newer tech, work from home/social distancing was possible due to IT, Social connect
- Space- Tracing location of patients,
- Robotics- patient care, automated sanitization devices, drones used to deliver food/meds/sanitation
- AI is helping to develop drugs and coronavirus vaccine using super computers, Modeling and prediction of future cases
- Big data analysis
- Wireless thermometer guns,
- Nano-technology:
- Biotech- Vaccines, testing kits, drug development, plasma therapy,
- However
    - Infodemic-fear,anxiety due to continuos news -social media

---

Biotechnology

- **Meaning**: Area of biology using living organisms to manufacture products or technology to improve human life.
    - The sector is divided into five major segments- Bio-pharma, Bio-services, Bio-agri, Bio-industrial, and Bio-informatics.
    - Bio-pharma sector accounts for the largest share of the biotech industry (>50%)
    - India only few countries with dedicated dept for BT
- **Applications/ Types of BT**
    - Red BT: (related medical sciences)
        - Stem cell
        - Bio-pharma
            - India leader in world, pharmacy of world, generic drugs, adresses health issues of poor and neglected areas,
        - Molecular Diagnosis eg: RT PCR tests done to detect COVID
        - Gene Therapy: allows correction of a gene defect that has been diagnosed in a child/embryo, Designer babies, Three parent baby
        - Genetically Engineered Insulin (via bacterias)
        - Vaccine are developed using bioreactor
        - Artificial limbs- bionics(using biotech to imitate functions of living org)
    - Green BT: (related to agirculture,farmer)
        - To get higher yield eg: GM Mustard
        - Pest resistance eg: Bt Cotton
        - Food fortification: eg: Golden rice having Vitamin A
        - Increased shelf life eg: Flavr Savr Tomatoes
        - Biotech-KISAN Hub Scheme - To use biotech to solve prob of small & marginal farmers
        - Reduced reliance on chemical pesticides leading to healthier soils
        - Lab meat- vegetable meat
        - Modified Crops- more food on less land,less CO_2 emissions from agri, Agro forestry- limits deforestation
        - Domestic animals on verge of extinction reproduce by BT- Murrah Buffalo cloning done in Hisar
        - Efficiency of mineral usage by plants has been increased
        - Crops have been made more tolerant to abiotic stresses (cold, drought, salt, heat)
    - White BT: (related to industrial use)
        - Development of biofuels such biogas, biodiesel (uses algae), Jatropha
        - Production of bioethanol
        - Waste treatment
        - Biomining using microbes

        - Industrial fermentation to produce eatables (such as cheese, bread)
        - Development of detergents
        - Cosmetics- makes them sustainable- replacing hazardous chemicals
    - Grey BT: (related to environment)
        - Clearing oil spills using Oil Zappers, Bio-remediation
        - To develop climate resistant crops
    - Blue BT (realed to marine)
        - Used to increase fishery stock or variety of species eg: Aquaculture
        - Food supply: eg: omega-3 fatty acids derived from fish oil
    - Other applications of BT
        - Bio-informatics- combines biology,computer sc,mathematics,statistics- eg using genomic info and big data analytics (Human gemome project)
        - Bio-weapons- Russia attack
- **Biotechnology in India**
    - National Bio-Tech Dev Strategy (2015-20)
        - Est India as world class bio manuf hub, create 100 billion USD biotech industry by 2025
        - Basic policy points(infra,HRD,coord etc)
        - Implemented by BIRAC-Not for profit co. for industry reseach assistance
    - National Bio-Pharma Mission
        - Industry-Academia collab, WB prog - i3 (Innovate in India)
        - Bioparks,clusters,incubators,centres of excellence etc
    - Atal Jai Anusandhan Biotech Mission
        - Expected to transform the Health, Agriculture and Energy sectors
        - Missions such as: GARBH-ini, IndCEPI (affordable vaccine), Mission on Antimicrobial Resistance, Clean Energy Mission (innovate tech for Swachh Bharat)
    - Biotech-KISAN: Scientist farmer partnership scheme launched in 2017; ~146 Biotech KISAN Hubs have been set up in all ADP distt covering all 15 agroclimatic zones
- **Concerns/ Challenges**
    - Only 0.67% of GDP in R&D (china- , japan-3)
    - Marketisation bottleneck- funds over in research only
    - Sec 3(d) of patents act 2005; Complusory licensing discourages foreign investment
        - Might lead to biopiracy
    - No Bio regulatory authority-Bill pending
    - Youth not as enthusaistic for Bio-T due to lack of awareness on achievements of sector

    - Dark Biotechnology: biological weapons, bioterrorism
    - Ethical challenges: Natural order is hurt, religious concerns, Issue of consent (there is no consent from person whose life will get changed at embryo stage)
- **Way Forward**
    - Tackle concerns, inc private involemet(Serum inst as role model for inc participation), Biocon(kiran M shaw)
    - Take guidance from Cartegena Protocal of CBD as it deals with biosafety (to protect against adverse effects of biotech) - It advises to conduct Risk assessment reports and share it with Biosafety Clearing Houses

2019: Improving the living standards of farmers (eg: bio fertilizers)

Refer Green BT

2018: General benefit for India? Impacts on 'bio'-pharma? (Difference with bio-tech)

Covered above

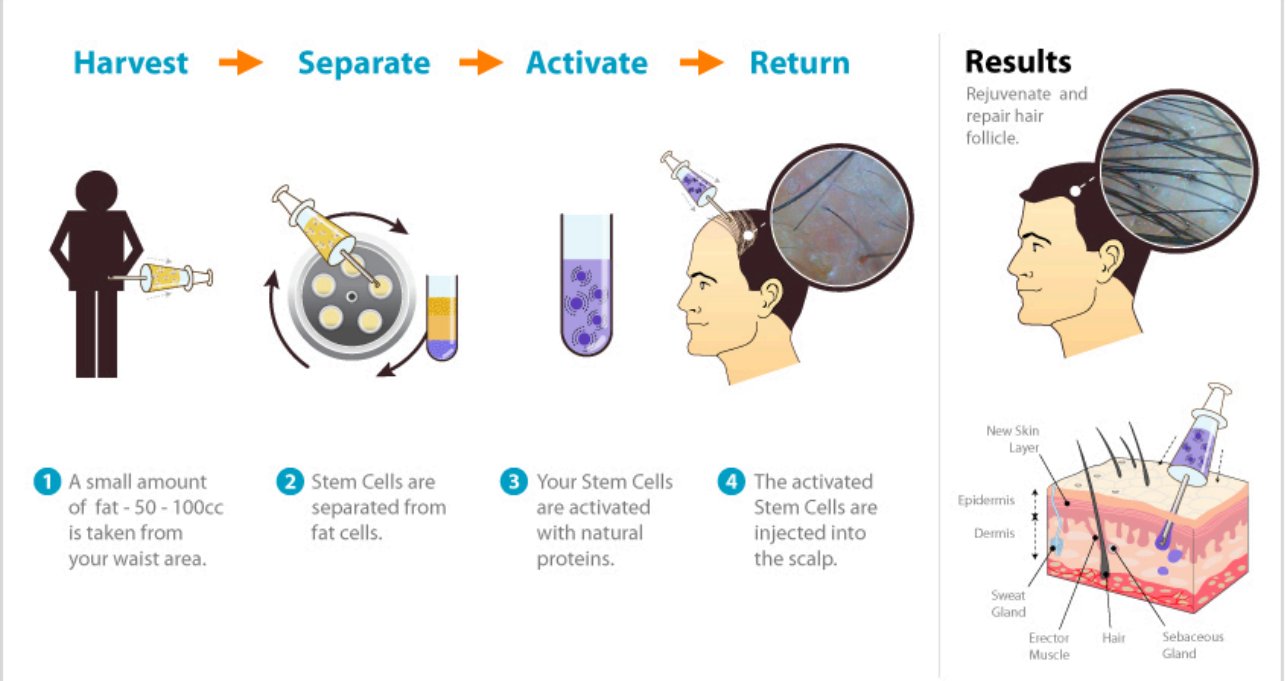
Biopharma is nothing but Red BT, therefore use points accordingly

Stem Cell Therapy

2017: Stem cell therapy: merits and demerits; advantages over other treatment? Various genetic diseases

- Stem cells are the body's raw materials — cells from which all other cells with specialized functions are generated
- Stem cells divide to form more cells called daughter cells. No other cell in the body has the natural ability to generate new cell types
- These daughter cells either become new stem cells (self-renewal) or become specialized cells (differentiation) with a more specific function, such as blood cells, brain cells, heart muscle cells or bone cells.
- Stem cell therapy, also known as regenerative medicine, promotes the repair response of diseased/ injured tissue using stem cells or their derivatives
- Types of Stem Cells: (formation at different times of human lives)
    - Embryonic stem cells: Stem cells in early stages of life

    - Adult stem cells: eg: Stem cells in bone marrow
    - Induced pluripotent stem cells or iPSC's: Made in labs
- Advantages over other treatment:
    - Diseases that were earlier considered degenerative, incurable can now be cured eg: diabetes, Parkinson's, Alzheimer's disease
    - Treat blood related disorders such as Leukaemia, Thalassemia
    - a) Lower risk of infection during the immune compromised portion of the treatment. b) Speed up the length of time it takes for injuries or wounds to heal c) Reduce pain, even chronic joint pain, with less need for medications d) Increase functionality, range of motion, flexibility and sleep quality e) Reduce muscle compensations and risk for future injuries f) Decrease nerve damage g) Increase collagen h) Help generate new heart and blood vessel tissue i) Help heal skin wounds, prevent formation of scar tissue and reduce hair loss j) Return patients to their normal activities as quickly as possible



Genetics

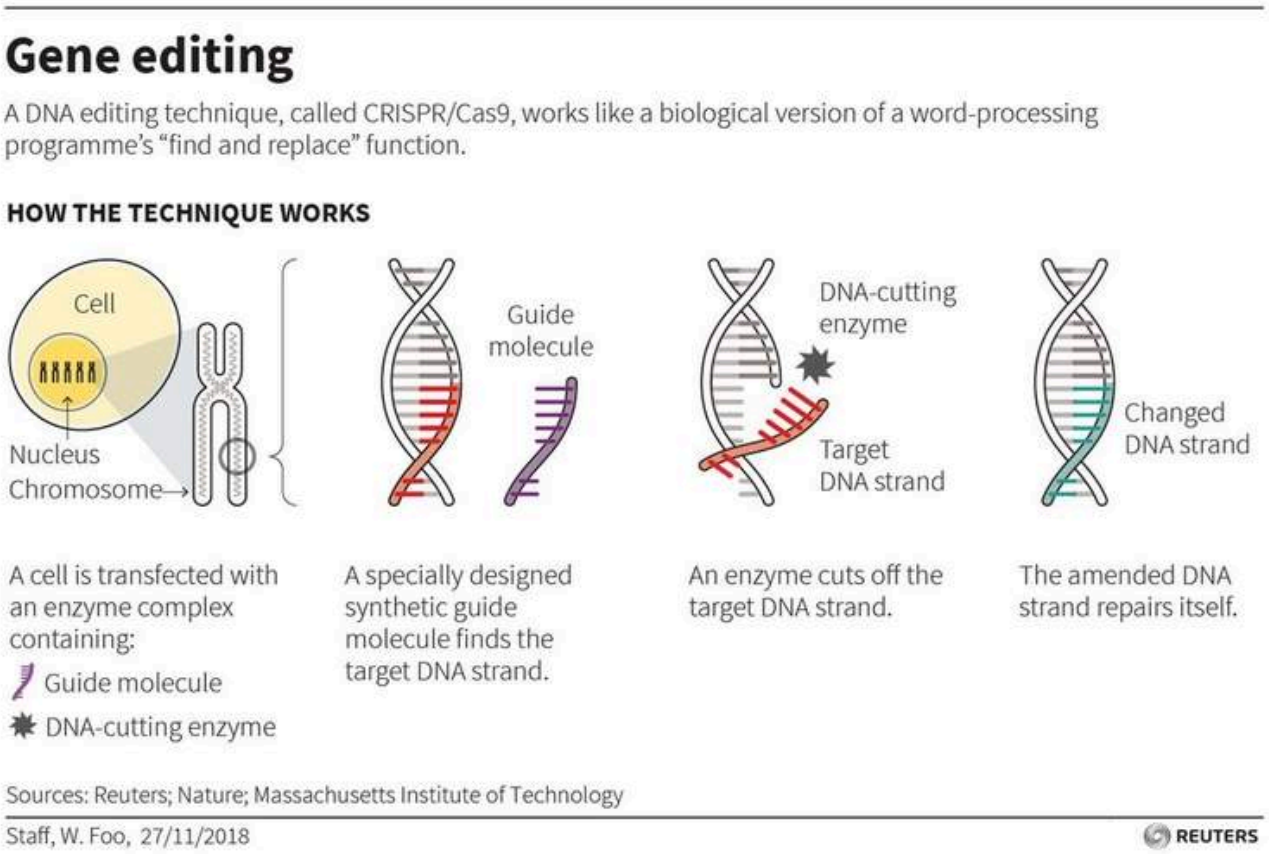
Basics, Uses, Merits/ Demerits; Projects at GOI and Global level; Uses of DNA Technology (eg: DNA fingerprinting)

GM Crops - Basics:

- Transgenic/ Genetically modified seeds are developed by transferring selected genes from one organism into another. (compare them with Hybrid seeds which are developed by cross-breeding / cross-pollination with other plants)

- Use of the unapproved GM variant can attract a jail term of 5 years and fine of Rs. 1 lakh under the EPA, 1986
- Merits:
    - Solve issues of food security as crops are much more tolerant to harsh environment, pests
    - Improve yields → Farmer's income ⬆️
    - Environmentally safe as lesser chemical pesticides have to be used
    - Less labour intensive and hence cost friendly
    - Reduced import dependence eg: of pulses
- Demerits:
    - Biosafety concerns may be unsafe for human and animal consumption (as some traits get revealed only after several generations)
    - Terminator gene allow dev of monopolistic practices eg: American company Monsanto's Bollgard
    - Trait fees can make the whole procedure expensive
    - Promote monoculture practices and hurt crop biodiversity, traditional knowledge
    - Gene crossover to other wild species
    - Regulatory miscarriage
- Suggestions by Economic Survey
    - We've a robust regulatory framework with GEAC. So, mischief is unlikely so we should allow GM crops with following precautions → 1. Allow GM seeds which don't have Terminator Gene or high cost. 2. Allow GM seeds that have following properties: 1) Disease, pest & drought resistant 2) Longer shelf life 3) Shorter crop duration 4) Nonfood / Tree format crops. 3. To prevent MNC monopoly on GM seeds, we've to encourage domestic companies

Gene Editing



Basics- DNA altered/inserted/replaced in genome of org using molecular scissiors(CRISPR-Cas9)

He Jiankui(China) controversy- produced world first genetically altered babies(scientific community accepts genetics only for treating diseases)

- **Merits**
  - Treat rare/orphan diseases like thallesemia,leukamaia
  - Next gen antibiotics acc to gene mapping(Indian specific medicine)
  - Protect engendered species(White rhino save from extinction in africa)
  - Introduce sterlite mosquito to control population
  - Food fortification
  - New org- E Coli- world first living org with fully synthetic DNA code made in lab
- **Demerits**
  - Wrong effects contrary to intention- eg desiner baby not so designer actually
  - Human germline issue-should not transmit to offspring
  - Ecological-can lead to disapperance of entire species
  - Difficult to regualte outside lab
  - Ethical- concern of bio-ethicist- Kant violate- no consent of baby

    - Threat to human race- in case 2 diff genes make new species- difficult to predict exact functioning
- **Way Forward**
    - Transparency and due care
    - Int agreed principles- for common humanity
    - Equity-should not increase inequality- share with world
- **Govt Efforts**
    - Manav Human Atlas Initiative-create atlas of human body-every tissue,molecule,cell- understand role in various diseases, precision drug and drug delivery
    - Genome India project - map India's genetic landscape(figuring out order of DNA nucleotide common to Indian gene)- preventive and predictive healthcare (global prog based on caucasian ra

---

Space & Defence

Basic Space Intro:

- 1957: Watershed year of space-launch of sputnik- US-soviet competion-influence for India- Sarabhai-ISRO
- ISRO- known for low cost and innovtive appraoch to space- this capability attracts large number of developed and developing countries to help launch their own missions

Develop framework of space advancement (incl inter-planetary) on humankind, PESTEL, new possibilities that have opened

- As per industry sources, the space sector in India accounts for 3% in the rising global space market
- Space Diplomacy: In 2018, France and India concluded the joint vision for space cooperation.
- Agriculture: Farmers benefit from remote sensing satellite's data on monsoon prospects and water availability; Prospective Fishing Zones can be put out by GAGAN,watershed mgmt
    - Rural-Village resource centre of ISRO- help Panchayats/NGO for socio-eco dev
- Health: Access diff to reach areas such as Ladakh via ISRO's Tele-medicine programme; Nuclear med
- Education: expand academic horizons through ISRO's Tele-education networks

- Environment: Monitoring signs of climate change, protecting wildlife by satellite tagging (eg: done for gharials), Using satellites to prepare heat map which can be used to locate potential geo thermal energy generation sites
- Business: Role played in functioning of critical infrastructure such as stock markets, banks, etc.
- More than 500 industries are involved in the development of launch vehicles and satellites. Over 90 per cent of the launch vehicle cost is accounted for by indigenised technology and materials eg: ISRO's ANTRIX is fueling progress
- Space R&D has ripple effects in various sectors such as medical, mechanics, material sciences, etc.
- Triggered the birth of television entertainment industry, DTH (through remote sensing satellites)
- Strategic angle: Protection & developments of islands & North east region
- Project Bhuvan: gives thematic maps and data on agriculture, water resources, land cover,
- Popularising science among youth and developing a scientific temper eg: Young scientist Program, YUVIKA,ISRO-Student Collaborations: ANUSAT (Anna University Satellite)

India's own space station

Benefits of India's own space station (2019)

- Space station- orbitral spacecraft revolving around sun capable of supporting a human crew for extended period of time for cutting edge scientific research that cannot be done on earth
- ISS - currently the only active SS,China planning to launch soon, Russia withdrew its station in 2001
- India plans to have own after 4-5 years of Gaganyaan
- Constructing a space station after being able to safely orbit a crew in Low Earth Orbit (LEO) is a natural progression that many advanced space-faring countries -therefore must for ISRO
- Characterstics (Preliminary Details)
    - The Indian space station would be stationed at an altitude of 400 kilometers from Earth.
    - Smaller in size than ISS(420 tonnes) weighing about 20 tonnes
    - Take another 5 to 7 seven years to construct, Will accommodate astronauts for up to 15-20 days in space but specific details after Gaganyaan
    - Help in microgravity exp,collabarative research with other countries.
    - ISRO conducting Space docking experiment- essential for any SS
- Benefits:

    - Will provide leverage to further carry out larger scale and precision experiments in space including human travel, also study long term effects of space on human body
    - Help to carry larger payloads into space
        - Scientific community can conduct research in astronomy to meteorology to biology and medicine.
    - Other spacecraft can dock- cross cultural collab experiments with countries
    - Help provide more room for astronauts to live and carry out experiments over longer time frames.
    - ISS expected to become redundant from 2024-28- so not benefical to only join ISS
        - India could not have been a part of the ISS as excluded from such projects because of Delhi's nuclear policy.
    - Major commercial and strategic benefits(Future of space weaponisation), maintain leadership in space
    - Agriculture: Seeds exposed to cosmic radiations & zero gravity can produce better yields when planted back on earth (eg: Space rice by China)
- Challenges:
    - After the Ganganyaan project -pose important challenges like approval and finance.
    - The ISS costs $3 billion a year (Rs. 20,000 crores) and 6.50,000 crore in assembling.- Financial issue
    - require a plan to upgrade the payload carrying capacity of the GSLV Mark III for space station requirements- frequent travel
- Way forward
    - Involve Private sector like Space-X helps NASA in docking astronauts
    - Need specialised astranauts and traning centre
- Conclusion- Need to recreate astonishment in world like MOM

IRNSS

Need for IRNSS, Advantages; Meaning of 'Standard Positioning Systems' and 'Precision Positioning Systems' in the GPS era (2018(GS1),2015,2008)

- GPS provides 2 types of services:
    - SPS: Used for civilian purposes and used standard receiver and technology
    - PPS: Used for military puropses (however this precision can be used in mining, etc as well)

- IRNSS: Indigenously developed navigation system having 7 satellites which will be used to provide accurate real-time positioning and timing services over India and region extending to 1500 km around India. IRNSS constellationwas named as **"NavIC"** (Navigation with Indian Constellation) by PM.
    - NavIC provides two types of services: Standard Positioning Service (SPS) is meant for the general public. Restricted Service (RS) is an encrypted service meant for authorised users and agencies
    - Advantages over GPS: IRNSS uses both L band & S band; Cost effective; Much more accurate (under 20m)
- Advantages:
    - Precision: Each satellite has 3 atomic clock each to provide accurate measurements
    - Mapping and town planning
    - Integration with mobile phones
    - Security: eg: Tracking enemy movements across rough terrains, US denied access to GPS during Kargil War
    - Terrestrial, Aerial, Marine Navigation
    - Disaster management to tackle forest fires, etc
- Additional Information: India is planning to put up a new satellite series called the Indian Data Relay Satellite System (IDRSS). At present, in the absence of a data relay satellite system, spacecraft are not visible all the time. IRDSS is important to monitor launches in the LEO (needed for Gaganyaan, future space station & other assets)

New Mars Mission by NASA, other players(2012)- Juno mission(GS1)

- First write about features of planet,specific mission
- Find common dimensions of any space mission
    - Origins & evolution of earth - through sample analysis
    - Impact of climate change, wind pressures,
    - Disater predictions and mitigatin strategies- eg Insights analysing quakes on Mars, volcanic analysis
    - Sign of life- Curiousity rover found methane of mars
    - Interstellear studies
    - Remove debris
    - Exoplanets within goldilocks zone
- **Mars** is the only possible hospitable planet in our solar system as Venus & Mercury are too hot whereas last 4 planets are gaseous

Manned space mission

Prospects, Causes for less dev., status (2017)

- Gaganyaan is the ₹10,000-crore Indian human space flight scheduled for 2022 (75th anniversary).
- Features:
    - It is designed to have 3-7 crew members spend 3-7 days in space in a 400-km orbit.
    - India -will be 4th
    - Use GSLV MK 3
- Benefits- same as space station
- First of the two pre-Gaganyaan flights with a humanoid will be launched along with some of the microgravity experiments
- Challenges:
    - Funding -10000cr
    - Research is pending wrt. biosciences (astronauts will receive over 10 times more radiation)
    - Need for high level of precision as humans are involved
    - Lack of training facilites
    - Building tech to carry heavy payloads to space
- Measures taken:
    - Crew Module Atmospheric Re-entry Experiment (CARE); Collaboration with Russia for astronaut training; Pad Abort Test
    - Humanoid Robot named 'Vyommitra'
    - Development of IRDSS

Private Sector in Space

Aatma Nirbhar Bharat Abhiyaan (Self-Reliant India Mission)- invited pvt sector for contribution in space sector

- Highlights:
    - Level playing field provided to private companies in satellites, launches and space-based services, use ISRO facilities (recent involvement in building PSLV), future projects such as outer space travel also open for pvt.
- Benefits:
    - Help in fulfilling demand for sattelite launches - increasing launches every year-burden on ISRO- take up demand of corporate,uni etc

    - New frugal innovations from academia-implement indepedently or complemet ISRO
    - Take up repetitive tasks of ISRO- letting it invest more time in space station,human spaceflight etc
    - Will reduce govt finance need ,taxpayer money - increase private investement
    - More jobs- student inspire- promotes research culture
        - Startup push- India's own spaceX(many startups currently inv in bangalore)
    - National security- As assets diversified- help during space wars
- Govt steps:
    - Indian National Space Promotion and Authorization Centre (IN-SPACe)- new entity of the Department of Space
        - Benefits: hand-hold, promote and guide the private industries in space activities, empower private companies in creation of launch vehicles and launch pads , interface btw ISRO and pvt sector
        - NSIL - commercial arm of ISRO -responsibility of enabling Indian industries to take up high technology space related activities. Its mandate is to transfer small satellite technology to industry and mass produce SSLVs and PSLVs in partnership with private
        - institutions
    - Atma Nirbhar Bharat
        - Level playing field provided to private companies in satellites, launches and space-based services; Private sector will be allowed to use ISRO facilities; Future projects for planetary exploration, outer space travel etc. shall also be open for private sector; Predictable policy and regulatory environment
    - Steps by ISRO
        - Space technology park in Banglore- use as test bed for pvt activities, contract with pvt sector to build 27 satellites in three years.
    - Make in India: 100% FDI has been allowed in the establishment and operation of satellites, subject to government approval
- Concerns;
    - Highly risky biz-not everyone is Elon Musk- in case of failure of joint projects- bail out-burden on tax payer
    - Security- inteligence interference of other countries relatively easy- sensitive info in wrong hands
    - Pvt sector fear fair evaluation of their application due to conflict of interest - where D/o Space is both sectoral regulator as well as service provider via ISRO
    - Lack of trust: Antrix-Devas deal 2005 was terminated the contract citing risk to national security (PCA in Hague ruled against Antrix Corporation)

- Way forward:
    - Predictible policy- should not lead to over regulation except security issues
        - Draft Space Activities Bill, 2017 was proposed to promote and regulate space activities of India.
    - Industry academia need mentorship of ISRO
- Conclusion- Needed for leapfrogging in space and harness frugal innovations as well as give platform to budding space scientist in remote corners of country

Different types of satellite

(incl remote sensing) and their uses in Indian context (incl socio-economic)

- Navigation Satellites:
    - Eg: Navic or IRNSS
- Earth Observation Satellites: aka Remote sensing satellites
    - Eg: Cartosat 3, OCEANSAT, ResourceSAT, HySIS, GISAT (first EOS in geostationary orbit)
- Communication Satellites:
    - eg: GSAT series (earlier called INSAT)

India's missile development programme, why defence tech not as successful to space tech (DRDO vs ISRO)

- IMDP is the brainchild of Former President Abdul Kalam. It was intended to attain self-sufficiency in the field of missile technology.
- 5 missiles under IMDP are:
    - Short-range surface-to-surface ballistic missile – Prithvi
    - Intermediate-range surface-to-surface ballistic missile – Agni
    - Short-range low-level surface-to-air missile – Trishul
    - Medium-range surface-to-air missile – Akash
    - Third generation anti-tank missile – Nag
- Issues with DRDO
    - Cost escalation and long delays have damaged the reputation of DRDO
    - Excessive bureaucratization and political inteference
    - Deals are opaque citing national security → Leading to scams
    - Less encouragement to pvt. sector (all 4 cos. in top 100 cos. in world of defence are PSUs)
    - Unable to reduce India's import dependence (use data from SIPRI report)

Significant milestones of Indian Space research (2016)

- 1963: First rocket launch; First Satellite in 1975

- 2009: Lunar mission showed possibility of water on moon
- 2014: Mars mission - Only country to reach mars in 1st try; Cost effective
- 2017: PSLV launched 104 satellites on a single mission (prev record Russia 37 satellites)
- 100% successful foreign satellites launches using PSLV rockets
- Charges just 60% of fees charged by other foreign players; Frugal Innovation is the USP of ISRO

Chandrayaan Mission's Significance

- Chandrayaan 1-PSLV-helped in detection of water, 3d atlas of moon
- Chandrayaan 2-completely. indigenous,orbiter,lander(vikram), rover(pragyaan)-GSLV MK 3- soft landing of south pole targeted
    - Benefits- Earth history determine, extent of water distribution on moon, rock types
    - Why south pole?- craters so chance of fossils, shadow areas of south pole-more chances of water, would have been 1st to land on south P
- Chandrayaan 3- another soft landing, Lander, rover

Brief Information - Future Missions

- Aditya L1- lagrange L1 point, study solar corona, PSLV, solar winds, imaging of sun(Nasa Parker solar probe)
- Shukrayaan 1(Venus)- write general points of mission

India's Space Vision & Current Challenges

- Our space vision also needs to address global governance, regulatory and arms control issues. As space opens up our space vision needs broadening too. India need visionary laws to meet **crimes done in space** and amend the IPC to include provision
- **Challenges:**
    - As outer space becomes democratised, commercialised and crowded, the multilateral framework for its governance is becoming **obsolescent** (Quote Outer Space Treaty 1967)
    - Space law **does not have a dispute settlement** mechanism, is **silent on** collisions and debris, and offers insufficient guidance on interference with others' space assets
    - Legal framework is **state-centric**, placing responsibility on states **alone**. However, non-state entities are now in the fray for commercial space exploration and utilisation

- Space is the highest ground. The **space arms race** is difficult to curb, especially since almost all space technologies have military applications (UNGA passed a resolution on Prevention of an Arms Race in Outer Space since 1982)
- We are facing sustanability challenges on earth as well as in space. The future of space needs to be a guiding force for tackling issues here back on earth (rather than aggreveate it)

Information & Communication Technologies

- **Meaning**: ICT is the diverse set of tools used to create, transmit and store information.
  - Tools used include computers, internet, satellites, transmission medium (Guided = physical cables; Unguided uses air vaccuum)
  - In the overall electromagnetic spectrum, microwave and radio wave are used for communication purposes. Radio wave range is further divided into various bands such as L band, X band, Ku band, etc.
  - Digital signals are better than analog signals as digital ones are discrete, can travel large distance w/o loss of strength. Modem is used to convert digital into analog and vice versa
- **Govt. Examples of using S&T**
  - Project Insight of Income tax dept. used big data analytics
  - GI Cloud named Meghraj launched by Meity, Digi locker
  - E-Gov: UMANG app, e-NAM portal,
  - NPCI launched Pai: An Artificial Intelligence Virtual Assistant
  - BharatNet project - funded by USOF and will use unused fibres
  - ICT for curbing Tax evasion by analysing FASTag and E-way bill data together
- For analysing applications of any S&T open various dimensions such as:
  - Role in businesses, education, healthcare, governance, agriculture, security angle, rural dev, disaster mgmt, environment,

Digital Indian Programme

2015: Digital Indian Programme: How it can help to improve farm productivity and income? Steps taken?

"Digital India" project launched in 2015 - empowering citizens with e-access to government services and livelihood services.

- The project has three core components, viz. digital infrastructure, digital services and digital literacy
    - It seeks to: transform rural India into a digitally-empowered knowledge economy
    - provide universal phone connectivity and access to broadband in 250,000 villages
    - extend timely services to farmers through information technology and its tools
- Why needed?
    - Low crop productivity & profitability: According to "Situation Assessment of Indian Farmers",- 72% of farmers no access to latest info on price,marketing opprtunites,latest tech,credit opportunities
- Digital India in Agri
    - **Technology**: Production-enhancing proved crop-specific technologies [from pre-sowing to harvesting and post-harvest management] based on soil & water analysis. Separate for dryland & irrigated farming focusing efficient use of seeds, fertilizers, water, pesticides
        - CHAMAN app- Horticulture,Kisan call center and Kisan portal
    - **Production inputs & farm equipment**: Crop-specific reasonably priced standard quality production inputs [seeds, fertilizers, pesticides, etc.] and farm equipment
        - Soil health card software for nutrient mgmt
    - **Post-harvest services: S**torage, transport, processing, packaging,
        - e-NAM,e-Kranti
    - **Institutional services**: Land records, farm credit, insurance, marketing, weather, farmer-producers' organizations, market yards, procurement centers.
        - Krishi Vigyan Kendras,ICAR knowledge through mobile
        - NABARD finance portal
    - **Government facilities**: Availability of subsidies, assistance available to mitigate effects of climate change, drought, floods, earthquake, cyclones
        - National e-Governance Plan in Agriculture [NeGP-A] information is provided to farmers through multiple channels including Common Service Centres Internet Kiosks and SMSs.
- Way Forward
    - Targeted e-initiatives acc to region
    - Analysis of farmer uptake and reform if necessary
    - Better and easy user interface etc

2015: Advantage and security implications of cloud hosting of servers vis-a-vis in-house machine-based hosting

- Cloud computing is all about storing and retrieving your data from your own little area on the Internet. The data is not stored here in your local hard drive
- Advantage of cloud hosting over in–house machine:
    - Data can be accessed from any location, any device → leading to increased flexibility
    - Saving is capex → Rather the utility model of computing is followed which makes it a service
    - Regular backups can prevent data losses
    - Example- Amazon web services
    - Govt- Cloud named Meghraj launched by Meity(for better egov services) , Digi locker
- Advantage of in–house machine over cloud hosting
    - Get physical control over data; no third party has access to information
    - No need of Internet connection to access data
    - Data servers of cloud cos. are still prone to cyberattacks, disasters- no own hardware required
    - Elasticity- can scale up and down computing needs acc to demand - pay per use feature
    - Easy collab and sharing among multiple location
- Security implication of cloud hosting
    - Data has to transmit via the internet which may make it vulnerable
    - Cos. may be linked to external state and non-state actors- neglects data privacy-
    - Vendor lock in- when want to migrate to another-very difficult
- There is a need for proper encryption of data stored on cloud servers; Govt. must store critical data pertaining to national security over its local servers

Digital Signature

2013: Digital signature: Features, Uses, Authetication, process

- A digital signature is a type of electronic signature which ensures that an electronic document is authentic
    - Example- Passcord enabled bank statements, Game passkeys
    - Benefits- save enviroment due to less paper
- Used to:
    - Authenticate the identity of the sender using the public key of the sender
    - Data integrity: ensure that data has not been tampered after its creation

    - When a person wants to use digital signature, he has to obtain a Digital Signature Certificate (DSC). For this, he has to apply to a 'Certifying Authority' which is the private professional agency authorised by the government under IT Act 2000 for this purpose. CA takes suitable verification about the applicant and then upon being satisfied, grants a digital signature certificate in the form of digital file to the applicant eg: of CA is emudhra
- Digital signature certificates are the digital equivalent of paper certificates. They can be provided electronically for proving one's identity for accessing any online service or information.
- Uses in India:
    - Compulsory for various assesses in IT filling, GST
    - Complying with legal requirements under MCA
    - Authentication of emails
    - Application for tenders
    - Applying at eprocurement websites of govt.

3D Printing Technology

2013: 3D printing technology: Advantages and disadvantages

Additive manufacturing - "making objects from 3D data, usually layer upon layer" - first designed in software then fed to computerised machines, which build that object layer by layer.

- heralds a future in which value chains are **shorter, smaller, more localised, more collaborative,** and offer **significant sustainability benefits.**
- A PwC report titled 'The Global Industry 4.0' in 2016 shows that in India, 27% of industries have either already invested or will be investing in AM technology within the next five years

Applications of 3D Printing

- Defence- The UK Royal Air Force and Navy use AM for repairing spare parts.
- Health- hearing aids,dental impants,organ printing through bio-printer, prosthetics
- Architecture- recreate heritage (like tajmahal carving)
- Food,industrial parts,etc

Advantages/ Benefits of 3D printing

1. **Low cost:** 3D printing is cheaper than traditional method of manufacturing. For example: China was able to able to construct 10 one storey houses at less than $5000 per house
2. **Less Time**: Printing of the 3D object can be done directly.
3. **Efficiency:** Generating prototypes with 3D printers is much easier and faster with 3D printing technology.
4. **Customization:** Every item can be customized to meet a user's specific needs without impacting the manufacturing costs.
5. **Employment opportunities:** The widespread use of 3d printing technology will increase the demand for engineers who are needed to design and build these printers and design blueprints of products.
6. **Reduced wastage:** AM process produces less waste in comparison with other traditional manufacturing techniques

Disadvantages/ Issues with 3D Printing

1. **Limited Raw Materials**: With 3D printing being an additive method (layer after layer), the materials available suited for it are limited- ceramics, resin, plastics, etc.
2. **Effect on employment**: Jobs in manufacturing will be rendered obsolete which will have a negative impact on developing economies.
3. **Concerns over copyright infringements:** There is concern over counterfeit printing of copyrighted or patented products.
4. **Production of dangerous items**:International regimes such as the Nuclear Suppliers Group, Missile Technology Control Regime and the Wassenaar Agreement that control technology have been concerned about the proliferation of high-performance 3-D printers, which have the capability to print parts for missile or nuclear weapon.
5. **Cybersecurity concerns**: Studies have shown that the 3-D printer connected to the online network is vulnerable to cyber attacks.
6. **Ethical concerns associated with use of 3D technology in healthcare:** concern about the development of personalised medicine is that it might increase cost of treatment and widen the disparity between rich and poor.

Way Forward

1. There is a need for strong support from the government and business houses for AM-related studies and R&D.
2. huge scope under the 'Skill India' initiative -reach out to the many technical institutes in the country to sensitise them
3. The "Make it the Indian Way" approach **needs public-private partnership** and multi-pronged efforts.- complement Make in india

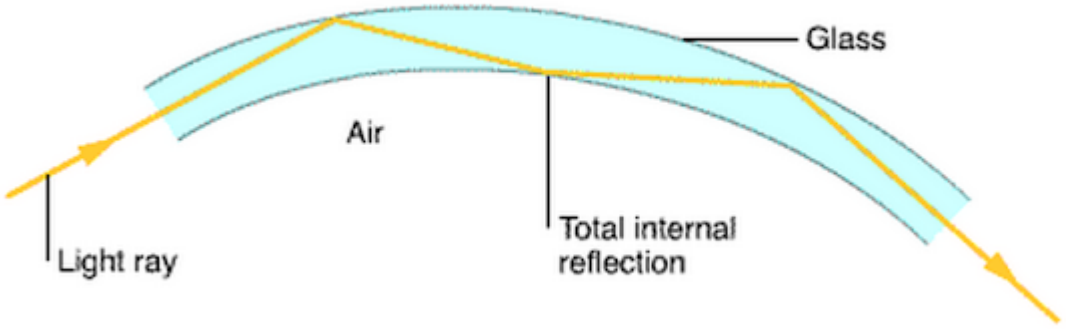
4. **International best practice-** China had launched the first national plan for 3-D printing, called 'Additive Manufacturing Industry Promotion Plan 2015–2016'.

IT sector: SWOT Analysis

Threats: Telangana loan apps blackmailing, Blue whale game,

Artificial intelligence: Current scenario, prospects (Also read abt Mach learning, etc.)

Basic of optical fiber and other developments in telecomm



Optical Fiber are used to when high bandwidth, long distance, or immunity to interference is required. They have 3 components: Core made of glass; Cladding material surrounding the core; Outside coating

It works on the principle of total internal reflection for which density of core has to be greater than density of clad. Light strikes at an angle greater than the critical angle of glass (ie. core) it leads to TIR → No loss of singal

Super Computers

- SC is a computer with a high level of computing performance compared to a general purpose computer. The performance is generally evaluated in petaflops.
- Applications:
    - Climate modeling and weather forecasting to take multiple variables into consideration eg: Pratyush and Mihir SCs are used for this

    - Big data analytics can allow huge unstructured data to be used for governance eg: Project insight
    - Strengthen national security architecture
    - Disaster simulation, prediction and management
    - Scientific R&D using various simulation such as affect of drugs on humans
    - Mineral exploration
    - Industrial revolution 4.0
    - Financial planning - eg: retirement planning
    - Culture: Restoration of mural art of Ajanta & preserving them digitally
- **National Supercomputing Mission 2015**
    - Aim is to build network of 70 supercomputers across India
    - Implemented by M/o S&T and MEITY through 2 institutions - CDAC and IISC Bengalore
    - Build a strong base of 20,000 skilled persons
    - SCs will also be networked on the National Supercomputing grid over the National Knowledge Network (which is a scheme of M/o HRD connects academic institutions and R&D labs over a high speed network)
    - Build a culture of SC; Empower academic & research institutions
    - Param Shibvay is the 1st SC under NSM
- Challenges:
    - Import dependent: India ordered French technology firm *Atos* the contract to build a network of 70 SCs
    - Difficulty in coordination between 2 ministries
    - Funding issues, Brain drain, Lack of industry academia collaboration
    - Only 4 indian SC in top 500 SCs

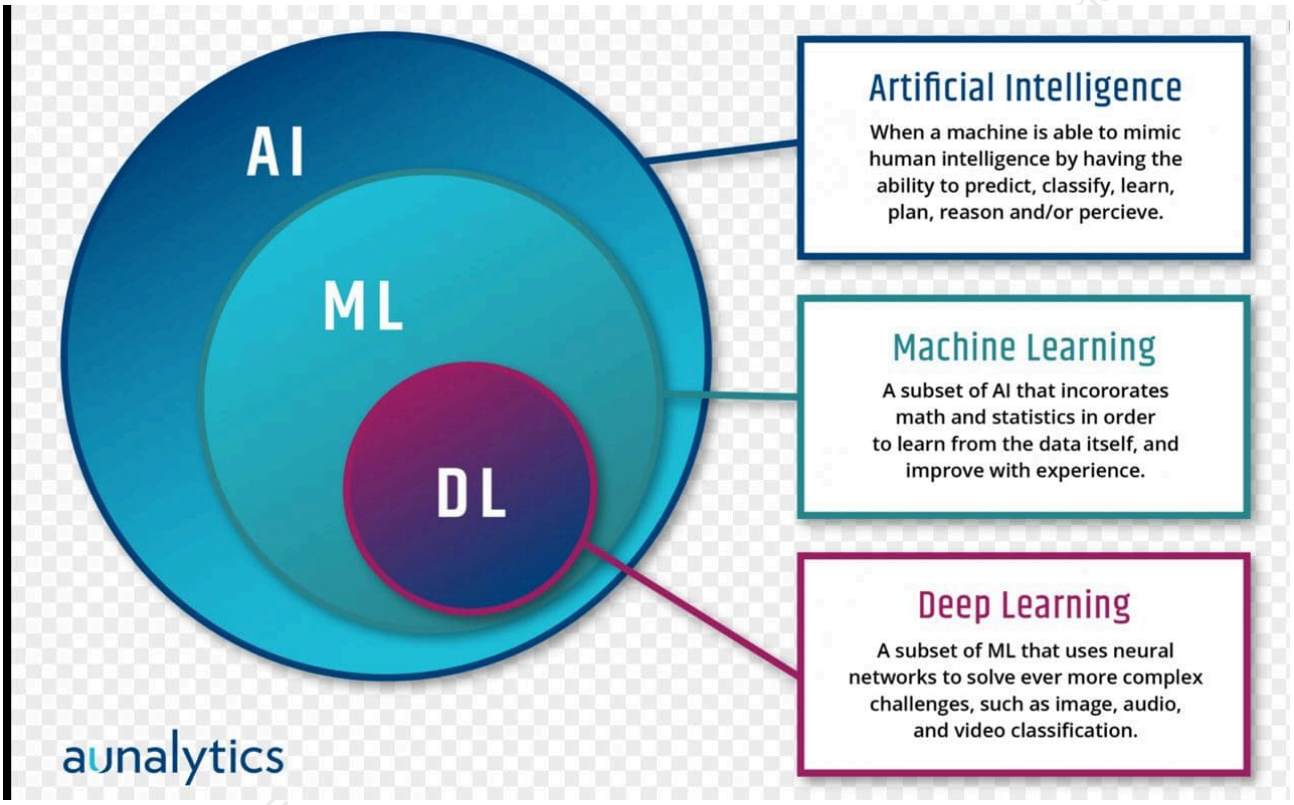
Quantum Technology

(8000 crore mission in Budget 2020)

- Quantum technology seeks to harness laws of quantum physics, which describe the behaviour of matter and energy at the atomic and subatomic level
- Quantum Computing is one of the applications of QT
- QC is the computer technology based on the principles of quantum mechanics. They encode information as quantum bits, or qubits. The power of QC increases 'exponentially' as quibits are increases.
- Quantum supremacy means that researchers have been able to use a quantum computer to perform a single calculation that no conventional computer, even the biggest supercomputer, can perform in a reasonable amount of time. eg: Google's Sycamore (200 seconds vs 10k years)
- QC use 2 important properties of QT:

    - Superposition: means that each qubit can represent both a '1' and a '0' at the same time until it is measuredrather than classical computers which can be either 1 or 0. This property allows QC to mimic several classical computers working in parallel
    - Entanglement: means that qubits become linked (entangled) in such as way that actions performed on one affect the other, even when separated by great distances
- Applications:
    - Same as Super Computers: GS-3 Science & Technology
    - Secure communication: Concept of entanglement can be used to transmit a msg with high level of secrecy (quantum key distribution)
    - Cyber Security
    - Data mining
    - Support current ongoing projects such as Genome India project
    - Health: In modelling new kinds of proteins
    - Aero-space engineering, numerical weather prediction, simulations, securing the communications & financial transactions, cyber security, advanced manufacturing, health, agriculture, education
- Govt Measures:
    - The National Mission on Quantum Technologies & Applications (NM-QTA = 8000 cr over 5 years) is still in processing stage
        - The areas of focus for the Mission will be in fundamental science, translation, technology development, human and infrastructural resource generation, innovation and start-ups to address issues concerning national priorities
        - The mission will help prepare next generation skilled manpower, boost translational research
    - D/o ST conducted a programme called QuEST (Quantum Enabled Science and Technology) to explore QT and engage with reasearchers
    - As of now there is not even a single QC in India
- Challenges:
    - It is quite expensive and difficult to work at very low temperatures
    - Quantum property may get lost if required environment is not maintained
    - QC can be used to breach security architecture as it can easily decrypt current traditional encryption system (which requires solving certain mathematical problems)
    - As quibits increase, it is difficult to manipulate superposition and entanglement
- Way Fwd: QT, AI, IOT, 3D printing are re-writing the world economic order and the time is right for India to make rapid strides towards the same

Artificial Intelligence

- It refers to the ability of machines to perform cognitive tasks like thinking, perceiving, learning, problem solving and decision making and execute tasks in real time situations without constant supervision.
- AI is simulation of human intelligence by machines. Machine learning is a subset of AI (in ML where machines learn by experience and acquire skills w/o human intervention)
- 

- Significance of AI: Propel social development, innovation and overcome limitations of current level of capital & labour
- Particular applications of AI includes expert systems, speech recognition and machine vision without human involvement
- Eg- Facebook's list of suggested friends for its users, a pop-up page, telling about an upcoming sale of the favourite brand of shoes and clothes.
- Global Developments in Artificial Intelligence (AI): Many countries have instituted dedicated public offices such as the Ministry of AI (UAE), and Office of AI and AI Council (U.K.).

Uses of AI

- **Healthcare:** AI-driven diagnostics, personalized treatment, early identification of potential pandemics, and imaging diagnostics.

- **Agriculture:** Applied AI addresses challenges such as lack of assured irrigation, inadequate demand prediction, excess use of pesticides, fertilizers, and fungicides, prediction of crop prices, and real-time advisory.
    - A Statement of Intent has been signed between NITI Aayog and IBM to develop Precision Agriculture using Artificial Intelligence (AI) in Aspirational Districts.
- **Transports, Logistics, and Smart Mobility:** monitoring and maintaining a predictive engine along with driver-assist (Tesla) , Other applications of AI include improved traffic management, autonomous trucking, and delivery.
- **Retail:** image-based product searches, and preference-based browsing, customer demand anticipation, improved inventory management.
    - **Manufacturing**: It can enable 'Factory of the Future' through flexible and adaptable technical systems, smart logistics.
- **Energy:** modeling and forecasting of the energy system to reduce unpredictability, smart meters to enable intelligent grids(help solar)
- **Smart Cities:** Traffic control for reducing congestion enhanced security by providing improved crowd management
- **Education and Skilling:** personalized learning, automating and expediting administrative tasks
    - Starting this year, **the CBSE has AI as an elective subject** for its ninth grade classes
    - **IIT Hyderabad** has launched a full fledged **Bachelor of Technology (B Tech) program in AI**
    - Proctored exams can be conducted where AI based software lock browsers and ensure no unfair means is used
- Predictive Policing
    - **predict the pattern of crime**, analyze lot of CCTV footage which are available across the country to identify suspects. CCTNS data use for AI.

Steps taken by India

- National Strategy for Artificial Intelligence- NITI Aayog has identified five areas where AI can be useful. It has noted the lack of regulation around AI as a major weakness for India.
    - NITI Aayog's draft 'Working Document: Enforcement Mechanisms for Responsible #AIforAll',- suggests setting up oversight body for AI
    - In 2018-19 budget, the government mandated NITI Aayog to establish the National Program on AI
- Center of Excellence in Artificial Intelligence (CoE in AI) by National Informatics Centre (NIC) which is a platform for innovative new solutions in AI space.

- Global Partnership on Artificial Intelligence (GPAI): Recently, India joined GPAI as a founding member. (multi-stakeholder partnership to promote responsible and human centric development and use of AI, grounded in human rights, inclusion, diversity,eco growth)

Challenges

- Concerns on privacy and security of data- Cambridge Analyitca- FB issue, deep fakes, criminal uses of facial recognition technology
- The technological singularity is a hypothetical point in time at which technological growth becomes uncontrollable and irreversible, resulting in unforeseeable changes to human civilization (in simple terms machine intelligence > human intelligence)
- NITI Aayog highlighted that lack of regulation as a major weakness for India
- Difficulty in access to industry-specific data required to build customized platforms and solutions is now currently in the hands of a few major players (Facebook or Google)- Technocracy fears
    - Data colonialism
- Biasness- in the process of self-learning, they can absorb and adopt the stereotypes that exist in society (garbage in garbage out)
    - When AI used for Monitoring social media: During the live broadcast of chess matches, commentators speak/write like "'Black's attack on White is brutal' etc. But it gets flagged as hate speech and YouTube accounts gets suspended as a result. Therefore human intervention is required to check the context of the words
- Accountability: If an AI system fails at its assigned task, someone should be made responsible for it. e.g. an anti-terrorism facial recognition program revoked the driver's license of an innocent man when it confused him for another driver.
- Super-intelligence: Will it be good to human kind? - Movie "Her", Robot and AI mixture
- Defence- AI wars- make tradional defence platform impotent
- Implementation challenges
    - Lack of sufficient talent - only 4% of AI professionals in India have worked on emerging technologies such as deep learning and neural networks. There is also a significant gap in Ph.D. research scholars in the field.
    - Funding,coordianation,awareness etc

Way Forward to Harness the Power of AI

- Getting India Ready for the AI Wave: India may appear to be relatively well-positioned to take advantage of the disruption in the AI system through its advanced IT sector and large youth demographic potential- should be a national priority.

- Accelerating Adoption: only 22% of the firms in India use AI in any business process. Government intervention is needed to promote AI adoption, lest India loses the chance to secure a prominent position on the global AI map.
- Ethics, Privacy, Security, and Artificial Intelligence: needs to be conscious of the probable factors of the AI ecosystem that may undermine ethical conduct, impinge on one's privacy, and undermine the security protocol.
    - Needs to take care of human autonomy while making AI responsive, inclusive and sustainable

These challenges, if addressed by relevant stakeholders, with the government playing a leading role could lead to fundamental building blocks that form the core to India's march towards leadership in AI in an expeditious manner through concerted and collaborative efforts.

- International agencies could be guided by the Asilomar AI Principles (by Future of Life Institute, a non-profit organization) which are 23 guidelines for the research and development of AI.

Data Localisation: Need and challenges

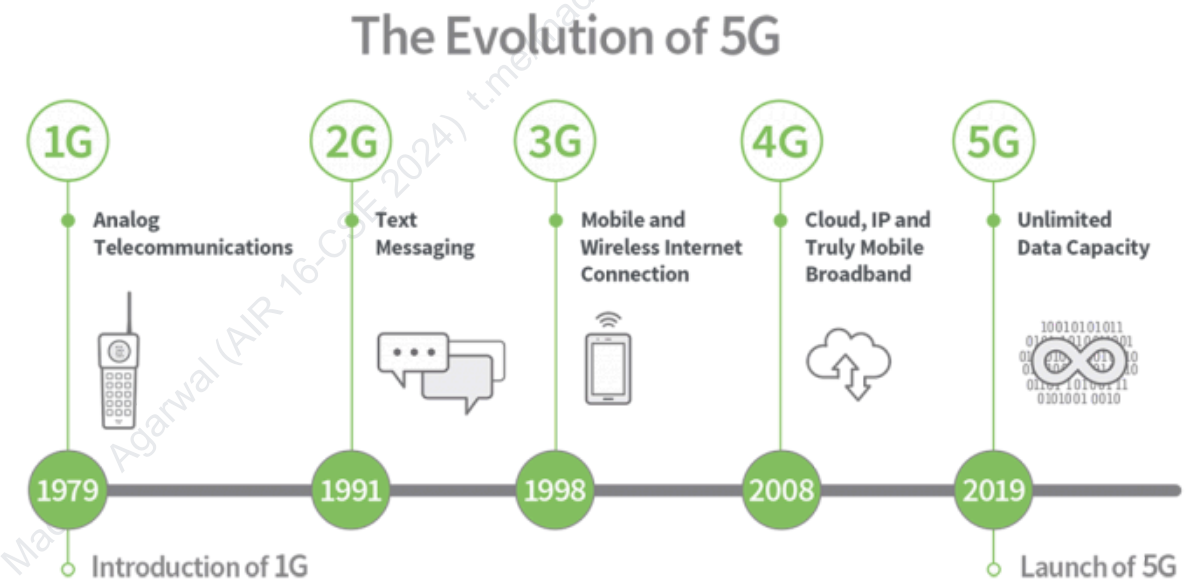
- Background: Report of Justice BN Shrikrishna Committee
    - Reserve Bank of India imposed a hard data localisation mandate to store payment systems data only in India
    - Many countries have implemented or are in the process of implementing data localisation laws, including — China, United States, Brazil, Indonesia and Russia
- Data localization is the act of storing data on any device that is physically present within the borders of a specific country where the data was generated
- Need for data localisation:
    - Economic development: Data is the new oil. Potential to create jobs in various fields; Cos. will also have to open data centres in India which also fuel economic activity
    - Data privacy and data sovereignty
    - National security concerns: DL will help law enforcement agencies which currently has to get access from foreign agencies through Mutual Legal Assistance Treaties (MLATs) (DL can reduce jurisdictional issues)
    - Control monetization of Indian user's data
- Challenges:
    - Harm Indian IT sector: Cross country flow of data is the main raw material fueling are IT sector. DL may hamper its progress
    - There is no evidence that DL leads to better privacy
    - Access issues might still remain as data may be stored in encrypted form

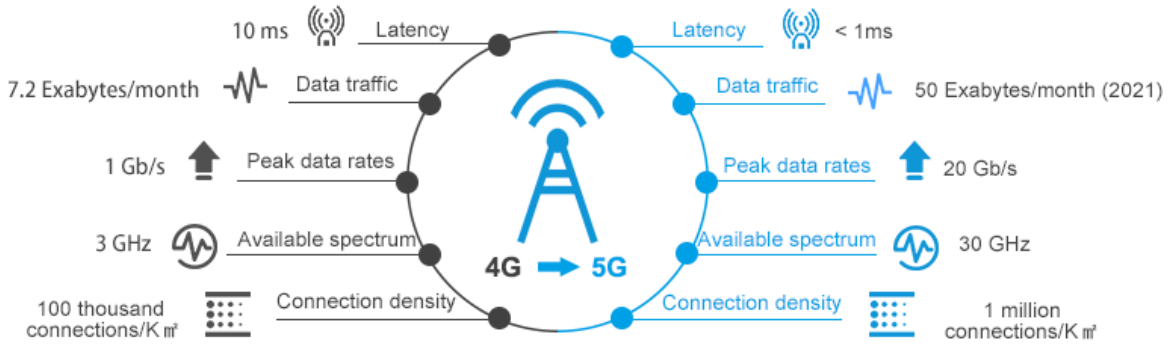
    - Hamper bilateral relation: Countries such as USA may see it as protectionism
    - Lack of data protection laws and strong cyber security framework poses threats for localised data
    - Balkanization of internet (called fractured internet) where the domino effect of protectionist policy can lead to other countries following suit
- We need to focus more on data access as that is the ultimate goal of DL.

5G

- 5G is a next generation mobile network technology after 4G LTE networks.
- Provide seamless coverage, high data rate, ultra-low latency and as a result highly reliable communications.
- Key technolgies required for 5G: (make a triangle for the same)
    - Millimeter waves (band of extremely high frequencies of radio wave suitable for 5G)
    - Massive MIMO antennas
    - Mobile Edge Computing

Evolution:





Comparing 4G and 5G

Advantages of 5G

- High speed use cases: high quality streaming, faster storage and access of cloud by businesses, better communication
    - To download a 2 hour film: 4G would take 6 minutes where as 5G will take 3.6 seconds
- Ultra-low latency: Latency refers to the time it takes for one device to send a packet of data to another device. In 4G the latency rate is around 50 milliseconds but 5G will reduce that to about 1 millisecond.
- Massive Internet of Things (IoT): Smart City Infrastructure and Traffic Management, Industrial Automation, Wearables and Mobile devices, Precision agriculture etc.
- Various fields:
    - In agriculture- precision farming, smart irrigation, improved soil and crop monitoring, to livestock management.
    - In manufacturing, use of robotics for precision manufacturing, particularly where humans cannot perform these functions safely or accurately. Eg Bandicoot Robot
    - In the energy sector, 'smart grids' and 'smart metering'.
    - In health-care- tele-medicine delivery, tele-control of surgical robotics and wireless monitoring of vital statistics (this can be possible through Network slicing where mobile operators to create multiple virtual networks within a single physical 5G network)

Challenges

- Huge Investment Required: India needs a massive Rs 5 lakh crore ($70 billion) investment to bring in 5G.(change statistics)
    - This is because when we switch to higher frequency the interference increases. Thus to reduce interference we need more number of smaller tower
- Expensive spectrum: Indian spectrum prices are some of the highest in the world, while 40% of the spectrum is lying unsold

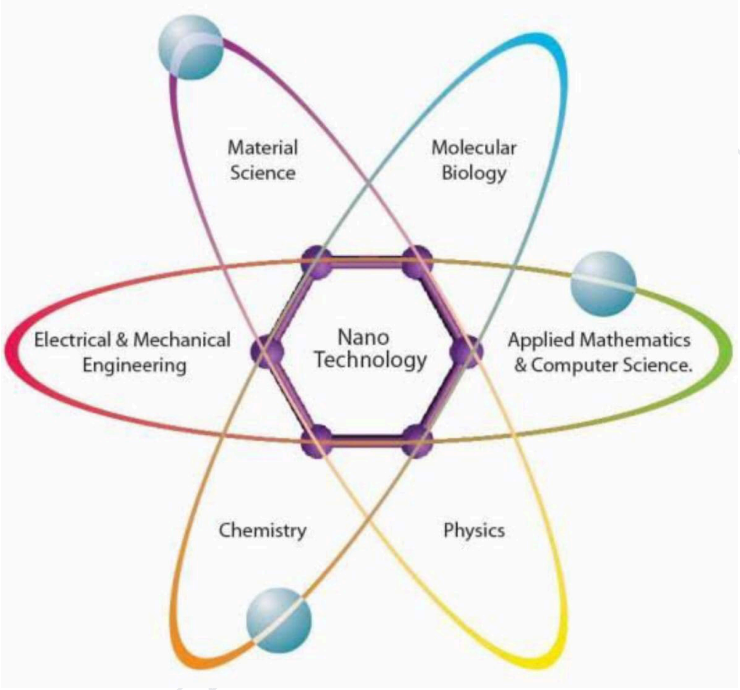
    - Debt scenario in the industry: According to ICRA- Rs 4.2 lakh crore.
- Lack of uniform policy framework: Delays due to complex procedures across states impacted telecom service providers in rolling-out Optical Fibre Cables (OFC) and telecom towers
- Low optical fibre penetration: Bharat Net - increase speed [Can also be written that we lack backhaul capacity]
- High Import of Equipment's: Imports account for a 90 per cent of India's telecom equipment market.- huawai issue
- Inter-operability: Devices working on old tech need to switch over to newer tech
- Rumours from 5G radiation ~ reluctance among people
- Security- US designated Huawai as national security threat
- Measure Taken
    - 5G High Level Forum 2017 to articulate vision for 5G
    - Govt has launched '5G Test Bed'
    - Bharat Net Project to promote adoption of optical fibers

Way forward:

- **Spectrum Policy:** India's spectrum allocation for public wireless services should be enhanced significantly. Also, the cost of spectrum relative to per capita GDP is high and should come down.
    - **Policy-**makers may consider the use of shared spectrum to promote efficiency
- **Create a Fifth Generation (5G) Program** Office within Department of Telecommunications and an Oversight Committee.
- **New civil infrastructure like** gas, electricity, water lines should be mandated to provide Common Telecom Infrastructure resources such as ducting and power junction boxes to support 5G infrastructure.
- **Privacy**- strong data protection policy and law
- **Security audits**, a prerequisite for importing of equipment before deploying in Indian networks
- **Fifth Generation (5G) Pilot:** encouraging 5G pilots and test beds to test 5G technologies
- **Support Fifth Generation (5G) investment**
    - Proirtise domestic investment- eg Jio plans for 5G as well as prevent monopoly in market

---

Nanotechnology

- **Basics**
  - Why NT - Conversion of material at nano scale shows remarkable & distinct properties which are not observed at larger scale (Properties can be optical, physical, chemical, etc.)
  - eg: Gold at macro is yellow but at nano scale turn red/purple (with a confined motion of electrons); Nano-gold is used to treat cancer
  - Works on the concept of Quantum (i.e small) mechanics.
  - Science of extremely small → b/w 1 nm to 100 nm (1nm = 1 billionth of meter)
  - Nobel Laureate physicist Richard Feyaman - considered Father of Nanotechnology
  - 

- **Measures taken with current status**
  - India ranks third in the number of researches in the field of nanotechnology after China and USA. According to a report by ASSOCHAM, india is expected to contribute 25% of global NT professional requirement in the coming years *(Data from Mains 365)*
  - Mission on Nano Science and Technology (Nano Mission): Umbrella programme for capacity building in the field of nanotechnology and to tap its applied potential for nation's development; Phase II was from 2014-20 Objectives:
    - Basic Research Promotion: Funding of basic research by individual scientists and/or groups of scientists and creation of centres of excellence.
    - Infrastructure Development for NT Research
    - Applications and NT in Development Programmes
    - Human Resource Development: Effective education and training to researchers and professionals

        - International Collaborations: Access to research facilities abroad, establish joint centres of excellence
    - Other General Schemes (to promote R&D; while writing answers mention that they are supporting NT)
        - Visveswaraya PhD fellowships offered by MeitY
        - INSPIRE scheme supports research fellows to work in interdisciplinary ares
        - Eighteen sophisticated analytical instruments facilities (SAIFs) established by DST across India
        - Others: SATHI, SRISTI Portal
        - Thematic units of excellence (TUEs) for ..... (*mention any topic of question*)
- **Application**
    - Medical & Health
        - Nanopharmaceuticals-precision targeting-drugs of cancer(eg Nanoxel by Dabur pharma), releif to patients of migraine,asthama in minutes rather than hours (DBT of M of ST draft guidelines for evolution of nano-pharmaceuticals in India.)
        - Nanoparticles- used in sunscreen
        - Disease diagnosis through nano devices
        - Killing of superbugs (related to AMR)
        - Nanotweezers- in future surgeons can operate on individual cells
        - Water treatment through nanomembrane
        - Recent Use of Nanotechnology- Antiviral nano coating on face masks PPE kits.
    - Agriculture
        - Nanogels to control pests
        - Food packaging to eliminate microbes
        - Nanofertilizers to reduce nutrient run off (eg: Nano Urea Liquid is much more effective when compared to conventional urea)
        - Improve plant productivity w/o impacting soil quality via nanotubes
    - Env: Cleaning oil spills
    - Defence: Nano sensors ,camera,precision sniper
    - ICT: Allow making devices smaller and smaller by using nanochips
    - Energy: Optimum utilisation of energy by using carbon nanotubes
    - Construction: Nanomaterial-robust structure-less water seepage
    - Clothing- silver nanoparticles in socks- remove odour
    - Administration: Nanosheets used as effective breath alcohol detection
- **Challenges**
    - Non biodegradable: Health issues as may lead to bioaccumulation; Nanotoxicology -study of potential health risks of nanomaterials.
    - Security: Using nano weapons in warfare

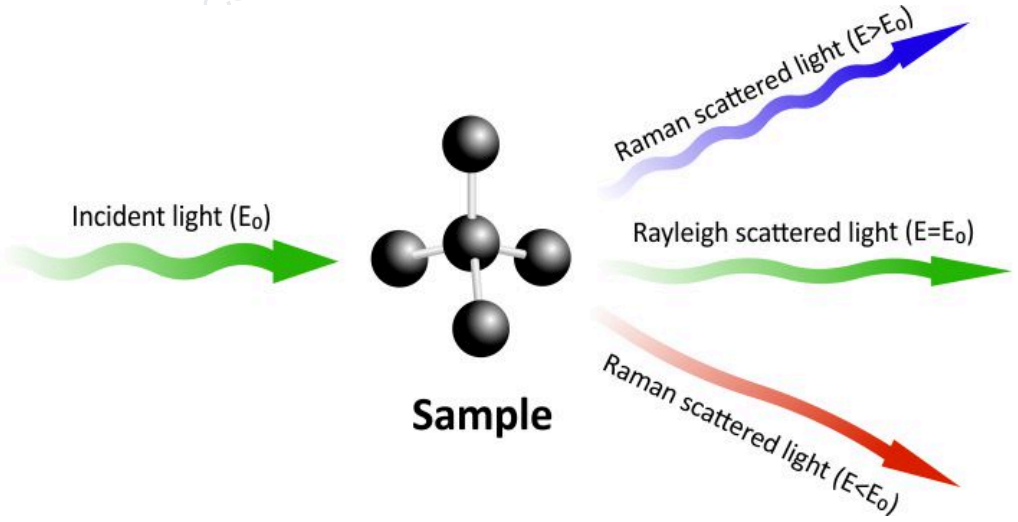
    - Agriculture: Reduces important bacterial diversity; Env impact on pollution of soil & water
        - Risk of nanoparticles toxicity is higher in plants due to their miniscule size that can easily translocate within plant body.
    - Privacy isssues due to use of NT for surveliance through nano cameras
    - Properties at the nano-scale maybe used to imitate the properties of rare minerals, thus affecting the export rates of developing countries having those mineral ores
    - Governance Issues: Difficult to regulate their use to their smaller scale
    - Challanges in implementation : gap btw academia reaseach and application, overlaps issue as multidisciplinary, high cost
        - Infrastructural bottlenecks, Information asymmetry
- **Way Fwd**: Need to emphasise on resposible use of NT to meet dev needs

---

Achievements of Indians, Indigenization

CV Raman - Nobel ☑️ Bharat Ratna ✔️

- On a voyage at sea he wondered "Why does sea appear blue whereas a glass of water is just colourless?" This led discovery based on scattering of light
- He discovered that when light traverses a transparent material, some of the deflected light changes wavelength and amplitude, which subsequently came to be known as Raman scattering and the process, the Raman Effect
    - Raman effect is the inelastic scattering of a light (photons) by molecules which are excited to higher or lower frequency



-
    - Applications:
        - Used to determine chemical composition of a material eg: To determine authenticity of Tanjore Painting

        - Used in understanding structure of DNA
        - Used in oil & gas exploration, geological studies, material sciences
- February 28, the day of the discovery, has since then been celebrated as National Science Day in India
- First to investigate the harmonic nature of the sounds of Indian drums
- After development of LASER technology it has gained more significance due to ease of use

Subrahmanyan Chandrashekhar - Nobel 1983 ☑️

- Contributions astrophysics (structure and evolution of stars), Physics, Applied mathematics
- The Chandrasekhar Limit is a value that determines whether dying stars become black holes or neutron stars
- Known for Chandrashekar limit- helped discovery of neutron stars and black holes
    - No white dwarf can be greater than 1.44 times the mass of sun
    - If mass is greater than it will collapse and form a neutron star
    - If mass is greater than 3 times of sun, it will collapse to form black hole
- Advanced X Ray observatory of NASA is named as Chandra X Ray Observatory

Shrinivasa Ramanujan - 🔥 100 year death anniversary in 2020 🔥

- **National Mathematics Day on birthday**
- Ramanujan was one of the youngest members of Britain's Royal Society and the first Indian to be elected a Fellow of Trinity College, Cambridge University
- Contributions:
    - Contributions to mathematical analysis, number theory, infinite series, and continued fractions
    - He developed an extremely efficient method of measuring pi in the early 20th century
    - 1729 is known as the Ramanujan number.-It is the smallest number which can be expressed as the sum of two different cubes in two different ways.(10,9) (12,1)
    - His work on Ramanujan prime, the Ramanujan theta function have propelled further reasearch
    - Ramanujam's theories are applied to areas which were not even developed during his era; Eg: Signal processing and black hole physics
    - Game Theory: He discovered a long list of new ideas to solve many challenging mathematical problems- gave impetus to the development of game theory

Satyendra Nath Bose

- Matter is what gives mass to this universe. All matter is made up of atoms, which are in turn made up of protons, neutrons and electrons.
- There are four natural states of matter: Solids, liquids, gases and plasma. The fifth state is the man-made Bose-Einstein condensates.
- BEC is an exotic material which only exists when atoms of certain elements are cooled to temperatures near absolute zero. At this point, clusters of atoms begin functioning as a single quantum object with both wave and particle properties
- Application
    - Light appears to slow down as it passes through a BEC, allowing scientists to study the particle/wave paradox
    - Dark matter is believed to be in BEC form
    - Help in study of black holes

Har Gobind Khorana - Nobel ☑️

- Main contribution to genetics
- Dedicated his research to bio technology and gene therapy
- Helped understand the r'ship between genetic code of cells and how does it produce proteins (synthesis of proteins)
- Khorana became the first to synthesize an artificial gene in a living cell

Homi Jehangir Bhabha

- Chairman of the Atomic Energy Commission of India
- Father of Indian Nuclear Power
- Aim of nuclear development should be to lessen the burden of poor rather than to dev atomic bombs
- Studies the cosmic radiations
- Estab. Tata Institute of Fundamental Research, Mumbai

Jagadish Chandra Bose

- Polymath, physicist, biologist, botanist and archaeologist
- Botanist - Made crescograph which is used to measure plant's response to various stimuli
- He hypothesized that plantcan feel pain and understand affection
- pioneered the study of radio and microwave optics; 1st person to demonstrate wireless communication
- Father of open technology, as he made his inventions and work freely available for others to further develop

M Visvesvaraya Bharat Ratna ✔️

- National Engineers Day, civil engineer

- Contributions:
    - Improved irrigation- role in construction of KrishnarajSagar Dam,Hyd (1924)- helped in DW, irrigation for agri
    - Modern techniques for improved water utilisation- inventing the Block System -automated doors that close in the conditions of overflow, water supply system of Sindh,Hyderabad flood control system
    - Hydropower dev- in Karnataka - elec to farmers
    - Navigation- dev of Vishakapatnam port -helped protect from marine erosion

MS Swaminathan

- Architect Modern agriculture,Indian geneticist,Indian civil service(also sec of M of Agri)
- director general of the Indian Council of Agricultural Research,International rice research institute during his career
    - Contributions:
        - Hybrid Variety of seeds- wheat and rice varieties able to sustain variable temp,diseases
            - Food security of India- through GR
        - Food fortification- developed crops with nutrients
        - Helped bring about greater acceptance of modern farming methods
        - Recently- report on doubling farmers income- his own computation of ideal price to farmer

A P J Abdul Kalam Bharat Ratna ✔️

- Worked with both DRDO and ISRO
- Part of team that launched 'Rohini' series of satellites (First satellite to be launched using Indian launch vehicle)
- He developed ballistic missile and launch vehicle technology, by this he also earned the title of 'Missile Man of India' eg: Contribution to AGNI, PRITHVI
- Design a coronary stent making health care accessible to all (Kalam-Raju Stent)

Vikram Sarabhai

- ISRO yearlong birth cenenary-2019, Named crater on moon after him, also Vikram lander of C-2
- Father of Indian space prog, was institution builder, awareded Shanti Swaroop Bhatnagar price
- Contributions:
    - Space-
        - After Russia sputnik conviced Indian govt for space prog- estb Indian national comittee for space research(1962)

        - Thumba centre- Thiruvananthpuram(Now on his name-VS space centre)
        - Worked on India's first satellite 'Aryabhatta'
    - Nuclear
        - Fast Breeder Test reactor,Kalpakkam
        - Became chairman of Atomic energy commision after Bhabha
    - Educational
        - IIM-A

Current Updates and Value Additions

- Committee:
    - AI [V Kamakoti-Setting up National Artificial Intelligence Mission (N-AIM), Digital ombudsman], 5G (AJ Paulraj), Global Innovation Index (Rank 40); Defence (Sheketakar), STEM Focus (Kasturirangan Cmt)
- Dimensions & Conclusions:
    - 💡: Use BB-NISAR shortform (Big data, Bio-tech, Nanotech, IT, Space, AI, Robotics + VR/AR, Metaverse, Web 3.0) for diverse technologies
    - Nehruji - saw **Science as the "enzyme of hope"** playing instrumental role in national building
    - **Common Conclusions:** Carl Sagan has said "we can do science and with that we can improve lives"
- M365 2024 Content Below
    - **Deepfakes: Video/image** that has been **edited using an algorithm** to replace original content with someone else; Challenges: **No specific regulation** measures; **Women target** (**90%** times); **Misinformation** & disinformation, **Breach of privacy/psych stress**; WF: **International coop; R&D; Social media accountability**
    - **CAR-T Cell Therapy**: Type of **cellular immunotherapy treatment** that **uses T cells** **(type of WBC) that are genetically altered** in a lab to enable them to **locate and destroy cancer cells** more effectively; **Key** Challenges **- Cytokine Release Syndrome, Neurological Toxicity** (confusion, seizures), **Limited patient eligibility** (age, health etc), **High cost**, **Manufacturing Challenges, Regulatory challenges**, etc
        - **Process**: Collected from blood → Receptors modified → Multiplied in lab → Infusion → Cancer cell destruction
    - **Space developments**: **350+ foreign satellites** launched; **New tech dev-Reusable LV**; **95% success rate**; **ASAT** (Anti-Satellite Missile Test

capability); **200+ Space Startups**: **Agnikul** Cosmos and **Skyroot**; Planning for **Bharatiya Antariksha Station**
    - **Common issues of S&T: 0.7% R&D**, **3 colleges** in top 200, **Weak institutions**, **IPR issues**, **Ethical issues; Inconsistency in govt policy; Budget constraints; Import dep, Brain drain, Cost makes it inaccessible, Weak Indus-academia collab, Privacy, Security risk**
    - World Health Organization (**WHO**) and Indian government **launched *Global Initiative on Digital Health*(GIDH)**
    - **Applications of Quantum Dots: (**Nobel Prize recently**) Man-made semiconductor particles of less than 10 nanometers;**
        - Application: **High Brightness**; For **Targeted drug** delivery; **Nano-medicine**; **Thinner solar cells**, **Flexible electronics**; **Television-Accurate colours**, **Tiny sensors**
- GM Mustard:
    - **Pros**: Higher yield (**Field trials DMH-11 inc 20-25% yield**); **Income security** for farmer (20-25% inc); **Herbicide tolerant** (**weed mgmt** is effective); **Reduce import bill (edible oil)**; Improve **food security** (for **edible oil**); **Env benefits** (**less land/chem usage**);
    - **Issues**: **Develop 'super weeds'**; **Health concerns**/biosafety; **Public perception (protest for Bt brinjal)**; Loss of trad varities; **Dependence on cos**; **Regulatory gap** is there; **Monsanto** terminator gene, Trait fees, **Gene crossover**,
    - Process: **Genetic Engineering Appraisal Committee (GEAC)** under MoEFCC **recommends → Govt finally approves**
    - Concl: **Multi-spatial and multi-temporal studies** are required; **Follow "Codex Alimentarius" Guidelines of WHO**
- Generative AI:
    - An AI capable of generating text, images, or other media, **using large language models (LLM) and Generative Adversarial Networks (GANs)**. *Eg: **ChatGPT** is conversational AI, **GEMINI, Dall-E***
    - Fullform: Chat **G**enerative **P**re-Trained **T**ransformer
    - Generative AI is a subset of artificial intelligence that focuses on creating new, original content rather than simply analyzing or acting on existing data

Feature	Generative AI	Traditional AI
Purpose	To create new content	To analyze and make decisions based on existing data
Methods	LLMs, diffusion models, GANs	Machine learning, rule-based systems, expert systems
Output	Text, images, music, videos	Predictions, classifications, recommendations
Examples	GPT-3 (text), DALL-E 2 (images), MuseNet (music)	Fraud detection systems, medical diagnosis tools, recommender systems

    - +ve: Boost productivity via **worker augmentation** (content generation for legal petition); **Dev role (boost learning outcome, Personalised med assistance** for health); Boost **innovation and creativity (drug discovery, music**/literature); **Decentralised internet** (Web 3.0); **Agriculture (Chat bots**, prediction); **Risk mitigation** (**identify potentially faulty software code and save privacy)**
        - **Make any random data** It is believed that by 2025, more than ~~30%~~ of new drugs and materials will be systematically discovered using generative AI techniques, up from zero today
    - -ves: **Deepfakes** → fake news; **Phishing/identity theft**; Digital have nots; **Inherent bias (Artificial hallucination)**; **Plagiarism**, Job loss, etc
        - **Make data NASSCOM Report**: Nearly 70% of the jobs in India will under threat due to automation in 20 years;
    - **WF**: **Update legal framework** Indus colab; Int collab (**GPAI**-Global Pship on AI); **AI Education** (**Future Skills Prime by MeITY NASSCOM**); Algorithm Accountability; Liability Framework
    - **Bletchley Declaration** is a global agreement on artificial intelligence (AI) safety
- Anusandhan National Research Foundation (NRF) Act, 2023
    - **It's a new bill to intoduce** Anusandhan NRF which will provide strategic direction, support and monitoring research in natural sciences, humanities, etc while repealing the erstwhile SERB
    - **Corpus of 14k crore over 5 yrs**; Governing **body headed by PM** then Minister of S&T as Vice President; modelled on the US National Science Foundation (NSF)
    - **Benefits:**
        - **Affects of NRF**: Reduce fragmented research; Inter-disciplicary research; Facilitate fast track clearance of the projects with PM led Governing Council
        - S&T - **Boost R&D of India (0.7% vs 2.1%)**, good for new projects like Supercomputer Mission, Quantam Tech; **Boost international collaboration**
        - GS3 - **Democractisation of science** - **projects for rural/semi-urban to get focus** (inclusive growth), Give a **push to manufacturing sector/infra** sector; **Pvt/PSU can invest** in the fund
        - GS2 - Education - **HE colleges/univ will get funds** (as of IIT/IIM/NIT get **50% funding with 3%** students)
        - GS1 - Research in social sciences, humanities, art
        - **Other benefits of NRF**: Inclusive dev (eg: vaccine dev), **Human capital dev (as HEIs** would improve **not a single in top 100** QS World); Global power and **Vishwa Guru**; Boost **security (as tech indigenisation)**; Boost to **startups** and 5TD

- **Conclusion**: achieve the objective of "**promoting culture of innovation" as mandated by the NEP, 2020**
- Artemis Accord
  - **Artemis Accords are a non-binding** set of principles designed to **guide space exploration**
  - **Common vision for peaceful**, **sustainable**, and transparent **cooperation in space**
  - What: US led international partnership on planetary exploration & research for peaceful purpose; Aim to **return astronaut to lunar surface** & carryout deep space exploration
  - **Significance for India**
    - Fast track India's human space capabilities (Gaganyaan)
    - **Entry into ISS**
    - Strong **ISRO-NASA collaboration**, enhance ISRO's capabilities
    - Help India shape the governance of resource extraction from moon
- **Aditya-L1 Mission**:
  - Launched by PSLV with **7** payload named **VLEC (imaging), SoLEXS (soft xray), PAPA (solar wind, particle analyser), HEL1OS (hard xray);**
  - **Distance of 1.5 million km**
  - **Aim**: study the Sun's **corona**, Sun's **photosphere**, **chromosphere**, solar emissions, solar winds and flares, and Coronal Mass Ejections (CMEs), and will carry out **round-the-clock imaging** of the Sun, Study **darkspots**
  - **Visible Line Emission Coronagraph** will be the main payload → help in studying the **temperature, velocity and density of the corona**, understand the processes that result in heating of the corona and **acceleration of the solar wind**, aid studies on drivers **of space weather, measure the magnetic field of corona** and study the development and **origin of coronal mass ejection (CME)**
  - Other applications: International Collaboration and Data Sharing (**shared data with 50+ inst**); **Technological spin-offs** (**Solar cells, AI on solar data**); Refining **climatic models and env monitoring**; Better military satellite operations due to accurate weather predictions; Educational push & boost SDG
  - **Other oribiters**. **SOHO, Parker Solar Probe**
  - 5 **Lagrange** Points: 1 is in front of earth, 2 is behind, then 3 behind sun and 4/5 above/below point 1 (Pt. 1 has continuous observation advantage)
- DR. VIKRAM SARABHAI
  - **Established INCOSPAR**; Set up **Thumba** launch station; **INSAT Commnunication** satellites developed; **Researching cosmic rays in IISC Bangalore**; Exploited the **potential of space satellites in areas like remote sensing, agriculture, telecom**; **Launched Aryabhatta**;

Training budding scientists like APJ Kalam; IIM-A); Led nuclear research after Bhabha;

- **NISAR**:
  - Dual 'L' & 'S' band; **Sampling earth every 12 days**; **All-weather** low earth orbit observatory (as **SAR can penetrate clouds/**darkness); **CC Monitoring (forests carbon stock, permafrost monitoring**, glacial, geo-spatial monitoring of climate change); **Disasters (Volcano, landslide, track** oil spills and their effect; K**ey terms daalo babu bhaiya**); **Resource tracking (oil/gas/water exploration)**
- Samudrayaan:
  - Part of deep ocean mission; **Mastya 6000** for **manned ocean mission**
  - **Pros** (**Deep sea mining** and **energy via OTEC,** Blue economy target of Rs.100 bn; Mitigating Climate ch; **Drug discovery via novel biomolecules**); Concerns (Env issues=leakages/harm marine biology; Tech= Designing diff due to corrosion; High cost; Loss of cultural value assoc with ocean; Transboundary impact due to jurisdiction)
- Space Tourism
  - Commercial activity related to the cosmos that includes **watching a rocket launch, stargazing, or traveling to a space** centric destination.
  - **Various steps in line with space tourism** have been taken in India like **Gaganyaan, IN-SPACe, Reusable Launch VehicleTechnology Demonstrator (RLV-TD),** etc
  - **Challenges**: High cost; Env impact (carbon footprint, ozone depletion); **Safety of passengers** at risk; Space debris issues; **Focus might shift from scientific space research** and toward commercial interests; Exacerbate existing social inequalities (as only few can afford due to high cost)
  - Drivers: Tech advancement, Cost reduced due to pvt players, Become 1 billion market by 2025
  - However, it is essential to recognise that the global space landscape is not static but constantly evolving. **India must embrace adaptability and strategic foresight** to keep pace with these rapid changes; **ISRO is planning space tourism by 2030**
- The Indian Space Policy 2023
  - Unveils the **government's plan to <u>let Non-Govt Entities</u> (NGE) carry out end-to-end activities** - from launching satellites and rockets into space to operating Earth stations; Delineate roles of various stakeholders (**NGE**-own/procure satellite/operate LVs,filinings with ITU, **NSIL**-comemrcialise space tech, **In-Space**-single window-authorisation, **ISRO**-core R&D, **Dept of Space**-overall guidelines)
  - **Need**: Regulation: unclear, difficult to coordinate, manage and supervise; Full Potential of India's Space Sector**; Enhancing Security (agencies**

spend nearly a billion dollars annually to procure Earth Obsv data and imagery from **foreign sources); Aatmanirbharta in Space Sector**

- Features:
  - Role of NSIL, In-Space specified:
    - InSPACe (Indian National Space Promotion and Authorisation Centre): It will be a single window clearance and authorisation agency for space launches, establishing launch pads, buying and selling satellites, etc; Act as a regulator
    - New Space India Limited (NSIL): It will be responsible for commercialising space technologies and platforms
    - Department of Space: It will provide overall policy guidelines and be the nodal department for implementing space technologies
  - Rationalising the role of ISRO: transition out of manufacturing of operational space systems and focus on cutting edge research and development and long-term projects such as Chandrayaan and Gaganyaan; ISRO will share technology with NGEs
  - NGEs (this includes the private sector) are allowed to undertake end-to-end activities in the space sector, own/procure satellites; design and operate launch vehicles; make filings with the International Telecommunication Union (ITU)

- Nuclear Energy:
  - **Relevance: Cost effective and cheapest as per IAEA**; Env 70x less emission; **Scalable from small reactors to larger ones (Bharat Modular Reactors)**; **Rising energy demands**;
  - **Challenges**: **India's Nuclear Liability law hinders investment**; Public protests; Waste generation (**Fukishima**); **GW contamination in Ur mining**
  - WF: Countries must respect **IAEA** Conventions
- Miscellaneous
  - **Space Sector Target:** Current 3% to **8% by 2033; Space VCF - 1000 crores**
  - As per **BIRAC**, India's **bioeconomy has reached USD 100 bn** and is likely to **touch USD 150 billion by 2025;** Includes - Bio-tech for Med (vaccines), For food systems/GM crops-agri/marine + Bio products/Bioplastics, Bio fuels, Biodegradable clothing, etc
  - **Q: Defense indigenization remains the Achilles heel of India's security architecture. "Examine" the importance of start-ups in defense sector to make India secure and self-reliant.**
    - Approach: Start the answer by describing the relevance of defense indigenization. In the body of the answer, first list the points on importance of start-ups in defense sector. Then list the challenges

for defense start-ups. Conclude the answer with way forward (you focused more on why it remains Achilles heel)
        - As per the Stockholm International Peace Research Institute (**SIPRI**), **India is the world's biggest arms importer (2018-2022**). **Import-dependence** in defense sector is a **strategic liability**
    - **Dr. Ritu Karidhal in space** and rocket segment; **Tessy Thomas Missile Woman of India** (Agni I-V series, aeronautical systems); Gangandeep Kang (children infections, Built National Rotavirus Surveliance)
    - **Metaverse ya xyz technology ka impact** aaye toh use syllabus approach (**thinking broad rakho**): **Agri benefits**, e-goverance/courts, **Economic (jobs change, virtual asset ownership**), Last mile delivery of health and education, **Virtual training, Manufacturing Boeing making plane metaverse, etc**