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PREFACE

The Science & Technology subject is an important component of the Civil Services Examination conducted by the Union Public Service Commission (UPSC). Aspirants who are preparing for this prestigious examination need to have a strong understanding of Ecology & Environment subject. This book of UPSC Power Bank of Science & Technology subject has been designed keeping in mind the needs of aspirants who are preparing for the Civil Services Examination. The book covers all the important topics of Science & Technology including Biotechnology, Space Technology, Technology & Innovation, Defence, Energy, Nuclear Technology & Human Disease.

The questions in this book are comprehensive and have been curated after extensive research to ensure that they cover all the aspects of Science & Technology subject. Each question is accompanied by a detailed answer that not only explains the correct option but also provides additional information related to the question. This will help aspirants to build a strong foundation in Science & Technology subject and understand the subject in greater depth.

The objective of this book is:

1. **Assessing Knowledge:** by testing the candidates' understanding and knowledge of these topics.
2. **Testing Critical Thinking Skills:** to apply it in new and different contexts, analyse and evaluate information, and draw conclusions.
3. **Providing Practice:** by making them familiar with the format and style of UPSC questions.
4. **Preparing for the Exam:** by covering the same types of questions and difficulty levels as the actual exam.
5. **Identifying Knowledge Gaps:** By using the question bank, candidates can identify areas where they need to improve their knowledge or skills, and focus their study efforts accordingly.
6. **Improving Time Management:** This question bank provides a variety of questions that test different aspects of knowledge and skills, so that candidates can learn to manage their time effectively during the actual exam.
7. **Encouraging Self-Assessment:** By detailed explanations and solutions to each question, candidates can assess their own performance and identify areas for improvement.

We hope that this book will prove to be a valuable resource for aspirants preparing for the UPSC Civil Services Examination and help them achieve their goals. We wish all the aspirants the very best for their preparation and future endeavours.

We also express our gratitude to **Ms. Geeta Rani & Mr. Sanjeev Kumar** who have contributed to the book, for their experience and their knowledge. Their contributions will help our readers gain valuable insights and knowledge and secure a high rank in the UPSC examination.

We wish the readers great success ahead!

All the best!
Team Oswaal

Study Approach for Science and Technology for UPSC Prelims

Following are certain guidelines which will help you to streamline your preparations:

- **Understand the syllabus:** Familiarise yourself with the science-related topics mentioned in the UPSC Prelims syllabus.
- **Focus on relevant study material:** NCERT textbooks for Science, PIB report. NCERT textbooks are a great resource for building a strong foundation in science subjects. Read the relevant chapters from NCERT books for science subjects like Physics, Chemistry, Biology, and Environmental Science. Pay attention to the concepts, theories, and fundamental principles.
- **Analyse previous years' question papers:** Go through previous years' question papers to understand the pattern and type of questions asked from science-related topics. This will give you an idea of the important areas to focus on.
- **Make your own notes:** While studying, create concise and well-organized notes that summarize the key points, and concepts. These notes will serve as a quick revision tool in the final days before the exam.
- **Practice objective questions:** Solve multiple-choice questions (MCQs) of Other UPSC exams such as CDS, NDA, CAPF etc.
- **Stay updated with current affairs:** Science and technology-related current affairs play an important role in the UPSC Prelims examination. Stay updated with the latest developments in the field of science through newspapers, magazines, and online sources.
- **Revision:** Set aside dedicated time for revision. Review your notes, practice questions, and solve previous years' papers to reinforce your knowledge and boost your confidence.

Best of luck for your exam!

Aashirvad Kumar

UPSC Consultant: **Oswaal Books**

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3 UPSC Interviews



Positive Affirmations

I realize what I cannot Control and let the good things flow

I courageously move in the direction of my dreams

I am Supported fully by the universe

I am wrapped in the loving energy of the universe

I allow my desires to flow to me now

All of my thoughts are aligned with my desires

Affirmations for the new "YOU"

I effortlessly attract my desires

// Accept yourself, love yourself, and keep moving forward. If you want to fly, you have to give up what weighs you down.

I am open to new experiences and welcome abundance into my life

When I let go, I create space for something better.

// I have the power to shift my mindset and see the good in everything.



Be mindful. Be grateful. Be positive. Be true. Be kind

01

Three things that make you special

02

Three people you are grateful for and why

03

Three simple things you are grateful for

04

A challenging experience that made you stronger

05

Three ways to inject gratitude into a current challenge

06

Describe the last time you did something nice for someone

07

A fear you have overcome

08

Three activities you enjoy most and why

09

What made you smile today?

10

Three things you love about your family

11

What is your favorite place, and why?

12

Three things you love most about yourself

13

The last time you were overcome with joy

14

A risk you are grateful you took and why

15

Three everyday items you are grateful for

16

Three songs that bring you joy

17

What skill do you have that you are grateful for and why?

18

One luxury you are thankful for

19

Describe a rejection you are grateful for

20

Three things about your body you are grateful for

21

What are you most grateful for in your daily life?

22

Three things you are grateful for about where you live

23

Three items in your home you are grateful for

24

Say thank you to someone

25

Something in nature you are grateful for

26

A person in your past you are grateful for

27

Something at school you're grateful for

28

Describe the last time you laughed so hard you cried

29

What is your proudest accomplishment?

30

Three things you want to manifest

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WRITING YOUR NOTES

**Just in case you have forgotten today, takedown your notes!
But why is it so important?**

Tools for the hands are tools for the brain writes Hetty Roessingh.
Handwritten notes are a powerful tool for encrypting embodied cognition and in turn supporting the brain's capacity for recuperation of information. If that sounds so scientific then in simple words: Writing notes by hand help you in:

- ◆ Increasing your comprehension
- ◆ Strengthening your memory
- ◆ Igniting your creativity
- ◆ Engaging your mind
- ◆ Increasing your attention span

Are these reasons enough to get you started?

- 1.
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Flash Facts

Unit-1: Space Technology

1. Space Science

Satellite

- A satellite is an object that moves or revolves around a larger object is a satellite because it revolves around the sun.
- The moon is a satellite because it revolves around Earth. Earth and the moon are known as “natural” satellites.
- Satellites orbit Earth at different speeds, different heights and along different paths. The two most common types of orbit are “geostationary” and polar orbits.

Geostationary Satellite

- It travels from west to east over the equator.
- It revolves at the same rate and in the same direction Earth is spinning. From Earth, a geostationary satellite looks like it is not moving since it is always above the same location.
- Geostationary orbit is used for communications satellites to use.
- This is a region above Earth’s equator at an altitude of 35,786 km.

Polar-orbiting Satellites

- It travels in a north-south direction from pole to pole.
- These are used for weather forecasting and reconnaissance.

Karman Line: Anything that crosses this Line at an altitude of 100 kilometres or 62 miles is considered in space.

Orbit

- An orbit is a regular and continuous path that an object in space takes around another object.
- An object in an orbit is known as a satellite.

Classification of Orbits

Low Earth Orbit, LEO

- Low Earth Orbit is relatively low in altitude states that the altitude range is between 200 and 1200 km above the Earth’s surface.
- Radiation levels are lower than experienced at higher altitudes is one of the main features.
- Less energy is needed to place the satellites in LEO than in higher orbits.
- Applications: Communication satellites, Earth monitoring satellites, International Space Station

Additional Info

International Space Station: One of the most complex international scientific and engineering projects in history.

- It lies at an average altitude of 400 kilometres above Earth.
- Operated by 15 countries
- Russia, the United States, Canada, Japan and several members of the European Space Agency are some members of the ISS.
- India is not a part of it.

Medium Earth orbit, MEO

- It is the region of space around the Earth above a low Earth orbit altitude of 2,000 kilometres and below a geostationary orbit altitude of 35,786 kilometres.
- Applications: Navigation, Communication and space environment science.

Geostationary Satellite Orbit, GEO

- The satellite remains in the same position throughout the day.
- Applications: Direct broadcast, Communications, Relay systems.

Launch Vehicle

- It is a rocket-powered vehicle used to transport a spacecraft beyond Earth’s atmosphere, either into orbit around Earth or to some other destination in outer space as required.

Fuel used in Launch Vehicles

Liquid fuels: they can range from

- Kerosene can be used at ground temperature
- liquid hydrogen, a cryogenic fuel, which must be kept at the extremely low temperature of 20 K.
- Hypergolic fuel ignites on contact with an oxidizer, has hydrazine, and is extremely toxic and difficult to handle.

Solid fuels: Some organic material or powdered aluminium.

Rocket Propulsion

- A rocket must clear the earth’s atmosphere to travel in space or go into an orbit.
- Minimum height for a satellite to go into Earth’s orbit is approximately 200 km.

Principle Behind Rocket Propulsion

Newton’s 3rd Law of Motion

- The only means available for any object to be put in orbit is rocket propulsion.
- Newton’s third law of motion governs the working of the rocket engine, viz for every action, there is an equal and opposite reaction.

2. Space Technology

Launch Vehicles in India

PSLV

- Polar Satellite Launch Vehicle is the workhorse launch vehicle of ISRO since 1994. The first Indian launch vehicle with a liquid stage & first operational launch vehicle.
- PSLV is primarily developed to launch remote sensing satellites into sun-synchronous orbits.

GSLV

- GSLV stands for Geostationary Satellite Launch Vehicle.
- Developed primarily to launch communication satellites (INSAT Series) of 2.5 tons in Geostationary Transfer Orbit & about 4.5 tons in Low Earth Orbit.
- It is a three-stage vehicle with solid fuel in the first stage, liquid in the second stage and cryogenic in the third stage.

GSLV MK-III

- GSLV Mk-III is the most powerful rocket in India.
- It is a three-stage heavy-lift rocket with an indigenous cryogenic engine in the third stage.
- It can carry satellites weighing more than 4 tonnes to Geosynchronous Transfer Orbit (GTO) or satellites weighing about 10,000 kg to a Low Earth Orbit (LEO).
- It was the designated launch vehicle for Chandrayaan India's first human space flight Gaganyaan to be launched in 2022 will also use GSLV Mk-III.

Cryogenic Technology

- Third stage of GSLV is an indigenous cryogenic stage. It uses liquid hydrogen as fuel & liquid oxygen as the oxidiser.
- Cryogenic stage is a highly efficient rocket stage that provides more thrust for every kg of propellant burnt compared to solid & earth-storable liquid propellant stages. It involves extremely low temperatures. Hydrogen liquefies at extremely low temperatures at minus 253 degrees centigrade.

Cryogenic Engine

- Cryogenics are used in the last stages of space launch vehicles. To lift and position heavy things in space, cryogenics is the study of the creation and behaviour of materials at very low temperatures (below -150 degrees Celsius).
- Because cryogenic stages use propellants at very low temperatures, they are technically more complicated than solid or liquid propellant (stored on Earth) stages.

Semi-Cryogenic Engine

- Instead of liquid hydrogen, a Semi Cryogenic engine employs refined kerosene. Oxidisers are made of liquid oxygen.
- That is one of the benefits of employing a Semi Cryogenic engine since it uses Refined Kerosene, which is lighter than liquid fuel and can be kept at room temperature

- In comparison to a cryogenic engine, a semi-cryogenic engine is more powerful, eco-friendly, and cost-effective.

SSLV

- ISRO has completed the design for the Small Satellite Launch Vehicle (SSLV).
- It will be used exclusively for small satellites such as nanosats and CubeSats.

Ion Rockets

- Ion rockets are the rockets of the future for deep space exploration.
- They are much more efficient than conventional rockets that use chemical fuels.
- Ion rockets use electric repulsion of ions to propel the rockets.

INSAT SERIES

- Communication satellites launched in Geosynchronous orbit at an altitude of about 36,000 km.
- **Applications:** telecommunication, broadcasting, telemedicine, meteorological services, disaster warning system.

Frequency Bands of Communication Satellites

The radio frequency bands that communication satellites operate in

C Band

- C-band operates within 4-8 Ghz.
- The C band is primarily used for voice and data communications.
- Because of its weaker power it requires a larger ground antenna.
- It provides lower transmission power over wide geographic areas.

Ku Band

- Ku-band operates within 12-18 Ghz.
- Ku band is used typically for consumer direct-to-home, tele-education applications.
- The antenna sizes are much smaller than the C band because of the higher frequency.

KA-BAND

- Ka-band operates within 26-40 Ghz.
- The Ka-band is primarily used for two-way consumer broadband and military networks.
- Ka-band frequency bands facilitate high transmission speed and significant information transfer with the use of small ground equipment and are thus used in broadband applications.
- Due to the higher frequencies of this band, it can be more vulnerable to signal quality problems caused by rain fade.

Latest Communication Satellites

GSAT 30

- ISRO's latest high-powered communication satellite
- GSAT-30 will replace INSAT-4A in orbit.
- The satellite will provide communication services to Indian mainland and islands through Ku-band
- Southeast Asia, Gulf countries and Australia through C-band

- **Applications:** DTH, connectivity to VSATs for ATMs, Stock-exchange, Television uplinking and Teleport Services, Digital Satellite News Gathering (DSNG) and e-governance applications.

GSAT 31

- High-powered communication satellite launched in Feb 2019.
- **Application:** VSAT networks, Television uplinks, Digital Satellite News Gathering, DTH-television services, and telephone services in the Middle East, South Africa and Europe.

GSAT 7A (Military Satellite)

- Known as India's 'Angry Bird'.
- It is a military communications satellite dedicated to the Indian Air Force.
- GSAT-7A is only the second dedicated military satellite after 'Rukmini' or GSAT-7 launched in 2013 (Indian Navy).

GSAT 11

- Launched in December 2018.
- ISRO's heaviest communication satellite (5.8 tonnes).
- High-throughput communication satellite carrying 40 transponders in the Ku-band and Ka-band frequencies.

High-Throughput Communication Satellites of India

- ISRO is planning to launch 4 high-throughput satellites to provide broadband connectivity of over 100 gigabits per second in India.
- It includes:
 - GSAT-19
 - GSAT-29
 - GSAT-11 (launched)
 - GSAT-20 (to be launched in 2024)
- It will provide satellite-based high-speed broadband connectivity in India, thus will be the backbone of Digital India, BharatNet, National Broadband Mission and VSAT Network.

Indian Remote Sensing Satellite System

Basics

- Also known as earth observation satellites
- They are mostly polar, sun-synchronous satellites in low-earth orbit (LEO) at about 800 km from the earth's surface.
- They are commonly called remote sensing satellites as they collect information about any object on Earth through the measurement of radiation of the Sun that is reflected and scattered by objects on the surface of the earth.

Applications

Natural Resource Management Land use assessment and mapping, mineral prospecting, forest surveys etc. Agriculture

Earth Observation Satellite (EOS-01)

- India successfully launched its latest Earth Observation Satellite EOS-01 and nine customer satellites from the United States, Lithuania and Luxembourg, onboard Polar Satellite Launch Vehicle (PSLV-C49).

- Land and forest mapping and monitoring, mapping of resources like water or minerals or fishes, weather and climate observations, soil assessment, and geospatial contour mapping are all done through earth observation satellites.

RISAT

- RISAT (Radar Imaging Satellite) is a series of Indian radar imaging reconnaissance satellites built by ISRO.
- They provide all-weather surveillance using synthetic aperture radars (SAR).
- Synthetic-aperture radar is a form of radar that is used to create two-dimensional images or three dimensional reconstructions of objects, such as landscapes.
- RADAR (Radio Detection and Ranging System) is a detection system that uses radio waves to determine the range, angle, or velocity of objects. Sunlight, clouds, and rain do not affect radio wave observations.
- The RISAT series is the first all-weather Earth observation satellite from ISRO.
- Previous Indian observation satellites relied primarily on optical and spectral sensors which were hampered by cloud cover.

NISAR

- Joint Earth Observing Mission Of NASA And ISRO.
- NASA and ISRO are collaborating on developing an SUV-sized satellite called NISAR (short for NASA ISRO-SAR).
- The primary goal of observation is tracking subtle changes in the Earth's surface, Spotting warning signs of imminent volcanic eruptions, Helping to monitor groundwater supplies, and tracking the rate at which ice sheets are melting.
- It will scan the globe every 12 days throughout its three-year mission of imaging the Earth's land.

Sentinel-6 Satellite: Jason-CS Mission

- Sentinel-6-Satellite is a part of the mission dedicated to measuring changes in the global sea level. The mission is called the Jason Continuity of Service (Jason-CS) mission.
- The objective of the Mission is to measure the height of the ocean, which is a key component in understanding how the Earth's climate is changing.
- It is a collaboration of the European Space Agency (ESA), National Aeronautics and Space Administration (NASA), European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the USA's National Oceanic and Atmospheric Administration (NOAA) and the European Union (EU), with contributions from France's National Centre for Space Studies (CNES).

Copernicus

- European Earth Observation Program.
- The main objective is to monitor our planet and its ecosystems.

Copernicus and India

- India joined Copernicus in 2018.

- Accordingly European Commission will provide India with free, full and open access to the data from the Copernicus Sentinel family.

GISAT: Geo-Imaging Satellite Series

- New series of remote-sensing satellite.
- GISAT series is the Earth Observation Satellites in the Geo-synchronous orbit.
- ISRO has planned to launch 2 satellites in this series including GISAT-1 and GISAT-12R.
- It will yield multi-spectral and multi-resolution (50m to 1.5 km) images in visible, near infra-red and thermal spectrum.
- Multi-wavelength imaging for land mapping.
- Designed for both military and civilian purposes.

Hysis: Hyperspectral Imaging Satellite

- India's first hyperspectral imaging satellite.
- Sun-synchronous polar orbit, 636 km above the surface of the earth.
- It observes the earth's surface in 3 different ranges including visible, near-infrared and shortwave infrared regions in 55 spectral or colour bands.

Hyperspectral Imaging

- Hyperspectral imaging combines digital imaging and spectroscopy.
- For this it uses a critical chip called an 'optical imaging detector array' which enables it to provide better-defined images that are more clear than regular optical or remote sensing cameras.

EMISAT

- It is an electronic intelligence satellite developed by ISRO and DRDO.
- It was developed under project KAUTILYA of DRDO.
- The 435 kg EMISAT was launched in the low earth orbit, 749 km above the surface of the earth.

Indian Regional Navigation Satellite System

- Also called NavIC, is like the GPS.
- While GPS has a constellation of 24 satellites, IRNSS has a 7-satellite constellation.
- NavIC has a position accuracy of 20 metres in its primary coverage area.
- It can service regions extending up to 1500 km around India's boundary.
- There are currently seven IRNSS satellites (1A to 1G) in orbit.

Other Navigation Systems

- Global Positioning System (GPS) – USA
- GLONASS – Russia
- QZSS – Japan
- Galileo – European Union (EU)
- IRNSS – India
- BeiDou – China

Tundra Satellite

- Tundra series of satellites, also known as EKS (Edinaya Kosmicheskaya Sistema), is the next generation of Russian early-warning satellites.
- The EKS was first developed in the year 2000.
- In the event of a nuclear war, these satellites will carry a secure emergency communications payload.

- They are launched into Molniya-orbits, which are inclined extremely elliptical 12 h orbits, using Soyuz-2- 1b Fregat rockets.

Double Asteroid Redirection Test (DART) Mission:

NASA

- The mission's major goal is to put to the test a newly developed technology that allows a spaceship to collide with an asteroid and alter direction.
- The mission is a suicide mission, and the ship will be destroyed altogether.
- The spacecraft is aiming towards Dimorphos (Greek for "two forms"), a tiny moonlet.
- It has a diameter of around 160 m, and it is predicted to crash with Earth when it is 11 million km distant.
- Dimorphos is orbited by Didymos (Greek for "twin"), a bigger asteroid with a diameter of 780 m.

Objectives of the Dart Mission

- DART is the first technical demonstration of the kinetic impactor method, which might be used to prevent an asteroid from colliding with Earth.

3. Space Missions

ISRO'S Space Exploration Missions

Astrosat

- India's 1st dedicated multi-wavelength space observatory.
- Studies outer space objects in X-ray, limited optical and UV spectrum.
- The 1500-odd kg satellite is launched into a 650 km orbit.

Exosat

- Exosat is a multi-wavelength space observatory to study deep space.
- It is planned as the successor to ASTROSAT.
- It will explore X-ray sources in the universe.
- It will study neutron stars, supernova remnants, pulsars, and black holes in multiple wavelengths.

Mangalyaan

- Also called Mars Orbiter Mission, it is India's 1st interplanetary mission.
- Main Objective: Exploration of Martian surface features, morphology, mineralogy and atmosphere

Chandrayaan 1

- ISRO's 1st mission to the moon.
- It is a lunar orbiter best known for helping to discover evidence of water molecules on the moon.
- Orbited the moon for almost a year (between October 2008 and August 2009).
- Major goals: to collect data on the moon's geology, mineralogy and topography.

Chandrayaan 2

- 2nd lunar exploration and 1st lander and rover mission of ISRO.
- Lunar Orbiter-Lander-Rover mission of India.
- India's 1st interplanetary mission to land a rover on any celestial body.

- Chandrayaan 2 is the world's 1st lunar mission to the South Pole of the Moon's near side.

Aditya-L1

- India's 1st first mission to study the Sun is to be launched in early 2020.
- Its main objective is to study the solar corona.
- Corona is the outermost region of the Sun's atmosphere. An interesting thing about Corona is it has high temperatures of more than 1 million degrees Kelvin far higher than the surface of the Sun (6000 degrees Kelvin).
- The reason for this is still unknown and this is what Aditya L-1 will aim to understand. (NASA's Parker probe is currently exploring this aspect).

Additional Information

- **Solar Wind:** Corona ejects millions of tonnes of high speed solar wind that engulfs the entire solar system including earth.
- These solar winds are composed of electrons and nuclei of hydrogen and helium atoms. According to the scientist, the interaction of magnetic fields of opposite polarity—North and South—through a process that solar physicists call magnetic flux cancellation provides the energy for the eruptions called solar spicules.
- **Significance:** Earth's magnetic field acts as a protective shield against the solar wind. However, these solar winds can be harmful to space-based instruments like satellites and thus to our communication networks, GPS etc.

Gaganyaan Mission

- Gaganyaan is a crewed orbital spacecraft that will serve as the foundation for India's human spaceflight program (IHSP).
- ISRO launched the IHSP in 2007 to develop the technology required to launch crewed orbital spacecraft into low Earth orbit.
- Gaganyaan 1, the first uncrewed mission, is set to launch on a GSLV Mark III rocket no sooner than June 2022.
- ISRO had been testing relevant technologies for the project, including a Crew Module Atmospheric Reentry Experiment and a Pad Abort Test.
- After Russia, the United States, and China, India will become the fourth country to perform independent human spaceflight if the project is completed in the meanwhile.

Components of Gaganyaan

- **Rocket:** GSLV Mk-III
- **Crew Module:** A crew module and service module.
- The crew members will be selected by the IAF and ISR.
- Crew will perform micro-gravity and other scientific experiments for a week.

Environmental Control & Life Support System ECLSS

ECLSS will:

- Maintain steady cabin pressure and air composition.

- Remove carbon dioxide and other harmful gases.
- Control temperature and humidity.
- Manage parameters like fire detection and suppression.

Suborbital Flight

- Sirisha Bandla, an Indian-born astronaut, was a member of the crew. After Kalpana Chawla and Sunita Williams, she was the third woman of Indian descent to journey to space.
- Virgin Galactic is a United States-based British American spaceflight firm.
- Once an object is above the atmosphere and travelling at a horizontal speed of 28,000 km/hr or higher, it enters orbit.
- To circle Earth, the satellites must attain that speed (orbital velocity).
- Due to gravity, such a satellite would accelerate towards the Earth, but its horizontal movement would be rapid enough to counteract the downward motion, resulting in a circular course.
- Any object that travels slower than 28,000 km/hr must ultimately return to Earth.
- Any item that is launched into space but does not attain a sufficient horizontal velocity to remain in space returns to Earth. As a result, they follow a suborbital trajectory.
- This implies that although these spacecraft will cross the ill-defined space border, they will not be able to remain in space once they are there.

Importance of Suborbital Flights

- Due to the high expected flight rates, it would give more flight access for design innovation and experimental modification.
- Microgravity studies will benefit from suborbital flights. The state of microgravity is when individuals or things are weightless.
- Suborbital flights might potentially be a viable alternative to parabolic aircraft flights, which are now used by space organisations to mimic zero gravity.
- Zero Gravity, often known as Zero-G, is the state or situation of being weightless.
- They would be a fraction of the cost of sending experiments and people to the International Space Station.

Space Debris

- Most Space debris comprises human-generated objects, such as pieces of spacecraft, tiny flecks of paint from a spacecraft, parts of rockets, satellites that are no longer working, or explosions of objects in orbit flying around in space at high speeds.
- Most space junk is moving very fast and can reach speeds of 18,000 miles per hour, almost seven times faster than a bullet.

Kessler Syndrome

- This is an idea proposed by NASA scientist Donald Kessler in 1978.
- It states that if there was too much space junk in orbit, it could result in a chain reaction where more and

more objects collide and create new space junk in the process, to the point where Earth's orbit becomes unusable.

- It is also known as collisional cascading.

How can Kessler Syndrome be Avoided?

- The successful 'passivation' of all spacecraft, which would limit on-orbit breakups, and the widespread, i.e., more than 90%, adoption of effective disposal strategies at the end of missions would contribute to containing the growth of space debris.
- Clean Space by cutting debris production from future space missions.
- Then an urgent need to reduce the total mass of current debris, such as the robotic salvage of derelict satellites.

Project NETRA

- NETRA stands for Network for space objects Tracking and Analysis. It is a project of ISRO to develop orbital debris tracking capability. This will provide an early warning system to safeguard space assets.
- It includes a network of observational facilities like connected radars, telescopes, data processing units and a control centre.
- The system is deployed to predict threats to Indian satellites from space debris, space attacks etc.
- The telescopes and radars under the network would be set up at four locations:
 - Ponnudi in Thiruvananthapuram (Kerala)
 - Mount Abu (Rajasthan)
 - One in Deep North (Leh)
 - One in the Northeast region
 - Multi-Object Tracking Radar at Nellore
- The telescope network will be set up under the Directorate of Space Situational Awareness and Management at Bengaluru.

NORAD

- ISRO currently depends on NORAD (North American Aerospace Defence Command) for tracking space debris and protecting its satellites in the course and during launches.
- NORAD is an initiative of the USA and Canada. It shares selective debris data with many countries.
- It uses satellites, ground & air radars to secure USA & Canada against attacks from air, space & sea.

Space Situational Awareness Pact

- Bilateral Space Situation Awareness Pact was signed between the Department of Space of India and the Department of Defence of the USA. The benefits of this agreement are:
 - Facilitate India to receive data from the USA about space debris and other objects in space and the potential threat that may pose to the safety & security of new and existing satellites and other space assets.
 - Ensure sharing of data & services for the long-term sustainability of outer space activities of the two countries by protecting the satellites of both countries from natural and manmade threats.

Inter-Agency Debris Coordination Committee (IADC): An international government forum for the worldwide coordination of activities related to the issues of manmade and natural debris in space.

Functions:

- Exchange information on space debris research activities between member space agencies.
- Facilitate opportunities for cooperation in space debris research.
- Identify debris mitigation options
- Review the progress of ongoing cooperative activities
- **Members:** Space agencies of 13 space-faring nations. ISRO is also a member.

Important Missions of NASA

NASA's Sunrise Mission

- NASA has announced a new Sunrise (The Sun Radio Interferometer Space Experiment) mission to study giant solar particle storms.
- It will investigate how Sun generates and releases giant weather storms, known as Solar particle storms, into space.

EUVST and EZIE

- NASA has approved two missions to explore the Sun and the system that drives space weather near Earth.
- These two missions are:
 - Extreme Ultraviolet High-Throughput Spectroscopic Telescope Epsilon Mission, or EUVST
 - Electrojet Zeeman Imaging Explorer, or EZIE.

EUVST

- Led by Japan Aerospace Exploration Agency (JAXA), in partnership with other international organizations.
- Planned to be launched in 2026.
- It is a solar telescope that will study how the sun's atmosphere releases solar wind and drives eruptions of solar material. NASA will do hardware contributions to the mission.

EZIE

- To be launched by NASA in June 2024.
- The EZIE mission is made up of three CubeSats which will study electric currents in Earth's atmosphere linking aurora to the Earth's magnetosphere.

Hammer

- It is a spacecraft designed to serve as
 - Kinetic impactor is like a ram that can be used to nudge an asteroid from its path.
 - As a transport vehicle for a nuclear device to annihilate the asteroid before it reaches the earth

Europa Clipper

- Spacecraft to conduct a detailed survey of Jupiter's moon Europa.
- It is aimed at assessing the suitability of Europa to harbour life.

Characteristics of Europa

- Icy Planet
- Hubble Space Telescope observed water vapour above Europa.
- It means that it has a subsurface ocean.

Messenger

- MESSENGER is a NASA's robotic spacecraft that orbited the planet Mercury between 2011 and 2015.
- It was launched in August 2004 to study Mercury's chemical composition, geology, and magnetic field.

MODIS

- Earth observation satellite of NASA.
- Monitoring large-scale changes in the biosphere to understand the change in the global carbon cycle.

Dawn Mission

- Main aim was to study two important objects in the asteroid belt, Ceres and Vesta.
 - **Ceres:** A dwarf planet and the largest object in the asteroid belt
 - **Vesta:** A protoplanet, is the second-largest object in the region.
- 1st spacecraft to orbit a body in the region between Mars and Jupiter.
- 1st mission to visit a dwarf planet.
- NASA's 1st deep space mission to be propelled by an ion engine.

SOHO

- Short for Solar and Heliospheric Observatory.
- Joint project between ESA and NASA.
- Main goal is to study the Sun, from its deep core to the outer corona, and the solar wind. (Remember Aditya: only Corona)

New Frontier's Program

- Aimed at exploring the solar system
- Various missions under New Frontiers Program are
 - New Horizons – Launched in 2006 to investigate distant solar system objects including Pluto and its moons and Kuiper Belt.
 - Juno – launched in 2016 to study Jupiter
 - OSIRIS-REx-mission to collect samples from an asteroid (Bennu) and carry it to Earth for further study.
 - Dragonfly – To be launched in 2026 to study Saturn and its icy moons.

Parker Solar Probe

- First ever visit to a star. It will be 6.2 million km to Sun at the closest approach.
- It will fly through Sun's Inner atmosphere to trace how energy flows through the corona.
- Robotic spacecraft to probe the outer corona of the Sun

Punch Mission

- It is a NASA mission which aims to understand the transition of particles from the Sun's outer corona to the solar wind that fills interplanetary space.
- It will image and track the solar wind and coronal mass ejections.
- Will be launched in 2022.

Telescopes

Event Horizon Telescope

- Imaged the 1st ever picture of a Black Hole.
- Network of 8 radio telescopes located in Hawaii.

- Arizona, Chile, Mexico and Spain, and the South Pole.
- It is synchronized in such a way in effect they form a radio telescope of the size of the earth itself.
- The name of the Blackhole captured was kept as 'Powehi'.

Thirty Meter Telescope

- Multi-wavelength Large telescope in near-ultraviolet to mid-infrared observations.
- Proposed sites: Mauna Kea in Hawaii, Hanle in India.
- Funding from Canada, China, Japan and India.

Dark Energy Spectroscopic Instrument (DESI)

- It is designed by Lawrence Berkeley National Laboratory, to explore the mystery of dark energy.
- DESI will peer deeply into the universe's infancy and early development—up to about 11 billion years ago—to create the most detailed 3-D map of the universe.

Starlink Inter-Net Constellation

- SpaceX deployed all 60 Starlink satellites into orbit through Falcon 9 rocket. Starlink satellite constellation will eventually have close to 12,000 satellites.
- These satellites will be deployed in Low Earth Orbit they will be deployed in the altitude band of 350 km to 1200 km.

Standard Model of Physics

- The fundamental questions that have intrigued humans for a long are "What is the world made of?" and "What holds it together?".
- The Standard Model is an attempt to explain these questions:
 - According to Standard Model, all the known matter is made up of fundamental particles called quarks and leptons.
 - Nucleus of an atom consists of protons and neutrons which are made of fundamental particles called quarks.
- Electrons are made up of leptons.
- These particles interact with each other following rules known as the "four fundamental interactions" which are:
 - Gravity
 - Electromagnetism
 - Weak Nuclear force
 - Strong Nuclear force
- For the weak and strong nuclear interactions to work, the Standard Model predicts the presence of a particle called Higgs Boson.
- Thus, according to the standard model elementary particles in nature are Quarks, Leptons and Bosons.

Quarks

- They join to form hadrons, such as protons and neutrons, which are components of the nuclei of atoms.
- Quarks and antiquarks are the only two fundamental particles that interact through all four fundamental forces of physics: gravitation, electromagnetism, and strong interaction and weak interactions.

- A quark exhibits confinement, which means that the quarks are not observed independently but always in combination with other quarks.
- This makes determining the properties (mass, spin, and parity) impossible to measure directly.

Leptons

- Like quarks, leptons too are of 6 types. However, they do not have any fractional charge. The leptons are ELECTRON, MUON, TAU and 3 Types OF NEUTRINOS.
- Electron being a Lepton is a fundamental elementary particle.

Fermion

- Fermions are particles which have half-integer spin and therefore are constrained by the Pauli Exclusion Principle. Fermions include electrons, protons, and neutrons.
- Fermions include all quarks and leptons.
- The fact that electrons are fermions is foundational to the build-up of the periodic table of the elements since there can be only one electron for each state in an atom (only one electron for each possible set of quantum numbers).

Boson

- Boson is a collective name given to particles that carry forces.
- It has been named after Indian scientist Satyendra Nath Bose.
- Gravity as a force of nature is yet not accepted by the Standard Model due to the failure to discover its Boson.
- Strong Nuclear Force is the strongest known force while gravity is the weakest.

Muon

- The muon, a heavier cousin of the electron, is expected to have a value of 2 for its magnetic moment (g).
- It occurs naturally in cosmic ray showers and has been produced copiously in the Fermilab experiments
- Like the electron, the muon has a magnetic moment because of which, when it is placed in a magnetic field, it spins.

God Particle

- Peter Higgs suggested that particles did not have mass just after Big Bang. As the universe cooled and the temperature fell below the critical point, an invisible force field got formed which has been termed Higgs Field.
- The associated particles with the Higgs field have been termed the Higgs Boson. It has been theorized that any particle that interacted with these Higgs Boson got mass and those particles that were left out of the Higgs field remained massless.
- As these Higgs Bosons can grant mass, the primary condition for the existence of matter, they were termed the God particle.

- Big Bang Theory is the leading explanation about how the universe began. It talks about the universe as we know it starting with a small singularity, and then inflating over the next 13.8 billion years to the cosmos that we know today.

Neutrinos

- Neutrinos are subatomic particles that are almost massless.
- They are generally emitted during nuclear decays
- They move nearly at the speed of light.
- The neutrinos are particles that have no electric charge and are not affected by electric or nuclear forces.
- Under most conditions matter is transparent to neutrinos and thus neutrinos pass through all matter almost entirely. Therefore, they are difficult to detect.
- Indian Neutrino observatory is being constructed at Bodi Hills, in the Theni District of Tamil Nadu.
- Neutrinos are chargeless elementary particles that travel close to the speed of light.

Antimatter: Every known matter has an antimatter which has the same mass and volume; the only difference being the inherent charge. Antimatter has an opposite charge when compared to its matter. While the Anti-matter of a proton is called Anti-Proton, the Antimatter of an electron is called Positron.

Dark Matter

- It was in the 1930s when Fritz Zwicky observed that many galaxies were moving faster than theoretical calculations. This implied that there was some mysterious gravitational pull towards the centre of those galaxies. The quantity of matter needed to exert such a pull far exceed the observed matter. This extra matter which is invisible and undetected has been termed Dark Matter.
- The light from distant galaxies gets distorted and magnified by massive, invisible clouds of dark matter in the phenomenon known as **Gravitational Lensing**.

Lithium in Stars

- As stars grow into red giants, they deplete lithium, according to established evolutionary principles.
- Planets have been found to contain more lithium than their stars, as the Earth-Sun pair does.
- However, several lithium-rich stars were discovered, resulting in a paradox.
- A recent study by an Indian researcher demonstrates that stars create lithium as they go from the Red Giant stage to the Red Clump stage.
- This is what enriches them with lithium and is known as a Helium Flash.

Lithium

- Lithium is a chemical element with the atomic number 3 and the symbol Li. It's a silvery-white alkali metal that's pleasant to the touch. It is the lightest metal and the lightest solid element under normal circumstances.
- Sun contains 100 times less lithium than Earth.

Gamma Ray Burst (GRB)

- GRBs are very intense explosions that have been seen in faraway galaxies.
- They are known to be the brightest and most intense electromagnetic occurrences in the cosmos.
- The duration of a burst may range from 10 milliseconds to many hours.
- After an initial burst of gamma rays, a longer-lasting “afterglow” at longer wavelengths is released (X-ray, ultraviolet, optical, infrared, microwave and radio).
- Most GRBs are expected to be emitted after a supernova or super luminous explosion, which occurs when a massive star implodes to become a neutron star or black hole.

Black Holes

- The term “black hole” refers to a point in space where matter is so compressed as to create a gravity field from which even light cannot escape.
- Albert Einstein explained the universe (relationship between space, time, gravity and matter) through his theory of general relativity. It opened the door to the theoretical possibility of a particularly mind-boggling phenomenon that would eventually be called black holes.

Gravitational Waves

- Electric charges oscillating up & down produce electromagnetic radiation. Similarly, the general theory of relativity predicts that oscillating massive objects should produce gravitational radiation or gravitational waves.
- Gravitational waves are ripples in the overall geometry of space and time produced by moving masses
- In 2016, gravitational waves finally were observed from the merger of two neutron stars.
- Two neutron stars rotate around each other; the closer they get, the faster they spin. Eventually, they collide. The energy from their spiralling and merging releases energy in form of gravitational waves, or ripples in space-time.

Lisa Pathfinder

- LISA stands for Laser Interferometer Space Antenna. It is a project led by European Space Agency to build a space-based observatory for detecting gravitational waves. It will consist of three spacecraft separated by 2.5 million km in a triangular formation, following Earth in its orbit around the Sun. It is expected to be launched in 2037.

Asteroids

- Asteroids orbit the Sun and are small bodies in the solar system.
- They are made up of metals and rocks.
- They tend to have shorter and elliptical orbits.
- They do not produce a coma or tail atmosphere.
- Asteroid belt is a torus-shaped region in the Solar System, located between the orbits of planets Jupiter and Mars.
- Many asteroids are known to have a small companion moon (some have two moons).

- Trojans: These asteroids share an orbit with a larger planet, but do not collide with it because they gather around two special places in the orbit (called the L4 and L5 Lagrangian points). There, the gravitational pull from the sun and the planet are balanced.

Hayabusa 2

- JAPAN’s JAXA has received a capsule from the unmanned Hayabusa 2, carrying the first extensive samples of dust from the asteroid Ryugu.
- The mission seeks to answer some fundamental questions about the origins of the Solar system and where molecules like water came from.
- **Asteroid 16 Psyche:** NASA has found out that asteroid 16 Psyche, which orbits between Mars and Jupiter, could be made 36 entirely of metal and is worth an estimated 10,000 quadrillion US dollars. Unlike most asteroids that are made up of rocks or ice, scientists believe that Psyche is a dense and metallic object thought to be the core of an earlier planet that failed in formation.

Nasa’s Psyche Mission

- to be launched in 2022
- to study this asteroid completely and confirm the assumptions being made by the scientists.
- Psyche spacecraft will land on the asteroid in early 2026.
- Since the composition of Psyche is similar to Earth’s core, its study will also give an insight into earth’s violent history of collisions and accretion that created it.

World’s First 6G Test Satellite

- China has launched the world’s first 6G satellite. It uses high-frequency Terahertz waves to achieve data transmission speeds many times faster than 5G.
- Currently, there is no agreement among telecom companies on 6G’s specifications, so it is not certain yet if the technology being developed by China will make it into the final standard.

Einstein Ring

- It is also known as Einstein-Chwolson Ring or Chwolson Ring.
- It is created when light from a galaxy or star passes by a massive object en-route to Earth.
- Due to gravitational lensing, the light is diverted.

Similar Initiatives In India

- **IndSpaceEx:** India’s first-ever simulated space warfare exercise.
- **Mission Shakti:** An Anti-Satellite (ASAT) Missile Test.

4. Space Organisations

In-Space

- Indian National Space Promotion and Authorization Center (IN-SPACe)
- IN-SPACe is an independent nodal agency under the Department of Space for allowing space activities and usage of DOS-owned facilities by NGPEs as well as to prioritise the launch manifest.
- IN-Space will have a Chairman, technical experts for space activities, Safety experts, experts from Academia

and Industries, Legal and Strategic experts from other departments, and members from PMO and MEA of the Government of India.

- IN-SPACE is to be established as a single window nodal agency, with its cadre, which will permit and oversee the following activities of NGPEs.

New Space India Limited (NSIL)

- The Public Sector Enterprise 'New Space India Limited (NSIL)' will endeavour to re-orient space activities from a 'supply-driven' model to a 'demand-driven' model, thereby ensuring optimum utilization of our space assets.
- NSIL is a Central Public Sector Enterprise (CPSE) under the Department of Space and has been incorporated as a wholly owned Government of India company under DOS and is the commercial arm of ISRO.
- These reforms will allow ISRO to focus more on research and development activities, new technologies, exploration missions and human spaceflight programs.
- Some of the planetary exploration missions will also be opened to the private sector through an 'announcement of opportunity' mechanism.

India's First Private Upper-Stage Rocket Engine

- Space startup Skyroot Aerospace has successfully tested an upper-stage rocket engine, becoming the first Indian private company to demonstrate the capability to build an indigenous rocket engine.
- 3D printed rocket engine – Raman, named after Nobel laureate CV Raman – has fewer moving parts and weighs less than half of conventional rocket engines with a similar capacity.
- It is India's first 100% 3D-printed bi-propellant liquid rocket engine injector. Compared to traditional manufacturing, this reduced overall mass by 50% and reduced the number of components & lead time by 80%.

VENUS: Scientists have discovered phosphine gas on Venus. Despite being similar in size to the Earth, having a rocky surface, and having an iron core, Venus has got very little attention in space exploration. Planet was considered hostile to life.

- Although Venus is the second closest planet to the Sun, it is still the hottest.
- Surface temperatures are above 460° Celsius. Many metals will be melted on the surface.
- Heavy atmosphere of carbon dioxide.
- Venus clouds are made of sulphuric acid, so acidic that they are off our pH scale.

Mars

- Fourth planet from Sun and the second-smallest planet in Solar System. Mars is about half the size of Earth.
- **Similarity to Earth (Orbit and Rotation):**
 - Mars rotates every 24.6 hours, which is very similar to one day on Earth (23.9 hours).
 - Mars' axis of rotation is tilted 25 degrees with respect to the plane of its orbit around the Sun. Earth's axial tilt is 23.4 degrees.

- Like Earth, Mars has distinct seasons, but they last longer than seasons on Earth since Mars takes longer to orbit the Sun (because it's farther away).

- Reason Mars looks reddish is due to oxidation or rusting of iron in the rocks, and dust of Mars. Hence, called Red Planet.
- Mars has the largest volcano in the solar system i.e., Olympus Mons. It is 3 times taller than Earth's Mt. Everest.
- Mars has a thin atmosphere made up mostly of carbon dioxide, nitrogen and argon gases.
- Mars has no magnetic field to date, but areas of Martian crust in the southern hemisphere are highly magnetized, indicating traces of a magnetic field.

Perseverance Mission

- **India's Mars Orbiter Mission:** Also known as Mangalyaan, it was launched from Satish Dhawan Space Centre in Andhra Pradesh by ISRO in 2013. It was launched on board a PSLV C25 rocket with aim of studying the Martian surface and mineral composition as well as scanning its atmosphere for methane (an indicator of life on Mars).

Lunar South Pole

- South Pole of the Moon is known to contain ice. This has evinced great curiosity about this region among astronomers.
- Permanent Shadows on Poles of the Moon: There are places on Moon that never receive direct sunlight.

Chandrayaan-3: India is working on Chandrayaan 3 (successor to Chandrayaan-2) and it will likely attempt another soft-landing on the lunar surface.

NASA's Orion Spacecraft: It is a human spacecraft for deep space missions to carry humans to Moon and the first human mission to Mars. It will carry the crew to space, provide emergency abort capability, sustain astronauts during their missions and provide safe reentry from deep space return velocities.

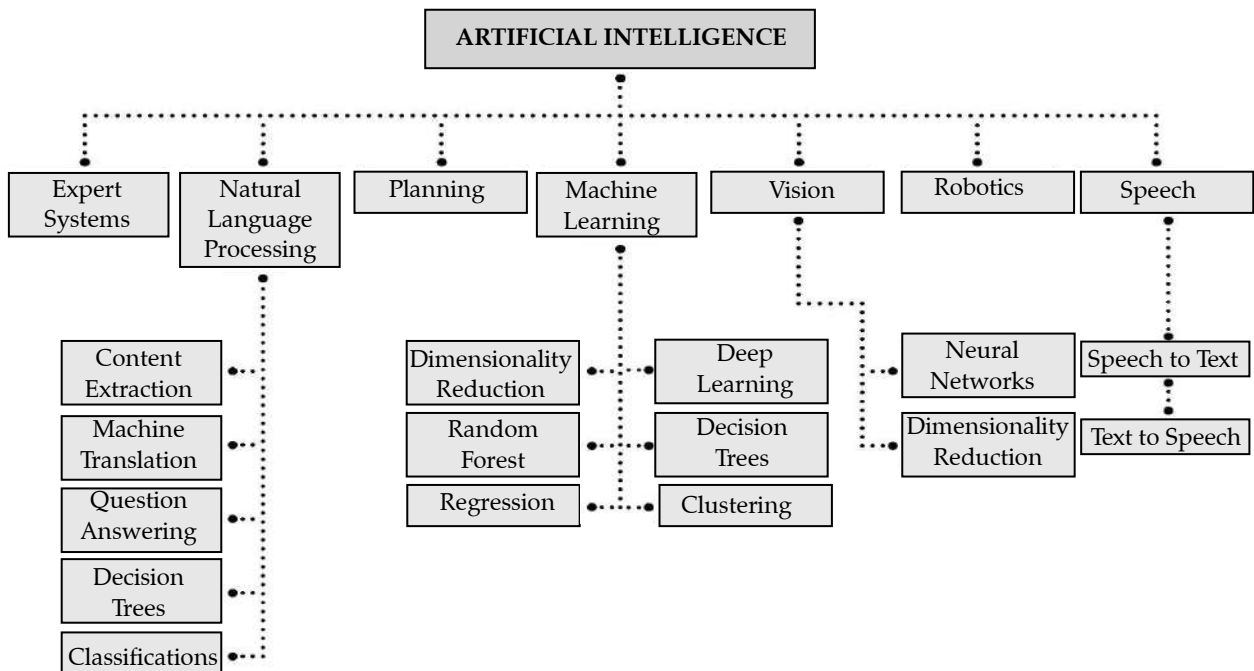
Unit-2: Artificial Technology

1. Artificial Intelligence and Its Application

Industrial Revolution 4.0

- It involves Artificial Intelligence, Robotics, Deep learning, 3D Printing, Blockchain AR, VR, IoT, Supercomputing, Machine Learning.
- IoT (Internet of Things): it is defined as a dynamic global network infrastructure having self-configuring capabilities.
- Deep Learning or Hierarchical Learning is a component of machine learning methods that are based on learning data representations.
- Applications like speech recognition, bioinformatics, facial recognition, drug delivery, bioinformatics and financial fraud detection, AI in healthcare, etc.

Artificial Intelligence (AI)



It can be defined as the **action of machines accomplishing tasks** that have **historically known to be based on human intelligence**.

- It have technologies like machine learning, big data, neural networks, pattern recognition, self algorithms etc.
- **Example: Facebook's list of suggested friends, Netflix's recommendations.**
- **This technology involves** involves complex things like adding particular data into the machine and designing it to react as per the different situations.
- AI is completely **different from hardware driven robotic automation**.
- AI is often **taken as machine learning**. But AI is a broader concept with a in which machine learning is a branch of it.

Benefits

- In Policing
- In Agriculture
- For solving complex issues like proper utilization of available resources.
- Analyzing the Data

India and Artificial Intelligence

- Global AI Report 2019, India was at the ninth position in case of the number of the AI specialists who are working in the field. The US, China and the UK topped the list.
- It is predicted that AI will add 957 billion dollars to India's GDP by the year 2035.
- In G20 Osaka Summit PM highlighted the significance of the Digital Economy & Artificial Intelligence.

US India Artificial Intelligence (USIAI) Initiative

- Initiative by Indo-U.S. Science and Technology Forum (IUSSTF).
- IUSSTF's USIAI Initiative main core idea is to focus on AI cooperation in critical areas that are important for both countries.
- Over the next year, IUSSTF will conduct a number of roundtables and workshops to collect input from different stakeholder communities.

Other Artificial Intelligence Initiatives by India

- Artificial Intelligence is being promoted through a network of 25 technology hubs under the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS).

National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS)

- NM-ICPS is to be implemented by the Department of Science & Technology for a period of five years. It covers entire India. Cyber-physical systems combine sensing, computation, networking and into physical objects and infrastructure and later connect them to the Internet and to each other.

Digital technology: Digital technology refers to the use of advanced information and communication technology to collect, analyze and share physical information and market information in each link of the product value chain, providing important technical support for innovation in various fields.

Semiconductors

- A semiconductor material can be defined as a device having electrical conductivity value falling between an insulator (such as glass) and a conductor (such as metallic copper) . It has Lattice structure and its atomic structure decide whether a particular material will be insulator, semiconductor or metal.

- On the basis of material:
 - Elemental semiconductors: Silicon (Si) and (Ge)
 - Compound semiconductors:

Wide Bandgap Semiconductor

- They are semiconductor materials which have a larger band gap than conventional semiconductors. Conventional semiconductors like silicon have a bandgap in the range of 1-1.5 eV (silicon and gallium arsenide), whereas wide-bandgap materials have bandgaps in the range above 2 eV. Examples of wide-bandgap semiconductors: Boron nitride, Diamond, Zinc, Gallium nitride, Zinc Oxide, Tin dioxide, Aluminium phosphide, Cadmium sulfide, Silicon carbide

Benefits of Wide Bandgap Semiconductors

- Devices can operate at higher temperatures of the order of 300°C.
 - Higher temperature tolerance allows these devices to operate at much higher power levels.
- Applications:** They are key components to make green and blue LEDs and lasers, certain radio frequency applications notably military radars.

Gallium Nitride

- It is a very hard, mechanically stable widegap bandgap semiconductor. It was commonly used in blue light-emitting diodes since the 1990s.
- Ministry of Electronics and IT (Meity) and IISc have jointly established GaN based Development Line Foundry facility called Gallium Nitride Ecosystem Enabling Centre and Incubator (GEECI), especially for radio frequency and power applications, including strategic applications.

Benefits of Gallium Nitride

- Higher breakdown strength
- Faster switching speed leading to faster devices
- Higher thermal conductivity
- Lower on-resistance giving lower conductance losses
- Less power needed to drive the circuit
- Ability to make smaller devices taking up less space on the printed circuit board
- Lower cost

Optical Fibre

Optical fibre is the backbone of digital infrastructure. In this technology data is transmitted with the help of light pulses that are travelling through long strands of thin fibre. In optical fibre communication metal wires are preferred as signals travel with fewer damages. It works on the principle of total internal reflection (TIR).

WEB 3.0

- Web 3.0 is the new version of internet in which services will run on blockchain.
- It is a form of decentralized internet that runs on a public blockchain.

Comparison between Web 1.0, 2.0 and 3.0

Web 1.0	Web 2.0	Web 3.0
Basic web pages	Social media	Semantic Web
Html	User generated content	dApps
Ecommerce	Mobile Access	Users Monetize data
Java and Javascript	High quality camera and Video	NFTs
	Apps	VR and AR
	High speed communication	Artificial Intelligence
	Global Internet Access	Interoperability

Quantum Computing

- Quantum computer runs on the laws of quantum physics as opposed to the classical computers (i.e., phones and laptops), which run on classical physics like Newton's laws of motion and utilising the flow of electricity.
- They are based on Qubits as compared to transistors on which traditional computers are based. Qubits can stay in three states (1,0 and intermediate undefined stage) while traditional bits are based on two states (0,1). This allows Quantum computers to solve complex problems which traditional computers have failed.
- The main properties of quantum computing are superposition, entanglement, and interference.
- The quantum computer was posited by Richard Feynman.

Quantum Dots

- It is a nanoparticle made of any semiconductor material such as silicon, cadmium selenide, cadmium sulfide, or indium arsenide.
- "Quantum dots" are more than 90% effective at wiping out antibiotic-resistant germs like Salmonella, E. coli and Staphylococcus.

Cyber Security Threat

India has been victim to the Cyber-attacks number of times in the recent past:

- 2017: WannaCry and Petya Ransomware
- 2018: Aadhaar Software hacked and Aadhaar details of the people leaked online.

Tools of Cyber Attacks

Malware: Malicious software to disrupt computers. It can include Virus, Spyware, Trojans etc.

Types of Malwares

- **Virus:** It is the most common type of malware. It can execute itself and spread by infecting other programs or files.
- **Stuxnet:** Malware that targeted Iranian nuclear enrichment facilities.

- **Worm:** It is a type of malware that can self-replicate without a host program. Worms typically spread without any human interaction or directives from the malware authors.
- **Trojan:** It is a malicious program that is designed to appear as a legitimate program. After activation following installation, Trojans will execute their malicious functions.
- **Xafecopy:** It is a Trojan Malware.
- **Spyware:** It is a kind of malware that is designed to collect information and data on users and observe their activity without users' knowledge.
- **Pegasus:** It is a spyware developed by the Israeli cyber arms firm NSO Group Technologies. It uses exploit links, clicking on which installs Pegasus on the target's phone.
- **Ransomware:** It is malicious software that is injected into the computer to limit the access of the system to the user and encrypt the data. Cyber criminals demand money in lieu of encryption key (that would unlock all the data and restore the access to the system). Nowadays, ransom is demanded in terms of Bitcoins. Examples - WannaCry Ransomware, Locky Ransomware etc
- **Phishing:** It is the method of trying to gather personal information using deceptive e-mails and websites.
- **Denial of Service attacks:** A Denial-of-Service (DoS) attack is an attack meant to shut down a machine or network, making it inaccessible to its intended users.
- **Crypto jacking:** Cryptocurrencies are created through a process called mining. To mine digital coins, miners need to use high-end processors that consume a lot of electricity.

HACKTIVISM Misusing a computer system or network for a socially or politically motivated reason. For example, the hackers can block access to Government's website, deface government's website or unblock the sites which have been blocked by the Government.

Social Engineering: Entice users to provide confidential information.

Advanced Persistent Threat: It is a type of cyber-attack in which an unauthorized user gains access to a system or network and remains there for an extended period without being detected. They generally do not cause damage to company networks or hardware. Instead, they are focused on stealing data.

Mobile Network

- Mobile phones communicate through ground-based cellular networks. Cellular networks are divided into 'communication cells' with which our mobile phones and mobile devices communicate.
- Mobile communication involves transmitting voice or data using wireless radio transmission.
- The first mobile systems were based on analogue transmission called as 1G.
- The second-generation mobile systems were based on digital transmission.
- Initially only voice was carried over the network.

- The commonly used standards for voice communication were GSM and CDMA.
- These days, most mobile communications use Long Term Evolution communication- or LTE which allows us to communicate with voice and data simultaneously over the same network.
- The rules for carrying voice or data in a network are defined under the standards for mobile network communications often seen as 2G, 3G, 4G and 5G.

1G : Mobile phones began with 1G technology in the 1980s. 1G is analog technology that supported only voice communications. The maximum speed is 2.4 Kbps

2G : 2G telephone introduced call and text encryption, SMS, picture messages, and MMS. Maximum speed under 2G networks with General Packet Radio Service (GPRS) was 50 kilobits per second. Launched in 2000 . General Packet Radio Service enabled mobile devices to send and receive e-mails and pictures. GPRS had operating speeds of up to 115kbit/s.

3G: The introduction of 3G networks in 1998 ushered in faster data-transmission speeds. Maximum speed of 3G is estimated to be around 2 Mbps for non-moving devices and 384 Kbps in moving vehicles.

4G: 4G uses LTE which allows us to communicate with voice and data simultaneously over the same network. Applications include amended mobile web access, IP telephony, gaming services, high-definition mobile TV, video conferencing, 3D television, and cloud computing. The max speed of a 4G network when the device is moving is 100 Mbps or 1 Gbps for low mobility communication like when stationary or walking.

5G: 5G is the next generation cellular technology that will provide faster and more reliable communication with ultra-low latency (Latency is gap time or transmission time for a packet of data). As per government panel report with 5G data speed would be 2-20 Gbps.

- **6G:** it is the successor to 5G cellular technology. It will use higher frequencies than 5G networks and will provide higher capacity and much lower latency (delay). One of the main goals of 6G internet will be to support one microsecond-latency communication. It will utilize the terahertz band of frequency which is currently not utilized.

2. Communication Technologies

Internet

- Internet is a system architecture that act as a revolution in communications and methods of commerce by allowing almost all of computer networks around the world to interconnect.

Wi-Fi

It is a networking technology that uses radio waves to provide high-speed data transfer over short distances. Wi-Fi help Local Area Networks (LANs) to operate without

wiring and cables. Wi-Fi allows wireless broadband Internet access for many modern devices, such as computers, smartphones, laptops and electronic gaming consoles.

Li-Fi

Li-Fi, or light fidelity, invented by German physicist Harald Haas, is a wireless technology which makes use of visible light instead radio waves to transmit data at terabits per second speeds that is much more than 100 times the speed of Wi-Fi. Here, data is fed into an LED light bulb and then sends data at high speeds to the photo-detector (photodiode).

Advantages

- Higher data transfer
- Multiple devices can connect
- More secure than Wi-Fi
- Green technology
- Consumes less power

Limitations of Li-Fi:

- Light cannot pass through opaque object.
- Require lightbulb is on at all times
- External interference
- High installation cost

Space Internet

- The internet is sent down from a satellite circling the Earth using this technique.
- Thousands of these satellites will be sent into space by Jio, Bharti Airtel's OneWeb, and billionaire Elon Musk's Starlink.
- OneWeb intends to launch 648 satellites, whilst Starlink has permission to launch 4,000.

3. Emerging Technology

Crypto Currency

- **Cryptocurrency:** Cryptocurrency is a digital currency. Cryptocurrency is an alternative form of payment created and using encryption algorithms. Cryptocurrency also known as digital currency or virtual currency. It has become the first digital asset to be widely accepted as a legitimate form of payment online and offline across the globe.
- The best-known cryptocurrency today is Bitcoin. Cryptocurrency was invented by an unknown person or group named Satoshi Nakamoto in 2008. The Central African Republic became the second country after El Salvador (country in central America) to adopt Bitcoin as legal tender.
- European Central Bank defined virtual currency as "a type of unregulated, digital money, which is issued and usually controlled by its developers, and used and accepted among the members of a specific virtual community. Examples of such currencies are Bitcoin, Ethereum, Dogecoin, Ripple, and Libra (of facebook) etc.
- All such currencies take help of Blockchain technology in their operation.

Issues with Cryptocurrencies

- Cryptocurrencies need to be continuously mined. Mining is a very energy intensive process that consumes lot of power.
- Cryptocurrencies are often subject to theft and cybercrimes.
- Beyond the remit of sovereign governments, they can be misused as there is lack of agency and regulations.
- Can be used by terrorist, drugs mafia etc.

Benefits of Cryptocurrencies

- Easy convertability from one currency to another.
- Cannot be subject to hacking. Leads to financial innovation etc.

Non-Fungible Tokens (NFT)

- NFTs are unique cryptographic tokens that exist on a blockchain and cannot be replicated.
- NFTs can be used to represent real-world items like artwork and real estate.
- 'Tokenizing' these real-world tangible assets allows them to be bought, sold, and traded more efficiently while reducing the probability of fraud.
- NFTs can also be used to represent peoples' identities, property rights, and more.

Government Instant Messaging System (GIMS)

- It is an Indian equivalent of popular messaging platforms, such as WhatsApp and Telegram, for secure internal use.
- Designed and developed by National Informatics Centre (NIC).
- It is being packaged for employees of Central and state government departments and organisations for intra and inter organisation communications.
- It is being developed as a secure Indian alternative without the security concerns attached with apps hosted abroad or those owned by foreign entities.
- Like WhatsApp, GIMS employs end-to-end encryption for one-to-one messaging.

Sycamore

- Google announced that it had reached quantum supremacy and made quantum computer called Sycamore.

Quantum Supremacy: It refers to a problem-solving process by the quantum computer that cannot be solved by a classical computer in its normal lifetime.

Deepnet and Darknet

Internet has three layers:

- The first layer is publicly accessible. It consists of sites that one uses frequently like social networking sites, e-commerce sites etc. This layer makes up only around 4% of the entire internet.
- The second layer, the deep web, is a network where data is stored in databases that cannot be accessed through traditional search engines like Google. It is used to provide access to a specific group of people.

- The data is generally sensitive and private (government private data, bank data, cloud data etc), so kept out of reach.
- The third layer is the darknet which is also known as a part of the 'Deep Web'. It is a network built over the internet which is encrypted.
- It is basically a layer of the Internet accessible only by using special software like Tor or I2P (Invisible Internet Project).
- Anything present on the dark web will not be pulled up in internet searches, thereby offering a high degree of anonymity.

QR CODE

- QR Code stands for Quick Response Code. Main purpose of development was to create a code that could be read quickly.

RFID Technology

- Radio Frequency Identification (RFID) refers to a wireless system having two components: tags and readers.
- Reader is a device that has one or more than one antennas that emit radio waves and later receive signals back from the RFID tag.
- Tags, which use radio waves to communicate their identity and other information to nearby readers, can be passive or active. Passive RFID tags do not have battery and are powered by the reader. Active RFID tags are powered by batteries.
- RFID tags can store a large amount of information from one serial number to several pages of data.
- Reader systems can be built into the architecture of a cabinet, room, or building.
- Edge computing enables data to be analyzed, processed, and transferred at the edge of a network – where things and people produce or consume that information.
- It brings computation and data storage closer to the devices where it's being gathered, rather than relying on a central location that can be thousands of miles away.

What are Blockchains?

- They are a new and modern data structure that is secure, based on cryptography, and distributed across a particular network. The technology supports cryptocurrencies such as Bitcoin, and the transfer of any data or digital asset.
- Blockchains are based on distributed nodes, allowing the transfer of digital goods and services without the need for centralized authorization of transactions.
- It is an extension of real world into the digital ecosystem and provide an immersive multi-user experience for anyone whoever accessing it around the globe. We need Internet and Digital Device to access virtual world. The technology that is behind this is called Virtual Reality (VR) and Augmented Reality (AR).

Facial Recognition Technology

- Facial recognition is an algorithm-based technology which provides a digital map of the face by mapping and identifying an individual's facial features and then matches it against the database to which it has access. In the Automated Facial Recognition System (AFRS), the big database (having photos and videos of peoples' faces) is used to identify and match the person.

AI System to Diagnose Zika

- Scientists have developed an artificial intelligence system that can accurately diagnosed Zika virus and several other viral bacterial and even genetic diseases from the patient's blood. The platform developed by scientists at the University of Campinas in Brazil, can identify tens of thousands of molecules present in blood serum with an artificial intelligence algorithm.

AI Powered News Anchor

- The world's first artificial intelligence (AI) news anchor has made "his" debut at the fifth World Internet Conference in east China's Zhejiang province. AI is a way of making a machine or a software 'think' and 'demonstrate' intelligently in a manner similar to humans. The AI anchor learns from live broadcasting videos by himself and can read texts as naturally as a professional news anchor.

4. Internet of Things

It is a seamless connected network of embedded objects/devices having identifiers, in which Machine to Machine (M2M) communication is possible without any human intervention by using standard and interoperable communication protocols

LoRa/LoRaWAN: It uses linear frequency modulation in the unlicensed frequency range in sub 1 ghz band. LoRa stands for Low Power, Wide Area networking protocol designed to wirelessly connect battery operating 'things'.

Near Field Communication: It is a communication protocol that enables communication between two electronic devices over a distance of 4 cm or less. It offers a low speed connection. It is based on inductive coupling between two antennas.

Zigbee: It is a communication technology used to create personal area networks with small, low power digital radios such as home automation, medical device data collection and low power low bandwidth needs, designed for small scale projects.

Sigfox: It is a standards-based low power wide area (LPWA) technology developed to enable a wide range of new IoT devices and services.

WiFi 6.0

- Next generation standard in WiFi technology. Also known as "AX WiFi"
- It was built for in response to the growing number of devices in the world of IoT (Internet of Things) due to faster data transmission rates.

Wi-Fi Certified 6 Networks Ensure

- Each connected device performs at an optimum level, in locations with hundreds or thousands of connected devices.
- Highest standards for security and interoperability.
- Lower battery consumption.
- Increased bandwidth to deliver greater performance with lower latency.

National Supercomputing Mission

- Jointly steered by MEITY and Department of Science and Technology (DST).
- Being implemented by CDAC and IISc with the objective of creation of state of art High Performance Computing facilities and infrastructure to enhance the national capability to enable cutting edge research in various domains in solving grand challenge problems.

Phase III will focus on increasing the indigenous content in supercomputers.

- **Param Shivay:** First supercomputer assembled indigenously. It is installed at IIT-BHU.
- **Param Shakti:** Indigenous, Installed at IIT Kharagpur
- **Param Brahma:** Indigenous, Installed at IISER, Pune
- **Param Shavak:** an affordable supercomputing solution in a box that aims to provide computational resource
- **Rudra:** Indigenous Server, which can meet HPC requirements of all government and PSUs. This is the first time that a server system was made in India, along with the full software stack developed by CDAC.

Trinetra

- It is the next generation indigenous HPC interconnect, being developed by CDAC.
- It will facilitate efficient inter-node communication between compute nodes under National Supercomputing Mission.

Shakti Processor Program

- India's first indigenously developed microprocessor that can be used in mobile computing, networking, wireless systems, and may be even for country's nuclear systems.
- Developed and booted by Indian Institute of Technology Madras.
- Note: India's first Indigenous Semiconductor Chips by Bengaluru based semiconductor company Signalchip for 4G/LTE and 5G.

Unit-3: Biotechnology

- Biotechnology is the set of techniques that are used to make or modify the products of living organisms, to improve plants' and animals' lives, and to develop useful microorganisms.
- In modern terms, biotechnology has come to mean the use of cell and tissue culture, cell fusion, molecular

biology, and in particular, recombinant deoxyribonucleic acid (DNA) technology (RDT) to generate unique organisms with new trait/s or organisms that have the potential to produce specific products.

1. Basics of Genetic Engineering**Fighting Infectious Diseases**

Biotechnology is used extensively in the study of emerging and existing infectious diseases. These are diseases as follows:

- New and previously unrecognized, such as SARS (Severe Acute Respiratory Syndrome) and COVID-19
- Known diseases that have increased in number and spread over the past three decades, such as foot-and-mouth disease and many others.
- Diseases that threaten to increase in severity and occurrence in the near future, such as influenza.

Antibiotics

- Antibiotics are natural or chemical substances that can be used to fight bacterial infections.
- They are produced and secreted naturally by bacteria and fungi.
- Biotechnology is used to produce them in such quantities and forms that allow safe administration to people suffering from microbial infections.

Reproductive Technologies

- Reproductive technologies have undergone a fast evolution.
- **In Vitro Fertilization:** In vitro fertilization (IVF) has collection of healthy ovum and sperms from healthy mother and father, respectively, and fusing them under appropriate conditions in lab. If fertilization happens, the resulting embryo is then transferred into the woman's uterus, where it will implant in the lining of the uterus and develop into a organism.
- **Embryo Transfer Technology:** It is a procedure by which a young embryo is taken from donor mother and transferred to recipient mother or from test tube (IVF) to the recipient mother. The perfect stage for transfer is 2- to 4-cell stage.
- **Cloning:** Cloning is the production of same looking animals, plants or single individual. A clone is defines as exact copy or copies of a single parent. Monozygotic identical twins are clones.
- 'Dolly,' the sheep, was a clone. Dolly was produced from a single cell from microorganisms taken from her mother. She had same genetic characteristics as her mother, the single parent.
- **Artificial Wombs:** Artificial wombs technique could be used to help premature or 'sick' human babies to survive longer and help foetus in the final stages of multiple pregnancies. The temperature is kept at constant. A machine pumps nutrients and oxygen into the baby's blood and help to grow.

Artificial Insemination: Artificial insemination is the artificial introduction of semen into the reproductive tract of a recipient female. Semen collected from a donor

male with desirable hereditary characters can be frozen and later transported through long distances to fertilize females.

Gamete Intra-transfer (GIFT): GIFT begins with ovulation induction same as in IVF followed by egg retrieval, insemination and gamete transfer. Sperms and eggs are mixed and injected into the fallopian tubes of a woman. The fertilization takes place there as it does naturally happens.

2. Application of Biotechnology

Nucleic acids – DNA and RNA | Recombinant DNA

Genetic Engineering

- Nucleus have thread-like structures called chromosomes.
- They are long continuous molecule of DNA.
- These chromosomes carry genes.
- Genes help in inheritance or transfer of characters from the parents to their children.
- The chromosomes can be seen only when the cell divides during M phase.
- Gene is a unit of inheritance in all living organisms.
- **Chromatin:** A entangled mass of thread of DNA, visible when cell is not dividing.
- **Nucleosome:** Fundamental subunit of chromatin. It is having less than two turns of DNA and eight proteins called histones.

Chromosomes

- Chromatin material gets organized into chromosomes during division.
- Rod-shaped structures.
- Contains DNA and Protein.
- Functional units of DNA are called genes.

Nucleotide and Nucleoside

- **Nucleoside:** Heterocyclic Rings and Ribose Sugar
- **Nucleotides:** Heterocyclic Rings, Ribose Sugar and a phosphate group

Nucleic Acids

- Made up of nucleotides.
- Polymers of nucleotides.
- Also known as polynucleotides.
- Nucleotides are joined to each another by covalent bonds between the sugar and phosphate.
- Form Sugar- Phosphate backbone.
- The heterocyclic compounds nitrogenous bases.
- Adenine, Guanine, Uracil, Cytosine, and Thymine.
- Adenine is paired with Thymine with double bond while Guanine is paired with cytosine with triple bond.

DNA and RNA

- DNA is the chemical basis of heredity.
- DNA have the coded message for proteins to be synthesized in the cell.
- Three types of RNA — mRNA, rRNA and tRNA.
- mRNA is used to convey genetic information.
- DNA is the chemical basis of heredity.
- DNA is exclusively responsible for maintaining the identity.

S.No.	DNA	RNA
1.	Sugar moiety is Deoxy ribose	Sugar Moiety is Ribose
2.	The bases present are Adenine, Thymine, Guanine and Cytosine. Uracil is not present.	The bases present are Adenine, Uracil, Guanine and Cytosine. Thymine is rarely present.
3.	Double stranded molecules	Single stranded molecules
4.	Obeys Chargaff's rule	Does not obey Chargaff's rule
5.	Bases are not modified	Bases are modified
6.	It is stable and not hydrolysed easily by alkalis	It is unstable and hydrolysed easily by alkalis
7.	It is stable and not hydrolysed easily by alkalis	Varies from cell to cell.
8.	The life time of DNA is comparatively high.	RNA is short lived.
9.	No natural DNA is catalytic	RNA is short lived.
10.	Present in the nucleus, mitochondria and chloroplast	Present in the nucleus, mitochondria, nucleolus, ribosomes and cytosol.

DNA Fingerprinting

- Every individual has unique fingertips.
- But these can be altered by surgery.
- Sequence of bases is unique in everybody's DNA.
- These are known as DNA Fingerprints, these cannot be changed by ant treatment.

Genetic Engineering

- We can modify DNA of bacteria, plants and animals to add genetic information and genes from a different organism of a different species.
- It involves joining of two different types of DNA to form a new DNA also known as Recombinant DNA.

Process of Genetic Engineering

- **Red Biotechnology:** Red biotechnology is applied to medical processes. For Example antibiotics.
- **White Biotechnology:** White biotechnology, also known as grey biotechnology, is the biotechnology applied to industrial processes.
- **Green Biotechnology:** Green biotechnology is the biotechnology applied to agricultural processes.
- **Bioinformatics:** Bioinformatics is an interdisciplinary field which addresses biological problems using computational techniques.

- **Blue Biotechnology:** The term 'blue biotechnology' has also been used to describe the marine and aquatic applications of biotechnology.

Biotechnology in India

- The Department of Biotechnology manages most of the programmes of biotechnology sector in India. It is under the Ministry of Science and Technology.
- The GEAC functions under the Ministry of Environment, Forest and Climate Change (MoEF&CC). It is responsible for the appraisal of activities involving.
 - Large-scale use of hazardous microorganisms and recombinants.
 - Release of genetically engineered (GE) organisms.
- Contribution of India in various Branches of Biotechnology.

Agriculture Biotechnology

- Two new rice varieties released are improved Pusa Basmati, improved Samba Mahsuri.
- Heat stress tolerant wheat
- Bunchy top virus resistant banana
- Charcoal-resistant sorghum
- *Fusarium wilt* resistant pigeonpea
- Low-phytate maize

Plant Biotechnology

- Sequence of chromosome-5 of tomato.
- Molecular marker based breeding programme was initiated in Eucalyptus.
- An ex-situ germplasm bank for conservation of important medicinal and aromatic plants of Manipur hills.

Animal Biotechnology

- Embryo transfer technology and its role in productivity enhancement in cattle.

Biofilters: Use of microbial stripping columns to treat.

- Production of cloned buffalo embryos using somatic cell nuclear transfer technique

Polymerase chain reaction, or PCR, is a method to make many copies of a DNA region in vitro or in a lab.

It is based on a thermostable DNA polymerase, Taq polymerase.

The basic steps are:

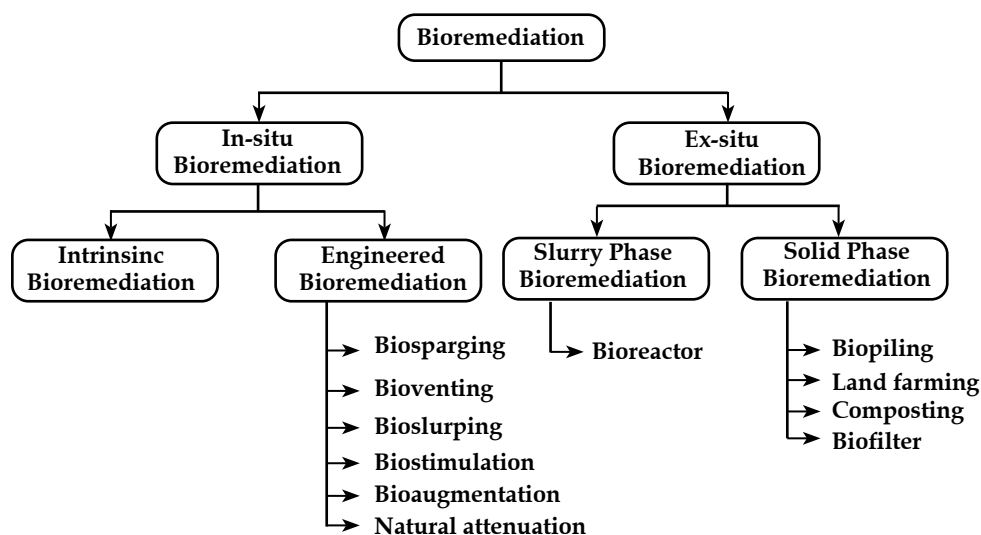
- **Denaturation** (96°): Heat the reaction strongly to denature, the DNA strands.
- **Annealing** (55- 65°C°): Cool the reaction to bind primers.
- **Extension** (72°C): Increase the reaction temperatures so Taq polymerase can act and produce new strands of DNA

RT-PCR

It is a variation of PCR, or polymerase chain reaction. RT-PCR has an added step of reverse transcription of RNA to DNA, or RT, to allow for amplification

Applications of RT-PCR:

- 'Remediate' means to solve a problem and 'bio-remediate' means to use biological organisms to solve an environmental problem, such as contaminated soil or ground water.
- These biological organisms can be bacteria, fungi and green plants, for example, clean-up of oil spills by addition of bacteria.
- **Ex-situ technique:** Physical removal of the contaminated material and transportation to another area for treatment.
- **In-situ technique:** It defines as treatment of contaminated material in place.
- **Bioaugmentation:** Addition of bacterial cultures to a contaminated medium.



Biosparging: The injection of air under pressure.

- **Biostimulation:** Stimulation of indigenous microbial populations in soils
- **Bioreactors:** Biodegradation in a container or reactor.

- **Bioventing:** Drawing oxygen through the soil to stimulate microbial growth and activity.
- **Composting:** Aerobic, thermophilic treatment process.

Biosensor

Biosensor is an analytical device consisting of a

- biocatalyst (enzyme, cell or tissue), immobilized in gel.
- A transducer which can convert a biological or biochemical signal into electrical signal
- Biological recognition system that can be microbial cell or an enzyme, antibody, hormone or nucleic acid.

A biomarker is anything that can be used as an indicator of a particular disease state. Biomarker is a measurable indicator of the severity of some disease.

- Stem cells have a very good capability to develop into many different cell types present in the body.
- They serve as a sort of repair system for the body
- They can divide almost without limit to replenish and repair other cells up to the time the animal or a person is still alive.
- When a stem cell divides, each new cell has the capacity to either be a stem cell or it can become another type of cell with a more specialized function, like a muscle cell, a red blood cell, or a brain cell or any other cell.
- Stem cells have two important features that distinguish these cells from other types of cells.
 - They are most unspecialized cells that can renew themselves for very long periods through cell division and replication.
 - The second is that under certain experimental or conditions, they can be stimulated to become cells with special functions such as the heart beating cells of the heart muscle cells or the insulin-producing cells of the pancreas or any other kind.

Genetically Modified Organism

A genetically modified organism (GMO) is an organism whose genetic material has been altered or changed using techniques of genetics generally known as recombinant DNA technology.

Genetically Modified (GM) Food: Benefits and Controversies

Benefits

Animals

- Increased resistance productivity, hardiness, and feed efficiency
- Better yields of meat, eggs and milk
- Improved animal health and diagnostic methods

Environment

- 'Friendly' bioherbicides and bioinsecticides

Bt Cotton

- Bt cotton is a genetically modified cotton variety.
- It produces insecticides against insects like bollworms.
- It is effective against plant bugs, stink bugs and aphids.
- It was first approved for field trials in 1993 in US.
- Came for commercial use in 1995 in US.
- Chinese gov. approved it in 1997.
- In 2002, a joint venture between MONSANTO and MAHYCO introduced Bt cotton to India.

Controversies

- Safety
- Access and Intellectual Property
- Ethics
- Labelling
- Society

Bacillus thuringiensis (BT) is a spare farming bacterium that produces crystals protein (cry proteins) which are toxic to many species of insects. It leads to production of Bt Cotton.

Human Genome

It refers to entire genetic makeup of human beings or total DNA content of an organism.

The human genome is the genome of *Homo sapiens*, which is having 24 distinct chromosomes (22 autosomal + X + Y) with a total of approximately 3 billion DNA base pairs. Human genome contains estimated 20,000-25,000 genes.

HGP is an international effort to identify and locate and map all the genes and their variants to understand their functioning and write down the sequence of nucleotides that are contained in the gene so that it can be used by everyone.

Gene Therapy

When genes are altered or changed so that the encoded proteins are unable to carry out their normal functions, it can result to genetic disorders. Gene therapy is a technique for correcting and solving this problem of defective genes that are responsible for disease development. Researchers may use one of several approaches for correcting faulty genes and curing diseases.

Plant Tissue Culture

It is a technique of growing tissues or cells of multicellular organisms or plants in an artificial environment. Tissue culture is the process whereby small pieces of living plant tissues (explants) are taken from a plant and grown on a semidefined or defined nutrient medium in controlled and managed environmental conditions. This is also known as micro propagation. Explants can include from large seedlings to small single cells and protoplasts, roots, stems, leaves or anything from plant.

Bioprospecting

- Bioprospecting can be defined as using the genetic diversity in the ecosystems of the earth for producing new drugs and new crops and benefit to humans. But of late this has become unscrupulous and reckless hunt for plant and animal genes in developing countries for new products and steals that out of the country without giving due benefits.

Bio-Piracy

- Though bioprospecting has the potential of putting earth's bio-assets and materials to human use but this can lead to exploitation of poorer nations, who are rich in bio-assets but poor in technology and expertise to use them.
- Bioprospecting is being equated with a new form of imperialism practiced by multinational companies and rich nations.
- Bio-pesticides

These are cultured microorganisms or organic products that biologically control chemicals. They destroy the pests that cause damage to plants.

Industrial Biotechnology

Disadvantages of Chemical Pesticides

- Development of resistance by insects to insecticides.
- Elimination of a host of friendly insects honey bees, nitrogen-fixing bacteria, pollinators etc.
- Accumulation of pesticide residue in the food, feed and fodder cause health hazards.
- In the absence of natural enemies certain pests grow with renewed vigour and immunity, e.g., snakes killed by pesticides but rodents will increase in number.

Examples of Bio-pesticides

- *Lysinibacillus sphaericus*: Kill mosquito vectors
- *Paenibacillus popilliae*: Infect larvae of Japanese beetle
- Granulosis Virus: Control hornworms in Cassava plants.

CRISPR

- Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) is a gene editing and modification technology.
- It mimics natural defence mechanism in bacteria to fight against virus attacks with the help of a special protein called Cas9.
- It usually has the introduction of a new gene, or suppression of an existing gene, by genetic engineering.
- An unwanted fragment in the DNA sequence, which can be the cause of disease or disorder, is identified, cut, and later removed and replaced with a 'correct' or wanted sequence.
- The process and equipments used to achieve this are biochemical that can be specific protein and RNA molecules.

DNA editing

A DNA editing technique, called CRISPR/Cas9, works like a biological version of a word-processing programmes "find and replace function.

HOW THE TECHNIQUE WORKS

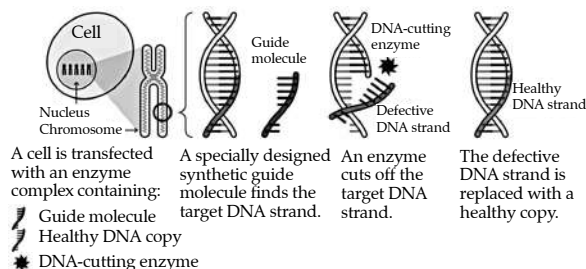


Figure: DNA Editing

Genetic Modification

Synthetic Biology

- The term 'synthetic biology' was first time coined by Barbara Hobomin in 1980.
- It can be defined as bacteria that had been genetically modified using recombinant DNA technology.

- Synthetic biology is known as science of using genetic sequencing, genetic editing, and changes to produce unnatural organisms or other organic molecules that can function properly in living systems.
- Synthetic biology helps scientists to design and produce new sequences of DNA from scratch in fresh way.

Applications of Synthetic Biology

- Standardised Biological Parts
- Applied Protein Design
- Natural Product Synthesis
- Synthetic Genomics

Negative Impacts of Synthetic Biology

- Negative Environmental Health
- Do-It-Yourself Biology.
- Ethical Concerns

Cloning

- Cloning is the process of producing an 'identical copy of an original organism.
- A cloning therefore is a single cell like a bacteria or a multicellular organism that has been directly copied.
- It is genetically identical to another living organism.
- Recombinant DNA Technology or DNA Cloning
- The terms 'recombinant DNA technology, 'gene cloning,' or 'DNA cloning' 'molecular cloning' all refer to the same process that involves the transfer of a DNA part of interest from one organism to a self-replicating genetic element or vector, such as a bacterial plasmid.

Reproductive Cloning

- Reproductive cloning is a technology used to generate an animal that has the similar nuclear DNA as another currently or previously existing animal.
- Dolly was created by same reproductive cloning technology.

Therapeutic Cloning

- Therapeutic cloning, also known as 'embryo cloning,' is the production of human embryos for use in research and development. The major goal of this process is not to create cloned human beings or animals, but to harvest stem cells that can be used further to study human development and to treat disease that can help in medical advancements.

Risks of Cloning

- Reproductive cloning is expensive
- Highly inefficient.
- Cloned animals have compromised immune function
- Higher rates of tumour growth, infection, and other disorders.
- Clones have been known to die mysteriously without any reason.

Application of Biotechnology

Cultured micro-organisms that enrich the soil with nutrients function as bio-fertilizers. It can be certain strains of bacteria, algae or fungi.