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Preface Science & Technology

Dear Learner,

Scientific temper and curiosity towards developments in Science & Technology have been incorporated in the syllabus of UPSC civil service exams so that civil servants have basic understanding of technologies which they will regulate and also help rational development of these technologies for solving problems of citizens efficiently. Emphasis on scientific temper has meant that India has been a leader in Space technology, nuclear technology, Information Technology etc.

In recent years, the weightage of questions in science and technology have been increasing with close to 10% of questions coming from science related topics in Prelims Exam. The nature of questions have also been evolving with more questions testing students on their fundamental understanding of scientific developments.

In this book, our effort has been to target topics which have been in news recently and also those topics which UPSC can ask based on our analysis of past UPSC papers.

Hope the book helps you achieve your dreams.

All the best!!!

Rau's IAS Study Circle

Themes asked in Prelims Exam in the last Three Years

SCIENCE & TECHNOLOGY		
PRELIMS 2021 - TOPICS	**PRELIMS 2020 - TOPICS**	**PRELIMS 2019 - TOPICS**
1. Recombinant Vector Vaccine	1. Carbon Nanotubes	1. LTE vs VoLTE
2. Bollgard I and II - BT cotton	2. Drone technology	2. Augmented Reality vs Virtual reality
3. Pressure Cooker	3. Evolved - LISA	3. Denisovan
4. Water properties - Dipolar	4. Gene editing	4. DNA technology
5. ACE2	5. Pneumococcal Vaccine	5. Digital signature
6. Bisphenol	6. Plant vs Human cells	6. Wearable technology
7. Astronomical distances in light Years.	7. Pronuclear transfer technology	7. 'RNA interference (RNAi)' technology
8. Bacteria , Virus and Fungi - Cultured in Artificial Medium	8. Artificial Intelligence	8. Gravitational waves
9.. Adenoviruses	9. "Visible Light Communication" technology	9. multi-drug resistance in microbial pathogens
	10. Blockchain technology	10. Crisper Cas 9
	11. Solar power Pumps	11. Hepatitis
		12. Remote sensing

SPACE TECHNOLOGY

SPEED TEST – 1

i. Geostationary Satellite is a special form of Geo-synchronous Satellite

ii. Sun-synchronous satellites pass over a section of the earth at the same time every day

iii. Working of rocket engine is guided by Newton's third law of motion

iv. Satellites launched by PSLV appear to remain permanently fixed in the same position in the sky, as viewed from a particular location on Earth.

v. GSLV is a 4-stage that uses alternate combination of liquid and solid fueled rocket stages.

vi. The indigenous cryogenic stage on the GSLV is the third stage and uses liquid hydrogen as fuel and liquid oxygen as oxidiser.

SPACE TECHNOLOGY

►ORBITS & TYPES

- Satellites are generally characterized by their orbit i.e., distance from earth at which they revolve around Earth. They are:

1. LEO Satellite (Lower Earth Orbit)
2. MEO Satellite (Middle Earth Orbit)
3. GEO satellite (Geo-Synchronous Earth Orbit & Geo-Stationary Earth Orbit)

- Geo-synchronous satellite is at 35786 Km from earth's surface. This height allows satellite to revolve around Earth in 24 hours, the time Earth itself takes to complete one day. Hence a GEO satellite always returns to same position in sky after each day. When observed from Earth, a Geo-Synchronous Orbit appears to form "8" (eight).
- Geostationary Satellite is a special form of Geo-synchronous Satellite which orbits Earth over equator. This kind of satellite has a circular orbit around Earth. When observed from Earth, such satellite appear to be fixed or hung always. They provide continuous service over a large area.
- Orbits may also be classified into Polar & Equatorial.
- Polar orbits revolve Earth at an inclination close to 90 degrees close to poles. Such Orbits may be "sun-synchronous" too, which implies that these satellites pass over a section of Earth at same time every day.
- Equatorial orbits are closer to Equator. A satellite in this orbit can cover almost half of earth.

►GEOSTATIONARY TRANSFER ORBIT

- A geosynchronous/geostationary transfer orbit (GTO) is an elliptical orbit, with an apogee (high point) of 35,784 kilometres, a perigee (low point) of a few hundred kms. Its inclination is roughly equal to latitude of launch site.
- It is orbit into which a spacecraft is initially placed before being transferred to a geosynchronous or geostationary orbit.

→ ROCKET PROPULSION

- A rocket must clear 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 200km.
- At a certain initial speed, as satellite tries to go off at a tangent to Earth, the Earth's gravity pulls it back.

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 working of rocket engine, viz for every action, there is an equal and opposite reaction.
- The mass of gas escaping through a rocket's nozzle gives a push or commonly called thrust to rocket to fly in opposite direction.

→LAUNCH VEHICLES IN INDIA

►PSLV

- Polar Satellite Launch Vehicle is workhorse launch vehicle of ISRO since 1994. First Indian launch vehicle with liquid stage & first operational launch vehicle.
- PSLV is primarily developed to launch remote sensing satellites into sun synchronous orbits.
- It is a four-stage that uses alternate combination of liquid and solid fuelled rocket stages.
- First & third stages are solid fuelled, second & fourth stages are propelled by liquid fuel.
- Strap-on motors are used in first stage of PSLV (solid stage) to provide additional thrust to the rocket to overcome air resistance in atmosphere to be launched in orbit.
- PSLV can deliver payloads of up to:
  - 3,250kg to Low Earth Orbit
  - 1600 kg to Sun Synchronous orbit
  - 1400 kg to Geosynchronous Transfer Orbit

PSLV'S ACHIEVEMENTS AND ITS SIGNIFICANCE

- With its capability to put small satellites in Lower Earth Orbit (LEO), PSLV is key to Indian presence in Global space business.
- ISRO has launched 237 foreign satellites from 28 countries successfully by PSLV between 1999-2018.
- PSLV-C37 launched 104 satellites in 2017, highest number of satellites launched in a single flight so far.

PSLV VARIANTS

Currently PSLV rockets have 4 variants

- PSLV-CA (core alone)
- PSLV-XL – 6 strap-on motors
- PSLV-DL – 2 strap-on motors
- PSLV-QL- 4 strap-on motors

►NEW PSLV ROCKET

For launch of EOS-01, ISRO used a new variant of PSLV rocket which does not become waste after depositing its satellite in the orbit.

Instead, last stage of rocket that remains after satellite is separated, can acquire its own orbit and be used as an orbital platform for other onboard instruments to perform experiments in space. Thus, fourth stage acts like another satellite for a period of six months.

►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 first stage, liquid in second stage and cryogenic in third stage.

GSLV MK-III

- GSLV Mk-III is the most powerful rocket of 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 designated launch vehicle for Chandrayaan 2.
- 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 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 degree centigrade.
- Nearly 50% of power for GSLV rockets as they push into space comes from cryogenic stage. As a result, engines operating with cryogenic technology can lift heavier satellites.

►SEMI-CRYOGENIC PROPELLANT TANK

- First developmental welded hardware, the semi cryo liquid oxygen (LOX) tank, is part of the SC120 stage,

which is designed to replace the L110 stage in the current Mk-III launch vehicle.

- In 2020, HAL produced the world's largest cryogenic liquid hydrogen tank (C32LH2), with a diameter of 4 m and a length of 8 m, far ahead of time.
- For the PSLV, GSLVMk II, and GSLVMk III launch vehicles, HAL has provided essential structures, tankages, and satellite structures.

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.
- When compared to other propellants, such as solid and liquid propellant rocket engines, a cryogenic engine produces greater force per kg of cryogenic propellant used and is more efficient.
- Liquid Oxygen (LOX) and Liquid Hydrogen (LH2), which liquefy at -183°C and -253°C, respectively, are used as propellants in cryogenic engines. The LOX and LH2 are kept in separate tanks.

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.
- The rocket's thrust is increased by combining kerosene with liquid oxygen. Because refined kerosene takes up less room in a Semi Cryogenic engine's fuel container, more propellant may be carried.
- 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.
- The payload capacity - 500-700 kilograms in the Lower Earth Orbit (LEO) (less than one-third the weight the PLSV can carry.)
- It has three stage solid propulsion system, and like the PSLV and GSLV, can accommodate multiple satellites, albeit smaller ones.
- Unlike the PSLV and GSLV, the SSLV can be assembled both vertically and horizontally.
- The decision of the US to deregulate small and micro satellites has given a fillip to the launch service markets.
- The small satellite industry has witnessed a manifold spike in the last few years and with latest innovations in nanotechnology, the size of the satellites is expected to further decrease in the future. Further, what was previously inconceivable for even big satellites, is being undertaken very smoothly and efficiently now by small satellites.

►STARSHIP

- Designed by SpaceX, a spacecraft and super-heavy booster rocket meant to act as a reusable transportation system for crew and cargo to the Earth's orbit, Moon and Mars.
- Starship has been under development since 2012 and is a part of Space X's central mission to make interplanetary travel accessible and affordable and to become the first private company to do so.
- Reusability is at the heart of making interplanetary travel accessible. A rapidly reusable space launch vehicle could reduce the cost of traveling to space by a hundredfold.
- Starship can deliver satellites further and at lower marginal costs than SpaceX's Falcon vehicles and it can ferry both cargo and crew to the International Space Station (ISS).
- Beyond the Moon, the spacecraft is being designed for carrying crew and cargo for interplanetary missions as well.

►VIKAS ENGINE

- The Vikas engine is used in
  1. Second stage of the light lifting PSLV
  2. Second stage and the four add-on stages of the medium lift GSLV.

3. Twin-engine core liquid stage of Mk-III

- In 2018, Vikas engine was improved for higher thrust by 6%, enabling it to carry 70 kgs of additional payload.
- Vikas engine uses Di-Methyl Hydrazine as a fuel and Nitrogen tetroxide as oxidizer.

►LOX METHANE ENGINE

- Liquid Propulsion Systems Centre of ISRO is developing 2 LOX methane-powered rocket engines.
- The 'LOX methane' engine uses methane as fuel and liquid oxygen as oxidizer.

ADVANTAGES

- Can be synthesized in space (Methane can be synthesised using water and carbon dioxide in space).
- It is non-toxic. (Di-Methyl Hydrazine and Nitrogen tetroxide is said to be highly toxic)
- Higher specific impulse.
- Easy to store; Does not leave a residue upon combustion; Less bulky

►ION ROCKETS

- Ion rockets are the rockets of the future for deep space exploration.
- They are much more efficient that conventional rockets that use chemical fuels.
- While chemical fuels generate velocities of up to 2 to 3 km/s, ion rockets can achieve velocities of about 4400 km/s.
- Ion rockets use electric repulsion of ions to propel the rockets.
- Small scale ion propulsion is used in several missions including NASA's Dawn mission and Deep Space mission, ESA's LISA Pathfinder and BepiColombo and Japan's Hayabusa Mission.

SPEED TEST – 1: SOLUTION

(i)-True; (ii)-True; (iii)-True; (iv)-False; (v)-False; (vi)-True

SATELLITE SYSTEMS OF INDIA

SPEED TEST – 2

i. Communication satellites are launched in Geo-synchronous orbit at an altitude of about 36,000 km.
ii. Ka band is used typically for consumer direct-to-home, tele-education applications.
iii. Indian Remote Sensing satellites can be used for telecommunications.
iv. Remote sensing data can be used for detection of Greenhouse gas emissions from rice paddies of a specific location.
v. Most earth observation satellites are in sun-synchronous orbit.
vi. Geostationary orbit allows uninterrupted coverage of more than 1/3 of the Earth.
vii. Amazonia-1 is an earth observation satellite of Brazil to monitor Amazon forest.
viii. ASTROSAT is India's 1st dedicated multi-wavelength space observatory.
ix. NISAR is the planned joint Earth Observation Satellite of U.A.E.
x. Sentinel-6 satellite is a collaboration of ISRO and NASA to monitor forest in tribal areas.
xi. GISAT series of Earth Observation Satellites will be placed in the geostationary orbit.
xii. IRNSS has three satellites in geostationary and four satellites in geosynchronous orbits.
xiii. Aditya-L1, India's first solar mission, launched in January 2020, has the objective of studying solar corona.
xiv. Interaction of magnetic fields of opposite polarity — North and South — through magnetic flux cancellation causes the solar eruptions.

India's satellite program may be classified under

→ INSAT SERIES

- Communication satellites launched in Geo-synchronous 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 C band because 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 transmissions speed and significant information transfer with the use of small ground equipment and 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.

IMPORTANT COMMUNICATION SATELLITES

INSAT series has more than 15 satellites including INSAT-3A, 3C, 4A, 4B, 4CR and GSAT-6, GSAT-6A, 7, 7A, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 29, 30.

►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, telephone services in the Middle East, South Africa and Europe.

►GSAT 7A (MILITARY SATELLITE)

- Known as India's 'Angry Bird'
- It a military communications satellite dedicated to the Indian Air Force.
- It will boost the remotely piloted aircraft operations by satellite-control of military unmanned aerial vehicles (UAVs). Thus, it will extend the reach, flexibility and endurance of UAVs in India beyond line-of-sight missions.
- It will enable the Air Force link various ground radar stations, ground airbase, airborne early warning and control system.
- 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 tonne)
- High-throughput communication satellite carrying 40 transponders in the Ku-band and Ka-band frequencies
- Capable of providing high bandwidth connectivity with up to 14 gigabit per second speed

►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 2021-22)
  - 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 surface.
- They zip around the circumference of the Earth in 1.5 hours.
- In a circular orbit few hundred km above the surface, the velocity of a satellite must be about 8 km/s. Therefore, they are put in polar orbit.
- They are commonly called as remote sensing satellites as they collect information of 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

- To assess net crop area, crop production
- To conduct damage assessments
- Classification of Agro-Climatic Zones: IRS-1A and 1B was used to enumerate 15 Agro-climatic regions in India

Meteorology: Early warning mechanism for cyclones, weather forecasting, monitoring for droughts and floods

Urban studies: To study urban sprawl, traffic management etc.

Defence

IMPORTANT REMOTE SENSING SATELLITES

- RESOURCESAT-1, 2, 2A CARTOSAT- 1, 2, 2A, 2B, RISAT-1 and 2, OCEANSAT-2, Megha-Tropiques, SARAL, SCATSAT-1, HYSIS etc
- Some remote sensing satellites are also put in the geostationary orbit for weather forecasting such as INSAT-3D, Kalpana & INSAT 3A, INSAT 3DR.

►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, on board Polar Satellite Launch Vehicle (PSLV-C49).

All satellites were placed precisely into 575 km orbit.

With EOS-01, ISRO is moving to a new naming system for its earth observation satellites which till now have been named thematically, according to the purpose they are meant for. Ex., Cartosat series of satellites were meant to provide data for land topography and mapping, while the Oceansat satellites were meant for observations over sea.

EARTH OBSERVATION SATELLITE

- *Earth observation is the gathering of information about Earth's physical, chemical and biological systems.* Earth observation satellites are the satellites equipped with remote sensing technology.
- Most earth observation satellites are in *sun-synchronous orbit*.
  - A *polar orbit* is one in which a satellite passes above or nearly above both poles on each revolution. It therefore has an inclination of (or close to) 90 degrees to the body's equator. A satellite in a polar orbit will pass over the equator at a different longitude on each of its orbits.
  - A *Sun-synchronous orbit* is a nearly polar orbit around a planet, which combines altitude and inclination in such a way that an object on that orbit ascends or descends over any given Earth latitude at the same local mean solar time. This consistent lighting is a useful characteristic for satellites that image the Earth's surface in visible or infrared wavelengths.
  - Typical Sun-synchronous orbits around Earth are about 600–800 km in altitude, with periods in the 96–100-minute range, and inclinations of around 98°.
- To get (nearly) global coverage with a low orbit it must be a polar orbit or nearly so. A low orbit will have an orbital period of close to 100 minutes and Earth will rotate around its polar axis with about 25° between successive orbits, with the result that the ground track is shifted towards west with these 25° in longitude.
- Spacecraft carrying instruments for which an altitude of 36000 km is suitable sometimes use a geostationary orbit. Such an orbit allows uninterrupted coverage of more than 1/3 of the Earth. Three geostationary spacecraft at longitudes separated with 120° can cover the whole Earth except the extreme polar regions. This type of orbit is used for meteorological satellites.
- Starting with IRS-1A in 1988, ISRO has launched many operational remote sensing satellites. Today, India

has one of the largest constellations of remote sensing satellites in operation.

- Currently, 13 operational satellites are in Sun-synchronous orbit – RESOURCESAT-1, 2, 2A CARTOSAT-1, 2, 2A, 2B, RISAT-1 and 2, OCEANSAT-2, Megha-Tropiques, SARAL and SCATSAT-1,
- 4 in Geostationary orbit - INSAT-3D, Kalpana & INSAT 3A, INSAT -3DR.

- Land and forest mapping and monitoring, mapping of resources like water or minerals or fishes, weather and climate observations, soil assessment, 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 waves observations.
- The RISAT series are the first all-weather Earth observation satellites from ISRO.
- Previous Indian observation satellites relied primarily on optical and spectral sensors which were hampered by cloud cover.
- EOS-01 will have applications in agriculture, forestry and disaster management support. EOS-01 is nothing but another Radar Imaging Satellite (RISAT) that will work together with RISAT-2B and RISAT-2BR1 launched last year. EOS-01 was initially named RISAT-2BR2 and was supposed to be the third of the three-spacecraft constellation aimed at providing all-weather round-the-clock service for high-resolution images.

►ISRO PUTS BRAZIL'S AMAZONIA-1 INTO ORBIT

The Indian Space Research Organisation opened its space calendar 2021 with the successful launch of PSLV-C51 from the first launch pad at Satish Dhawan Space Centre in Sriharikota on Sunday.

Amazonia-1

- Amazonia-1, the main payload, an *optical earth observation satellite* from Brazil.
  - Optical Earth observation is monitoring our planet from satellites, using photography, imaging in various wavelengths, lidar and other optical sensing technologies.
  - This satellite will provide remote sensing data to users for monitoring deforestation in the Amazon region and analysis of diversified agriculture across the Brazilian territory.
  - Amazonia-1 was the first commercial venture for ISRO's two-year-old marketing arm, New Space India Limited. After ISRO's earlier marketing company, Antrix, has been bogged down by long litigation in the controversial Devas deal.
  - The success of Brazil's Amazonia-1 satellite by ISRO marks a new high point in space cooperation between the two countries. It would "open the door for multiple business and governmental opportunities" and help "fulfil the environmental commitments of the Brazilian government" towards the Amazon rainforest.

►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)
  - SAR refers to the Synthetic Aperture Radar that NASA will use to measure changes in the surface of the Earth.
- It will detect movements of the planet's surface as small as 0.4 inches over areas about half the size of a tennis court. Primary goal of observation
  - 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.
- The satellite will be launched in 2022 from the Satish Dhawan Space Center into a near-polar orbit.
- Synthetic Aperture Radar is used for producing high-resolution images. Because of the precision, the radar

can penetrate clouds and darkness, which means that it can collect data day and night in any weather.

- It will scan the globe every 12 days over the course of its three-year mission of imaging the Earth's land, ice sheets and sea ice to give an unprecedented view of the planet.
- NASA will provide one of the radars for the satellite, a high-rate communication subsystem for science data, GPS receivers and a payload data subsystem. NISAR will be equipped with the largest reflector antenna ever launched by NASA.
- ISRO will provide the spacecraft bus, the second type of radar (called the S-band radar), the launch vehicle and associated launch services.
- Expected Benefits:
  - Better management of natural resources and hazards
  - Information on effects and pace of climate change.
  - Better understanding of the causes and consequences of land surface changes.
  - It will also add to our understanding of our planet's hard outer layer, called its crust.

►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 satellite was launched from the Vandenberg Air Force base in California aboard a SpaceX Falcon 9 rocket
- 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 Joint 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).
- The satellite will send pulses to the Earth's surface and measure how long they take to return to it, which will help in measuring the sea surface height. It will also measure water vapour along this path and find its position using GPS and ground-based lasers.

►COPERNICUS

- European Earth Observation Program.
- Main objective is to monitor of our planet and its ecosystems.
- Constitutes a constellation of 6 families of satellites known as Sentinels
- Coordinated and managed by the European Commission.
- Copernicus allows full, free and open access to all data collected.
- Scientists, policy makers, entrepreneurs and ordinary citizen can use this data.
- 6 themes

1. Atmospheric monitoring
2. Marine environment monitoring
3. Land monitoring
4. Climate change
5. Emergency management
6. Security

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.
- On the other hand, Department of Space will provide the Copernicus program with a free, full and open access to the data from ISRO's land, ocean and atmospheric series of civilian satellites (OCEANSAT-2, Megha-Tropiques, Scatsat-1, SARAL, INSAT-3D, INSAT-3DR) except for commercial high-resolution satellites data.

→OTHER REMOTE SENSING SATELLITES

►CARTOSAT 3

- 3rd-generation agile advanced earth observation satellite launched at an altitude of 509 km.
- It has a pan-chromatic resolution capability of 25cm (highest in the world).
- Application: Cartography for large scale urban planning, rural resource and infrastructure development, Land Information System and

Geographical Information System application for various uses, coastal land use.

►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.

SIGNIFICANCE

- Normally earth observation satellites are put in the Low Earth Orbit at 600km above the surface of the earth. GISAT series is the 1st among the earth observation satellites in the Geo-stationary Orbit)
- Currently imaging satellites map a particular area only once in 22 days. (remember they in LEO)
- GISAT can scan or map an area every 2nd day as it will be placed in geostationary orbit.

►MICROSAT R

- Microsat R is target satellite chosen under Mission Shakti.
- Under Mission Shakti, A-SAT missile targeted and destroyed the live Microsat R satellite in the Low Earth Orbit at about 300 km above the surface.

►HYSIS: HYSPECTRAL IMAGING SATELLITE

- India's first hyperspectral imaging satellite.
- Sun-synchronous polar orbit, 636 km above the surface of the earth.
- It observes earth's surface in 3 different ranges including visible, near infrared and shortwave infrared regions in 55 spectral or colour bands.
- In short HysIS enables us to do a 'CATSCAN' equivalent of Earth from space.

APPLICATION

- Monitoring agriculture, forestry
- Assessment of coastal zones, inland waters, soil
- Oil and minerals mapping
- Military surveillance

►HYPERSPECTRAL IMAGING: BASICS

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

►PRINCIPLE OF SPECTROSCOPY AND DIGITAL IMAGING

- When an electromagnetic wave shines on the surface of an object, some wavelengths are absorbed while others are reflected.
- Example: The colour of plant leaf is green because it absorbs red and violet light but reflects green light which what we see as colour green.
- Similarly, all objects absorb and reflect certain wavelengths of electromagnetic spectrum unique to that object.
- Thus, every object has its own 'spectral signature'.
- The sensors or cameras which are sensitive to a particular wavelength (say visible light, UV light, Infrared etc) capture the image in that wavelength.
- This 'image' captured in 'visible light', or 'infrared' is super-imposed and converted to usable data.

►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.

SIGNIFICANCE

- Satellite-based electronic intelligence to augment the armed forces to counter radars.
- Electronic Intelligence basically involves interception of signals from radars.
- Once the signal is intercepted, the ELINT system collects data related to radar signals including its bandwidth, intensity, location from where it is emitted etc creating what is called a RF signature. (Radio frequency)
- Once the RF signature is created it can be used for locating and identifying the radar in subsequent encounters.
- It can also help in developing appropriate jamming techniques to counter the enemy radar.

→INDIAN REGIONAL NAVIGATION SATELLITE SYSTEM

- Also called NavIC, is like the GPS.
- While GPS has a constellation of 24 satellites, IRNSS has a 7-satellites 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.
  - A, B, F, G are placed in a geosynchronous orbit. (1A is replaced by 1I recently)
  - C, D, E, are in geostationary orbit.
- NavIC provides two types of services
  - Standard positioning service- meant for all users.
  - Restricted service-Encrypted service provided only to authorised users like military and security agencies.

APPLICATIONS

- Terrestrial, Aerial and Marine Navigation
- Disaster Management
- Vehicle tracking and fleet management
- Integration with mobile phones
- Precise Timing
- Mapping and Geodetic data capture
- Terrestrial navigation aid for hikers and travellers
- Visual and voice navigation for drivers

►BeiDou NAVIGATION SATELLITE SYSTEM

- China has recently completed its BeiDou Navigation Satellite System (BDS) constellation, which can potentially rival the US Global Positioning System (GPS).
- BeiDou uses a network of satellites and can provide positional accuracies of under ten meters (GPS provides positioning accuracies of under 2.2 m).

OTHER NAVIGATION SYSTEMS

- Global Positioning System (GPS) – USA
- GLONASS – Russia
- 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.

TUNDRA ORBITS

- Tundra orbits are very elliptical geosynchronous orbits with a high inclination (about 63.4°) and a one sidereal day orbital period.
- The phenomenon known as apogee dwell occurs when a satellite in this orbit spends most of its time over a certain location of the Earth.
- This makes spacecraft ideal for communications satellites that serve high-latitude locations.
- A satellite on a Tundra orbit has a closed figure 8 ground track with a smaller loop over the northern or southern hemisphere.
- This distinguishes them from Molniya orbits, which have same inclination but half the period and do not hover over a single location and are meant to serve high-latitude regions.

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.
- The impulsive deflection of the asteroid by the abrupt addition of momentum is the kinetic impactor

mitigation approach. DART is being launched to crash with an asteroid to alter its orbital period.

CONFIGURATION

- Weight: This is a very low-cost spaceship. DART weighs around 610 KG before launch and will lose some weight throughout flight, weighing about 550 KG after impact.
- The main structure is a box (1.2 1.3 1.3 m in length). The spacecraft has two solar panels and is propelled by hydrazine propellant.
- The spacecraft carries a high-resolution imager called Didymos Reconnaissance and Asteroid Camera for Optical Navigation (DRACO) that will provide scientists with exact photos and data to assess the effect of the collision on the asteroid's course.
- LICIACube, a tiny satellite or CubeSat, will also be carried by DART (Light Italian CubeSat for Imaging of Asteroids).

ASTEROID TARGETED BY THE DART MISSION

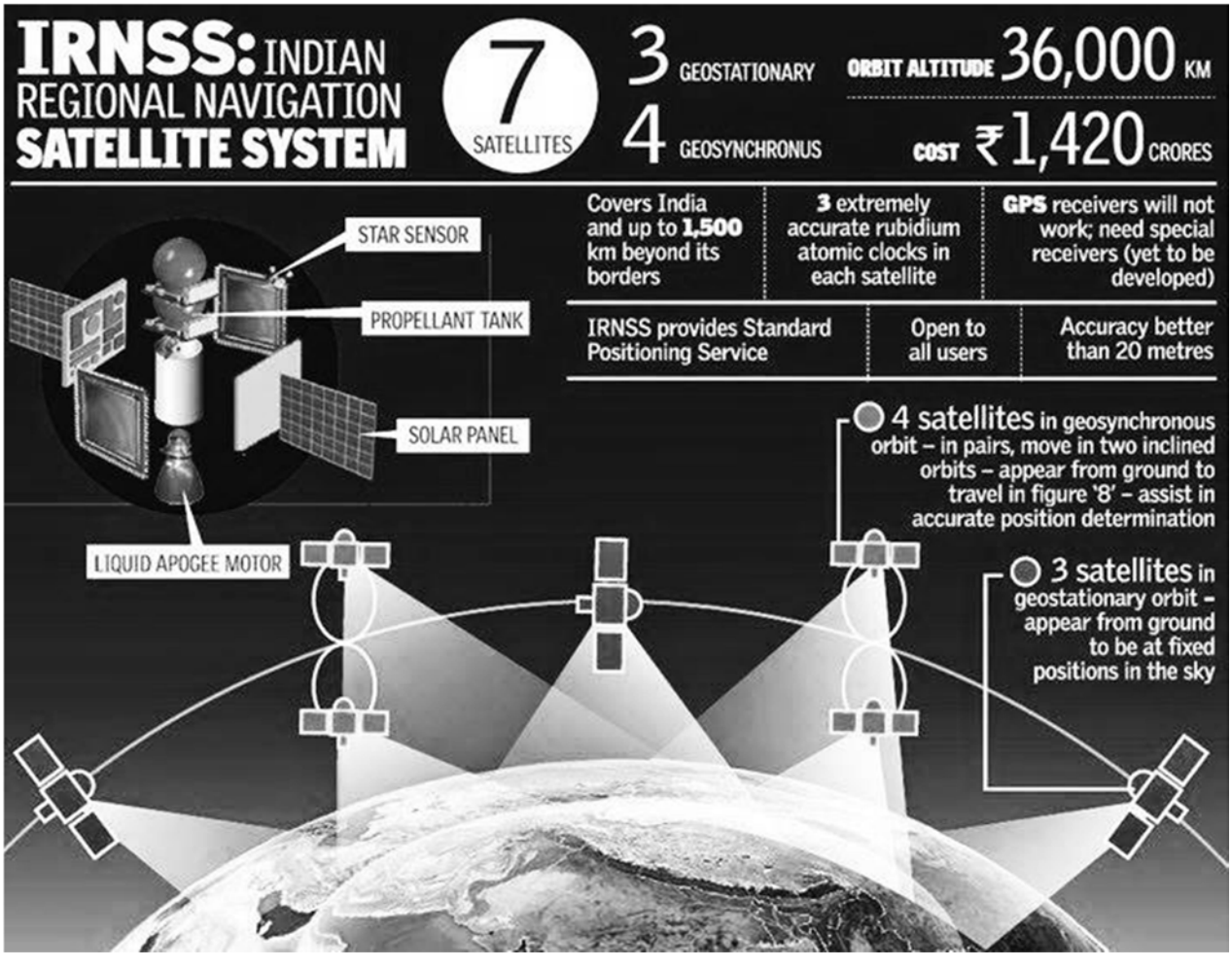
- It will aim for Dimorphos, a binary (two-body) asteroid system's much smaller "moonlet."
- Dimorphos is orbited by Didymos (Greek for "twin"), a bigger asteroid with a diameter of 780 m.

WHY DIMORPHOS?

- Didymos is an ideal test system since it is an eclipsing binary, meaning it contains a moonlet that circles the asteroid on a regular basis and can be observed when it passes in front of the main asteroid.
- Earth-based telescopes can investigate this brightness change to figure out how long Dimorphos takes to circle Didymos.

DART IS IMPORTANT FOR PLANETARY DEFENCE

- NASA formed Planetary Defense Coordination Office to oversee the agency's continuing planetary defence program.
- The PDCO's objectives are to offer early detection of potentially hazardous items, monitor and describe the objects, research tactics and technologies for minimising potential consequences, and play a key role in US government response plans in the event of a real-world incident.
- PDCO's first planetary defence test mission is DART.



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.

MAIN OBJECTIVES

- To estimate magnetic field of neutron stars
- Study of binary star system
- Study of regions where stars are born

►EXPOSAT

- ExpoSAT is a multi-wavelength space observatory to study the 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, 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

IMPORTANT PAYLOADS

1. Lyman-Alpha Photometer: Measures the deuterium and hydrogen concentration in the upper atmosphere to estimate the water loss to outer space.
2. Methane Sensor: To measure methane in Martian atmosphere and to map its sources.
3. Thermal Infrared Imaging Spectrometer: To study the composition and mineralogy of Martian surface by creating a temperature map by recording the emission radiation.

- Note: ISRO is also planning a Lander mission to Mars under Mangalyaan-2 by 2024. The main objective is to study the surface geology, magnetic fields and interplanetary dust.

►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 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 inter-planetary 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.

KEY COMPONENTS

- Orbiter: Placed in an orbit 100km above the moon.
- Orbiter payload
  - Large Area Soft X-ray Spectrometer (CLASS) for mapping of elements.
  - Synthetic Aperture Radar to collect evidence confirming the presence of water ice below the shadowed regions of the Moon.
  - Imaging IR Spectrometer for mapping of lunar surface for the study of minerals, water molecules and hydroxyl
  - Neutral Mass Spectrometer (ChACE-2) to study the lunar exosphere.
  - Terrain Mapping Camera-2 for preparing a 3-d map for mineralogical and geological studies.

LANDER: 'VIKRAM' AND ROVER NAMED 'PRAGYAN'

- The lander-rover integrated module was supposed to soft-land near south pole (about 600 km) of the moon
- The 6-wheeled rover was planned to spend one lunar day or 14 Earth days on the moon's surface and walk up to 150-200 km.
- However, a last-minute software glitch led to crash-lading of Vikram and Pragyan.

LANDER PAYLOAD

- A seismometer to study moonquakes
- Langmuir probe to measure characteristics of plasma on the moon surface.

ROVER PAYLOAD

- Laser-induced Breakdown Spectroscope (LIBS)
- Alpha Particle Induced X-ray Spectroscope (APIXS)

PURPOSE

- To find traces of water and helium 3.
- On-site chemical analysis of the surface
- To send pictures to earth via the orbiter.

►CHANDRAYAAN-3

The Chandrayaan-3 mission is a follow-up to Chandrayaan-2, which landed a rover on the lunar South Pole in July 2019.

THE ORBITER'S USEFULNESS

- The Orbiter component of the mission has been performing well. It has eight instruments on board.
- Each of these devices has generated a substantial quantity of data that shines fresh light on the moon and provides new insights that might be useful in future exploration.

LAUNCH OF CHANDRAYAAN 3

Following the failure of the Vikram lander, another mission was launched to show the landing capabilities required for the Lunar Polar Exploration Mission, which was planned in collaboration with Japan for 2024.

DESIGN

- Only four throttle-able engines would be available on the Chandrayaan-3 lander.
- Unlike Vikram, who had five 800N engines on Chandrayaan-2, one of which was centrally installed and had a set thrust.
- A Laser Doppler Velocimeter will also be installed on the Chandrayaan-3 lander (LDV).

CHANDRAYAAN-2

- Chandrayaan-2 was made up of three spacecraft: an orbiter, a lander, and a rover, all of which were equipped with scientific equipment for studying the moon.
- From a 100-kilometer orbit, the Orbiter would observe the moon, while the Lander and Rover modules would be separated for a gentle landing on the moon's surface.
- The Lander module was given the name Vikram in honor of Vikram Sarabhai, India's space pioneer, while the Rover module was given the name Pragyaan, which means wisdom.

CHANDRAYAAN-1

- The Chandrayaan-1 mission, launched in October 2008, was ISRO's first exploring trip to the moon, or any other celestial body.
- The mission's only purpose was to circle the moon and conduct observations using the sensors aboard.
- The Chandrayaan-1 spacecraft reached the closest to the moon at 100 km from its surface.

►CHANG'E-5 LUNAR MISSION

- About 2 kg of stony pieces from Moon were transported to Earth by Chang'e-5 lunar mission.
- It had landed the far side of the Moon that had never been landed upon.
- As a result, it was able to gather bits of youngest lunar rocks ever brought back to Earth for study in labs.
- The rocks are also not same as ones that were returned decades ago.

KEY FINDINGS

- 90% of the elements gathered by Chang'e-5 are assumed to have come from landing site and its immediate surrounds, which are composed of'mare basalts.'
- These volcanic boulders may be seen as deeper grey regions that spilled across most of the Moon's nearside during previous lava outbursts.
- However, 10% of the pieces had chemical compositions that are markedly different and 'strange.'

EXOTIC COMPOSITIONS

- The different 10% pieces might have records of other sections of the lunar surface, as well as insights about the sorts of space objects that have collided with the Moon's surface.
- Researchers investigated into sources of quickly cooled glassy material particles.
- They've linked the glassy droplets to the 'Rima Mairan' and 'Rima Sharp' extinct volcanic vents.

These shards might provide details about previous periods of explosive, fountain-like volcanic activity on the Moon.

►ADITYA-L1

- India's 1st first mission to study the Sun 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. Interesting thing about Corona is it has

high temperatures of more than 1-million-degree 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 basically composed of electrons and nuclei of hydrogen and helium atoms. According to the scientist, 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 with the goal of developing 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 Re-entry 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.

DETAILS OF THE MISSION

- The spaceship will be able to transport three people, and an updated version will be able to rendezvous and dock with another spacecraft.
- This capsule will circle the Earth at 400 km altitude for up to seven days on its first crewed mission, with a two or three-person crew on board.
- In 2014, this crew module built by HAL had its maiden unmanned testing flight.
- Critical human-centric systems and technology including as space-grade food, crew healthcare, radiation monitoring and protection, parachutes for the safe return of the crew module, and a fire suppression system will be supported by DRDO.

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.

CREW MODULE ATMOSPHERIC RE-ENTRY TECHNOLOGY - CARE

- Satellites that are launched for communication or remote sensing are meant to remain in space.
- However, a manned spacecraft needs to come back.
- While re-entering Earth's atmosphere, the spacecraft needs to withstand very high temperatures created due to friction.
- A prior critical experiment was carried out in 2014 along with GSLV MK-III when the CARE (Crew Module Atmospheric Re-entry Experiment) capsule successfully demonstrated that it could survive atmospheric re-entry.

CREW ESCAPE SYSTEM - PAT

- The Crew Escape System is an emergency accident-avoidance measure.
- In July 2018, ISRO completed the first successful flight 'pad abort test' or Crew Escape System.

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 spacecrafts 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 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 can spot, track and catalogue objects as small as 10 cm, up to a range of 3,400 km and equal to a space orbit of around 2,000 km.
- 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:
  - Ponmudi 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 of space debris and protect its satellites in course and during launches.

- NORAD is an initiative of 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 Department of Space of India and Department of Defence of USA. Benefits of this agreement are:
- Facilitate India to receive data from USA about space debris and other objects in space and potential threat that may pose to safety & security of new and existing satellites and other space assets.
- Ensure sharing of data & services for long term sustainability of outer space activities of two both countries by protecting satellites of both countries from natural and manmade threats.

INDIA AND SPACE DEBRIS

- NASA releases the quarterly report called Orbital Debris Quarterly News. According to this report, India has 103 active or defunct spacecraft and 114 objects categorised as space debris.
- USA has 4,144 spacecraft (active and defunct) and 5,126 objects that can be categorised as space debris in Earth's orbit. China has 517 spacecraft and 3,854 objects as space debris.
- ISRO has established a Directorate of Space Situational Awareness and Management at its headquarters to deal with issues related to space debris.
- A dedicated Space Situational Awareness Control Centre is set up in Bangalore to coordinate all space debris related activities within ISRO and to safeguard Indian operational space assets from collision threats.
- India has been pursuing Active Debris Removal to contain growth of space debris objects.

ACTIVE DEBRIS REMOVAL (ADR)

- ADR refers to complex technology.
- Examples of Active Debris Removal Technologies:
  - Self Eating Rockets
  - Vanishing Satellites

INTER-AGENCY DEBRIS COORDINATION COMMITTEE (IADC)

An international government forum for worldwide coordination of activities related to the issues of man-made and nature 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 progress of ongoing cooperative activities
- Members: Space agencies of 13 space faring nations. ISRO is also a member.

►NEW SPACE INDIA LIMITED

Newly created second commercial arm of the Indian Space Research Organisation.

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 the giant weather storms, known as the Solar particle storms, into space.
- The mission will help understand how such storms affect interplanetary space can help protect spacecraft and astronauts.

►SOLAR ENERGETIC PARTICLES (SEP)

- They are high-energy particles coming from the Sun.
- They were first observed in the early 1940s.
- They consist of protons, electrons and HZE ions with energy ranging from a few tens of keV to many GeV.
- They are of particular interest and importance because they can endanger life in outer space (especially particles above 40 MeV). But their onset is extraordinarily hard to predict, in part because we still don't know exactly where on the Sun they come from.
- The greatest mystery about gradual SEPs is not what speeds them up, but where they come from in the first place. For reasons still not fully understood, SEPs contain a different mix of particles than the other solar material streaming off the Sun in the solar wind – fewer carbon, sulfur, and phosphorous ions, for instance.

- Many scientists thought Solar Energetic Particles would be found at the edges of the active region where the magnetic field is already open, and material can escape directly. But the fingerprint matched only in regions where the magnetic field is still closed.
- The SEPs had somehow broken free from strong magnetic loops connected to the Sun at both ends. These loops trap material near the top of the chromosphere, one layer below where solar flares and coronal mass ejections erupt.

►CORONAL MASS EJECTIONS (CMEs)

- Strong magnetic fields shape the corona, the outer solar atmosphere. When these fields are closed, frequently over sunspot groups, the constrained solar atmosphere may forcefully discharge coronal mass ejections.
- CMEs are enormous plasma and magnetic field expulsions from the Sun's corona. CMEs may excite electrons and protons trapped in Earth's changing magnetic field.
- There is an embedded magnetic field (frozen in flux) that is greater than the baseline solar wind interplanetary magnetic field (IMF).
- CMEs leave the Sun at speeds ranging from less than 250 km/s to about 3000 km/s.
- The fastest Earth-directed CMEs arrive in 15-18 hours. Slower CMEs might come days later.
- They grow as they travel away from the Sun, and by the time they reach Earth, they may be a fifth of the distance between Earth and the Sun.

IMPACT OF CORONAL MASS EJECTIONS (CMES)

- Magnetic reconnection occurs when highly twisted magnetic field structures (flux ropes) in the Sun's lower corona become too strained and realign into a less tension form.
- This may cause a solar flare, which is usually associated with a CME (coronal mass ejection).
- These CMEs originate from areas of the Sun with high magnetic fields, such as active zones associated with sunspot groups. CMEs may also come from filaments and prominences in the inner corona, where cooler, denser plasma is trapped and suspended by magnetic flux. Changes in flux rope configuration may result in either a quiet resorption of the dense filament or prominence or a CME.
- CMEs that move faster than the solar wind may cause shock waves.
- That increases the potential for or intensity of radiation storms.

►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:

i. Extreme Ultraviolet High-Throughput Spectroscopic Telescope Epsilon Mission, or EUVST

ii. Electrojet Zeeman Imaging Explorer, or EZIE.

NASA's contribution to the missions will help us understand the Sun and Earth as an interconnected system. Understanding the physics that drive the solar wind and solar explosions -- including solar flares and coronal mass ejections -- could one day help scientists predict these events, which can impact human technology and explorers in space.

►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.

►DART MISSION

- Double Asteroid Redirection Test Mission
- It is a *kinetic impactor* technique to change the motion of an asteroid to prevent its impact on Earth.
- It will impact on the small moon of asteroid Didymos.

►HAMMER

It is a spacecraft designed to serve as

1. Kinetic impactor is like a ram that can be used to nudge asteroid from its path.

2. 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 vapor above Europa.
- It means that it has a subsurface ocean.

►MESSENGER

Mission to Mercury

►NASA'S MISSION TO VENUS

- Mariner 2: 1st flyby of Venus in 1962
- Magellan: Orbiter Mission

►CASSINI HUYGENS

- Joint mission of NASA, ESA and Italian Space Agency to Saturn
- Final flyby in 2017
- 1st spacecraft to observe presence of hydrocarbon rains, rivers, lakes and seas on Titan.

►DISCOVERY

Mars lander and Rover Mission

►INSIGHTS

Mars' lander mission under Discovery program, Landed near the equator of Mars to study its interior.

►OTHER MISSIONS TO MARS

- Mars Exploration Rovers 'Spirit' and 'Opportunity'.
- Viking Mission also flew past Mars
- MAVEN: Mars Atmosphere And Volatile Evolution Mission

►OPPORTUNITY

- Mars Rover Mission.
- Formal ended recently

►CURIOSITY

Mars Rover Mission

►KEPLER MISSION

- Mission to search for Earth-like planets around the Milky Way galaxy that might harbour life.
- Kepler Mission retired recently

IMPORTANT DISCOVERIES

- Kepler-22b: 1st planet found in the "habitable zone".
- A habitable zone or 'goldilocks zone' is a region around a star at a distance where liquid water could pool on a planetary surface and possibly support life.
- TRAPPIST-1 system: home to seven Earth-size planets.

►TRANSITING EXOPLANET SURVEY SATELLITE (TESS)

- Successor of Kepler Mission
- 2-year mission in search of exoplanets.

►MODIS

- Earth observation satellite of NASA
- Monitoring large-scale changes in the biosphere to understand change in 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)
- Objective of SOHO is to study the fundamental scientific questions about the Sun including

- What is the structure and dynamics of the solar interior?
- Why does the solar corona exist and how is it heated to the extremely high temperature of about 10 Lakh°C?
- Where is the solar wind produced and how is it accelerated?

►NEW FRONTIER'S PROGRAM

- Aimed at exploring the solar system
- Various missions under New Frontiers Program are

1. New Horizons – Launched in 2006 to investigate distant solar system object including Pluto and its moons and Kuiper Belt.
2. Juno – launched in 2016 to study Jupiter
3. OSIRIS-REx mission to collect samples from an asteroid (Bennu) and carry it to Earth for further study
4. Dragonfly – To be launched in 2026 to study Saturn and its icy moons

►NEW HORIZON

- NASA's space mission to Pluto
- Also, the 1st mission to explore the solar system's region beyond the giant planets called Kuiper Belt.
- Ultima Thule is a small rocky and icy trans-Neptunian planetesimal in Kuiper belt. (recent encounter of New Horizon)
- Arrokoth: Recently New Horizon encountered this primordial body in Kuiper Belt. This is a planetesimal and thus will help us understand early solar system and its origin.

►DRAGONFLY

- Lander Mission to Saturn's Titan

CHARACTERISTICS OF TITAN

- Nitrogen-based atmosphere
- Clouds and rain of methane.

►DISCOVERY PROGRAM

- It is a series of Solar System exploration missions.
- It is a faster, better, cheaper planetary science missions of NASA.
- Important Discovery missions
  - *Lucy*
  - *Psyche*
  - *Davinci*
  - *Io Volcano Observer*
  - *Veritas*
  - *Trident*

►LUCY MISSION

- Lucy will pass by eight Jupiter asteroids—seven Trojans and one main-belt asteroid.
- First time in NASA history that a single spacecraft has explored so many distinct asteroids.
- Lucy will be powered entirely by solar energy and will travel 850 million km from the Sun.
- According to NASA, this makes it the farthest-flung solar-powered spacecraft ever.

JUPITER TROJAN ASTEROIDS

- They are a collection of asteroids that share Jupiter's orbit around Sun. Known as Trojans.
- In a gravitationally stable environment, thousands of similar asteroids exist.
- Jupiter is led and followed by swarms as it orbits Sun.

TROJANS

- Lucy's Trojan destinations are stranded at Jupiter's Lagrange (L) points, which are gravitationally stable areas where the Sun's and Jupiter's gravity cancels out.
- This indicates that their orbits are steady, and the Trojans are locked between them.
- Asteroids are also the same distance from Jupiter as they are from the Sun.
- The leading and trailing Lagrangian points (L4 and L5) of Jupiter have remained constant throughout the solar system's history.
- This suggests that many asteroids have gathered in their orbits.
- A Trojan is a co-orbital object since it revolves around one of the two stable Lagrangian points.

LAGRANGE'S PROPOSITIONS

- Over a century ago, Mathematician Joseph-Louis Lagrange anticipated this situation of strange behaviour.
- From the viewpoint of the planet, Lagrange postulated that if a tiny celestial body is put at one of two stable locations in its orbit around the Sun (the L4 and L5), the asteroid would stay stationary.
- This is due to the planet's and the Sun's combined gravitational pull.

- As a result, Lagrange's prognosis gained credence. Over the next several months, other asteroids of this kind were identified at Jupiter's Lagrange point L5.

ORIGIN OF NAME: LUCY

- It's the remains of a hominid from 3.2 million years ago.
- She is regarded as one of history's most renowned pre-human fossils.
- A team of paleoanthropologists headed by Donald Johanson uncovered about 40% of the fossilised skeleton of this hominid in 1974.
- The name was inspired by the Beatles' song "Lucy in the Sky with Diamonds," which Johanson's crew was listening to at camp the night of their discovery.

►PSYCHE

- It is a NASA mission to explore the origin of planetary core by studying metallic asteroid Psyche.
- Psyche is the heaviest known Metallic asteroid in the asteroid belt. It is thought to be exposed iron core of a protoplanet.
- It appears to be the exposed metal core of an early planet. (made of nickel-iron like earth's core)
- Psyche Mission is NASA's 1st mission to examine an object made not of rock and ice, but metal.

►DAVINCI

- Proposed atmospheric probe to Venus.
- Short for Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging
- Main aim is to study the chemical composition of Venus' atmosphere

►IO VOLCANO OBSERVER

To study volcano on IO. (one of the Galilean moons of Jupiter)

►VERITAS

- Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy mission
- Proposed mission to map with high resolution the surface of planet Venus.

►TRIDENT: NEPTUNE'S MOON

Proposed mission to study Neptune's largest moon Triton.

►PARKER SOLAR PROBE

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

►PUNCH MISSION

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

►HUBBLE SPACE TELESCOPE

- Edwin Hubble, an astronomer, was the inspiration for the name.
- Since its launch, the observatory has achieved ground-breaking discoveries in astronomy as the first significant optical telescope to be put in space (into Low Earth orbit in 1990).
- The "biggest important improvement in astronomy since Galileo's telescope," according to the press release.
- It's part of NASA's Great Observatories Program, which includes four space-based observatories that each look at the Universe in a unique way.
- The visible-light Spitzer Space Telescope, the Compton Gamma-Ray Observatory (CGRO), and the Chandra X-Ray Observatory are among the other missions in the program (CXO).
- Its length (13.3 m) is longer than a school bus, and it boasts a 7.9-foot mirror.
- It takes photographs of deep space and aids scientists with their understanding of the cosmos by seeing the furthest stars, galaxies, and planets.
- On any given day, anybody may check the Hubble database to see which new galaxy it discovered, what remarkable features it saw about our stars, solar system, and planets, and what patterns of ionized gases it discovered.

CONTRIBUTION OF HST

- The accelerated expansion of the universe in the 1990s led to the conclusion that dark energy made up most of the universe.
- Southern Ring Nebula (1995) revealed two stars, a dazzling white star and a duller star at the nebula's core, where the dull star created the nebula.
- Dwarf galaxy merger (1998), one of which is I Zwicky 18. This created a new Star.
- Colorful gas patterns in the 'Circinus Galaxy', propelled by a black hole (1999).
- Two galaxies UGC 06471 and UGC 06472 collide (2000).
- Neptune (2011): The scan of the furthest planet shows high-altitude clouds made of methane ice.
- In 2012, two planets, light-scattering dust, and debris were identified in the disc encircling the star 'Beta Pictoris'.
- 'Galaxy Cluster Abell 2744' in 2013. In it are multiple clusters of tiny galaxies.
- It also has a powerful gravitational field that functions as a lens for over 3,000 nearby galaxies.
- In 2014, a comet dubbed C/2013 A1 collided with Mars.
- 'Comet Siding Spring' passed Mars at just 87,000 km.
- 'Gum 29', a 20,000-light-year distant bright stellar being ground, was caught in 2014.
- This massive star cluster is named Westerlund 2.
- In 2016, the comet 332P/Ikeya-Murakami disintegrated.
- In 2017, the Triangulum Galaxy was seen with a dazzling blue glow spreading over the galaxy in spectacular nebulas of heated gas.
- Observation of Galaxy ESO 243-49 in 2012.
- The 20,000 suns black hole was located on a galaxy glacier plane.

SUCCESSOR OF HST

- James Webb Space Telescope (JWST), Hubble's replacement, is set to launch later this year.
- Many astronomers, though, believe that the two will be able to work together - at least for the time being.

►JAMES WEBB SPACE TELESCOPE (JWST)

- It's a space telescope that NASA, the European Space Agency (ESA), and the Canadian Space Agency are working on together (CSA).
- It took 30 years and $10 billion to build and is being hailed as one of the most significant scientific achievements of the twenty-first century.

GOAL OF THE JWST

- Entire sky can be seen it.
- It does, however, have one overarching goal: to observe the light emitted by the Universe's very earliest stars.
- About 100-200 million years after the Big Bang, or a little more than 13.5 billion years ago, these pioneer stars are expected to have turned on.
- Webb will separate these stars into groups.
- They are so far away that even if light travels at 300,000 km/s, it will take billions of years for it to reach us.

JWST MIRROR

- A huge mirror, which will assist gather light from the things being seen, will be one of the most crucial items it will carry.
- The main mirror is made up of 18 hexagonal mirror pieces, each measuring 1.32 m in diameter, which are sewn together in a honeycomb pattern.
- The main mirror is an engineering wonder.
- When completely deployed, the lightweight mirrors, coatings, actuators and motors, electronics, and thermal blankets combine to create a single accurate mirror.
- Each mirror piece is composed of beryllium and weighs around 20 kg.

BERYLLIUM

- According to NASA, beryllium was chosen because element is both powerful and light.
- Beryllium is a lightweight metal that retains its form well over a wide range of temperatures. Beryllium is a non-magnetic metal that conducts electricity and heat well.
- Beryllium is utilised to make components for supersonic jets and the Space Shuttle because it is light and robust.
- It went on to say that while dealing with beryllium, extra caution was necessary since inhaling or swallowing beryllium dust is harmful.

OTHER FUTURE OBSERVATORIES OF NASA

NANCY GRACE ROMAN SPACE TELESCOPE

- Formerly known as WFIRST (Wide Field Infrared Survey Telescope), is a next generation observatory to

be launched to study exoplanets, dark energy and galaxies.

- This telescope will employ a mirror of 2.4 m in diameter of same size and sensitivity as Hubble Space Telescope's primary mirror. But the mirror will have field of view 100 times larger than Hubble.

►ARTEMIS

- Joint mission of NASA, ESA, JAXA and Canadian Space Agency.
- Aim is to land the first female and next man on the Moon, specifically at the lunar south pole region by 2024. Further, it will establish sustainable exploration by 2028. Learnings from the mission will be used to send astronauts to Mars.
- To study effects of solar wind from a lunar orbit.
- Deployed primarily to observe Moon's interaction with the solar wind.

►LUNAR ORBITAL PROGRAM – GATEWAY (LUNAR GATEWAY)

- It is an in-development space station in lunar orbit intended to serve as a solar powered communications hub, science laboratory, short term habitation module, and holding area for rovers and other robots. Critical to human presence on Moon.
- It would play major role in NASA's Artemis Program.
- It is being developed by all International Space Station partners: ESA, NASA, Roscosmos, JAXA and Canadian Space Agency.

►COBE SATELLITE

- Short for Cosmic Background Explorer (COBE)
- 1st to confirm CMB radiation

►AURA

Earth observation satellite for stratosphere ozone and aerosol in upper atmosphere.

OTHER IMPORTANT MISSIONS

►EXOPLANETS

- Definition: Planets outside our solar system.
- Most exoplanets are part of star systems.
- Besides there are some "rogue" exoplanets that are not a part of any star system.
- According to NASA, there are more than 5,000 confirmed exoplanets. They are part of NASA Exoplanet Archive. The archive records discoveries that appear in peer reviewed and have been confirmed by multiple detection or analytical techniques.
- Some types of Exoplanets: (a) 'Hot Jupiters': These are exoplanets which are gaseous and very close to their stars. (b)
- The search for exoplanets is also the search for alien life and habitable spaces beyond our star system.
- NASA's Kepler and K2 missions have identified several such candidates.
- To be considered habitable exoplanets must orbit within a distance of their stars in which liquid water can exist on the planet's surface. This distance is called the "Goldilocks" zone.
- It is found that red dwarfs are the best place to find 'exoplanets.

FUTURE MISSIONS FOR EXOPLANETS

ARIEL SPACE MISSION OF ESA

European Space Agency (ESA) has formally adopted ARIEL (Atmospheric Remote-sensing Infrared Exoplanet Large-survey), the explorer that will study the nature, formation, and evolution of exoplanets, by surveying

- First mission of its kind dedicated to measuring chemical composition & thermal structures of hundreds of exoplanets.
- It will focus on exceptionally hot planets in our galaxy, with temperatures greater than 600°F. Such planets are more likely to transit their stars than planets orbiting farther out, and their short orbital periods provide more opportunities to observe transits in a given period of time.
- First spacecraft to be fully dedicated to observing hundreds of exoplanet atmospheres.
- The mission is expected to be launched in 2029.

PLATO MISSION OF ESA

- PLATO stands for PLanetary Transits and Oscillations of stars. ESA's next generation planet hunting mission as part of its COSMIC VISION PROGRAM.
- Objective: To find and study many extrasolar planetary systems, with emphasis on properties of terrestrial planets in the habitable zone around solar-like stars.

- It has been designed to investigate seismic activity in stars, enabling the precise characterisation of the planet host, including its age.

►MOON-FORMING REGION SEEN AROUND AN EXOPLANET

EXOPLANETS

- Exoplanets are planets that have been found outside of our solar system.
- Most exoplanets circle other stars, while rogue planets, or free-floating exoplanets, orbit the galactic center and are unattached to any star.
- Except for the two newborn gas planets circling PDS 70, no circumplanetary discs have been discovered until today since all known exoplanets were in "mature" – completely matured – solar systems.

NEW FINDING

- A disc of spinning material has been seen collecting around one of two young planets, according to the researchers.
- They were discovered circling a young star named PDS 70, which is just 370 light-years away from Earth.
- It's a circumplanetary disc, and it's from this that moon emerges.
- The finding adds to our knowledge of how planets and moons develop.

FORMATION OF DISC

- The spectacular rings of Saturn, a planet with more than 80 moons around it, are a remnant of a primordial moon-forming disc in our solar system.
- PDS 70, an orange-colored star having approx. same mass as our Sun, is just around 5 million years old– a blink in cosmic time.
- Even younger are the two worlds. Jupiter, a gas giant, is comparable to both planets (but Jupiter is bigger).
- A Moon-forming disc was discovered surrounding one of the two planets, designated PDS 70c.

BIRTH OF A MOON

- Within clouds of interstellar gas and dust dispersed across galaxies, stars erupted.
- Planets form from leftover material revolving around a young star, and circumplanetary discs around certain planets produce moons in the same way.
- "Core accretion" is the major process assumed to underlie planet creation.
- Small ice-coated dust grains get bigger and larger when they collide with other grains in this scenario.
- This process continues until the grains reach the size of a planetary core, at which time the newborn planet's gravitational potential is strong enough to accrete gas that will create its atmosphere.
- Some embryonic planets draw a disc of material around them, resulting in the production of moons around planets by the same mechanism that produces planets around stars.
- The disc surrounding PDS 70c has enough material to form up to three moons the size of Earth's moon, with a diameter about comparable to the distance between the Earth and the sun.

►BEPI COLOMBO

Joint mission of ESA and JAXA to Mercury.

►JUICE

- JUpiter ICy moons Explorer of ESA's (European Space Agency)
- Orbiter mission to explore Jupiter and three of its icy moons: Europa, Callisto and Ganymede.
- 1st non-American outer Solar System mission

►ROSETTA MISSION

ESA's mission to Comet Rosetta

►SOLAR ORBITER

- Will perform unprecedented close-up observations of the Sun and from high latitudes, providing the first images of uncharted polar regions of the Sun, and investigating Sun-Earth connection.
- Collaboration of NASA and ESA.
- At its closest, it will 42 million km, inside the orbit of planet mercury.
- It will use the gravity of Venus to enter a highly elliptical orbit around the Sun.

►COSMIC VISION

- ESA's campaign for space exploration like Discovery and New Frontiers Programs of NASA
- Will include several missions in solar system exploration including
  - CHEOPS
  - Comet Interceptor
  - LISA
  - ATHENA

►CHEOPS

- ESA's measure known exoplanets' size by photometry

►ATHENA

- Advanced Telescope for High Energy Astrophysics
- X-ray telescope planned for 2031

►AIDA

- Short for Asteroid Impact and Deflection Assessment
- Space probe to test impact models of whether a spacecraft could successfully deflect an asteroid on a collision course with Earth.

►COMET INTERCEPTOR

- Robotic spacecraft mission of ESA planned for a 2028 launch.
- It will be parked at the Sun-Earth L2 point (Lagrange Point)
- It is to intercept a long-period comet that will flyby in 2-3 years

►VENUS EXPRESS BY ESA

Orbiter mission of European Space Agency launched in 2005

►TIANGONG-1

- Chinese space station
- Also called Heavenly Palace or Celestial Palace 1.
- Launched in 2011, retired in 2018

►TIANGONG-2

- Launched in 2016
- Successor to Tiangong-1.
- Currently in orbit
- Aim is to test capabilities for long-term human presence in space.

►TIANZHOU 1

1st Chinese cargo spacecraft to service the Tiangong 2

►TIANHE-1

- Permanent space module of China
- Also called "Harmony of the Heavens"

►FAST ARRAY/ TIANYAN

- Chinese Radio Telescope
- Short for the Five-hundred-meter Aperture Spherical radio Telescope
- Also called "Sky Eye" or "The Eye of Heaven"

►HAYABUSA MISSION

- Japanese space exploration mission to study asteroids.
- Hayabusa 1 (2003): to study the features of asteroid 'Itokawa'.
- Hayabusa 2 mission (2014): asteroid 'Ryugu'

►HERACLE

Joint lunar mission of ESA, JAXA and Canada

►BIRDS PROJECT

- Japan's project to support non-spacefaring countries to build their first satellite.
- Called as The Joint Global Multi-Nation Birds Satellite project (BIRDS).
- Birds1: Five countries participated in the first Bird program: Ghana, Mongolia, Nigeria, and Bangladesh.
- Birds-2: Bhutan, the Philippines, and Malaysia

►SPICA

- Joint effort of Japan and ESA.
- Proposed infrared space telescope
- Short for Space Infrared Telescope for Cosmology and Astrophysics
- Aims to elucidate the process that enriched the universe with metal and dust and led to the formation of habitable world by observing "metal and dust enrichment through galaxy evolution" and "planetary system formation of habitable systems".

→ TELESCOPES

►THE GIANT METERWAVE RADIO TELESCOPE

- Located near Pune
- Deep space objects such as galaxy, neutron star, pulsar, etc.
- An array of 30 fully steerable parabolic radio telescopes of 45 metre diameter.

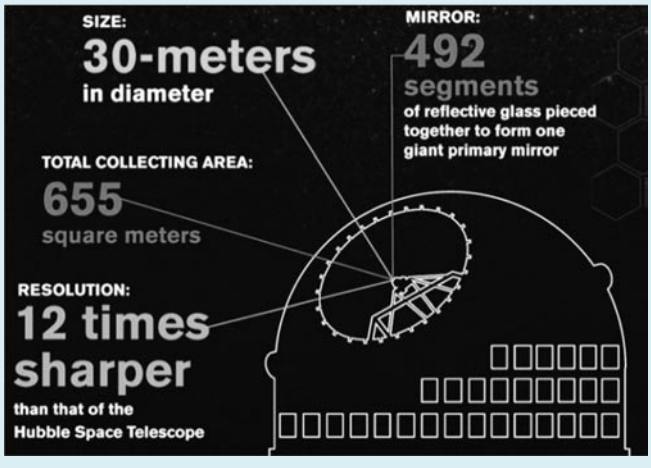
►GEMINI TELESCOPE IN HAWAII

- Radio telescope of USA
- It was used to measure the distance to the galaxy.
- The distance of radio galaxies is measured in redshift.
- The farther away galaxies are, the faster they move away from us and therefore appear to be redder due to Doppler shift.

►EVENT HORIZON TELESCOPE

- Imaged the 1st ever picture of Black Hole.
- Network of 8 radio telescopes located in Hawaii,
- Arizona, Chile, Mexico and Spain, and at 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 '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's components are designed to automatically point at preselected sets of galaxies, gather their light, and then split that light into narrow bands of color to precisely map their distance from Earth and gauge how much the universe expanded as this light travelled to Earth.
- 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.

►MEERKAT

- Inaugurated by South Africa, it will be the biggest radio telescope of its kind in southern hemisphere.
- It will be incorporated into complex Square Kilometre Array (SKA) instrument.
- It will address some of the key science questions in modern astrophysics – formation of galaxies, how are they evolving, how did we come to be here.

►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.

WHY LOW EARTH ORBIT FOR SPACE INTERNET?

1. It will have lower latency when compared internet provided by satellites in Geostationary orbit. (Less distance to travel)
2. However, to cover the area of the earth and provide continuous internet cover, many more thousands of satellites will be needed.

AIMS

1. Provide low-cost, reliable and uninterrupted space-based internet services to the world.
2. About 4 billion people do not have access to reliable internet as the traditional method to access internet using fibre optic networks and wireless networks

SPEED TEST - 3

i. Every known matter has an antimatter which has the same mass and volume; only difference being the inherent charge.

ii. Thus, according to the standard model elementary particles in nature are Quarks, Leptons and Bosons.

iii. Neutrinos have zero mass.

iv. Existence of Dark matter comes as a natural outcome of Einstein's theory of relativity.

v. Dark matter doesn't interact with matter and is completely invisible to light and other forms of electromagnetic radiation.
vi. Dark matter causes the universe to expand faster and faster.
vii. The further away the galaxies are, the faster they are moving.
viii. Einstein was convinced of the real existence of Black holes and predicted them to discovered latter.
ix. Black hole is made up Dark matter.
x. Light can be bent by Black hole.
xi. Bodies behind the Black hole can be visible to us.
xii. Radio telescopes are used to study Black holes.
xiii. Black holes always remain stationary in the space.
xiv. Event Horizon Telescope project is a joint initiative of NASA and ESA.
xv. Isotropic component of gravitational wave has not been detected yet.
xvi. Sagittarius A* is a star.
xvii. The first woman to win the prize was Marie Curie in 1903. She won it for discovery of radium.
xviii. Marie Curie is the only person to be honored by Noble Prize in two separate sciences.
xix. So far only four women have received Noble Prize in physics.
xx. Radio signal from an exoplanet hint towards life on the planet.

BASIC PHYSICS AND ASTRONOMY

►STANDARD MODEL OF PHYSICS

- The fundamental questions that has intrigued humans for 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 in accordance with 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.
- The antiparticle of a quark is the antiquark.
- There are 6 principal quarks and, hence, 6 anti-quarks.
- Quarks and antiquarks are the only two fundamental particles that interact through all four fundamental forces of physics: gravitation, electromagnetism, and the 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, 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).

- The fermion nature of electrons also governs the behaviour of electrons in a metal where at low temperatures all the low energy states are filled up to a level called the Fermi energy.

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 g-2 EXPERIMENT

Fermilab has released the first results from its 'muon g-2' experiment.

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. As the muon spins, it also interacts with the surrounding environment, which consists of short-lived particles popping in and out of a vacuum. So, its g value (magnetic moment) is altered by its interactions with these short-lived excitations.

THE 'muon g-2' EXPERIMENT RESULT

Fermilab has announced that the measured 'g' deviated from the amount predicted by the Standard Model. That is, while the calculated value in the Standard Model is 2.00233183620 approximately, the experimental results show a value of 2.00233184122.

SIGNIFICANCE OF THE RESULT

- The Standard Model is supposed to contain the effects of all known particles and forces at the particle level., if the measured g factor differs from the value calculated by the Standard Model, it could signify that there are new particles in the environment that the SM does not account for.
- So, a contradiction of the Standard Model would imply that there exist new particles, and their interactions with known particles would enlarge the canvas of particle physics.
- These new particles could be the dark matter particles which people have been looking out for, in a long time.

►GOD PARTICLE

- Peter Higgs suggested that particles did not have mass just after Big Bang. As universe cooled and temperature fell below 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 have the capability to grant mass, the primary condition for the existence of matter, they were termed as the God particle.
- Big Bang Theory is the leading explanation about how universe began. It talks about universe as we know it starting with a small singularity, then inflating over next 13.8 billion years to cosmos that we know today.
- Scientist at CERN observed Higgs boson decaying to fundamental particles known as bottom quarks.

►NEUTRINOS

- Neutrinos are subatomic particles that are almost mass less.
- 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.
- Japan is planning to build Hyper-Kamiokande neutrino detector which will be world's largest neutrino observatory.

Q. India-based Neutrino Observatory is included by the Planning Commission as a mega science project under the 11th Five Year Plan. In this context, consider the following statements: [2010]

1. Neutrinos are chargeless elementary particles that travel close to the speed of light.
2. Neutrinos are created in nuclear reactions of beta decay.
3. Neutrinos have a negligible, but nonzero mass.
4. Trillions of Neutrinos pass through human body every second.

Which of the statements given above are correct?

a) 1 and 3 only

b) 1, 2 and 3 only

c) 2, 3 and 4

d) 1, 2, 3 and 4

►ANTIMATTER

Every known matter has an antimatter which has the same mass and volume; 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 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 invisible and undetected has been termed as Dark Matter.
- It has not yet been observed yet directly. It doesn't interact with matter and is completely invisible to light and other forms of electromagnetic radiation making it impossible to detect.
- Scientists are confident it exists because of the gravitational effects it has on galaxies and galaxy clusters.
- The light from distant galaxies gets distorted and magnified by massive, invisible clouds of dark matter in the phenomenon known as Gravitational Lensing.

►DARK ENERGY

- Roughly 68% of the universe is dark energy. It is a property of space so does not get diluted as space expands. As more space comes into existence, more of this energy-of- space appears. As a result, dark energy causes the universe to expand faster and faster.
- While Dark matter exerts a “pull” on the universe, Dark Energy has a contrasting expansionary effect. As is it evident, our universe is expanding, indicating that Dark Energy has a greater abundance than dark matter.
- By the laws of cosmology, the total amount of mass in the universe cannot increase. Hence while the amount of Dark matter remains constant, Dark Energy which is a property of space itself is bound to increase exponentially. Eventually, Dark energy would overcome the influence of dark matter and lead to further expansion of the universe.

►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 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.
- S is a light element that is extensively employed in communication device technology nowadays. It has a fascinating history.
- It was created together with other elements in Big Bang, 13.7 billion years ago, when universe was born.
- While the quantity of other elements has increased millions of times, the current abundance of lithium in the universe is just four times what it was before the Big Bang. In the stars, it is truly obliterated.
- 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.

WHY GRB IS SPECIAL?

- The explosions are both tremendously powerful (a typical burst releases as much energy in a few seconds as the Sun does over the course of its 10-billion-year lifespan) and exceedingly infrequent.
- Although a comparable class of occurrences, quiet gamma repeater flares, relate to magnetars inside the Milky Way, all observed GRBs originated from beyond the galaxy.
- A gamma-ray burst in Milky Way, directed straight at Earth, is proposed as a cause of mass extinction.

►EVOLUTION OF UNIVERSE

Modern day understanding of evolution of the universe says that the beginning of the universe was marked by a spectacular event called Big Bang.

EXPANDING UNIVERSE AND BIG BANG

- Newtonian understanding was that universe was an infinite expanse of stars that are static.
- Hubble's law changed this understanding by stating that universe is expanding.
- The Hubble's law showed that the universe has been expanding for billions of years which means that in the past the matter in the universe must have been closer together and therefore denser than it is today.
- This leads us to conclude that some sort of tremendous event caused ultra-dense matter to begin the expansion that continues to the present day.
- This event is what is called the Big Bang that marks the creation of the universe.

PERIODS OF UNIVERSE

- For its first 3,70,000 years, the universe was filled with a hot, dense fog of ionized gas. As the universe cooled and expanded, electrons and protons were able to combine to form the first neutral atoms. When this happened, thermal energy from the Big Bang was able to travel freely throughout the universe. This high-energy radiation has, over the cosmic time, cooled and been red-shifted by a factor of more than 1,000, due to the expansion of the universe. We see the remnants of this today as the Cosmic Microwave Background (CMB).
- Studies of the CMB, beginning in the early 1990s, revealed that the very early universe, though generally smooth, contained tiny density fluctuations (on the order of one part in 1,00,000), that rippled through the space. More fine-grained studies by instruments, such as the Wilkinson Microwave Anisotropy Probe (WMAP), helped better-establish the composition of the universe and fixed its age at 13.7 billion years.
- After the CMB became imprinted on the universe, the cosmos became opaque at the shorter wavelengths, due to the absorbing effects of the atomic hydrogen. This began a long period, known as the Dark Ages, so-called because of the absence of stars and the extremely dense intervening neutral hydrogen gas.
- Over time, the areas of higher-gas density began to collapse under gravity and the neutral matter in the universe began to clump together. Eventually, these regions cooled and collapsed, igniting nuclear fusion in their cores, and leading to the first stars and galaxies.
- As the first stars emerged, their energy heated the surrounding medium, once again ionizing the hydrogen in the universe. At first, these areas were like small bubbles of ionized gas, surrounding the bright energy sources.
- As these bubbles grew and punched ever-larger holes into the neutral universe, they eventually began to overlap, enabling ionizing radiation to travel farther and farther through the space. The first stars also significantly altered the chemical makeup of the cosmos. Through nucleosynthesis in the cores of these short-lived stars – which may have been as much as 1,000 times more massive than the Sun – and as a result of powerful supernovae, a fraction of the universe's initial constituents of hydrogen and helium were converted into carbon, oxygen, iron and other heavier elements.
- Once the majority of the universe was re-ionized, approximately one billion years after the Big Bang, light across much of the electromagnetic spectrum could travel unimpeded through the cosmos, eventually revealing the universe, as we see it today.

COSMIC MICROWAVE BACKGROUND RADIATION AS PROOF OF BIG BANG

- Immediately after the big bang, the universe was so hot that the thermonuclear reactions (that are usually seen in stars today) happened everywhere in the universe leading to formation of primordial elements, hydrogen and helium.
- The thermonuclear fusion of hydrogen into helium atoms led to release of high-energy shortwave photons which is known to be cosmic background radiation.
- As the universe expanded this radiation also expanded becoming long-wave (microwave) which is

why it is called cosmic microwave background radiation which fills the entire space.

- Thus, CMB is evidence for expansion of universe.

RED-SHIFT AS PROOF OF BIG BANG

Astronomers have discovered that, in general, the further away a galaxy is, the more red-shifted its light is. This means that the further away the galaxies are, the faster they are moving. This is like an explosion, where the bits moving fastest travel furthest from the explosion. Red-shift data provides evidence that the Universe, including space itself, is expanding.

The discovery of red shift in light from distant galaxies led to the development of the Big Bang theory. The discovery of the CMBR, after it had been predicted by the theory, provided very strong support for the Big Bang theory.

Q. Which of the following is/are cited by the scientists as evidence/ evidence for the continued expansion of universe? [2012]

1. Detection of microwaves in space
2. Observation of redshift phenomenon in space
3. Movement of asteroids in space
4. Occurrence of supernova explosions in space

Select the correct answer using the codes given below:

(a) 1 and 2

(b) 2 only

(c) 1, 3 and 4

(d) None of the above can be cited as evidence

►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.
- For years, physicists questioned whether black holes could really exist but Mr. Penrose, a professor at the University of Oxford, used mathematical modelling to prove back in 1965 that black holes can form. His calculations proved that black holes — super dense objects formed when a heavy star collapses under the weight of its own gravity — are a direct consequence of Einstein's general theory of relativity.
- The unveiling of the first-ever picture of a black hole by the Event Horizon Telescope in April 2019. The black hole is approx. 55 million light years away.

PROOF OF BLACK EXISTENCE

- The existence of this black hole was first guessed at because the Messier87 galaxy when imaged at radio frequencies shows the signature twinjets of plasma that are squirted out at near-relativistic speeds to reach well beyond the galaxy into intergalactic space.
- Furthermore, studying the movement of gas clouds in the central region shows gas moving at enormous speeds both towards and away from us, and these speeds are consistent with the hypothesis that the gravitational force of a central billion-solar mass black hole drives this gas.
- It is the hot gaseous material that is swirling into the black hole that is being consumed by the black hole, and the light is coming from this swirling material.
- Matter in the close vicinity of a black hole shines because it gets extremely hot, and light from "behind" the black hole also reaches us because the gravitational field of the black hole bends this light towards us.
- We do not get any light or other signals from within the black hole

DETECTING UNIFIED CALL OF BLACK HOLES

Just as studying the cosmic microwave background tells us about the early universe, its formation, the stochastic gravitational wave background would reveal the structure of the universe around us.

Detections till now have been of events that were relatively close to us. Distant binary coalescences, milli-second pulsars, etc are expected to produce a background, and detecting any of this would be a great breakthrough.

The gravitational wave background consists of an isotropic component and an anisotropic component. The isotropic component is constant when you look in different directions and the anisotropic component depends on the direction.

Isotropic component has not been detected yet. Future improved versions of the detectors will have to work below this level to detect the background. "If the gravitational wave background is discovered, it will be a major discovery in astronomy, probably one of the most celebrated ones"

BLACK HOLE RESEARCHERS GET NOBEL PRIZE FOR PHYSICS

Roger Penrose of Britain, Reinhard Genzel of Germany and Andrea Ghez of the U.S. won the Nobel Physics Prize for their research into what the Nobel committee called "one of the most exotic phenomena in the universe, the black hole".

Mr. Penrose won the Nobel Physics Prize for showing that *"the general theory of relativity leads to the formation of black holes"*.

While Mr. Genzel, and Ms. Ghez, were jointly awarded for discovering *"that an invisible and extremely heavy object governs the orbits of stars at the centre of our galaxy"*. They have led research since the early 1990s focusing on a region called Sagittarius A* at the centre of the Milky Way.

Ms. Ghez is just the fourth woman to receive the physics prize since 1901 when the first Nobel prizes were handed out. The first woman to win the prize was Marie Curie in 1903, who was also the first person to receive two Nobel prizes when she won the 1911 chemistry prize.

MOVING BLACK HOLE

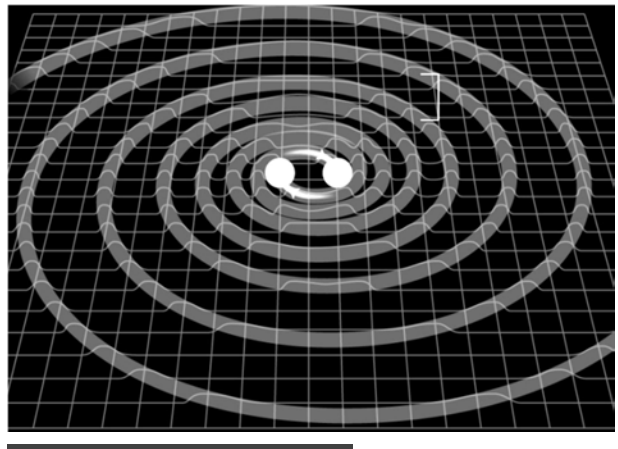
- Scientists have discovered the first moving supermassive black hole whose mass is about three million times that of our Sun.
- Scientists studied 10 faraway galaxies with supermassive black holes in the center, expecting them to have the same velocity as that of the galaxies they reside in.
- As the spiraling mass circles around the black hole before falling into it like liquid in a sink, it produces a laser-like beam of radio light known as a maser. These masers can tell the velocity of black holes very accurately.
- Besides the empirical evidence, the enormous size of these black holes had led people to imagine them to be stationary objects planted in the middle of galaxies as opposed to objects floating around in space.
- The observed blackhole is moving with a speed of about 1,10,000 miles per hour inside its galaxy.
- Possible Causes for the Motion:
  - Two Supermassive Black Holes Merging: Scientists might have spotted the resulting black hole moving in a rearward motion after the merger before settling down in a position.
  - One in a Binary System of Black Holes, where not one but two supermassive black holes might exist within the host galaxy held together by a shared center of gravity, which they might be orbiting.

►GRAVITATIONAL WAVES

- Electric charges oscillating up & down produce electromagnetic radiation. In a similar way, general theory of relativity predicts that oscillating massive objects should produce gravitational radiation, or gravitational waves.
- Gravitational waves are ripples in overall geometry of space and time produced by moving masses.
- Some cosmic events that produce such ripples are exploding stars, collisions between ultra-dense neutron stars or merging black holes or supernovae.
- Gravitational radiation is exceedingly difficult to detect because gravity by nature is much weaker than electromagnetic radiation.

HOW ARE GRAVITATIONAL-WAVE PRODUCED?

- In 2016, gravitational waves finally were observed from 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.



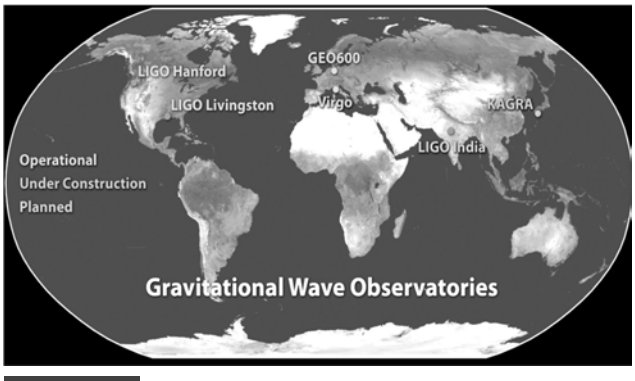
SIGNIFICANCE OF DISCOVERY

- Discovery of gravitational waves is beginning of new era in astronomy. So far, all observations of universe are made through electromagnetic radiation emitted from objects from visible light to 'gamma rays.
- Gravitational waves are a new way of "seeing" what happens in space.
- We can now detect events that would otherwise leave little to no observable light, like black hole collisions.
- It will also help untangle mysteries about the dense, dead objects known as neutron stars.

LIGO

- Laser Interferometer Gravitational-wave Observatory (LIGO) is designed to detect gravitational waves.

- In 2017, for first time, scientists directly detected gravitational waves from collision of two neutron stars using US based LIGO, Europe-based Virgo detector & other ground & space-based observatories
- LIGO detectors use laser interferometry to measure minute ripples in space-time caused by gravitational waves from mergers of pairs of neutron stars or black holes, or supernovae.
- LIGO has detected the gravitational twice now, the second time witnessing the merging of a second black hole pair. The signal from this merger was weaker than the 1st observed gravitational waves. Hence a special technique called matched filtering was adapted for gravitational wave data analysis which was developed at IUCAA (Inter-University Centre for Astronomy and Astrophysics), Pune.



LIGO-INDIA

- IndIGO (Indian Initiative in Gravitational-wave Observations) is a consortium of Indian physicists to set up experimental gravitational-wave observatory facilities in India.
- It is a planned gravitational-wave observatory to be in India as part of worldwide network as part of collaborative project between a consortium of Indian research institutions and LIGO observatory in US along with its international partners Australia, Germany and UK.
- To establish this, a site near Aundha Nagnath in Hingoli District, Maharashtra has been selected.

LISA PATHFINDER

- LISA stands for Laser Interferometer Space Antenna. It is project led by European Space Agency to a build a space-based observatory for detecting gravitational waves. It will consist of three spacecrafts 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.

The mystery behind declining star formation

Why are some galaxies forming more stars at the center and while others don't?

HYPOTHESIS

The current hypothesis is that the bar structure acts as a type of stellar nursery, fueling star birth at their centers. The bar is thought to act as a mechanism that channels gas inwards from the spiral arms, in effect funneling the flow to create new stars. This process is also thought to explain why many barred spiral galaxies have active galactic nuclei.

Since so many spiral galaxies have bar structures, it is likely that they are recurring phenomena in spiral galaxy development. The oscillating evolutionary cycle from spiral galaxy to barred spiral galaxy is thought to take on the average about two billion years.

Recent studies have confirmed the idea that bars are a sign of galaxies reaching full maturity as the "formative years" end.

BARRED SPIRAL GALAXY

- A barred spiral galaxy is a spiral galaxy with a *central bar-shaped* **structure** composed of stars.
- Some barred galaxies have shown a higher concentration of newly formed stars, suggesting that the bar nurtures star formation.
- The stars move in elongated orbits near the center so that, from far, this **portion** appears like an **illuminated** bar.
- 2/3rd of disc galaxies in local universe are found to have this bar structure.
- The Milky Way Galaxy, where the Solar System is located, is classified as a barred spiral galaxy.

FIRST POTENTIAL RADIO SIGNAL FROM EXOPLANET

An international team of scientists has collected the first possible radio signal from a planet beyond our solar system, emanating from an exoplanet system about 51 light-years away.

TAU BOOTES STAR-SYSTEM

- Tau Bootes system contains a binary star system and an exoplanet.
- So far only the Tau Bootes exoplanet system has exhibited a significant radio signature, outside our solar system.
- Around 51 light-years away

SIGNIFICANCE OF THE OBSERVATION

- Observing an exoplanet's magnetic field helps astronomers decipher a planet's interior and atmospheric properties, as well as the physics of star-planet interactions.
- Earth's magnetic field protects it from solar winds. Magnetic field of Earth-like exoplanets may contribute to their habitability by shielding their atmospheres from solar wind & cosmic rays and protecting the planet from atmospheric loss.

►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 Solar System, located between 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.
  - Lagrange Points: These are positions in space where the gravitational forces of a two-body system like the Sun and the Earth produce enhanced regions of attraction and repulsion. These can be used by spacecraft to reduce fuel consumption needed to remain in position.

ASTEROID '2001 FO32'

- It is the largest to pass by Earth in 2021.
- It provided a rare opportunity for astronomers to get a good look at a rocky relic that formed at the dawn of our solar system.
- It is in a highly eccentric orbit around the Sun. It completes one orbit every 810 days.
- It is faster than the speed at which most asteroids encounter Earth. The reason for the asteroid's unusual speed is its close approach to the earth.
- It will provide an opportunity for astronomers to get a more precise understanding of the asteroid's size and albedo.
  - When sunlight hits an asteroid's surface, minerals in the rock absorb some wavelengths while reflecting others. By studying the spectrum of light reflecting off the surface, astronomers can measure the chemical "fingerprints" of the minerals on the surface of the asteroid.

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.
- Hayabusa 2 was launched in 2014 and took four years to reach the asteroid Ryugu.
- The mission builds on the original Hayabusa mission that was launched in 2003 and successfully linked up with asteroid Itokawa in 2005. It returned samples to Earth in 2010 marking the first time when sample materials from an asteroid were brought back to Earth.
- The space probe orbited above the asteroid for a few months to map its surface before landing. Then it used small explosives to blast a crater, collected the resulting debris and headed back to Earth in November 2019.
- The mission seeked to answer some fundamental questions about the origins of the Solar system and where molecules like water came from.

Significance

- Asteroids and comets are primitive bodies that can be the building blocks of the early Solar system and they hold a record of the birth and initial evolution.
- They retain a record of when, where and in what conditions they were formed. Exploration of these primitive bodies is essential in gaining insight into the formation of the Solar system.
- Gases trapped in the rock samples could reveal more about the chemical mixture from the planets formed.

ASTEROID 16 PSYCHE

NASA has found out that asteroid 16 Psyche, which orbits between Mars and Jupiter, could be made

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 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 composition of Psyche is similar to Earth's own core, its study will also give an insight to earth's violent history of collisions and accretion that created it.

►WORLD'S FIRST 6G TEST SATELLITE

- China has launched 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 of 6G's specifications, so it is not certain yet, if the technology being developed by China will make it into 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

ABOUT GRAVITATIONAL LENSING

The phenomenon occurs when a huge amount of matter, such as a massive galaxy or cluster of galaxies, creates a gravitational field that distorts and magnifies the light from the objects behind it, but in the same line-of-sight.

In effect, these are natural, cosmic telescopes. Thus, they are called gravitational lenses.

- These large celestial objects will magnify the light from the distant galaxies that are at or near the peak of star formation.
- Helps to map the distribution of dark matter in the space.
- Allows researchers to study the details of the early galaxies too far away to be seen otherwise with even the most powerful space telescopes.

►FRANCE'S FIRST SPACE MILITARY EXERCISE: ASTERX

France has begun its first space military exercises to test its ability to defend its satellites. The exercise drills are codenamed "AsterX" to commemorate the first French satellite Asterix from 1965.

- The exercises are part of France's strategy to become the world's third-largest space power, after the USA and China.
- These space military exercises are the first ever attempt not only for the French army but also for Europe.
- Moreover, France has planned to develop anti-satellite laser weapons and to strengthen surveillance capabilities to close the gap with rivals, China and Russia.
- In 2019, France announced its Commandment de l'Espace (CdE) (French Space Command).

SIMILAR INITIATIVES OF INDIA

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

PRIVATE PARTICIPATION IN SPACE SECTOR

SPEED TEST - 4

i. Anand is the first satellite to be launched from an Indian start-up.

ii. New Space India Limited (NSIL) now acts as a single-point interface between ISRO and everyone who wants to participate in space-related activities

iii. Spacecom Policy 2020 allows for the commercial use of satellites, orbital slots, and ground stations for communication needs.

iv. Indian National Space Promotion Board would be set up under PMO to promote private space entrepreneurs.

v. Amazonia-1 is an *optical earth observation satellite* from Brazil with the aim to monitor Amazon Forest.

vi. ANASIS-II is the first military-only communications satellite of France.

ISRO through PSLV-C51 has recently launched Amazonia-1. Amazonia-1 is the first fully Brazilian-made satellite, which would help to monitor the Amazon forests.

However, a satellite from Pixxel India could be launched (which was planned earlier)

Bengaluru-based Pixxel India has planned a vast constellation of earth-imaging satellites that would continuously monitor every part of the globe and beam high-resolution imagery and other data that can be used for a variety of applications related to climate change, agriculture, and urban planning.

The government has initiated reforms, and within eight months, the first satellite Anand from a start-up called Pixxel India was going to be launched.

Space reforms that opened the space sector to facilitate participation of private companies

- IN-SPACe: It will act as a single-point interface between Indian Space Research Organisation (ISRO), and everyone who wants to participate in space-related activities or use India's space resources.
  It will also handhold, promote and guide the private industries in space activities through encouraging policies and a friendly regulatory environment.
- Indian National Space Promotion Board: It would be set up to strengthen the Department of Space and for the promotion of the private space entrepreneurs or non-government space entrepreneurs.
- Role of ISRO: The overall idea is to let ISRO concentrate on essential activities like research and development, planetary exploration, and strategic use of space, while freeing itself from ancillary or routine work which could easily be done by private industry.
- The Public Sector Enterprise 'New Space India Limited (NSIL)' to re-orient space activities from a 'supply driven' model to a 'demand driven' model, thereby ensuring optimum utilization of our space assets.
- Demand Driven Model: By the support of New Space India Limited (NSIL), It would endeavour to reorient space activities from a 'supply driven' model to a 'demand driven' one, thereby ensuring optimum utilisation of the nation's space assets.
  - Till now Indian industry's role has been mainly that of suppliers of components and sub-systems. Indian industries do not have the resources or the technology to undertake independent space projects of the kind that US companies such as SpaceX have been doing or provide space-based services.
  - Additionally, the demand for space-based applications and services is growing even within India, and ISRO is unable to cater to this. The need for satellite data, imageries and space technology now cuts across sectors, from weather to agriculture to transport to urban development, and more.
  - The main objective of NSIL is to scale up industry participation in Indian space programs in comparison to IN-SPACe which gives emphasis on the participation of the private sector.
- Released the draft of a new Spacecom Policy 2020:
  - The policy will regulate the commercial use of satellites, orbital slots, and ground stations for communication needs. The policy also details how private players can get authorization for setting up new communication satellites and ground stations.
  - The private players in the space communication sector will also enable India to keep pace with the growing demand for satellite-based broadcasting, network connectivity, and global mobile personal communication.

IN-SPACE

- Indian National Space Promotion and Authorization Center (IN-SPACe)
- IN-SPACe is an independent nodal agency under 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 expert, experts from Academia and Industries, Legal and Strategic experts from other departments, members from PMO and MEA of Government of India.
- IN-SPACe is to be established as a single window nodal agency, with its own cadre, which will permit and oversee the following activities of NGPEs.
  - Space activities including building of launch vehicles and satellites and providing space based services as per the definition of space activities.
  - Sharing of space infrastructure and premises under the control of ISRO with due considerations to on-going activities.
  - Establishment of temporary facilities within premises under ISRO control based on safety norms and feasibility assessment
  - Establishment of new space infrastructure and facilities, by NGPEs, in pursuance of space activities

based on safety norms and other statutory guidelines and necessary clearances.
- Initiation of launch campaign and launch, based on readiness of launch vehicle and spacecraft systems, ground and user segment.
- Building, operation and control of spacecraft for registration as Indian Satellite by NGPEs and all the associated infrastructure for the same.
- Usage of spacecraft data and rolling out of space-based services and all the associated infrastructure for the same.

NEW SPACE INDIA LIMITED (NSIL)

- The Public Sector Enterprise 'New Space India Limited (NSIL)' will endeavor 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 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 program.
- Some of the planetary exploration missions will also be opened to private sector through an 'announcement of opportunity' mechanism.

NSIL MANDATE

- Owning satellites for Earth Observation and Communication applications and providing space-based services
- Building satellites and launching them as per demand
- Providing Launch Services for satellite belonging to customer
- Building launch vehicles through Indian Industry and launch as per satellite customer requirement
- Space based Services related to Earth Observation and Communication satellites on commercial basis
- Satellite building through Indian Industry
- Technology Transfer to Indian Industry.

►INDIA'S FIRST PRIVATE UPPER STAGE ROCKET ENGINE

- Space startup Skyroot Aerospace has successfully tested an upper-stage rocket engine, becoming first Indian private company to demonstrate 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%, reduced number of components & lead time by 80%.

►ANASIS-II

- SpaceX (Private Space company) has launched South Korea's first-ever military communications satellite.
- ANASIS-II aims to enhance South Korea's ability to defend itself against nuclear-armed North Korea.
- This launch made South Korea 10th country to own a military-only communications satellite, providing "permanent and secured military communications".

►VENUS

Scientists have discovered phosphine gas on Venus.

Despite being similar in size to the Earth, having rocky surface, and having an iron core, Venus has got very little attention in space exploration.

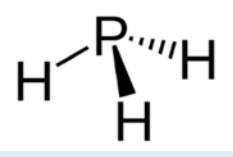
Planet was considered hostile to life

- Although Venus is the second closest planet to the Sun, it is still the hottest.
- Surface temperatures is 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.

Planned Missions to Venus

PHOSPHINE GAS

- A compound of one phosphorous atom and three hydrogen atoms.
- It is given out by some microbes during biochemical processes.
- In an atmosphere rich in carbon dioxide, it is likely to get destroyed soon.



- The researchers estimate that phosphine forms about 20 parts per billion of Venus's atmosphere.

Significance of Phosphine gas

- It is considered as a biosignature gas.
- Phosphene is natural biproduct of life. (It is either manufactured by us or is produced as a by-product of life.)

- Phosphene has no abiotic false positives (nothing but life can naturally produce the gas on earth)

CURIOSITY WITH CAUTION

- It is possible that the signal could be observed by another gas, SO_2.
- Some researchers are suggesting that there could be thick shell of sulphur to defend themselves from sulphuric acid.

This can now only be taken further by making in situ measurements in the atmosphere of Venus. This poses its own challenges. Apart from the high surface temperature and dense atmosphere, the presence of sulphuric acid in the atmosphere of Venus makes it a highly corrosive environment. Perhaps flying at a height and sending down drones or balloons would be more feasible than a landing.

BIOSIGNATURE GASES

A biosignature is any substance – such as an element, isotope, or molecule – or phenomenon that provides scientific evidence of past or present life.

On Earth, PH_3 is associated with anaerobic ecosystems, and as such, it is a potential biosignature gas in anoxic exoplanets.

Biosignature Gases

i. Oxygen
ii. Ozone
iii. Methane
iv. Nitrous Oxide
v. Methyl Bromide
vi. Methyl Chloride
vii. Hydrogen Sulfide
viii. Carbonyl Sulfide
ix. Phosphine
x. Sulfur Dioxid

PAST MISSIONS TO VENUS

- There's one spacecraft currently flying around Venus — Japan's *Akatsuki orbiter*. Second dedicated Venus mission.
- ESA's *Venus Express* mission operated in orbit around the planet from 2006 through 2014.

FUTURE MISSIONS TO VENUS

- Shukrayaan-1 Mission of ISRO: A proposed orbiter to Venus to study surface and atmosphere of Venus.
- ENVISION Mission of ESA: It proposed orbiter of ESA which will explore surface and subsurface geological processes, interior geophysics and geodynamics and atmospheric pathways of key volcanogenic gases
- DAVINCI Mission of NASA: After exploring top of Venus's atmosphere, DAVINCI will drop a probe to the surface of Venus. In its hour-long descent, it will send close pictures images of the surface.
- VERITAS Mission of NASA: NASA orbiter to explore how Venus lost its potential to be a habitable world. It will help create first global high resolution topographic and radar images of Venus. Make first maps of regions where geologic processes are actively deforming the surface of Venus. Produce first near global map of surface rock composition and refine our estimates of Venus' core size and composition.

►MARS

- Fourth planet from Sun and second-smallest planet in Solar System. Mars is about half size of Earth.
- Similarity to Earth (Orbit and Rotation):
  - Mars rotate 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 of 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 rocks, and dust of Mars. Hence, called Red Planet.
- Mars has largest volcano in 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 till date, but areas of Martian crust in southern hemisphere are highly magnetized, indicating traces of a magnetic field.
- Mars has two small moons, Phobos and Deimos, that may be captured asteroids.
- Soviet Union in 1971 became first country to carry out a Mars landing, Mars 3. The second country to reach Mars's surface is the USA.

REASONS FOR FASCINATION WITH MARS

i. Mars is a planet where life may have evolved in the past. Conditions on early Mars were very similar to that of Earth. It was once warm enough to allow water to flow through it. It had a thick atmosphere,

which enabled stability of water on surface of Mars. This means life could have existed there too.

ii. Red Planet has several Earth-like features– such as clouds, polar ice caps, volcanoes, and seasonal weather patterns.

iii. Mars is only planet that humans can visit or inhabit in the long term. Mars is comparatively hospitable in terms of temperature, with an approximate range between 20 degrees C at Equator to minus 125 degrees C at poles.

iv. However, no human has set foot on Mars yet because atmosphere on Mars is very thin, consisting of mostly carbon dioxide with no breathable oxygen, making it difficult for astronauts to survive there.

►MISSION TO MARS

There are currently 10 spacecraft from five different space agencies — United States, European Union, India, China, and United Arab Emirates:

- NASA has a lander - Mars Insight, a rover - Curiosity, and three orbiters - Mars Reconnaissance Orbiter, Mars Odyssey, MAVEN.
- India has an orbiter – Mangalyaan-1
- EU has 2 orbiters – Mars Express and ExoMars Trace Gas Orbiter
- China has an orbiter – Tianwen-1
- UAE has an orbiter – Hope

UAE'S HOPE MARS MISSION

UAE's first-ever interplanetary Hope Probe mission has successfully entered orbit around Mars. The mission was launched from Tanegashima Space Centre in Japan.

Mission's aim: The mission will collect data on Martian climate dynamics and help scientists understand why Mars atmosphere is decaying into space. The instruments will collect different data points on the atmosphere to also gauge seasonal and daily changes. Together, this will shed light on how energy and particles, like oxygen and hydrogen, move through the atmosphere of Mars.

UAE become the fifth entity to reach the Red Planet, joining NASA, the Soviet Union, the European Space Agency and India. It is the Arab world's first interplanetary mission.

TIANWEN-1

- It is the first mission to Mars from China.
- It carries an orbiter, a lander, and a rover.
- It will orbit Mars for a few months before attempting to land in May this year.
- It will look for water under the Martian surface. The rover is scheduled to land at Utopia Planitia, a location with possible ancient groundwater deposits.

►PERSEVERANCE MISSION

- NASA's 4th generation Mars Rover. It is the most advanced, most expensive & most sophisticated mobile laboratory sent to Mars. It is different from previous missions as it can drilling & collect core samples of most promising rocks & soils.
- It has landed at Jezero Crater - an ancient river delta that has rocks and minerals that could only form in water.
- Goal is to look for biosignatures – hints of life – in either the chemical measurements or morphological observations, in the dried-up lakebed at Jezero Crater.
- Perseverance will drill and collect rock samples that will be returned to Earth by a subsequent European Space Agency/NASA mission.
- It has a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) which converts heat from the natural radioactive decay of plutonium (Plutonium Dioxide) into electricity.
- Perseverance will carry the Radar Imager for Mars' Subsurface Experiment (RIMFAX). RIMFAX will provide high resolution mapping of the subsurface structure at the landing site. The instrument will also look for subsurface water on Mars – which, if found, will greatly help the case for a human mission or the cause of a human settlement on Mars.
- One of the objectives of the mission is also to demonstrate technology for future robotic and human exploration. Perseverance will produce oxygen on the Martian surface for the first time, using atmospheric CO2 from the Martian atmosphere.
- Ingenuity Helicopter: It is the name of the small robotic helicopter onboard NASA's Perseverance mission to Mars. It became the first powered controlled flight machine on a planet after Earth. It is powered by solar power.

MOXIE

- Mars Oxygen In-Situ Resource Utilisation Experiment is known as MOXIE. It's a golden box that sits in front of the rover.
- "Mechanical Tree" is another name for MOXIE. This is because it splits CO_2 molecules into carbon and

oxygen. Carbon monoxide is produced as a byproduct of the operation.

- In its first run, MOXIE generated five gm of oxygen. For an astronaut undertaking a regular activity, it is equivalent to 10 minutes of breathing oxygen. MOXIE can produce 10 gm of oxygen in one hour.
- Nickel-alloy was used to construct it. The alloy is heat resistant and can withstand temperatures as high as 1,470 degrees Fahrenheit.
- MOXIE has a gold covering on it so that the heat it emits does not hurt the rover.
- The presence of ice on Mars has been confirmed by previous expeditions. Scientists think that obtaining oxygen from the carbon dioxide-rich Martian atmosphere is more possible than extracting oxygen from ice on the planet's surface.

►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 Martian surface and mineral composition as well as scan its atmosphere for methane (an indicator of life on Mars).

►PHOBOS

- Mars Color Camera onboard ISRO's Mars Orbiter Mission has captured image of Phobos, the closest and biggest moon of Mars.
- Phobos is made up of carbonaceous chondrites.
- Stickney, the largest crater on Phobos along with other craters (Shklovsky, Roche & Grildrig) are also seen.

LUNAR MISSIONS

►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 Moon: There places on Moon that never receive direct sunlight. Most of these sites are located at lunar poles. Reasons: Low angle at which sunlight strikes Moon's surface in polar regions (Moon's tilt on its axis 1.54 degrees compared to 23.5 degrees for Earth) and no atmosphere on Moon. These permanently shadowed craters have some of the lowest temperatures in the solar system, down to -414^{o}C. It is believed that some of these craters have ice deposits. Ice at these temperatures is stable and studying it will allow us to know about early solar system.
- NASA's LCROSS (Lunar Crater Observation and Sensing Satellite) showed that there are hydrogen, methane, ammonia, and metal like Sodium, mercury, silver. Moon's South pole has vast resources for future explores to use.
- Chandrayaan–2 was to attempt to soft land the lander – Vikram and rover – Pragyan in a high plain between two craters, Manzinus C and Simpelius N, at a latitude of about 70° south.
- LUPEX MISSION: A joint mission of ISRO (India) and JAXA (JAPAN) to send a rover and lander to explore south pole of Moon. JAXA will provide its H3 launch vehicle and rover, while ISRO would be responsible for lander.
- Chandrayaan-3: India is working on Chandrayaan-3 (successor to Chandrayaan-2) and it will likely attempt another soft-landing on lunar surface.
- Chang'e 4: Chinese spacecraft, was first to soft land in Von Kármán crater, which is within South Pole - Aitken Basin on southern far side of Moon.
- Chang'e-5 mission will seek to collect lunar material to help scientists understand more about moon's origins and formation.
- UAE's Rashid: UAE has decided to send an unmanned spacecraft named Rashid to the moon in 2024.

OTHER MISSIONS PLANNED TO MOON

International Lunar Research Station

- Joint project of China & Russia to build an International Lunar Research Station (ILRS) on moon's surface.
- The station will be built on lunar surface and/or lunar orbit and help carry out scientific research for lunar exploration and utilisation, lunar-based observation, basic scientific experiment and technical verification.

Beresheet 2

- It is an unmanned private spacecraft to launch on Moon in 2024. The spacecraft will be sent by Israel foundation SpaceIL.
- This mission has been planned after the failure of Beresheet Mission to Moon by SpaceIL.

►RUSTY MOON

As per data acquired by Moon Mineralogy Mapper onboard Chandrayaan-1, there are oxidized iron mineral called hematite (Fe_2O_3) at high latitudes on Moon.

- This lunar hematite is formed through oxidation of iron on Moon's surface by oxygen from Earth's upper atmosphere, as more hematite on lunar nearside has been observed. (Moon is tidally locked with earth, meaning always same side of moon faces earth)
- Along with the oxygen, water on the lunar surface and heat from interplanetary dust also helped in the oxidation process.
  - Hematite is not absent on lunar far side. There, a small amount of iron oxides "might be formed under the presence of water and energies induced by interplanetary dust impacts and then be decomposed to hematite."
- Hematite formed at lunar craters of different ages may help understand the oxygen of Earth's atmosphere in the past 2.4 billion years and reveal facts about the evolution of Earth's atmosphere in the past billions of years.
- NASA's ARTEMIS missions can bring some hematite samples, and detailed chemical studies can confirm if lunar hematite was indeed oxidised by Earth's oxygen.

►ARTEMIS PROGRAM

- NASA's Program that aims to send first woman and first person of color on Moon by 2024. Astronauts will be landed on Moon's South Pole.
- NASA will collaborate with commercial and international partners and establish the first long term presence on the Moon (Artemis Base Camp). Later, the Moon base will be used for sending first astronauts to Mars.
- Artemis I is most likely to be launched 2021 and involves an uncrewed flight to test the Space Launch System (SLS) and Orion spacecraft.
- Artemis II will be the first crewed flight test and is targeted for 2023.
- Artemis III will land astronauts on Moon's South Pole in 2024.

COMPONENTS OF ARTEMIS PROGRAM

- NASA's Orion Spacecraft: It is a human spacecraft for deep space missions with aim to carry humans to Moon and 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.
- Space Launch System: It is a super heavy lift launch vehicle (capacity to send more than 50 tones to Low Earth Orbit). It is the only rocket that can send Orion, astronauts and cargo directly to Moon on a single Mission and will be world's most powerful rocket. In other configurations it will facilitate human space travel to Moon and Mars & robotic scientific missions to places like Moon, Mars, Saturn and Jupiter.
- Gateway Lunar Orbiting Outpost: A small spaceship that will orbit the Moon, meant for astronaut missions to Moon and later, for expeditions to Mars. It will be much smaller in size (Studio apartment) compared to ISS. It will act as an airport, where spacecraft bound for lunar surface of Mars can refuel or replace parts and resupply things like food and oxygen, allowing astronauts to take multiple trips to the Lunar surface and exploration of new locations across the Moon.

ARTEMIS ACCORDS

- Artemis Accords are an intergovernmental agreement between governments participating in Artemis Program of NASA.
- Drafted by NASA and U.S. Department of State, the Accords establish a framework for cooperation in the civil exploration and peaceful use of Moon, Mars, and other astronomical objects.
- They are explicitly grounded in UN Outer Space Treaty of 1967, which signatories are obliged to uphold, and cite most major U.N.-brokered conventions constituting space law.
- Signatories: Space agencies of more than dozen countries have signed these. India has not.

Key features:

- Peaceful purposes: All activities to be conducted for peaceful purposes, as per tenets of Outer Space Treaty.
- Transparency: Partner nations to publicly describe their policies and plans in a transparent manner.
- Interoperability: Partner nations to utilize open international standards, develop new standards when necessary and strive to support interoperability to the greatest extent.
- Emergency Assistance: Reaffirm partner nations commitments to the Agreement on the Rescue of

Astronauts, Return of Astronauts and Return of Objects launched into Outer Space and taking all reasonable steps to render assistance to astronauts in distress.

- Registration of Space Objects: Reinforces critical nature of registration and urges any partner which is not a member of the Registration Convention to join as soon as possible.
- Release of scientific data: Partner countries will release their scientific data publicly to ensure benefit for wider world from Artemis Journey and discovery.
- Protecting Heritage: Partner nations will commit to protection of sites and artifacts with historic value.
- Space Resources: Space resource extraction and utilization can & will be conducted under terms of Outer Space Treaty.
- Deconfliction of Activities: Partner nations will provide public information regarding location and general nature of operations which will inform the scale and scope of 'Safety Zones' to prevent harmful interference.
- Orbital Debris & Spacecraft Disposal: Partner nations will plan for mitigation of orbital debris, including safe, timely and efficient passivation and disposal of spacecraft at the end of the missions.

NUCLEAR SCIENCE

BASICS

- An atom is made up of a Nucleus (with Protons and Neutrons) and electrons revolving around the nucleus.
- The mass of the atom is concentrated in the nucleus. The number of protons (Z) in an atom determines the atomic number of an element. While the term atomic deals with 10^{-10} m, the term nuclear deals with 10^ (-15) m.
- The volume of an atom is about 1015 orders of magnitude larger than the volume of a nucleus. It is the electrons that are responsible for the chemical behaviour of atoms, and which identify the various chemical elements.
- The total number of Protons and Neutrons, called Nucleons is called the Atomic Mass Number(A)
- Atoms such as 1H, 2H whose nuclei contain the same number of protons, but different number of neutrons (different A) are known as isotopes. Uranium, for instance, has three isotopes occurring in nature – 238U, 235U and 234U.Hydrogen has 3 types of isotopes, Protium, Deuterium and Tritium.

→ NUCLEAR FUEL

- A good nuclear fuel is essential to sustainability of a nuclear power plant. A nuclear fuel generally sustains a chain reaction, has a very high chance of fission when bombarded with neutrons, releases 2 or more neutrons under collision, enabling it to compensate for unsuccessful fissions, has a reasonable half-life and is available in sustainable quantities.
- The Uranium U-235 is a suitable candidate for a nuclear fuel; however, it is not available in abundant quantities across the world.

TYPES OF FUEL

- Fissionable Fuel consists of isotopes that can undergo nuclear fission. Typical fissionable materials: 232Th, 233U, 235U, 238U, 239Pu, 240Pu, 241Pu.
- Fertile material are isotopes that are non-fissionable by neutrons but can be converted into fissile isotopes (after neutron absorption and subsequent nuclear decay). Th- 232(Thorium) is a fertile isotope, Th-232 cannot be fissioned by a fast-moving neutron. Th-232 is not capable of sustaining a nuclear fission chain reaction, because neutrons produced by fission of 238U have lower energies than original neutron. Upon capturing a neutron, Th-232 converts to U-233 which is fissionable. Typical fissile materials: 235U, 233U, 239Pu, 241Pu.
- Fissile material are fissionable isotopes that can undergo nuclear fission. Typical fertile materials: 238U, 232Th.

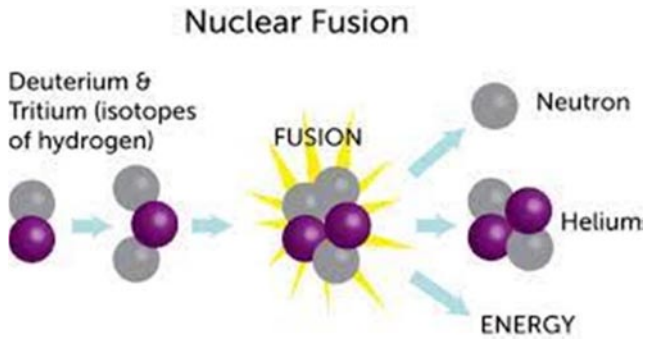
NUCLEAR ENRICHMENT

- To ensure that the Nuclear Reaction is sustainable, a Nuclear Reactor uses such a fuel that has a high probability of fission when bombarded by a fast-moving Neutron. To ensure this, a process called Enrichment is carried out.

- The process of increasing the concentration of one isotope relative to another is called "enrichment."
- Naturally occurring uranium contains 0.72% of the U-235 isotope. The remaining 99.28% is the u-238 isotope, which is a fertile isotope, but is not a fissile isotope. The level of enrichment required depends on specific reactor design (e.g., PWRs and BWRs require 3% – 5% of 235U) and specific requirements of the nuclear power plant operator. Without required enrichment these reactors are not able to initiate and sustain a nuclear chain reaction.
- Enrichment accounts for almost half of the cost of nuclear fuel and about 5% of the total cost of the electricity generated. Enrichment processes require uranium to be in a gaseous form at relatively low temperature, hence uranium oxide from the mine is converted to uranium hexafluoride in a preliminary process, at a separate conversion plant.
- The radioactive half-life for a given radioisotope is the time for half the radioactive nuclei in any sample to undergo radioactive decay. After two half-lives, there will be one fourth the original sample, after three half-lives one eighth the original sample, and so forth.

►NUCLEAR FUSION

- Nuclear fusion is defined as combining of several small nuclei into one large nucleus with subsequent release of huge amounts of energy.
  - It is the opposite reaction of fission, where heavy isotopes are split apart.
- Harnessing fusion, the process that powers the Sun, could provide a limitless, clean energy source.
  - In the sun, the extreme pressure produced by its immense gravity creates the conditions for fusion to happen.
- Fusion reactions take place in a state of matter called plasma. Plasma is a hot, charged gas made of positive ions and free-moving electrons that has unique properties distinct from solids, liquids and gases.
  - At high temperatures, electrons are ripped from atom's nuclei and become a plasma or an ionised state of matter. Plasma is also known as the fourth state of matter.



ADVANTAGES OF NUCLEAR FUSION?

- Abundant energy: Fusing atoms together in a controlled way releases nearly four million times more energy than a chemical reaction such as the burning of coal, oil or gas and four times as much as nuclear fission reactions (at equal mass).
  - Fusion has potential to provide base load energy needed for electricity for cities and industries.
- Sustainability: Fusion fuels are widely available and inexhaustible. Deuterium can be distilled from all forms of water, while tritium will be produced during fusion reaction as fusion neutrons interact with lithium.
- No CO_2: Fusion doesn't emit harmful toxins like carbon dioxide or other greenhouse gases into the atmosphere. Its major by-product is helium: an inert, non-toxic gas.
- No long-lived radioactive waste: Nuclear fusion reactors produce no high activity, long-lived nuclear waste.
- Limited risk of proliferation: Fusion doesn't employ fissile materials like uranium and plutonium (Radioactive tritium is neither a fissile nor a fissionable material).
- No risk of meltdown: It is difficult enough to reach and maintain the precise conditions necessary for fusion—if any disturbance occurs, the plasma cools within seconds and the reaction stops.

FUSION IGNITION

Recently, laser energy was put on fuel pellets to heat and pressurise them at conditions like that at the centre of our Sun. This triggered the fusion reactions. These reactions released positively charged particles called alpha particles (helium), which in turn heated the surrounding plasma. The heated plasma also released alpha particles and a self-sustaining reaction called ignition took place. Ignition helps amplify the energy output from the nuclear fusion reaction and this could help provide clean energy for the future

→ NUCLEAR FISSION VS FUSION

PARAMETER	NUCLEAR FISSION	NUCLEAR FUSION
Definition	Fission is the splitting of a large atom into two or more smaller ones.	Fusion is the fusing of two or more lighter atoms into a larger one.
Natural occurrence of the process	Fission reaction does not normally occur in nature.	Fusion occurs in stars, such as the sun.
By-products of reaction	Fission produces many highly radioactive particles.	Few radioactive particles are produced by fusion reaction.
Conditions	High-speed neutrons are required.	High density & high temperature environment.
Energy Requirement	Takes little energy to split two atoms in a fission reaction.	Extremely high energy is required to bring two or more protons close enough that nuclear forces overcome their electrostatic repulsion.
Energy Released	The energy released by fission is a million times greater than that released in chemical reactions, but lower than the energy released by nuclear fusion.	The energy released by fusion is three to four times greater than the energy released by fission.
Nuclear weapon	One class of nuclear weapon is a fission bomb, also known as an atomic bomb or atom bomb.	One class of nuclear weapon is the hydrogen bomb, which uses a fission reaction to "trigger" a fusion reaction.
Energy production	Fission is used in nuclear power plants.	Fusion is an experimental technology for producing power.
Fuel	Uranium is the primary fuel used in power plants.	Hydrogen isotopes (Deuterium and Tritium) are the primary fuel used in fusion power plants.

→NUCLEAR POWER REACTORS

▸FISSION REACTORS

WORKING

- When a neutron hits a nucleus of a radioactive atom (U-235, Plutonium-239), it triggers a breakup of that nucleus into two large pieces called fission fragments. In addition to the two large fragments, two neutrons are usually released which in turn hits the nucleus of other atoms in the reactor setting up what is called a chain reaction. The chain reaction of fission generates heat which is then used to move a turbine to produce electricity.

MODERATOR

- The neutron released in the chain reaction move at extremely faster speed and may lead to uncontrolled chain reaction leading to explosion. Thus, to slow down the neutron, the reactors use moderator.
- Moderators are generally atoms with lighter nuclei and does not absorb neutron. Generally ordinary water, heavy water and graphite rods are used as moderators.

CONTROL RODS

- In a nuclear reactor, generally only one of the neutrons released from uranium fission is used to produce another fission reaction. The other is absorbed using control rods.
- Control rods absorb neutrons but do not release energy in the process.
- Note: Plutonium (Pu-239) is sometimes manufactured using U-238 by hitting the neutron so released in the reactor.

CRITICAL MASS

- Minimum number of uranium-235 atoms required to set up the chain reaction is called the critical mass.

FUELS USED IN NUCLEAR REACTORS

- Fissile material
- Only U235, Pu-239 and U-233 are fissile material, meaning they can set up chain reactions.
- U-235 releases 2 neutron when the atom is split

- Plutonium-239: releases 3 neutrons instead of 2.
- U-233: U-233 is not found in nature. It is produced in Thermal breeder reactors where thorium-232 absorbs a neutron to form U-233 which is fissile.
- Enrichment: About 99% of the uranium found on earth is U-238 which is not suitable for fission as they are stable. As a result, U-238 is converted to U-235 and this process is called enrichment.
- U-238 is generally used in 'Breeder reactors' where U-238 is converted to Plutonium -239 due to absorption of a neutron
- Thorium 232 is used to produce U-233.

►TYPES OF FISSION REACTORS

LIGHT WATER REACTOR

- They use H20 as both moderator and coolant. They require the use of enriched fuel. Depending on the type of technology employed they are further divided into Boiling Water Reactor (BWR) and Pressurized Water Reactor (PWR)

1. Boiling Water Reactor

- BWR uses boiling water to generate electricity. Fukushima Daichi was the first such BWR. Tarapur Nuclear Power station in India hosts a BWR.

2. Pressurised Water Reactor

- PWR uses specially built reactor where in the pressure inside the reactor core is greater than atmospheric pressure. This prevents the water from boiling and allows the water to attain greater temperatures. The hot water that leaves the pressure vessel is looped through a steam generator, which in turn heats a secondary loop of water to steam that can run turbines and generator. (BWRs don't have any steam generator). INS Arihant and Kudankulam Plant in Tamil Nadu use a PWR.
- All liquids, at any temperature, exert a certain vapour pressure. The vapor pressure increases with temperature, because at higher temperature the molecules are moving faster and are more able to overcome the attractive intermolecular forces that tend to bind them together. Boiling occurs when the vapor pressure reaches or exceeds the surrounding pressure from the atmosphere.
- At standard atmospheric pressure, water boils at approximately 100 degrees Celsius. That is simply another way of saying that the vapor pressure of water at that temperature is 1 atmosphere. At higher pressures (such as the in a pressure cooker), the temperature must be higher before the vapor pressure reaches the surrounding pressure, so water under pressure boils at a higher temperature. This is what happens in a PWR.
- A similar condition also occurs in areas of higher altitudes, atmospheric pressure decreases. The vapor pressure reaches that pressure at a lower temperature. This leads to early boiling of water when cooking, however the food may not cook properly!

HEAVY WATER REACTOR

- It is also referred to as CANDU reactor. Use of heavy water (D2O) as both moderator and coolant. Can be used with unenriched uranium fuel. Also known as Pressurized Heavy Water Reactor (PHWR).
- The use of Deuterium instead of Hydrogen gives a neutron to better perform the moderation and increases the probability of a chain reaction.

FAST BREEDER REACTORS

- In contrast to most normal nuclear reactors, however, a fast reactor uses a coolant that is not an efficient moderator, such as liquid sodium, so the neutrons remain high-energy.
- Although these fast neutrons are not as good at causing fission, they are readily captured by U-238, which then becomes plutonium Pu-239.
- These reactors are designed to maximize plutonium production and produce more fuel than they consume (Breed). Pu-239 is formed in every reactor and fissions as the reactor operate.

►NUCLEAR FUSION

- Fusion reactors is increasingly seen as future of energy security due to following factors:
  - Abundance of fuel (Hydrogen in form of water in oceans)
  - Clean source of energy as it involves no release of carbon dioxide
  - Elimination of risk from nuclear waste
- Two main factors to achieve fusion reaction are fuel and conditions for fusion.
- A typical fusion reactor uses hydrogen as a fuel that is abundant in the water of the oceans.
- However, the main problem in fusion is that the hydrogen nuclei repel each other.
- The electric repulsion of 2 hydrogen nuclei can be overcome by heating the hydrogen to temperatures

of millions of degrees C. This is what happens in a typical hydrogen bomb

- However, the challenge for building a fusion reactor is that such high temperatures leads to high pressure posing the problem of explosion.
- This problem is currently being addressed in 3 ways.

1. The first is to make the hydrogen work at a very low density, so the pressure will not get high. This is the approach used in Tokamak approach.
2. The second method is to let the hydrogen explode, but to keep the explosions small. This is done in laser method.
3. The third way to achieve fusion is by keeping the hydrogen cold. This is called cold fusion.

COLD FUSION

- One way to get fusion without requiring high temperatures is to cancel its electric charge (remember high temperature is required only to overcome the electric repulsion). This is done by making a particle with negative charge stick to hydrogen nucleus.
- When a negative charge sticks to a hydrogen (or heavy hydrogen) nucleus, it cancels the proton charge. This electrically neutral nucleus can then get close to another hydrogen nucleus. Then the nuclear force brings the two nuclei together in fusion.
- To do this the hydrogen or deuterium is made to react with metals like palladium, zirconium and nickel at low temperature. (as these metals are hydrogen 'soakers')
- Cold Fusion is also called Low Energy Nuclear Reaction (LENR)
- India's Bhabha Atomic Research Centre has recently restarted research into it 25 years after it was shut.

TOKAMAK

- It is a machine that confines a plasma using magnetic fields in a donut shape (Torus). Tokamaks are leading plasma confinement concept for future fusion power plants.
- At such high temperatures, hydrogen gas is in plasma state (electron and nucleus are not bound) and thus difficult for ordinary containers to hold the hydrogen.
- Thus, under Tokamak approach magnets are used which confines hydrogen if the nuclei are in motion.
- As a result, this method is sometimes called 'magnetic confinement". In this, magnetic field coils confine plasma particles to allow the plasma to achieve conditions necessary for fusion.

►ITER

ITER stands for International Thermonuclear Experimental Reactor. It is a fusion reactor being built on Tokamak approach for completion by 2025.

DETAILS

- Being built Saint-Paul-les-Durance, France.
- It is a collaboration of 35 countries with following members China, the European Union, India, Japan, Korea, Russia and the United States.
- ITER is designed to produce 500 MW of fusion power from 50 MW of input heating power. (Net Energy Positive ie Produce more energy than what is required to initiate the fusion).
- It will not produce electricity, but it will take nuclear fusion to the point where industrial applications can be designed. Based on learnings from this a demonstration fusion power plant called DEMO will be established.

►GENERAL APPLICATIONS OF NUCLEAR TECHNOLOGY

1. Nuclear Medicine:

a. Nuclear technology is applied to various branches of medicine: Oncology, cardiology, neurology, pneumology or paediatrics.

b. Medical professionals use diagnostic techniques such as radio pharmaceuticals, scans or radio-isotopes and apply radiotherapy treatments that include X-rays as well as radiations from radio-active elements or radiation producing equipment's such as accelerators.

c. Used in sterilisation of medical equipment, learn about biological processes with use of tracers or study of properties of tumorous cells. BARC is planning to develop a Research Reactor for production of radio-isotopes for nuclear medicines.

2. Applications in Hydrology: Isotope hydrology is a nuclear technique that uses both stable and radioactive isotopes to follow the movements of the water in the hydrologic cycle. These techniques help research subterraneous fresh water resources and determine their origin, their charge, whether there is a risk of intrusion or contamination by salt water.

3. Sewage treatment: Nuclear technology is also employed in sustainable waste management. BARC

has set up a Technology Demonstration project "Sewage Sludge Hygienisation Plant" in Ahmedabad, Gujarat. The plant is loaded with Cobalt-60 and is in continuous operation since then.

4. Food and agriculture: Radio-isotope and radiation techniques are used to improve the quality of food by inducing mutations in plants and seeds to obtain desired crop varieties. Nuclear technology is also employed for pest control, increasing food production and reducing fertiliser usage. Direct irradiation of food reduces losses after harvest and improves shelf life of food products. This technique consumes less energy than conventional methods and can replace or radically reduce the use of additives and fumigants. (Ex. Employed to increase shelf life of onions at Lasalgaon, Nashik, Maharashtra).
5. Applications in Industry: Use of isotopes and radiations in modern industry is highly important to the development and improvement of processes, measurement, automatization and quality control. Use cases: Used to obtain information that makes it possible to extend its operative life and obtaining X-rays of the internal structure of certain pieces to check their quality.
6. Art: X-ray radiography makes it possible to get a deep look at a work of art to determine artists technique, change of composition, authenticity and age of art works.
7. Space Exploration: Nuclear batteries are used in space exploration as they can remain functional and active to power space missions over centuries.
8. Strategic uses: Nuclear power submarines which allow them to remain operational for long periods of time without having to come to surface to energy supplies.

NUCLEAR SECTOR IN INDIA

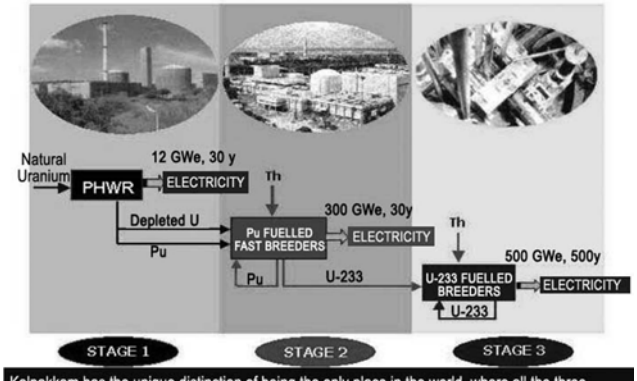
→3-STAGE NUCLEAR PROGRAM

India has a 3-stage nuclear program. The 3-stage nuclear program is developed with the aim of utilizing the vast Thorium reserves in India (about 25% of the world) as India has limited availability of Uranium reserves (about 2% of the world's uranium reserves)

1ST STAGE

- Pressurized Heavy Water Reactors are based on natural uranium that contains 99.3% U-238 and 0.7% U-235.
- U-235 being fissile sets up the chain reaction and U-238 being non-fissile gets converted to Pu-239 as a by-product (spent fuel) which is in turn used in the Fast Breeder Reactors in the 2nd stage.

Three Stages of Indian Nuclear Power Programme



Kalpakkam has the unique distinction of being the only place in the world, where all the three fissile isotopes viz., U-235 [MAPS], Pu-239 [FBTR] & U-233 [KAMINI] are used as fuel in reactors.

2ND STAGE

- Fast Breeder Reactors are primarily based on Plutonium.
- Further the breeder reactors use mix of Plutonium-239 produced in the 1st stage and U-238 that is abundantly found on earth to produce Plutonium inside the reactor.
- Note that U-238 is not fissile material and thus cannot set up chain reaction.
- Since the amount of Plutonium produced inside the reactor is more than that initially used, it is called Breeder reactor.
- To increase the probability of neutron hitting U-238, these reactors do not use a moderator to slow down neutrons and thus they are called Fast Breeder Reactors.
- Once the Plutonium-239 is completely used, Thorium is introduced in the reactor to convert it into U-233 that will be used in 3rd stage.

3RD STAGE

- Thermal Breeder Reactors uses thorium-232.
- Thorium is also not radioactive and thus not fissile.
- In these reactors thorium-232 is converted into Uranium-233 which is a fissile material. (*KAMINI*)
- Since India has abundant thorium reserves in the form of monazite sand, the 3rd stage is critical for India's nuclear energy basket.

→NUCLEAR POWER IN INDIA

- Nuclear power contributes to 2.1% of the total energy basket of India.
- Currently India has 22 nuclear reactors operating in 7 plants generating about 6780 MW of power.
- India plans to build 48 new plants with a target of 63000MW of power by 2032.

►NUCLEAR RECTORS IN INDIA

LOCATION & STATE	TYPE	CAPACITY
Kakra par, Gujarat	PHWR	2X700MW
Rawathbhata, Rajasthan	PHWR	100X1, 200X1, 220 × 4 = 1080MW
Gorakhpur, Haryana	PHWR	2 × 700MW
Kudankulam, Tamil Nādu	VVER	2 × 1000
Kalpakkam, Tamil Nadu (Being Implemented by BHAVINI)	Prototype Fast Breeder Reactors (PFBR)	500
Chutka, Madhya Pradesh	PHWR	2 × 700
Kaiga, Karnataka	PHWR	4 × 220
Mahi Banswara, Rajasthan	PHWR	4 × 700
Jaitapur, Maharashtra (France AREVA)	EPR	6 × 1650 MW
Kovvada, Andhra Pradesh (USA)	Light Water Reactors	5 × 1208
Chhaya Mithi Virdi, Gujarat (USA)		6 × 1000
Haripur, West Bengal (Russia)		6 × 1000 MW
Bhimpur, Madhya Pradesh	PHWR	4 × 700MW
Tarapur, Maharashtra	BWR and PHWR	160 x 2 and 540 × 2
Narora, Uttar Pradesh	PHWR	220 x 2 = 440 MW

►INDO-US CIVIL NUCLEAR DEAL

- India and USA signed the landmark Civil Nuclear Agreement in 2008.
- The Indo-US Civil Nuclear Agreement enabled the transfer of nuclear technology and fuel to India by US companies.

►INDIA'S NUCLEAR COMMERCE

- Despite the signing of Indo-US nuclear deal, the nuclear liability regime in India was seen as hurdle for foreign companies to invest in India's nuclear sector.
- The major hurdle for companies to do nuclear commerce with India was the Civil Liability for Nuclear Damage Act, 2010 (CLINDA) which held the suppliers of nuclear power projects liable in case of nuclear accidents.

RATIFICATION OF CSC

- This was solved in 2016 when India ratified the Convention of Supplementary Compensation.
- This marked India's willingness to accede to international nuclear liability regime which holds the operator liable to pay up for damage in case of nuclear accidents. (However, it provides for operator to have the right to recourse with the supplier in the contract)
- India also launched an insurance pool with a liability cap of ₹ 1,500 crore to cover the suppliers' risk of potential liability.

- As a result of this foreign companies have showed interest in nuclear commerce with India

►CIVIL LIABILITY LAW IN INDIA

- Accordingly in April 2015 India ratified the 1997 Convention on Supplementary Compensation for Nuclear Damage (CSC). CSC establishes a worldwide liability regime and provides for increase in the amount of compensation available to the victims of nuclear accidents.
- A State which is a party to either 1963 Vienna Convention or 1960 Paris Convention could become a party to the CSC. A State which is not a party to either of these conventions could also become a party to the CSC if its national law on nuclear liability is following the provision of the.
- India not being party to the Vienna, or Paris Conventions signed the CSC on 29 October 2010 based on its national law namely the Civil Law for Nuclear Damage (CLND) Act. This has paved the way for India to sign civil nuclear cooperation agreements with number of countries.

So far India signed civil nuclear agreements with 14 countries including USA, France, Russia, Canada, Argentina, Australia, Sri Lanka, the UK, Japan, Vietnam, Bangladesh, Kazakhstan, South Korea and Czech Republic.

REGULATION AND DEVELOPMENT OF NUCLEAR TECHNOLOGY IN INDIA

►DEPARTMENT OF ATOMIC ENERGY

- It is apex body under the direct charge of Prime Minister working toward development and regulation of nuclear technology in India.
- In addition, it is responsible for application of radioactivity in the field of agriculture, medicine, industry and basic research.
- DAE comprises of regulatory bodies, research centres, industrial organisations, five public sector undertakings etc.

►ATOMIC ENERGY COMMISSION

- It is the governing body of Department of Atomic Energy
- Important function include
  - Promote nuclear research
  - Prospecting and extraction of atomic minerals in India
  - Extends financial assistance to autonomous national institutes doing research
- Accordingly, 5 five research centres under AEC are
  - Bhabha Atomic Research Centre (BARC), Mumbai
  - Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam (Tamil Nadu)
  - Raja Ramanna Centre for Advanced Technology (RRCAT), Indore
  - Variable Energy Cyclotron Centre (VECC), Kolkata
  - Atomic Minerals Directorate for Exploration and Research (AMD), Hyderabad.
  - Indian Neutrino Observatory (INO)

►ATOMIC ENERGY REGULATORY BOARD (AERB)

- AERB is the regulatory authority responsible for safe operations of nuclear reactors as well as regulation at all other nuclear facilities in India.
- It derives its powers from Atomic Energy Act, 1962 and the Environmental (Protection) Act, 1986.
- Important functions include
  - Ensuring safety of population and environment from risks arising out of the use of radiation and nuclear energy.
  - Overseeing the design and construction of the new reactors

►PUBLIC SECTOR INSTITUTIONS

- Electronics Corporation of India (ECIL), Hyderabad
- Indian Rare Earths Limited (IREL), Mumbai
- Uranium Corporation of India, Singhbhum (PSE for uranium mining and processing)
- Nuclear Power Corporation of India (NPCIL), Mumbai, Maharashtra (PSE for generation of electricity from nuclear power)
- Bhartiya Nabhikiya Vidyut Nigam Limited (BHAVINI), Kalpakkam, Tamil Nadu (Operating Stage II FBR at Kalpakkam)

►NUCLEAR POWER CORPORATION OF INDIA LIMITED (NPCIL)

- NPCIL is responsible for design, construction, commissioning and operation of nuclear power reactors under the Atomic Energy Act, 1962.

- NPCIL also has equity participation in BHAVINI which implements Fast Breeder Reactors program in the country.
- In 2016 the Atomic Energy (Amendment) Act was passed by the parliament that enables NPCIL to form joint ventures with any government company to produce, develop, control, and use atomic energy.
- Accordingly, a license may be granted to any government company to
  - produce atomic energy
  - acquire and use substances or minerals from which atomic energy can be obtained

INTERNATIONAL ORGANISATIONS

►INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA)

- It is also known as the world's "Atoms for Peace". The organization works within the United Nations.
- The IAEA is the international centre responsible for cooperation in the peaceful uses of nuclear energy under Nuclear non-Proliferation Treaty.
- It is headquartered in Vienna.

►WORLD ASSOCIATION OF NUCLEAR OPERATORS

- It is an international NGO of nuclear scientists that certifies the safety of nuclear reactors.
- India is a member of WANO

►IMPORTANT NUCLEAR NON-PROLIFERATION TREATIES

PARTIAL TEST BAN TREATY

- Signed in 1963 by USA, USSR and UK, it prohibited all test detonations of nuclear weapons except for those conducted underground.
- It is a treaty banning nuclear weapon tests in the atmosphere, underwater and in outer space.
- One of the main aims of PTBT was to limit the amount of radioactive fallout emitted from nuclear explosions.

NUCLEAR NON-PROLIFERATION TREATY

- NPT is an international nuclear disarmament treaty to *prevent the spread of nuclear weapons* and *to promote cooperation in the peaceful uses* of nuclear energy.
- Signed by 191 countries, the treaty restricts nuclear non-weapon states (countries which had no nuclear weapon till 1968) from developing or acquiring nuclear weapons.
- On the other hand, the nuclear weapon states shall work towards disarmament and share the benefits of peaceful nuclear technology (civilian) to countries that have signed the NPT.
- 5 states recognised as nuclear-weapon states include the United States, Russia, the United Kingdom, France, and China.
- The countries that receive nuclear technology or fuel for civil nuclear purposes (power generation) are subject to export controls under the Nuclear Suppliers Group and verification measures of the IAEA Additional Protocol.
- 4 UN member states that have never joined the NPT: *India, Israel, Pakistan and South Sudan*.
- Though Iran is a signatory to NPT, it was declared non-compliant by IAEA in 2002. Recently in 2020 after the US's withdrawal from Joint Comprehensive Plan of Action and consequent sanctions, Iran has threatened to withdraw from NPT and resume nuclear enrichment.
- North Korea had signed the NPT in 1985 as a nuclear non-weapon state. Thereafter in 1993 it unilaterally withdrew from NPT. However, there is no definitive legal opinion regarding the membership of N. Korea which has resorted to nuclear test time and again.

IAEA SAFEGUARD AGREEMENT AND INDIA

- Though India is not a part of NPT, it has signed the Comprehensive Safeguards Agreement IAEA in 2009.
- Besides India also signed the Additional Protocol in 2009 and entered into force in 2014.
- Accordingly, India has kept 20 of its 22 civilian nuclear facilities under IAEA safeguards.

COMPREHENSIVE TEST BAN TREATY (CTBT)

- Adopted in 1996 by UNGA, it prohibits all forms of nuclear tests in space, water & underground.
- India has not signed the treaty as it does not talk about nuclear disarmament.

- So far it has been signed by 184 states, of which 168 have ratified the treaty.
- However, the treaty has not come into force yet as many countries that possess nuclear technology have not yet signed or ratified the
- Those that have signed but not ratified: China, Egypt, Iran, Israel, USA.
- Those that have not signed: India, Pakistan and North Korea.

►EXPORT CONTROL REGIMES

NUCLEAR SUPPLIERS GROUP

- Established in 1974 after Pokhran test.
- NSG is a mechanism to fulfil one of the key aims of NPT; to share the benefits of peaceful use of nuclear energy.
- It is a 48-member export-control regime that regulates *export of nuclear technology and fuel*.
- Accordingly, nuclear non-weapon states who have signed NPT can have access to items listed in NPT.
- In 2008, India was granted a special waiver by NSG for supply of nuclear fuel and technology to India. Thus, India became the first and only non-NPT signatory to have this privilege.
- Consequently, India signed civil nuclear agreements with 14 countries including USA, France, Russia, Canada, Argentina, Australia, Sri Lanka, the UK, Japan, Vietnam, Bangladesh, Kazakhstan, South Korea and Czech Republic.

AUSTRALIAN GROUP

- Established in 1985 during Chemical Weapon use in Iran-Iraq war in 1984
- It is aimed at controlling exports of *biological and chemical agents* used as weapons.
- Headquartered in Paris, its members include India, US, Canada, EU, Turkey, Argentina, Australia, Japan etc.

WASSEGNAR ARRANGEMENT

- It is a multilateral export control treaty that aims to regulate the export of conventional arms/munitions and dual-use goods and technology.
- It includes not only arms but also technologies that can be used for military purposes including computers, sensors, lasers, electronics, surveillance technologies etc.
- Currently, it has 42 members including India, US, Canada, Mexico, Argentina, Australia, Japan, Russia, South Africa etc

MISSILE TECHNOLOGY CONTROL REGIME

- Established in 1987, MTCR aims to regulate the export of weapon delivery systems signatories to non-signatories.
- It restricts export of weapon delivery system that delivers any type of weapon including conventional weapons, chemical weapons, biological weapons and nuclear weapons.
- Accordingly, weapons delivery system carrying more than 500 kg payload for over 300 km is restricted under MTCR.
- India officially became a signatory of MTCR in 2018 which enabled India to
  - increase the range of Brahmos (from 290KM to 450KM)
  - get access to predator drones from different countries

►NUCLEAR FREE ZONES

- Antarctica by Antarctic treaty
- Space by Outer Space Treaty
- Seabed by Seabed arms control treaty
- Tlatelolco treaty for Latin America and Caribbean
- Bangkok Treaty for Southeast Asia
- Pelindaba Treaty for Africa

►ROOPPUR NUCLEAR POWER PROJECT

- India and Bangladesh have signed a Civil Nuclear Cooperation Agreement.
- Rooppur Nuclear Power Project is the collaboration between India, Russia and Bangladesh.
- This will be the first time Indian companies will be able to participate in a nuclear power project abroad.

►CHINA TURNS ON 'ARTIFICIAL SUN'

China successfully powered up its "artificial sun" nuclear fusion reactor for the first time.

The HL-2M Tokamak reactor is China's largest and most advanced nuclear *fusion* experimental research device, and scientists hope that the device can potentially unlock a powerful clean energy source.

It uses a powerful magnetic field to fuse hot plasma and can reach temperatures of over 150 million degrees Celsius, - approximately ten times hotter than the core of the sun. The reactor is often called an "artificial sun" on account of the enormous heat and power it produces and its mimic of the nuclear fusion process that the real sun uses to generate energy.

- A 'Tokamak' is a reactor design that resembles a donut — a donut that generates powerful magnetic forces to contain unimaginably hot plasma inside the reactor during nuclear fusion. The walls of a tokamak are built to absorb the massive amounts of heat from the continuous splitting of atoms in the reactor's core.

SIGNIFICANCE OF EXPERIMENT

- Very large-scale continuous energy production, with zero greenhouse gas emissions and no long-life radioactive waste.
- The project has been endorsement by International Thermonuclear Experimental Reactor (ITER), the massive multinational initiative that aims to produce the world's largest magnetic nuclear fusion device. This shoes that global energy aims will be a collaborative and cooperative process.
- EAST will be one of only a few international devices that can serve as an important experimental test bench for conducting ITER-related steady-state advanced plasma science and technology research.

►LITHIUM PRODUCTION IN STARS

- Scientists from Indian Institute of Astrophysics (IIA) found that Lithium production is common among low mass Sun-like stars during their He-core burning phase.
- They identified "He flash" (on-set of He-ignition at the star's core via violent eruption), at the end of the star's core hydrogen-burning phase, as the source of Li production. The Sun will reach this phase in about 6-7 billion years.

►EXTREME HELIUM STAR (EHe)

- A study by the Indian Institute of Astrophysics (IIA) which detected the presence of singly ionized fluorine for the first time in the atmospheres of hot Extreme Helium Stars makes a strong case that the main formation of these objects involves a merger of a carbon-oxygen (CO) and a Helium (He) white dwarf.
- The origin and evolution of these Hydrogen deficient objects have been shrouded in mystery. Since there are no known conditions where stars devoid of hydrogen can be formed from molecular clouds, it is theorized that they are the product of the mergers of helium-core and carbon-oxygen core white dwarfs.

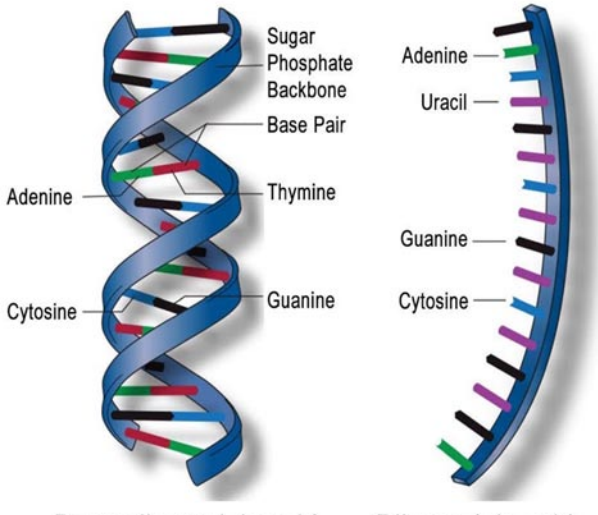
►KAKRAPAR-3

- The third unit of the Kakrapar Atomic Power Project (KAPP-3) in Gujarat achieved its first criticality a term that signifies the initiation of a controlled but sustained nuclear fission reaction.
- KAPP-3 is the country's first 700 MWe (megawatt electric) unit, and the biggest indigenously developed variant of the Pressurised Heavy Water Reactor (PHWR).
- The PHWRs, which use natural uranium as fuel and heavy water as moderator, are the mainstay of India's nuclear reactor fleet. Until now, the biggest reactor size of indigenous design was the 540
- MWe PHWR, two of which have been deployed in Tarapur, Maharashtra
- The first two units at Kakrapar of 220 MWe (Megawatt electric) each were based on Canadian technology. The third unit is fully indigenous.

BIOTECHNOLOGY

►BASICS: DNA, CHROMOSOME, GENE, GENOME

- Deoxyribonucleic Acid (DNA) is a molecule that all living organisms carry in every cell in their body.
- DNA is a "code" that holds the detailed instructions for the building of the organism.
- In humans, this information is laid out in long linear strands of DNA in the nucleus.
- Rather than being one long DNA strand, we have DNA in the form of many smaller, more manageable pieces, called chromosomes.



Deoxyribonucleic acid (DNA) | Ribonucleic acid (RNA)

- Humans have three billion base pairs divided into two copies of 23 chromosomes (one from our mother and one from our father) with six billion base pairs in every cell.
- Chromosomes influence everything from a person's hair color to susceptibility to disease.
- For example, chromosome 1 contains the gene that controls whether you're susceptible to some forms of malaria while chromosome 16 has a gene that influences hair color.
- Some people have a missing chromosome, an extra chromosome, an inverted chromosome or any other mutation, which can cause disorders.

►RIBONUCLEIC ACID (RNA)

- RNA is a polymer of ribonucleotides.
- It is principally involved in the synthesis of proteins, carrying the messenger instructions from DNA, which itself contains the genetic instructions required for the development and maintenance of life.
- **RNA differs from DNA in three basic respects:**
  - RNA employs uracil as a nitrogenous base, in place of the thymine used in DNA.
  - RNA nucleotides possess a hydroxyl group at the 2nd position, while DNA is deoxygenated at that position to a proton.
  - RNA is more often found single-stranded than DNA, which is typically completely base-paired into a double helix.

►DNA PROFILING

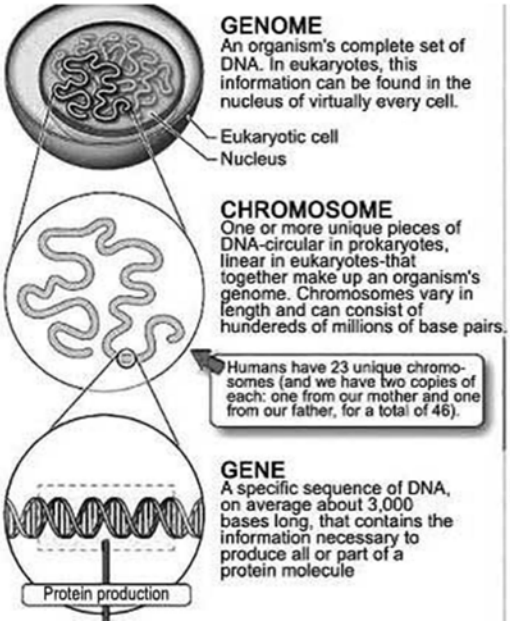
DNA profiling or DNA fingerprinting is creation of a biometric database comprising DNA information of individuals.

ESTABLISHING DNA PROFILES

- While DNA is unique to an individual's genetic makeup, it is 99.9% similar between all individuals within the human species.
- The variable regions (0.1%) also called Variable Number of Tandem Repeats (VNTR) that are unique to individual's DNA constitute the DNA profile of that individual.
- The DNA profile of an individual varies in some regions in terms of the number of times a sequence of nucleotide base pairs is repeated.
- Thus, by counting the number of times these base-pair sequences are repeated in these variable regions a DNA profile of an individual is established.

APPLICATION

- To establish the identity of persons.
- Helps in determining biological relationships to establish parentage, viability of organ transplantation etc.



A visual representation of the human genome.
(Each color represents a different nucleotide.)

HOW DO GENES WORK?

- Every cell in an organism contains all the information needed to manufacture every protein in its body.
- The genes in strands of DNA are a storehouse of information, an instruction book.
- The genes that an organism carries for a particular trait is its genotype and the physical manifestation of the instructions are the organism's phenotype.
- Further a gene (a sequence of bases in a section of DNA) affects the phenotype in two main steps.
- Transcription, in which a copy of a gene's base sequence is made, and
- Translation, in which that copy is used to direct the production of a protein.
- Transcription: Gene's base sequence or code is copied into a middleman molecule called messenger RNA (mRNA).
- In translation, the mRNA moves out of the nucleus and into the cytoplasm of the cell, where the messages encoded in the mRNA molecules are used to build proteins

ABOUT GENOME SEQUENCING

- The full set of DNA present in an individual organism is called its genome.
- DNA sequencing is a procedure for determining the linear order of nucleotide bases in DNA.
- Sequencing a gene is like reading a book one letter at a time to look for any spelling mistakes.
- Mapping out a person's entire genetic code, or genome or in other words reading each of the 3 billion base pairs that make up a person's genetic code is called genome sequencing.
- By creating a genome sequence, we will be able to test specific genes to detect the presence of mutations associated with genetic disorders.
- Within the next few years, experts expect the turnaround time to improve and the cost to drop so much that analyzing a person's genome will be no more expensive than zeroing in on just one gene.

- Techniques of DNA sequencing:

1. Shotgun sequencing: It involves randomly breaking up DNA sequences into lots of small pieces and then reassembling the sequence by looking for regions of overlap.
2. Next Generation Sequencing: It also known as Massively Parallel Sequencing. This led to fall in time and cost of Human Genome Sequencing and made it accessible.

►GENOME MAPPING IN INDIAN OCEAN

National Institute of Oceanography is going to launch project for Genome Mapping in Indian Ocean.

AIM

- To gather samples for genome mapping of microorganisms in the Indian Ocean and
- to understand the biochemistry and the response of the ocean to climate change, nutrient stress and increasing pollution

IMPORTANT ASPECTS

- Just like gene mapping is carried out on blood samples collected from humans, scientists will map these in bacteria, microbes found in ocean.
- Mapping of DNA & Ribonucleic Acid (RNA) will show the nutrients present in them, and those lacking in different parts of the ocean.
- It will give holistic understanding about nutrient cycling and productivity of the oceans.
- The project is expected to generate new information about trace metals from underexplored regions of the Indian Ocean.
- The genome mapping will show the presence of which these microbes have adapted to, in addition to their reaction to atmospheric carbon dioxide.

►GENE THERAPY

- Gene therapy involves removal of defective stem cells from patient's bone marrow. The stem cells so removed are genetically modified for correction
- The genetically modified cells are infused back in the bone marrow using a virus vector.
- The corrected stem cells in the bone marrow develop healthy blood cells.

TYPES OF GENE THERAPY TECHNIQUES

1. Gene Augmentation Therapy

- Used to treat diseases caused by a mutation that stops a gene from producing a functioning product, such as a protein.
- This therapy adds DNA containing a functional version of the lost gene back into the cell.
- New gene produces a functioning product at sufficient levels to replace the protein that was originally missing.

2. Gene inhibition Therapy

- Suitable for the treatment of infectious diseases, cancer and inherited disease caused by inappropriate gene activity.
- It aims to introduce a gene whose product either inhibits expression of another gene or interferes with the activity of the product of another gene.
- The basis of this therapy is to eliminate the activity of a gene that encourages growth of disease related cells.

►MITOCHONDRIAL DNA & NUCLEAR DNA

- The DNA we have been referring to is the DNA that is present in the nucleus
- In addition to DNA in the nucleus, some DNA is also present in the mitochondria.
- During fertilization it the nuclear DNA (with 46 chromosomes) that is formed where 23 chromosomes is inherited from the mother and 23 from the dad.
- Mitochondrial DNA only has one chromosome and it codes for only specific proteins responsible for metabolism.
- It is the nuclear DNA that is responsible for inheritance (from both father and mother).
- Mitochondrial DNA is inherited only from the mother and thus it is more effective to trace human ancestry.

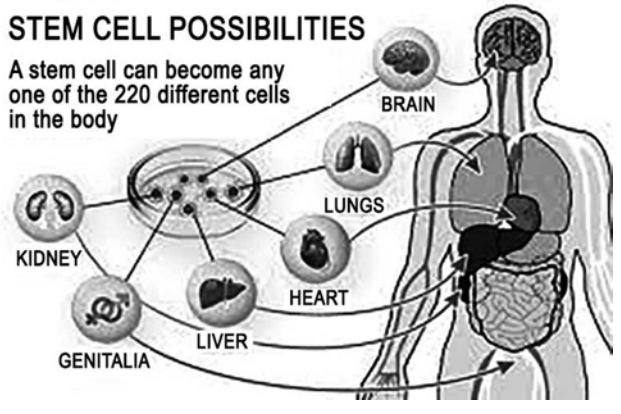
►THREE PARENT BABY

- Apart from receiving the usual "nuclear" DNA from its mother and father, the embryo would also include a small amount of healthy mitochondrial DNA from a woman donor.
- This is resorted to when the actual mother is suffering from an incurable mitochondrial disease.
- This technique involves removing the faulty mitochondrial DNA from the actual mother and nucleus form the mother's egg and the resultant egg

fertilizes with the sperm cell of the father outside the body (in-vitro).

►STEM CELLS

- The most basic unit of any organism is a cell.
- It is the smallest unit of life that can function independently and perform all the necessary functions of life.
- Cells develop to form tissues which in turn develop to form organs.
- Broadly speaking, cells are of two types, differentiated and undifferentiated.
- Differentiated cells are the building blocks of tissues and organs and are specialised to from that tissue or organ.
- Undifferentiated cells are those that have the potential to develop into many diverse types of cells like those in muscles, kidney, liver etc.
- Stem cells are these undifferentiated, primitive cells. They are special cells which not only have ability of self-renewal but can also be a lifelong source of specialized functional cells of different human organs.
- Self-renewal ability of stem cells ensures that stem cells are not depleted, and enough stem cells remain to produce enough specialized cells of the organ during long human lifespan.
- Stem cells are of two types, Embryonic and Adult/Somatic stem cells.



DIFFERENCE BETWEEN EMBRYONIC AND ADULT/SOMATIC STEM CELLS

- Embryonic stem cells are derived from embryos.
- They are totipotent in that they can be differentiated into most of the cell types.
- They can produce a clone of the entire organism.
- Somatic stem cells or adult stem cells are undifferentiated cells present in differentiated cells in a tissue or organ.
- They help in repair and maintenance of specific tissue or organ where they are present.

INDUCED PLURIPOTENT STEM CELLS (IPS CELLS) AND THEIR SIGNIFICANCE

- iPS are adult stem cells are adult stem cells, like in umbilical cord cells or bone marrow cells, which can be induced to show properties of stem cells. They are pluripotent in nature are capable of differentiation into ectodermal, mesodermal and endodermal cells. They can be derived from somatic cells by a variety of genetic and epigenetic methods.
- They are mostly use in therapeutic cloning to treat degenerative diseases like diabetes, Parkinson's, Alzhiemers etc.
- They are created by stimulating mature, already specialised cells back into a juvenile state without the need for an embryo.
- These can be derived from the patient themselves, making them less likely to be rejected.
- The cells can be transformed into a range of diverse types of cells, and their use is a key sector of medical research.
- Further owing to ethical issues embryonic cells are banned in countries such as Ireland and in Latin America.
- Therefore, use of iPS cells in therapeutic cloning is significant.

Diverse types of Stem Cells:

1. Mesenchymal stem cell:
2. Hematopoietic stem cell: A stem cell that gives rise to all red and white blood cells and platelets.

Based on Potency:

1. Totipotent stem cell: Having the ability to give rise to all the cell types of the body plus all the cell types that make up the extra embryonic tissues such as the placenta.
2. Pluripotent stem cell: Having the ability to give rise to all the various cell types of the body. They cannot make extra-embryonic tissues and components of placenta.

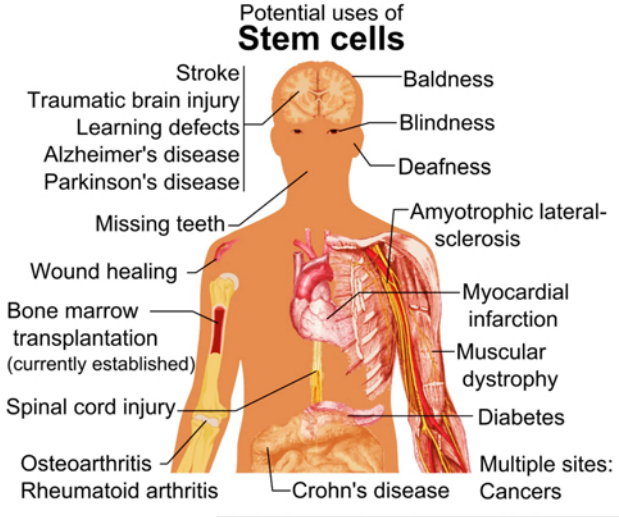
3. Multipotent stem cell: Having the ability to differentiate into diverse types of specialized cells constituting a specific tissue or organ.

ALLOGENIC STEM CELL TRANSPLANTATION

- In an allogeneic transplant, stem cells are collected from a matching donor and transplanted into the patient to suppress the disease and restore the patient's immune system.
- It is different from an autologous stem cell transplantation, which uses stem cells from the patient's own body.
- Doctors use HLA test to compare patient's blood and tissue type against a donor's blood samples. HLA stands for human leukocyte antigens (HLA).
- Before an allogeneic stem cell transplant, patient undergoes a conditioning regimen, which typically involves intensive treatment—high doses of chemotherapy and radiation therapy, for example—to destroy as many cancer cells as possible

SIGNIFICANCE OF STEM CELL THERAPIES

- Currently available therapies for Parkinson's disease treat symptoms without slowing or halting the disease progression.
- On the other hand, the new research aims to actively reverse the disease.



GROWING HUMAN ORGANS IN ANIMAL BODY

- Recently Japanese researchers have successfully developed functional mouse kidneys inside rats using stem cells.
- In the first step, CRISPR/Cas9 technique was used to genetically silence rat embryos so that the rats did not grow kidney on their own.
- Then the genetically modified blastocysts (clusters of cells formed after egg fertilization), of the rat embryo were inserted with pluripotent stem cells from mice.
- The altered rat embryo was then implanted back into rat wombs to continue fertilization.
- The stem cells then differentiated to form the missing kidney in the rats that was functional.
- This could be replicated in Humans.
- In Regenerative Medicine

►GENE EDITING

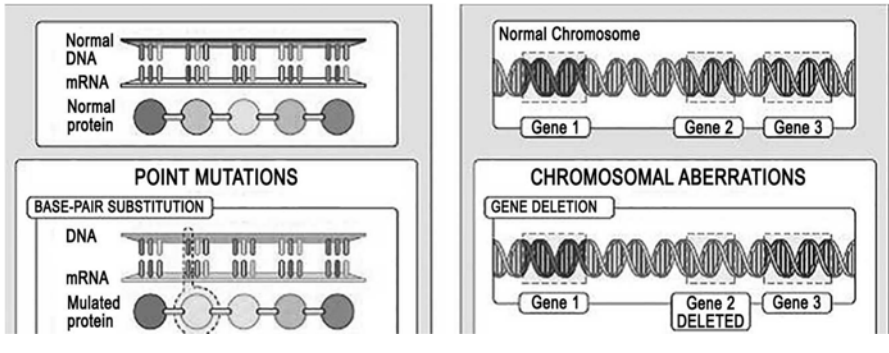
Gene Editing is the process of disabling faulty genes, correct the harmful mutation, insert a missing gene or change the activity of specific genes in living organisms.

TYPES OF EDITING:

- Germline Editing: A form of gene editing that involves changing genes in eggs, sperm, or early-stage embryos. This type of genome modification is heritable, meaning that genes could appear not only in offsprings that result from the procedure, but also in the subsequent generations.
- Somatic Cell Gene Editing: It affects targeted cells/tissues/organs in patient and is not passed on to subsequent generations. This includes genome modification by CRISPR-related techniques and epigenetic modulation by gene therapy approaches. It can be done

EX VIVO

ex vivo (gene editing outside the body followed by transplantation into the same or different individual)



APPLICATIONS

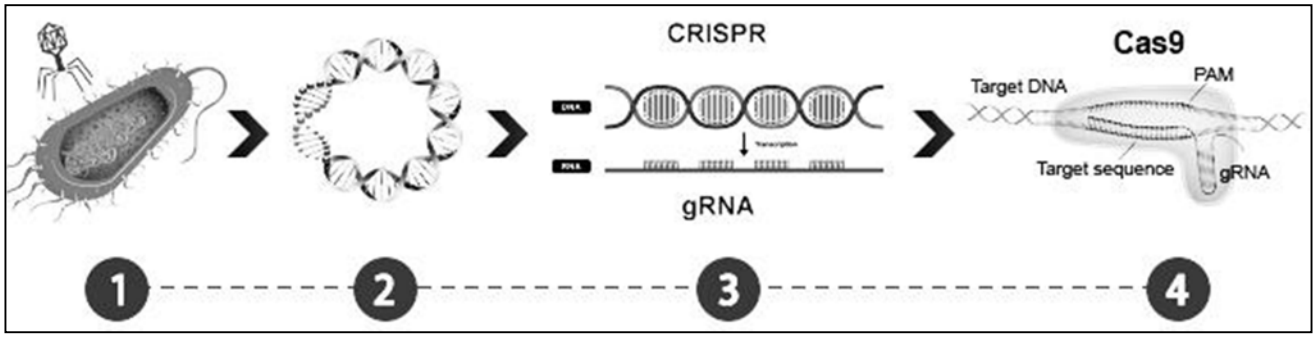
- Treating genetic disorders like cystic fibrosis, sickle cell anaemia and muscular dystrophy.
- Gene editing is widely used to modify immune cells to fight cancer, increase resistance in HIV cases.
- Used correct defective genes in human embryos and prevent inheritance of genetic disorders
- Faster, cheaper and precise than conventional techniques in genetic modification of crops.
- Extremely helpful in gene therapy including building ofdiagnostic tools, drugs, organ transplantations etc.

IN-VIVO GENE EDITING

- Recently gene editing was carried out inside the human body (in-vivo) for the 1st time to treat Hunter's syndrome.
- The zinc finger nucleases (ZNF) technique was used to insert the corrective gene in the DNA of the patient through Intravenous therapy (IV).

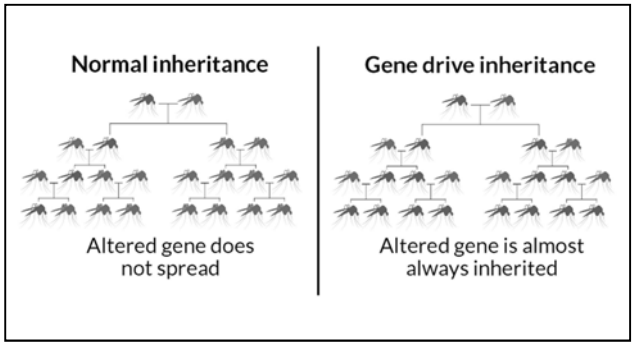
CrispR Cas9

- It is the revolutionary gene editing technique.
- Short for "clustered regularly interspaced short palindromic repeats".
- CRISPR uses an enzyme called Cas9 to cut strands of DNA at precisely targeted locations and insert new genetic material into the gap.
- CrispR is a replica of the natural process when a virus infects a bacterium.
- The bacterium has evolved the CRISPR/Cas9 system adaptive immune system.



►GENE DRIVE TECHNOLOGY

- In a breakthrough in the global fight for malaria, scientists have wiped out an entire population of malaria-carrying mosquitoes in lab conditions using a CRiSPR gene drive technology.
- Gene drive technology is a genetic engineering technology that can permanently change the traits of a population or even an entire species.
- Gene drives are genetic elements that pass from parents to unusually high numbers of their offspring, thereby spreading quickly.



- Gene drives occur naturally but can also be engineered.

GENE DRIVE TECHNOLOGY: HOW DOES IT WORK?

- The gene drive technology is designed to introduce a genetic tweak in the population of a species **by altering the rules of inheritance** from parent to offspring.
- Firstly, using CRiSPR gene editing tool, a gene called 'doublesex' in female mosquitoes is disrupted.
- This genetic tweak of double-sex gene follows gene drive inheritance.
- Here the gene drive inheritance makes the female mosquitoes inherit two copies of the disrupted gene.
- When the female mosquitoes inherit two copies of the disrupted gene, they develop like males and are unable to bite or lay eggs.

►GM CROPS

- Transgenic (GM) plants are those that have been genetically modified using recombinant DNA technology.
- Genetic modification is done to confer a particular trait to the plant with one of the following properties
- Increased yield of a crop

- Increased nutritional content of a crop
- Developing resistance to
  - Abiotic stresses like temperature, salinity or herbicide-resistant
  - Biotic stresses like insect-resistant crops.
  - BT cotton is the only genetically modified crop that is commercially allowed in India from 2002.

►ARKA SHUBHA

- Indian Institute of Horticultural Research has developed a new marigold variety named Arka Shubha.
- Arka Shubha has carotene content of around 2.8% (for all marigolds, it's maximum upto 1.4%) which is the highest among all plant sources.
- This new variety of marigold can be used for extraction of crude carotene even if spoiled after full bloom, unlike that of other varieties.
- India imports most of its carotene from other countries, including China. This development can significantly reduce import dependency. Therefore, both cultivation area and investment on carotene extraction should be increased.

►WHEAT STRAW POLYSACCHARIDE

- DBT-National Agri-Food Biotechnology Institute (DBT-NABI) has developed a wheat straw polysaccharide derived novel edible coating formulation to prevent the post-harvest shelf-life of perishable fruit crops such as Apple, Peach and Banana.
- In addition to that, antibody assisted graphene oxide coated gold nanoparticles for rapid bacterial detection and near infrared light enhanced antibacterial activity has been developed which detects food borne pathogens.

►GRAPHENE

- It is an allotrope of carbon with a sheet like structure.
- It is a solitary layer (monolayer) of carbon molecules.
- It is one molecule thick. Slenderest compound known.
- It has the structure square of Graphite.
- It is tougher than diamond yet more flexible than rubber; harder than steel yet lighter than aluminum.
- It is the lightest material known.
- It is the most grounded compound found (between 100-300 times more grounded than steel).
- It is the best conductor of heat and electricity.
- It is impermeable to gases. Graphene is known for against bacterial properties.
- Graphene has arisen as one of the most encouraging nanomaterials on account of its novel mix of brilliant properties.

PROPERTIES OF GRAPHENE

- Electronic properties: atomic arrangement of the carbon in graphene permits electrons to effectively go at high speeds without dissipating energy.
- Mechanical properties are a result of sp2 bonds that structure the hexagonal cross section and go against an assortment of in-plane disfigurements.

USES OF GRAPHENE

- Energy storage and solar cells
- Lubrication
- Graphene ink
- Transistors and memory
- Flexible, stretchable and foldable electronics
- Photodetectors
- Face Mask, etc.

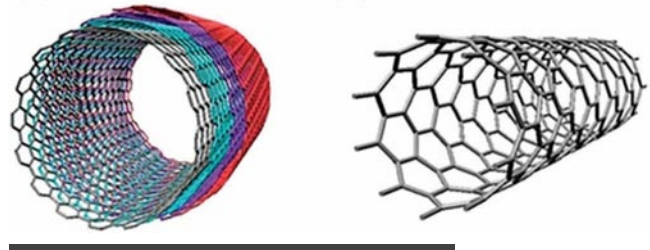
GRAPHENE MASK AND CORONAVIRUSES

- Graphene is known for anti-bacterial properties. It has also shown to be effective in against COVID-19 virus.
- All carbon-containing materials, like cellulose or paper, can be changed over into Graphene.
- Graphene is reusable.

►CARBON NANOTUBES

Carbon nanotubes are cylindrical large molecules consisting of a hexagonal arrangement of hybridized carbon atoms, which may be formed by rolling up a single sheet of Graphene (single-walled carbon nanotubes) or by rolling up multiple sheets of Graphene (multi-walled carbon nanotubes).

(a) (b)



PROPERTIES OF CARBON NANOTUBES

1. Strongest and stiffest materials discovered yet in terms of tensile strength and elastic modulus.
2. Very good thermal conductors along the tube, exhibiting a property known as ballistic conduction.

3. High surface area per unit mass ratio.

DIFFERENCE BETWEEN SINGLE WALLED AND MULTI-WALLED CARBON NANOTUBES

Single-walled carbon nanotubes	Multi-walled carbon nanotubes
It is a single layer of Graphene.	It has multiple layers of Graphene.
Requires catalyst for synthesis.	Can be produced without catalyst
Bulk synthesis is difficult	Bulk synthesis is easy
More defection during functionalization	Less defection, but difficult to improve
Poor in purity	Purity is high
Less accumulation in the body	More accumulation in the body
It can twist easily	Difficult to twist
Easy characterization and evaluation	Difficult characterization and evaluation.

APPLICATIONS OF CARBON NANOTUBES

1. CNT based transparent electrodes can be developed which are essential components of organic solar cells as well as organic light emitting diodes.
2. Electrodes for Lithium-Ion Batteries
3. Super capacitors
4. Metal/CNT Capacitors
5. Polymer/CNT Composite Capacitors
6. CNT based electronic components such as nanowires, transistors and switches.
7. CNTs are promising candidates for catalysts.
8. Immobilization of bio macromolecules
9. Developing highly sensitivity sensors
10. Biomedical applications
11. Mechanical applications

CHALLENGES FOR APPLICATIONS OF CARBON NANOTUBES

1. Impurities such as residual metal particles in carbon nanotubes.
2. Processing & manufacturing of carbon nanotubes is challenging.

►REGULATION OF GMO IN INDIA

- Genetically modified organisms and the products thereof are regulated under Environment (Protection) Act, 1986.
- India is also a signatory to the Cartagena Protocol on Biosafety.
- India adopted biosafety rules under EPA in 1989 called Rules for the manufacture, use, import, export & storage of hazardous microorganisms, genetically engineered organisms or cells.
- Accordingly Genetic Technology, Genetic Engineering including gene editing and gene drives are regulated under EPA in India.

REGULATORY AUTHORITIES

- GM Crops – Genetic Engineering Appraisal Committee under MoEFCC is the final approval authority for environmental release of GM crops in India including confined field trials. It also includes approval for commercial cultivation of GM crops.
- GM Food – Food Safety and Standards Authority of India regulates manufacture, storage, distribution, sale and import GM food.

BT COTTON

- BT cotton is the only genetically modified crop that is commercially allowed in India from 2002.
- BT cotton grown in India is genetically modified for developing resistance to the pink bollworm pest in the crop.
- This is done by inserting 'Cry1Ab' and 'Cry2Bc' genes from the soil bacterium, Bacillus thuringiensis (Bt), into the cotton seed.

PBKNOT TECHNOLOGY

South Asia Biotechnology Centre and Agrovision Foundation with the help of PI Foundation has carried out a novel experiment on mating disruption to control Pink Bollworm pest in cotton.

PBKnot involves use of gossyplure sex pheromones to prevent male insects finding females thus eliminating the possibility of egglaying and pest population.

HTBT COTTON

- Short for Herbicide Resistant Bt Cotton
- The cotton seed is inserted with 'Cp4-Epsps' gene from soil bacterium, Agrobacterium tumefaciens. This produces a modified protein glyphosate which makes it herbicide resistant.
- It is not allowed to be cultivated in India.

DMH-11 MUSTARD

In DMH-11 mustard, genetic modification allows cross-pollination in a crop that self-pollinates in nature.

Bt BRINJAL

- Bt brinjal is genetically engineered by inserting a gene from the soil bacterium Bacillus thuringiensis for its insecticidal property.
- The gene disrupts the digestive system of the insect that feeds on the crop, thus killing the insect.
- Since 2010 there is an indefinite moratorium on commercial cultivation of Bt Brinjal in India.

►NATIONAL STEM CELL REGISTRY

- India is developing a National Stem Cell Registry of its own.
- It is a government managed database of unrelated bone-marrow donors.
- Main aim is to find matching donors for treating patients with blood-related disorders such as
  - blood cancers (lymphoma, leukaemia)
  - thalassaemia,
  - sickle-cell anaemia,
  - haemophilia
- The registration to the database is voluntary.

IMPORTANCE

- About 3.5-5Lakh people in India suffer from blood-related disorders like thalassemia which require frequent blood transfusions. The only cure for blood related disorders is bone-marrow transplantation.
- Matching Donors
- For bone-marrow transplantation, the donor and patient should have the same white blood cell type.
- Siblings usually have the exact match and thus suitable for bone-marrow transplantations.
- Thus, matching donors is extremely low. The database will help connect unrelated matching donors.

►MANAV: HUMAN ATLAS INITIATIVE

- Launched by Department of Biotechnology
- It is a project to construct a comprehensive map of every tissue of the human body.
- It seeks to capture human physiology at the tissue level in natural and diseased state.

OBJECTIVES

- To provide better biological insights of human physiology
- To understand the roles of tissues and cells linked to various diseases.
- Develop disease models through predictive computing
- Drug discovery

►GENOME INDIA PROJECT

- Aims to conduct whole-genome sequencing of Indian.
- Also called 'Bioscience Mission for Precision Health and Optimal Well-being'
- Aimed at studying diversity of Indians and its impact on lifestyle, environment and genes that is inherited.
- It will help in development of personalized medicines.
- The initiative will involve large number of Indians from various geographies, caste, tribal and linguistic groups.
- Genome Sequencing will be a combined initiative of Ministry of Health and Family Welfare, Department of Health Research, Department of Biotechnology
- The initiative will include sequencing genomes and link it to human health disease as a research initiative.

IMPORTANT GENOME SEQUENCING EFFORTS

- UK - Genomics England
- Australia- 100,000 Genomes Project
- South and South-East Asia including 50000 Indians - GenomeAsia100K.

►INDIGEN INITIATIVE

- 'IndiGen' is the 1st of its kind whole genome sequencing of Indians.
- Under the initiative, genome sequencing of 1000 odd representatives of all states and ethnicities
- It was carried out by CSIR to accelerate the study of genomics in India.
- 'Indigen' is precursor to Genome India project under Bioscience Mission for Precision Health and Optimal Well-being of Department of Biotechnology.
- 'Indigen' initiative will go a long way in development of precision medicine, personalized medicine for various diseases and increase awareness of genetic disorders in India.

WHOLE GENOME SEQUENCING

- **Exome,** the portion of the genes responsible for making proteins occupies just about 1% of the actual gene. Rather than sequence the whole gene, many geneticists rely on **"exome maps".** However, the non-exome portions also affect the functioning of the genes.
- Hence to know which genes of a person's DNA are "mutated" the whole genome sequencing is required.

- Whole genome sequencing is the process of determining the complete DNA sequence of an organism's genome at a single time.
- This entails sequencing all an organism's chromosomal DNA as well as DNA contained in the mitochondria and, for plants, in the chloroplast.
- In practice, genome sequences that are **nearly complete** are also called whole genome sequences.

►HUMAN MICROBIOME PROJECT

- Aim: Characterize human microbiome and to assess how this core microbiome changes during disease.
- The project will include collection of saliva, stool and skin swabs of 20,000 Indians across various ethnic groups from different geographical regions.
- The project will help us to understand the impact of the human microbiome on human health and disease which range from neo-natal health, gastro-intestinal disorders, rheumatoid arthritis, diseases associated with skin, lung, liver, urogenital tract, neurological disorders, cancer to lifestyle associated diseases like obesity and diabetes.

►HUMAN PROTEOME PROJECT

- International collaboration organized by the Human Proteome Organization (HUPO)
- Aims to map the entire human proteome. (*Map of the protein based molecular architecture of the human body.*)
- Will enhance understanding of human biology at the cellular level
- Thus, it helps in development of diagnostic, prognostic, therapeutic, and preventive medical applications

►PROTEOMICS

The study of entire set of proteins that is produced or modified by an organism or system.

APPLICATION

- Identification of potential new drugs for the treatment of diseases
- In plant used for studying plant-insect interactions and develop pest-resistant solutions.

►BIONICS

It refers to design and development of technology inspired by biological methods.

APPLICATION

- Medicine: Bionic organs like bionic ear, bionic nose, bionic eye, silicon retina, artificial heart, bionic hand etc.
- Robotics: Robots are often designed inspired from biological processes.

►ARTIFICIAL BLOOD

- Substitute for red blood cells
- Designed for the sole purpose of transporting oxygen and carbon dioxide throughout the body.
- Produced though synthetic production, chemical isolation, or recombinant biochemical technology.

LIMITATION

- It performs the function of RBC only and not of **white cells, platelets, and plasma.**
- Lab-cultured Meat/ Transgenic Meat

►BIO-COMPUTING

- Biocomputing uses molecular biology parts as the hardware to implement computational devices.
- By following pre-defined rules, often hard-coded into biological systems, these devices can process inputs and return outputs—thus computing information.

►DNA DATA STORAGE

- Use of DNA to store data as an alternate data storage to binary data storage.
- Encoding and decoding binary data to and from synthesized strands of DNA.
- An alternative to hard drives storage system is progressing in the form of DNA-based data storage.
- DNA—which consists of long chains of the nucleotides A, T, C and G—is life's information-storage material.
- Data can be stored in the sequence of these letters, turning DNA into a new form of information technology.
- It is already routinely sequenced (read), synthesized (written to) and accurately copied with ease. Currently 16 GB of text from Wikipedia has been encoded into synthetic DNA.

►DNA OF THINGS (DOT)

- DoT encodes digital data into DNA molecules, which are then embedded into objects.
- While Internet of things is a system of inter-connected computing devices, DoT creates objects which are independent storage objects.

►NATIONAL GENOMIC GRID

- It will collect samples from cancer patients, through a network of pan-India collection centres by bringing all cancer treatment institutions on board.
- This research is carried out through the technique of Genome Sequencing.
- NGG will help to study genomic factors influencing cancer and identifying the right treatment modalities for the Indian population. The grid to be formed will be in line with the National Cancer Tissue Biobank (NCTB) set up at the Indian Indian Institute of Technology, Madras.
- National Cancer Tissue Biobank (NCTB) is a joint initiative of the Department of Science and Technology (DST), Government of India and Indian Institute of Technology, Madras.
- The biobank collects cancer tissue samples with consent from patients diagnosed with cancer.
- The aim is to provide researchers with high quality of cancer tissues and the patient data to facilitate cancer research that will lead to improvements in cancer diagnosis and treatment.

►EARTH BIO-GENOME PROJECT

- International collaboration to sequence and digitize the genomes of every eukaryotic biodiversity on Earth over a period of 10 years.
- It is an open-source DNA database.

APPLICATION

Planning environmental conservation initiatives.

ISSUE

May lead to digital bio-piracy (because it is open-source) which is against the principle of Nagoya protocol to convention of Biodiversity that requires sharing of benefits with the local communities

►IN-VITRO FERTILIZATION & FROZEN EMBRYOS

- In case of sexual reproduction, beginning of development of an offspring is fertilization of male and female gametes into zygote (a fertilized egg or embryo).
- The zygote (embryo) is then implanted into the uterus where it develops into full-fledged organism in various stages.
- From the day of fertilization (union of male and female gamete) up till 8 weeks the undeveloped zygote is called embryo.

INFERTILITY

- Infertility may occur due to various reasons
- Insufficient production of sperm for zygote formation
- Insufficient production of oocyte
- Failure to implant embryo into uterus

IN-VITRO FERTILIZATION

- One way of assisted reproductive technology is IVF
- In in-vitro fertilization, the fertilization of egg occurs externally outside the body.
- The externally developed fertilized zygote or embryo is then implanted inside the uterus of the mother for full-fledged development into human.

FROZEN EMBRYOS

- The embryos so developed in-vitro are sometimes frozen and stored for future use.
- The embryos are stored in liquid nitrogen or nitrogen vapour at a temperature below -190°C.

REASONS FOR STORING EMBRYOS

- Some couples store embryos for conceiving later. (Implanting in the uterus)
- In-vitro fertilization is done choosing desirable gametes. (Say a male European gamete)
- Patients with terminal illness like cancer may store gametes or even embryos before they undergo a radiation therapy.
- Couples may store frozen embryos to continue in-vitro fertilization in countries where IVF procedures are cheaper and cost effective like in India.
- Further some couples may choose to store frozen embryos to continue the IVF procedure in countries where commercial surrogacy is allowed.

IMPORT OF FROZEN EMBRYOS

- India has emerged as the surrogacy hub of the world since 2002.
- There has been rampant misuse of frozen embryos leading to illegal surrogacy in India because of the low cost of IVF procedure here.
- Until 2015, import of frozen embryos or gametes was allowed in India subject to a 'No Objection Certificate' from Indian Council of Medical Research (ICMR).

LAW GOVERNING IMPORT OF EMBRYOS IN INDIA

- To stop this practice, commercial surrogacy was banned in India when the parliament passed the Surrogacy (Regulation) Bill 2016 recently.
- Further import of human embryo is "prohibited" except for research purposes from 2015.

ASSISTED REPRODUCTIVE TECHNOLOGIES (ART)

All techniques that attempt to obtain a pregnancy by handling sperm or oocyte outside human body & transferring gamete or embryo into reproductive tract of a woman. Following are included in ART services:

Invitro Fertilisation (IVF): A complex series of procedures to treat infertility in people who are struggling to conceive. It can also be used in same sex couples. Processes involved are:

1. Ovarian stimulation: Aims to harvest as many eggs as possible from women's ovaries. Normal ovulation cycle produces one mature egg per month. Medications are used for stimulating ovaries to produce additional eggs. Hormones Follicle Stimulating Hormone (FSH) and Luteinizing Hormone (LSH), nature hormones involved in normal ovulation process are used. Stimulation process ends with a trigger shot of hCG, a large dose hormone injection that causes developing follicles to mature and sets ovulation in motion.
2. Egg retrieval: Egg retrieval happens right before ovulation occurs. Physicians puncture the ovary and drain the follicular flued and eggs from each mature follicle.
3. Intra-Uterine Insemination (IUI)
4. Intracytoplasmic Sperm Injection (ICSI): A single sperm is manually inserted directly into an unfertilised egg. Sperm is injected using tiny pipettes called micro-injectors.
5. Embryo transfer

TECHNIQUE FOR SPERM HARVESTING

1. Microsurgical Epididymal Sperm Aspiration (MESA): A surgical microscope is used to open small tubes within the epididymis for collecting sperms. This technique works well in conditions when sperm are being produced in adequate numbers but are blocked from travelling to the ejaculate.
2. Testicular Sperm Extraction (TESE): A tissue is taken directly from the testicle and examined for the presence of sperm. Often a surgery is done to find sperm in testicles. Any sperm found can be used immediately to fertilise an egg or they can be frozen for later use.
3. Percutaneous Epididymal Sperm Aspiration (PESA): A needle is used to extract sperm from the testicle or epididymis. Epididymis is an organ that lives behind the testicle and is the location where sperm mature and develop ability to move.
4. Cryopreservation of gametes and embryo: Frozen Embryo

►DESIGNER BABIES

- It refers to a baby that has been given special traits through genetic engineering.
- This is done by altering the genes of the egg, sperm, or the embryo.

►FIRST GENE-EDITED BABIES

- In 2018, a Chinese doctor for the first time performed gene editing on embryonic stem cell using CrispR technique.
- CRISPR technique was used to modify CCR5 gene on embryonic cells of couples making them resistant to HIV virus.
- One of the couples subsequently gave birth to twins – Lulu and Nana.
- However, CCR5 gene is not just associated with HIV, it may also play an important role in the inflammatory response and in cognitive function.

►CRISPR-CAS 9

- Nobel Prize in Chemistry in 2020 was awarded to Emmanuelle Charpentier and Jennifer Doudna for development of a method for genome editing technique called CRISPR-Cas 9 (genetic scissors).
- This technique helps to edit DNA of animals, plants and microorganisms with extremely high precision.
- This technology has had a revolutionary impact on the life sciences, is contributing to new cancer therapies and may make the dream of curing inherited diseases come true.
- Researchers need to modify genes in cells if they are to find out about life's inner workings. Earlier, gene editing used to be time-consuming, difficult and sometimes impossible work. Using the CRISPR/Cas9 genetic scissors, it is now possible to change the code of life over the course of a few weeks.
- There is enormous power in this genetic tool as it has not only revolutionized basic science but has also resulted in innovative crops and will lead to ground-breaking new medical treatments.

ABOUT GENE

- Nucleus contains thread-like structures called chromosomes. These carry genes and help in inheritance or transfer of characters from parents to offspring. Gene is a unit of inheritance in living organisms. Genes are made up of DNA. DNA (deoxyribonucleic acid) is the hereditary material in humans & almost all other organisms.
- Information in DNA is stored as a code made up of 4 chemical bases: adenine (A), guanine (G), cytosine (C), & thymine (T). Human DNA consists of about 3 billion bases. DNA base pair up with each other, A with T and C with G, to form units called base pairs.
- Each base is also attached to a sugar molecule and a phosphate molecule. Together, a base, sugar, and phosphate are called a nucleotide. Nucleotides are arranged in two long strands that form a spiral called a double helix.
- Structure of double helix is like a ladder, with the base pairs forming the ladder's rungs and the sugar and phosphate molecules forming the vertical sidepieces of the ladder.

WHAT ROLE DO CRISPR/Cas9 GENETIC SCISSORS PLAY?

- CRISPR/Cas9 system or technology which allows for adding, altering and deleting the genomic code in living beings.
- The essence of CRISPR is simple: it's a way of finding a specific bit of DNA inside a cell. After that, the next step in CRISPR gene editing is usually to alter that piece of DNA. However, CRISPR has also been adapted to do other things too, such as turning genes on or off without altering their sequence.
- When these components are transferred into other, more complex, organisms, it allows for the manipulation of genes, or "editing."
- Its many potential applications include correcting genetic defects, treating and preventing the spread of diseases and improving crops.

HOW DOES CRISPR-Cas9 WORKS?

- CRISPRs are specialized stretches of DNA. The protein Cas9 (or "CRISPR-associated") is an enzyme found in bacteria that acts like a pair of molecular scissors, capable of cutting strands of DNA.
- CRISPR-Cas9 was adapted from a naturally occurring genome editing system in bacteria. The bacteria capture snippets of DNA from invading viruses and use them to create DNA segments known as CRISPR arrays. The CRISPR arrays allow the bacteria to "remember" the viruses (or closely related ones). If the viruses attack again, the bacteria produce RNA segments from the CRISPR arrays to target the viruses' DNA. The bacteria then use Cas9 or a similar enzyme to cut the DNA apart, which disables the virus.

RESEARCH BASED ON tracrRNA

- Emmanuelle Charpentier, who is now director, Max Planck Institute for Infection Biology, Berlin, had studied Streptococcus pyogenes, a species of bacteria known to be associated with a range of illnesses such as pharyngitis, tonsillitis and scarlet fever.
- While studying this, she discovered a previously unknown molecule, tracrRNA. Her work showed that tracrRNA is part of bacteria's ancient immune system, CRISPR/Cas, which disarms viruses by cleaving their DNA, the Nobel release explains.
- Dr. Charpentier published her discovery in 2011. The same year, she initiated a collaboration with biochemist Jennifer Doudna, now a professor at the University of California, Berkeley.
- Together, they succeeded in recreating the bacteria's genetic scissors in a test tube and simplifying the scissors' molecular components, so they were easier to use.

GAME CHANGING EFFORT

- In a significant experiment, they reprogrammed the genetic scissors. "In their natural form, the scissors recognise DNA from viruses, but Charpentier and Doudna proved that they could be controlled so that they can cut any DNA molecule at a predetermined site. Where the DNA is cut it is then easy to rewrite the code of life.
- Other genome editing systems like TALENs and Zinc-Finger Nucleases can do similar jobs, but several users consider the Charpentier-Doudna tool more adaptable and easier to use.
- the technology allows researchers to find out what genes do, move mutations that are identified and associated with disease into systems where they can be studied and tested for treatment, or where they can be tested in combinations with other mutations.

APPLICATIONS OF CRISPR-Cas9

- Earlier this year, a person with hereditary blindness became the first to have a CRISPR/Cas-9-based therapy directly injected into her body.
- Gene-editing company CRISPR Therapeutics announced in June that two patients with beta thalassemia and one with sickle cell disease would no

longer require blood transfusions after their bone marrow stem cells were edited using CRISPR techniques.

- Beta thalassemia is a blood disorder that reduces the production of hemoglobin. Hemoglobin is the iron-containing protein in red blood cells that carries oxygen to cells throughout the body. In people with beta thalassemia, low levels of hemoglobin lead to a lack of oxygen in many parts of the body.
- Sickle cell disease is a group of inherited red blood cell disorders that affects hemoglobin, the protein that carries oxygen through the body. Normally, red blood cells are disc shaped and flexible to move easily through the blood vessels. If you have sickle cell disease, your red blood cells are crescent or "sickle" shaped. These cells do not bend and move easily and can block blood flow to the rest of your body.
- Dr. Doudna launched a new company, Scribe Therapeutics, to begin work on treatments for amyotrophic lateral sclerosis. Reuters reported that Dr. Doudna is already employing CRISPR in the battle against the COVID-19 as a co-founder of biotech startup Mammoth, which has tied up with GlaxoSmithKline to develop a test to detect infections.
- Amyotrophic lateral sclerosis (ALS) is a group of rare neurological diseases that involve the nerve cells (neurons) responsible for controlling voluntary muscle movement. Voluntary muscles produce movements like chewing, walking, and talking. The disease is progressive, meaning the symptoms get worse over time.
- This year, the CSIR-Institute of Genomics and Integrative Biology (CSIR-IGIB) in Delhi developed a COVID-19 testing kit, nicknamed 'Feluda', after the fictional Bengali detective, based on the CRISPR/Cas9 system.

There are commercial CRISPR-based home kits that allow amateur researchers to develop their own biotechnology applications, triggering a sub-culture called 'bio-hacking' – hacking one's gene for further evolution – trans-human.

BIO-LIPOSOME MEDIATED CRISPR-Cas9 DELIVERY SYSTEM

A novel bio-inspired lipid nanocarrier system for efficient intracellular delivery of CRISPR-Cas9 based genome editing tools has been developed.

The development of bio-inspired lipid nanocarrier delivery systems would open new vistas for devising novel gene therapy-based therapeutic solutions for various rare and genetic diseases.

►LIQUID NANO UREA

IFFCO has entered a MoU with public sector fertiliser manufacturers National Fertilisers Limited (NFL) and Rashtriya Chemicals and Fertilisers Ltd (RCF) for 'transfer of technology' aimed at increasing production Liquid Nano Urea.

ABOUT LIQUID NANO UREA

- Developed by IFFCO. India will be first country to start commercial production of Liquid Nano Urea.
- It is a nanotechnology-based fertilizer. It contains Nano scale nitrogen particles which have more surface area and number of particles, which make it more impactful.

BENEFITS OF NANO UREA

As compared to conventional urea, uptake of Nano Urea is more than 80%. It is thus required in lesser amounts as compared to the conventional urea fertiliser to fulfil plant's nitrogen requirement.

- Cheaper than conventional urea
- Reduced input costs to farmer.
- Easy to apply as when Nano urea is sprayed on leaves Nano Urea
- Reduced transportation cost
- Easy to store
- Reduced import of conventional urea saving precious foreign exchange.
- Increased income for farmers.

►PRIME EDITING

The first thing to point out is that prime editing is a relatively new technique, only published in late 2019. Since it is a targeted genetic editing technique, so it can focus on specific DNA sites to replace genetic information. Therefore, it can facilitate insertions, deletions and conversions without breaking both strands of DNA or using DNA templates.

COMPONENTS OF PRIME EDITING

Prime editing has three major components:

A prime editing guide RNA (pegRNA) identifies the sequence of bases to be edited and then encodes the new sequence to replace the target. pegRNA is made up of an extended single guide RNA (sgRNA) with a primer binding site (PBS) and a reverse transcriptase template sequence. During prime editing, the PBS allows the DNA strand to hybridise to the pegRNA, while the reverse transcriptase template sequence serves as the template for the edited genetic sequence.

A fusion protein made up of two enzymes: The first enzyme is a Cas9 H840A nickase, which specifically nicks a single strand ("nickase"). The Cas9 enzyme section of the nickase has a substitution in it to cause a single-strand break, rather than a double-stranded cut.

The second enzyme is an M-MLV (Moloney Murine Leukemia Virus) reverse transcriptase which synthesises DNA from a template of single-stranded RNA. Another second sgRNA that directs the fusion protein to the DNA strand to be edited.

HOW DOES PRIME EDITING WORK?

Prime editing works by introducing the pegRNA and fusion protein to the target cell, then once inside the cell, the fusion protein nicks the cell's DNA at the target sequence, initiating reverse transcription of the template sequence found in the pegRNA. Then, it creates an edited strand and an unedited strand of DNA. First, the unedited strand is removed then the newly edited strand is annealed back to form double-stranded DNA.

This then creates a mismatch in the base pairs between the two strands, which can have two outcomes. On one hand, using the mismatch repair mechanism of the cell, the edited strand is copied to the complementary strand, which incorporates the edited strand into the DNA of the cell. Conversely, the original base sequence is reincorporated into the edited strand from the complementary strand, removing the edit from the DNA of the cell.

ADVANTAGES OF PRIME EDITING

Since prime editing uses the cells' intrinsic DNA mismatch system to incorporate changes in the nucleotide order into the cell, this reduces the number of unwanted or random by-products of genome editing. There are potentially fewer off-target effects than with the CRISPR-Cas9 system – potentially marking it as a future technology for human therapeutic uses.

Prime editing is also highly precise and can be used flexibly along the DNA genome due to the single-stranded pegRNA, which allows for all types of insertions into the gene sequence, such as substituting or transitioning bases.

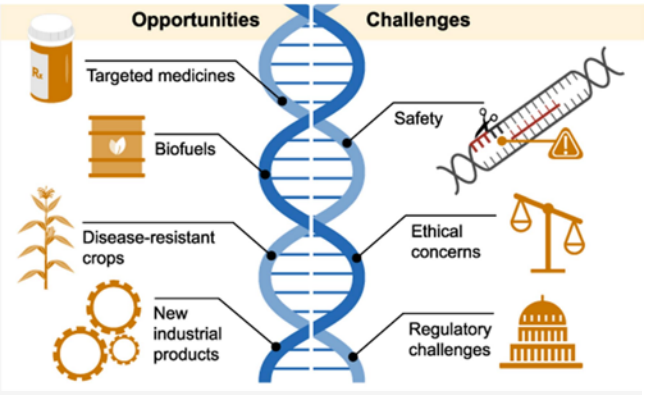
Overall: CRISPR-Cas9 is an older and much more embedded technique than prime editing. The two systems also differ in how they 'cut' into DNA strands. CRISPR-Cas9 removes both strands at the place they make an edit, while prime editing only nicks one of the two strands of DNA. While CRISPR has been used in many settings, prime editing is still at an early stage of proof of principle. Nevertheless, it will be interesting to see what role prime editing plays in the future of genomic editing.

►SDN-1 & SDN-2

The proposal for Indian regulators to consider a new gene editing technique has been pending with the Genetic Engineering Appraisal Committee for almost two years.

GENE EDITING

- Genome editing (also called gene editing) is a group of technologies that give scientists the ability to change an organism's Deoxy-Ribonucleic Acid (DNA).
- These technologies allow genetic material to be added, removed, or altered at locations in the genome.



KEY POINTS

- About:
  - Indian Agricultural Research Institute (IARI) has now moved to newer technologies such as Site Directed Nuclease (SDN) 1 and 2.
  - New technique aims to bring precision and efficiency into the breeding process using gene editing tools such as CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats), whose developers won the Nobel Prize for Chemistry in 2020.
  - SDN genome editing involves the use of different DNA-cutting enzymes (nucleases) that are directed to cut the DNA at a predetermined location by a range of different DNA binding systems.
  - After the cut is made, the cell's own DNA repair mechanism recognizes the break and repairs the damage, using one of two pathways that are naturally present in cells.
  - It involves the use of gene editing tools to directly tweak (improve\change) the plant's own genes instead.

- It would allow plants to be genetically modified without the need for conventional transgenic technology.

SDN 1 and 2:

- The ministry of environment and forest exempted SDN1 and SDN2 genome-edited plants from Rules 7-11 of the Environment Protect Act (EPA), which govern the manufacture, use, import, export, and storage of dangerous microorganisms or genetically modified organisms or cells.
- The notification will pave the way for the government to approve and notify the genome-edited plant guidelines.

What are SDN 1 and SDN 2:

- SDN 1 & 2 (Site-Directed Nuclease technology) are Gene-editing technologies which do not involve the introduction of any foreign DNA.
- Site-Directed Nuclease (SDN) genome editing involves the use of different DNA-cutting enzymes (CRISPR-Cas9) that are directed to cut the DNA at a predetermined location. After the cut is made, the cell's own DNA repair mechanism recognizes the break and repairs the damage.
- In the case of SDN1 and SDN2 approaches, the CRISPR components used to edit the selected native genes for a desirable trait can easily be removed by segregation of the plant progeny in the next and subsequent generations. In this way, one can produce transgene-free edited plants (in other words, non-genetically modified or non-GMOs) that are indistinguishable from conventional breeding material. But this method is faster and cheaper than traditional crossing, which results in a host of unwanted traits also getting transferred and, hence, requires several more breeding cycles in order for the offspring to have only the desired traits.

- Current Application:
  - A research coalition under the Indian Council of Agricultural Research (ICAR), which includes the IARI, is using these techniques to develop rice varieties which are drought-tolerant, salinity-tolerant and high-yielding. They could potentially be ready for commercial cultivation within three years.
    - The IARI has previously worked on golden rice, a traditional GM variety which inserted genes from other organisms into the rice plant but ended trials over five years ago due to agronomic issues.
- Significance of New Techniques:
  - Safe:
    - In this case, you are just tweaking a gene that is already there in the plant, without bringing in any gene from outside.
    - When a protein comes from an outside organism, then you need to test for safety. But in this case, this protein is right there in the plant, and is being changed a little bit, just as nature does through mutation.
  - Fast:
    - It is much faster and far more precise than natural mutation or conventional breeding methods which involve trial and error and multiple breeding cycles. It is potentially a new Green Revolution.
- Status of New Techniques Globally:
  - The U.S, Canada, Australia and Japan are among the countries which have already approved the SDN 1 and 2 technologies as not akin to GM, so such varieties of rice can be exported without any problem.
  - The European Food Safety Authority has also submitted its opinion that these technologies do not need the same level of safety assessment as conventional gene mutation, though the European Union is yet to accept the recommendation.
- Related Laws in India:
  - In India, several rules, guidelines, and policies backed by the "Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Microorganisms/Genetically Engineered Organisms or Cells, 1989" notified under the Environment Protection Act, 1986, regulate genetically modified organisms.
  - Apart from it, the National Ethical Guidelines for Biomedical and Health Research involving human participants, 2017, by the Indian Council of Medical Research (ICMR), and the Biomedical and Health Research Regulation Bill implies regulation of the gene-editing process.
    - This is especially so in the usage of its language "modification, deletion or removal of parts of heritable material".
    - However, there is no explicit mention of the term gene editing.

GENETIC ENGINEERING APPRAISAL COMMITTEE

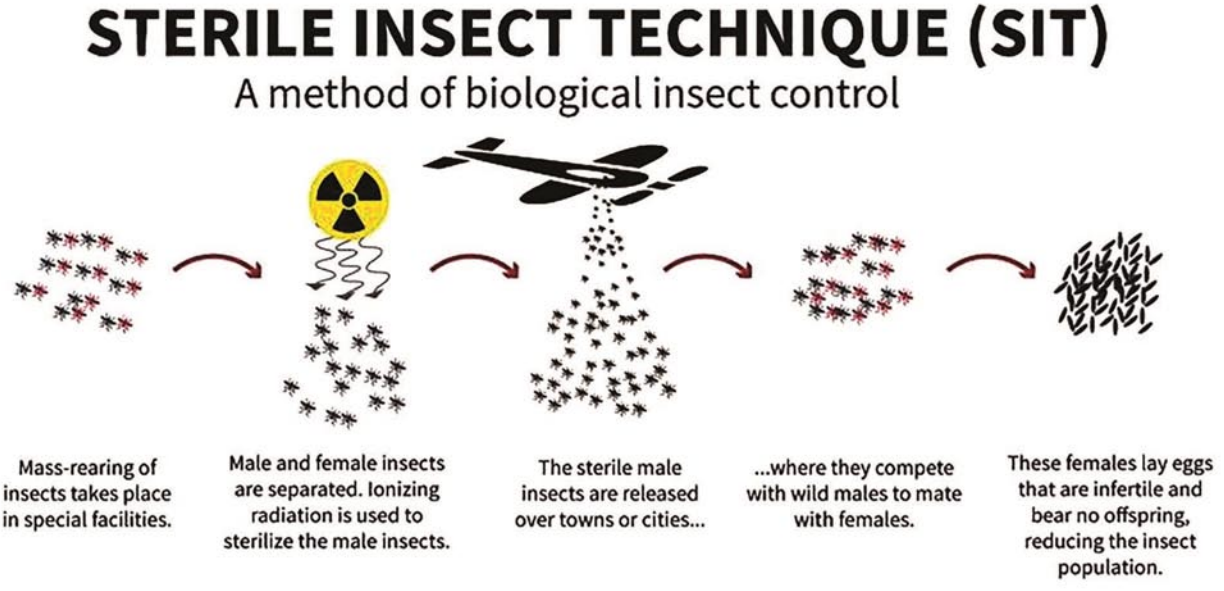
- Functions under MOEFCC.

- It is responsible for the appraisal of activities involving large-scale use of hazardous microorganisms and recombinants in research and industrial production from the environmental angle.
- The committee is also responsible for the appraisal of proposals relating to the release of genetically engineered organisms and products into the environment including experimental field trials.
- GEAC is chaired by Special Secretary/Additional Secretary of MOEFCC and co-chaired by a representative from the Department of Biotechnology (DBT).

►RESTRAINING MOSQUITO POPULATION WITH CRISPR

Recently, researchers have created a system that restrains populations of mosquitoes by leveraging advancements in Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) – based genetic engineering.

- Mosquitoes infect millions each year with debilitating diseases such as dengue and malaria.



- Sterile Insect Technique:
  - SIT is an environmentally safe and proven technology to suppress wild populations.
  - To further advance its utility, a novel CRISPR-based technology, termed precision-guide Sterile Insect Technique (pgSIT) is described.

pgSIT

It is a new scalable genetic control system that uses a CRISPR-based approach to engineer deployable mosquitoes that can suppress populations.

- Males don't transmit diseases, so the idea is to release more and more sterile males.
- The population of mosquitos can be suppressed without relying on harmful chemicals and insecticides.
- It alters genes linked to male fertility—creating sterile offspring—and female flight in Aedes aegypti, the mosquito species responsible for spreading diseases including dengue fever, chikungunya and
- PgSIT mechanistically relies on a dominant genetic technology that enables simultaneous sexing and sterilization, facilitating the release of eggs into the environment ensuring only sterile adult males emerge.
  - The system is self-limiting and is not predicted to persist or spread in the environment, two safety features that should enable acceptance for this technology.
- pgSIT eggs can be shipped to a location threatened by mosquito-borne disease or developed at an on-site facility that could produce the eggs for nearby deployment.
- Once the pgSIT eggs are released in the wild, sterile pgSIT males will emerge and eventually mate with females, driving down the wild population as needed.

►EPIGENETICS

Epigenetics is the biochemical changes dictating expressivity of a gene in a cell.

The functioning of cells and tissues in our body are controlled by thousands of proteins that regulate

various cellular functions. These proteins are in turn encoded by the respective genes which are a part of our genome or the cellular DNA. Any minor or major changes to our inherited DNA (addition or mutation) can result in altered protein production, which in turn leads to defective cellular functions. This forms the basis for many heritable genetic disorders affecting the mankind.

Apart from DNA or protein sequence level alterations, there are other biochemical changes that influence and dictate if a gene should be active or inactive in each cell type. For example:

- Gene that encodes for the insulin protein is present in exact form, in every cell of the body. However, it is allowed to express only in the insulin secreting beta cells of the pancreas and is kept inactive in the rest of the cells of the body. This phenomenon is tightly regulated by a combination of regulatory proteins that changes the expressivity of the gene.
- Also, the histone proteins that bind the DNA and help to compactly wrap it inside the chromosomes can undergo chemical modifications such as methylations and acetylation on different lysine amino acids within the protein. These modifications both on the DNA and its associated proteins alter the chromosomal conformations and regulate gene expression. These changes can either unwind the DNA and allow gene expression or can compact the DNA and render the genes in the region inactive or silent.
- Unlike DNA mutations that are permanent, such epigenetic changes are reversible and are mediated by regulatory proteins.

►Z-DNA

- Most organisms DNA comprise of 4 nitrogenous bases of
  1. Adenine (for A)
  2. Cytosine (for C)
  3. Guanine (for G)
  4. Thymine (for T)
- Scientists have discovered that Bacteriophages write their genomes using a chemical nitrogenous base called 2-aminoadenine in place of Adenine. This base has been given a symbol of Z and DNA comprising Z base pair have been called Z-DNA.
- Z base that replaces A in the genetic alphabet forms three hydrogen bonds instead of two, making the two DNA strands tougher to pull apart.

ABOUT BACTERIOPHAGE

- Also known informally as a phage. It is a virus that infects and replicates within bacteria and archaea.
- Like other viruses, they vary a lot in their shape and genetic material.
- Phage genome can consist of either DNA or RNA and can contain as few as four genes and as many as several hundred.

►AEG 12

- It is a mosquito protein that strongly inhibits family of viruses that cause yellow fever, dengue, West Nile and Zika and weakly inhibits coronaviruses.
- Researchers have demonstrated that AEG12 was most effective against flaviviruses (Zika, West Nile etc belong to flavivirus).
- There is a possibility that AEG12 works against COVID-19.
- AEG12 also breaks red blood cells, changes need to be made so that the protein acts against only coronavirus.

►TRANSFAT

- Trans fat, or trans-fatty acids, are unsaturated fatty acids that come from either natural or industrial sources.
- Naturally occurring trans-fat come from ruminants (cows and sheep).
- Industrially produced trans-fat are formed in an industrial process that adds hydrogen to vegetable oil converting the liquid into a solid, resulting in "partially hydrogenated" oil (PHO).
- This is because on lipid levels: trans-fat increases LDL ("bad") cholesterol levels while lowering HDL ("good") cholesterol levels.
- Partially hydrogenated oils (PHO) are solid at room temperature and prolong the shelf life of products.
- They are primarily used for deep frying and as an ingredient in baked goods. PHOs were first introduced into the food supply in the early 20th century as a replacement for butter and lard; they are not a natural part of the human diet and are fully replaceable.
- FSSAI caps trans fatty acids to 2% in all oils and fats.

►ARBOVIRUS

- Arbovirus (arthropod-borne virus) applies to any virus that is transmitted to humans and/or other

vertebrates by certain species of blood-feeding arthropods, chiefly insects (flies and mosquitoes) and arachnids (ticks).

- They typically affect the central nervous system and have a lot of similarities in their clinical and epidemiologic aspects.
- Arboviral diseases include Chikungunya, dengue, West Nile, Yellow Fever, and Zika.

GLOBAL ARBOVIRUS INITIATIVE

- The Global Arbovirus Initiative is an integrated strategic plan to tackle emerging and re-emerging arboviruses with epidemic and pandemic potential focusing on monitoring risk, pandemic prevention, preparedness, detection and response, and building a coalition of partners.
- The initiative is a collaborative effort between the World Health Emergencies Program of WHO, the Department of Control of Neglected Tropical Diseases, and the Immunization, Vaccines and Biologicals Department.

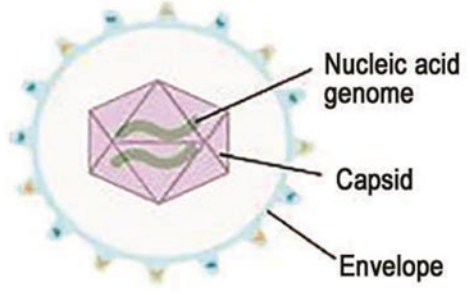
SCIENCE OF COVID-19

SPEED TEST – 1 (T/F)

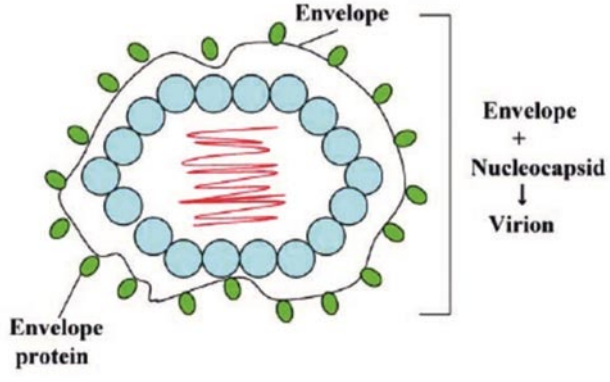
i. Viruses have RNA as the nuclear material and completely lack DNA.
ii. Coronavirus is zoonotic in nature.
iii. Middle East Respiratory Syndrome (MERS) is caused by coronavirus.
iv. Almost everyone gets a coronavirus infection at least once in lifetime.
v. Coronavirus is RNA based Virus.
vi. All viruses have an outer lipid layer that protects them when they are outside the cell.
vii. Coronavirus has different structure than rotavirus.
viii. Virus is not a living entity.
ix. Sanitizers protect against viral infection through denaturation, dissolving the outer lipid layer, stressed mutation of the virus and dissolution of protective protein called capsid.
x. RNA viruses are prone to quick changes.
xi. Corona virus RNA structurally resembles the m-RNA of our cell.
xii. Corona virus can enter nucleus of the host cells and replicate.
xiii. Ribosomes of the host cells can read the genetic code in the RNA of corona virus and help it replicate.
xiv. SARS-CoV-2 is a double stranded RNA based virus.

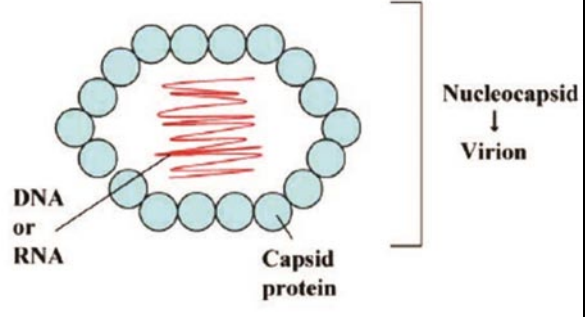
►BASICS OF VIRUS

- Viral particles consist of two (non-enveloped or naked viruses) or three parts (enveloped viruses):
  - the genetic material made from either DNA or RNA (not both)
  - a protein coat, called the capsid, which surrounds and protects the genetic material



- an envelope of lipids that surrounds the protein coat when they are outside a cell





- Enveloped viruses have outer lipid layer of glycoprotein and lipoproteins.
- Function of the envelope:
  - Protection against the host immune system (as these membranes are usually obtained from host cells)
  - Receptors usually located on that envelop which recognize the host cells.
  - Contain ligands helping in the attachment to the host cell surface
  - These membranes are also effectively infused to the cell membrane and release the core of virus or its genetic material into the cell.
- Thus, losing the membrane will impair the infectivity of the virus.
- Enveloped viruses can only survive under special conditions ("wet conditions"), and they are transmitted in "wet" body fluids, like blood or respiratory droplets. Naked viruses can survive under harsh conditions.
- The protein capsid of naked viruses is less susceptible to environmental conditions (lipid solvents, pH, temperature etc.) than enveloped viruses. Ex. norovirus, rotavirus, Human papillomavirus (HPV) and polio etc.
- Coronaviruses (including COVID-19 virus) have a lipid membrane that makes up their outer coating.
- Virus does not have DNA producing machinery. So, it enters the cell and used the machinery of the cell. It does so by reprogramming and instead of producing its own DNA, cell produces the DNA of the virus.
- Because they can't reproduce by themselves, viruses are not considered living.

►CORONAVIRUS

- Large family of viruses, first identified in the 1960s.
- Can infect both animals and humans.
- It causes illness ranging from the common cold to more severe respiratory illness like SARS & MERS.
- WHO has named it as COVID-19.

►NOVEL CORONAVIRUS (COVID-19)

- A new strain that has not been previously identified in humans.
- First detected in Wuhan, China.
- Relative of SARS. Hence the name of the virus is SARS-CoV-2
- The novel coronavirus like any other corona virus has its genetic material as a single-stranded RNA.
- The challenge with RNA virus as compared to DNA virus is that RNA viruses are prone to quick changes and thus continuously mutating into new forms.

TRANSMISSION

- These viruses are zoonotic – transmitted from animals to humans.
- Human-to-Human: Mother to baby: Breastfeeding and placenta

►HAND SANITIZERS

- For a virus, sanitizers work by disrupting the virus's outer coat. [However, they are not effective against viruses that do not have these coatings like norovirus, rotavirus, Human papillomavirus (HPV) and polio etc.]
- The most feasible explanation is denaturation of protein structures that stick out of the lipid structure. It also dissolves the lipid envelope.
- For a bacterium, they work by disrupting its cell membrane.

ADVANTAGES OF HAND SANITIZERS

- The bacteria it kills don't develop a resistance to it, so alcohol doesn't lose effectiveness with continued use.
- Ethanol is so powerful that in high concentrations, it's better at getting rid of— Escherichia coli, Serratia marcescens and Staphylococcus saprophyticus — compared with washing hands with regular or antibacterial soap.

LIMITATION OF HAND SANITIZERS

- Alcohol doesn't work for all germs, such as norovirus; Clostridium difficile, which can cause life-threatening diarrhea; or Cryptosporidium, a parasite that causes a diarrheal disease.
- Hand sanitizers also don't remove harmful chemicals like pesticides or heavy metals, nor does hand sanitizer work well on especially dirty or greasy hands.
- Swallowing alcohol-based hand sanitizers can cause alcohol poisoning.

►MECHANISM OF VIRAL INFECTION

- Virus gets attached to a receptor at the outer layer of the cell.

- Through endocytosis and other mechanisms virus enters the cell.
- After virus gains entry to the cytoplasm of our cell, it commanders the lysosomes and ribosomes and other protein making machinery in the cytoplasm to make new copies of itself.
    - Lysosomes contains number of chemicals like protease that breaks down the protein structure of food and pathogens.
- The lysosome fuse with the envelope of the virus allowing its content to work of the envelop and surface protein. This allows the viral genome to enter the cytoplasm.
- Corona virus genetic material is a positive sense RNA genome of about 30,000 bases.
    - Positive sense means the viral RNA structurally resembles the m-RNA of our cell and therefore can be read and translated directly by ribosomes, to make proteins.
    - But there is no way to use the host cell organelle to replicate the genetic code to make more viral particles or reproduce.
- All our DNA duplication takes place in the confines of our nucleus, isolated from the cytoplasm. HOWEVER, the virus has figured this out.
- First 20,000 bases, (2/3rd of the entire genetic code) are used in the production of a protein molecules called, RNA dependent RNA polymerase (or RNA replicase). This protein molecule serves multiple function in the protein replication process. It can now read the viral RNA and make complementary RNA strands, a matching template of original positive sense RNA. However, it is a negative sense RNA, meaning it cannot be read by ribosomes. But the newly assembled RNA dependent RNA polymerase can read the complementary strand to make new positive sense RNA, replicating the original RNA.
- RNA replicase can read the negative sense RNA a second time and produce fragments of positive sense genetic material, which encodes for four structural proteins of the new virus.
- The smaller RNA fragments are then read by the host's Ribosome to produce the structural part of the new virus.
- The new structures and surface protein are then assembled to form viral structure. This then loaded with the copy of RNA, encapsulated with a membrane, is then delivered outside the cell through exocytosis.
- The single stranded RNA replication process is horribly inaccurate, resulting in many coding errors (mutations). Since the replication happens freely in the host cytoplasm, the process is completely unregulated. The replicase with haphazardly replicate its own genetic code or the code of another infecting virus or the sub-type. The segments of genetic codes from both sub-types can be combined into a new organism, a process called genetic chimerism.
- Abundant genetic material, mutation and chimerism allows the virus to adapt quickly to new and changing environment, making it difficult to treat the infection.

SPEED TEST – 1: SOLUTION

i. False; ii. True; iii. True; iv. True; v. True; vi. False; vii. True; viii. True; ix. False; x. True; xi. True; xii. False; xiii. True; xiv. False

SPEED TEST – 2

i. Mutations may increase infectivity of a virus.

ii. T cell are type of leukocyte which develops in the thymus gland. It is an essential part of the immune system.

iii. Memory T cells are antigen-specific T cells that remain long-term after an infection has been eliminated.

iv. T-cells in the body secretes anti-bodies.

v. Angiotensin-converting enzyme or ACE controls blood pressure by regulating the volume of fluids in the body.

vi. Binding of SARS-CoV-2 virus with ACE2 is considered as the trigger point for the damage of lungs, heart and other organs.

vii. Herd immunity can be achieved only through mass vaccinations.

viii. SARS-CoV-2 uses the cleaved form of Angiotensin-Converting Enzyme 2 (ACE2), as its doorway into the host cell.

ix. ACE2 is a protein on the surface of only lungs, kidney, GI tract and blood vessels.

x. Angiotensin-2 causes vasodilation.

xi. ACE-2 is a pressure modulating membrane protein.

xii. Mutation of SARS-CoV-2 is happening only in the spike protein.

xiii. T cell immunity does not cause prevention of disease.

xiv. High level of coronavirus antibody presence signifies a healthy body, ready to fight infection.

xv. Anti-bodies are produced by T-cells

xvi. Renin-Angiotensin system is related with blood pressure regulation in our body.

xvii. Healthy individuals have high Angiotensin-2 to Angiotensin (1-7) ratio.

xviii. Angiotensin Converting Enzyme (ACE) is released by the lungs.

xix. BRADYKININ STORM is related to hyper immune response resulting in intense action of Killer T-cells.

xx. Vaccines immediately gives immunity against the pathogen.

►MECHANISM OF CORONA VIRUS INFECTION

- Spike proteins on the surface of SARS-CoV-2 are how it attaches to cells targeted for infection. The spikes first get attached to a molecule called heparan sulfate.
- Heparan sulfate is a large, complex sugar molecule found on the surface of cells in the lungs, blood vessels and smooth muscle making up most organs.
- Facilitated by its initial binding with heparan sulfate, SARS-CoV-2 then uses another cell-surface component, the protein known as Angiotensin-Converting Enzyme 2 (ACE2), as its doorway into the attacked cell.
- ACE2 is a protein on the surface of many cell types like lungs, kidney, GI tract, blood vessels. Recently it has been discovered that ACE2 is also present in our nose.

To understand the role of ACE-2 in the corona virus infection, we first must understand Renin-Angiotensin system, involving the kidney, liver, lungs and blood vessels and adrenal gland.

RENIN-ANGIOTENSIN SYSTEM

- It is a close-loop feedback mechanism that help maintain renal blood flows.
- The kidneys are designed to filter the nitrogenous waste from our body.
- To function normally they need a steady flow of blood, receiving around 25% of total cardiac output.
- A drop in blood pressure, either systemically from heart failure or locally due to narrowing to renal artery, causes the kidney to secrete a chemical, called renin, into the blood stream.
- Renin then link to a protein hormone produced in the liver called angiotensinogen, converting it to Angiotensin-1.
- Lungs produce an enzyme called Angiotensin Converting Enzyme (ACE). ACE links to angiotensin-1, converting it to angiotensin-2, the active configuration of the hormone.
- Angiotensin-2 then acts on the peripheral arteries throughout the body and the adrenal gland. The arteries constrict and the adrenal gland produces a hormone called *Aldosterone*. Aldosterone causes the kidney to reabsorb more salt and water from the urine.
- The combination of vascular constriction and saltwater retention raises the blood pressure and restores the blood flow to the compromised kidney.

ACE-2 PROTEIN

- ACE-2 is a pressure modulating membrane protein.
- Active form of ACE-2 is produced by a protein called *Sheddase*.
- Sheddase cleave the external component of the ACE-2 protein and release it into the blood stream.
- The released part of ACE-2 then interacts with the Angiotensin-2, converting it to *Angiotensin (1-7). Angiotensin (1-7)* is a powerful antioxidant and vasodilator, dilating the blood vessels of the body and eliminating the action of angiotensin-2 on the adrenal.
- *Angiotensin (1-7)* lowers the blood pressure and is basically the counterbalance to the Renin-Angiotensin system.

Angiotensin-2 and *Angiotensin (1-7)* are in direct competition and the dominant component is determined by individual baseline health status. In young healthy and physically fit individuals, *Angiotensin (1-7)* is dominant. However, in the elderly individuals with heart failures, hypertension, diabetes, poor diet, Angiotensin-2 would rule.

However, the spikes protein recognise the intact ACE-2 protein and not the cleaved part. In healthy individuals with the abundance of Angiotensin (1-7), most of the ace-2 proteins would have been cleaved, reducing he gateway for the virus and reducing the chance of cytoplasm of reaching that critical mass.

In the situation where *Angiotensin (1-7)* is dominant, we expect *Sheddase* to be working overtime, cleaving he upper part of ACE-2 protein and thereby converting *Angiotensin-2* to *Angiotensin (1-7)*.

- When SARS-CoV-2 attacks the ACE2 receptors to proliferate and infect more cells in the human body, it also prevents Factor H from *using* the sugar molecule to bind with cells and causes factor D to overstimulate the immune response, which in turn prevents factor H from mediating that response.
  - factor H and factor D proteins help the immune system clear pathogens from the body.
  - factor H's main function is to regulate the chemical signals that trigger inflammation and keep the immune system from harming healthy cells.
- By blocking factor D, it is possible to stop the destructive chain of events triggered by SARS-CoV-2. There are already drugs in development for other diseases that can block this protein.
- The virus also hijacks the cell mechanism and fights back by letting the human cell produce PLpro.
  - PLpro is a protein which suppresses the development of type 1 interferons. Due to this, killer cells are not informed about the infection.
  - Hence, PL pro plays a crucial role in the replication of the virus.

►BRADYKININ STORM

The impact of COVID-19 on some people is very severe. A supercomputer's recent analysis of data on the contents collected from the lungs of patients with the COVID-19 infection has showed that a phenomenon called a 'bradykinin storm' might explain how the virus works in the body.

THE BRADYKININ HYPOTHESIS:

- Bradykinin is an important part of the vasopressor system that induces hypotension and vasodilation and is degraded by ACE and enhanced by the *Angiotensin (1-9)* produced by ACE2.
- Once in the lungs, the virus commanders the lungs cells to decrease gene expression of ACE in combination with increase in ACE2.
- This in turn elevates bradykinin levels in multiple tissues and systems (Bradykinin Storm) that will likely cause increases in vascular dilation and vascular permeability, leading to swelling of the surrounding tissue. These bradykinin-driven outcomes explain many of the symptoms being observed in COVID-19. Bradykinin storm causes the blood vessels to expand and become leaky.
- The levels of a substance called hyaluronic acid also increases.
  - Hyaluronic acid is a sugar molecule that occurs naturally in the skin, and it helps to bind water to collagen (a protein). It can absorb more than 1,000 times its own weight in water to form a hydrogel.
- The bradykinin storm-induced leakage of fluid into the lungs combined with the excess hyaluronic acid would likely result in a Jello-like substance that prevents oxygen uptake and carbon dioxide in the lungs of severely affected Covid-19 patients.
- This rapid accumulation of fluid in the lungs of patients impedes the transfer of oxygen from the lung to the blood and subsequently to all other tissues, a common abnormality in COVID-19 patients. This makes even the most sophisticated intensive care, including ventilators, futile.

►MUTATION AND REINFECTION

Mutation is an alteration in the genetic material (the genome) of a cell of a living organism or of a virus that is permanent and that can be transmitted to the cells or the virus's descendants.

HIGHER RATE OF MUTATION IN RNA-VIRUS

- When cells multiply, the DNA within them replicates as well, to make copies for the new cells. During replication, random errors are introduced into the new DNA.
- While the errors in DNA virus genomes can be corrected by the error-correcting function of cells in which they replicate, there are no enzymes in cells to correct RNA errors. Therefore, RNA viruses tend to have a higher mutation rate than DNA viruses.
- Mutation of SARS-CoV-2 is happening in the spike protein as well as in other genomic regions

SIGNIFICANCE OF MUTATION

- Some mutations may allow a selective advantage, say higher infectivity, transmission, or escape from immune system of the body. Then the new viruses out-compete the older ones in a population.
- For instance, a mutation called D614G emerged in January 2020 to change the amino acid at a position in the coronavirus' Spike protein. Because this variant infected and replicated better and produced 'fitter' viruses, it now accounts for over 99% of the virus

circulating globally. Other mutations are now emerging in this background.

It is generally known that *protective immunity* against the four species of common cold coronaviruses does not last for more than year. This observation suggests that the duration of protection against SARS-CoV-2 reinfection, too, may not be for long. *Reinfection is a common feature of all human coronaviruses.*

Reinfection has implications for vaccine development

- If COVID-19 reinfections are common, it would imply that vaccines might not completely protect against the virus.
- Even those who have been infected with the virus would have to get vaccinated to protect themselves from reinfections.
- We might have to design and use seasonal shots – like with the flu – as a new 'variant' of the virus takes over from an older one in the population.
- Choosing the antigen – the component of the virus used in the vaccine to prepare our immune system – is key. Careful mutation studies are required. Analysing the virus's genome could help us understand which parts of proteins in the virus haven't changed much. And researchers could use these so called 'conserved immunodominant areas' to make vaccines.

►IMMUNE RESPONSE AGAINST VIRAL INFECTION

Our Immune system, predominantly White Blood Cells (or Leukocytes), defends us against the invasion by recognising the virus or bacteria as foreign and mounting a coordinated attack against the same. The major players in the process are:

- B-cells
- T-cells
- Phagocytic cells:
  - Macrophages and
  - Dendritic cells, also known as Antigen Presenting Cells or (APC).

On the corona virus there are four major structural proteins on the surface of the virus that can serve as potential identifiable antigens for our immune systems:

i. Spike (N protein)

ii. Nucleocapsid (N protein)

iii. Membrane (M Protein)

iv. Envelope (E protein)

SEQUENCE OF STEPS IN IMMUNE RESPONSE

- The dendritic cells phagacitize and digest or break up the virus or bacterium. These cells can then present some of the protein structures or antigens of the invaders on the cell surface.
- The dendritic or the APC cells then travel to the lymph nodes where it presents its findings to the other members of the white blood cell line.
- The T-cells learn the various antigens and use them to identify the infected host cells in the body. They also alert the immune system of the invasion recruiting other members of the leucocytes.
- The T-cells destroy the already infected cells, preventing the virus from replicating.
- The B-cells analyse the various antigens and develop anti-bodies, specifically designed to attach to freely circulating viral particles.
- One B-cells line can produce antibodies to the spike protein, another to the envelope, another to the nucleocapsid and membrane.
- Once trained, each of these B-cells turn to plasma cells or memory B-cells. Plasma cells are anti-body factories, pumping out the newly developed anti-bodies. These anti-bodies can attach to the specific antigen, deactivate them directly or calls other members of immune system to destroy.
- With a novel pathogen, this leucocytes training process takes time, during which the virus or bacterium continues to multiply and infect the body. If the immune system identifies identical antigen in future.
- Memory B-cells can be quickly mobilized if the new infection from the same virus occurs in the future, Memory B-cells can rapidly divide, convert to plasma cells and begin flooding the host with anti-bodies to quickly fight the infection. In other words, the host has now developed immunity against this pathogen.

►MEMORY T CELLS MAY REDUCE COVID-19 SEVERITY

- T cell are type of leukocyte which develops in the thymus gland (hence the name). It is an essential part of the immune system. T cells are one of two primary types of lymphocytes (one of the types of white blood cells) —B cells being the second type—that determine the specificity of immune response to antigens (foreign substances) in the body.
- Memory T cells are antigen-specific T cells that remain long-term after an infection has been eliminated.

The memory T cells are quickly converted into large numbers of effector T cells upon re-exposure to the specific invading antigen, thus providing a rapid response to past infection.

- killer T cell recognizes and kills a virus-infected cell because of the viral antigen on its surface, thus aborting the infection because a virus will not grow within a dead cell.

All categories of people — recovered from moderate or severe COVID-19 disease, or in the convalescent phase (recovering) after mild or severe disease or exposed family members or healthy people — exhibited "robust memory T cell responses months after infection, even in the absence of detectable circulating antibodies specific for SARS-CoV-2

Pre-existing T-cell immunity to SARS-CoV-2 could be relevant because it is plausible that they play a role in reducing COVID-19 infection severity. It is plausible that people with a high level of pre-existing memory CD4 (white blood cells that play an important role in the immune system) + T cells that recognise novel coronavirus could mount a faster and stronger immune response upon exposure to the virus and thereby limit disease severity

HOW MEMORY T CELLS MAY HELP REDUCE THE SEVERITY OF THE DISEASE?

The cross-reactive memory T cells on activation would help in the development of plasma cells and thus antibody production, and in the development of killer T cells that would kill virus infected cells. The latter reduces the reservoirs of infection. This would most likely reduce disease severity.

However, the memory T cells are extremely unlikely to prevent SARS-CoV-2 infections. T cell immunity does not cause prevention of disease.

►HERD IMMUNITY

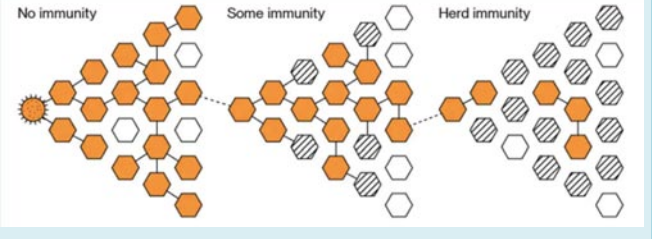
To deal with SARS-CoV-2 virus, herd immunity, an important tool in epidemic control, was proposed to overcome the pandemic.

HERD IMMUNITY

- When enough people are vaccinated, a pathogen cannot spread easily through the population. If a person is infected with measles but everyone s/he interact with has been vaccinated, transmission will be stopped.
- Only a certain proportion of the population needs to be infected to stop large outbreaks, either through naturally acquired disease, or through vaccination.
- Herd immunity refers to preventing an infectious disease from spreading by immunizing a certain percentage of the population. It is really like having a barrier of people who are protected, who break that chain of transmission
- Herd immunity can be achieved in two ways.
  - The first way is through mass vaccinations
  - The second way is through the infection which means that a person gets infected and after a while, they develop antibodies to fight the infection and thus become immune to it.

Since currently, the vaccine for COVID-19 is absent; countries around the globe like, the United Kingdom, the Netherlands, Sweden and Holland are experimenting with the second method.

There are many people who are asymptomatic – who show no symptoms at all or have just mild symptoms like mild fever, mild cough. Most of these people will recover from the virus without getting hospitalized. This will contribute to increasing the herd immunity.



Herd immunity is achieved when one infected person in a population generates less than one secondary case on an average, which corresponds to the effective reproduction number R (that is, the average number of persons infected by a case) dropping below 1 in the absence of interventions

THE PROBLEM WITH APPLYING HERD IMMUNITY CONCEPT IN SARS-COV-2

- The SARS-CoV-2 virus is easily transmissible and would require around 60-70% of the population to be infected to acquire herd immunity.
- It will take a long time but more importantly, it is going to do a lot of collateral damage
- Even if 1% of people who get infected are going to die, then this can add up to a huge number of people, considering global population.

- And that is why *herd immunity is* not a strategy or a solution. It is surrender to a preventable virus
- It is not a good idea to achieve herd immunity by just letting the infection run wild in the general population and infect a lot of people.
- We should talk about herd immunity in the context of a vaccine. vaccines are particularly suited for creating herd immunity because "their allocation can be specifically targeted to highly exposed populations, such as healthcare workers or individuals with frequent contact with customers."

SPEED TEST – 2: SOLUTION

i. True; **ii.** True; **iii.** True; **iv**. False; **v.** False; **vi.** True; **vii.** FALSE; **viii.** False; **ix.** False; **x.** False; **xi.** True; x**ii.** False, **xiii.** True; **xiv.** True; **xv.** False; **xvi.** True, **xvii.** False; **xviii.** True; **xix.** False; **xx.** False

SPEED TEST – 3

i. The RT-PCR test detects the presence of antibodies in a patient to identify the infection

ii. RT-PCR tests are effective only in the later stages of the infection after the immune system has responded by synthesizing antibodies.

iii. RT-PCR provides direct evidence whereas Antibody Tests and Rapid Antigen Detection Tests provide the indirect evidence.

iv. RT-PCR test detects the virus genetic material, which is the RNA.

v. The antibody test detects the body's response to the virus.

vi. RNA vaccines can be produced faster and its cheaper.

vii. mRNA is very fragile, and thus the vaccine must be kept at very low temperatures to avoid degrading

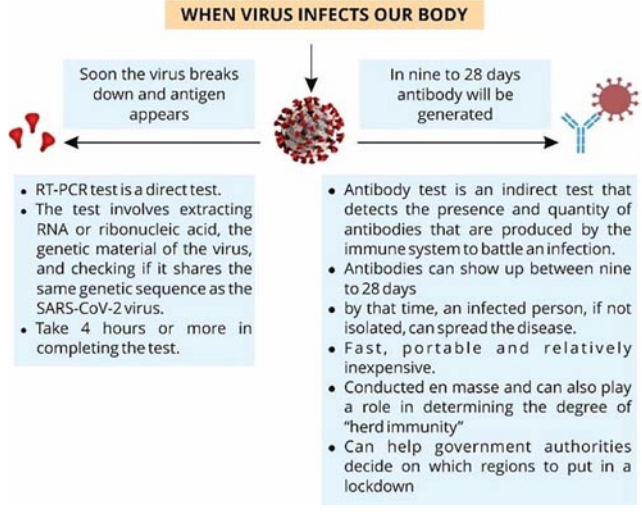
viii. As RNA vaccines are not developed from an active pathogen or an inactivated pathogen, they are non-infectious.

ix. FELUDA is CRISPR gene-editing technology-based kit to perform rapid anti-body test against SARS-CoV-2.

x. High level of mitochondrial DNA in the bloodstream is a sign of high rate of cell death.

►DETECTING THE VIRUS

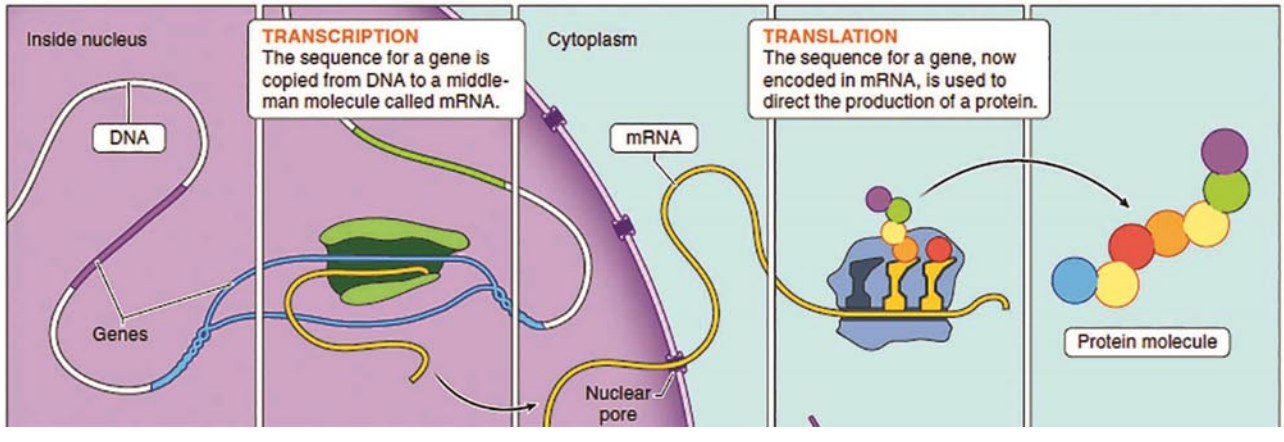
There are two ways to detect the presence of a virus, directly or indirectly.



►RT-PCR TEST: BASICS

The government set the Reverse Transcription-Polymerase Chain Reaction (RT-PCR) as the only standard for the COVID 19 tests (rapid antibody test cannot replace it)

Normally DNA holds information about ingredients that make up a living being. The information coded in the DNA is converted into functional proteins in a living being which is called as gene expression.



The process of gene expression happens in 2 processes namely transcription and translation. In the 1st step the information coded in the DNA is transcripted on to an RNA in the nucleus. The job of copying this information onto RNA is done by an enzyme in the nucleus called RNA polymerase.

PCR TECHNIQUE

Kary Mullis, an American biochemist invented the PCR technique. He was awarded the Nobel Prize for Chemistry in 1993. Under this, copies of a segment of DNA (deoxyribonucleic acid) are created using an enzyme called Polymerase. The 'chain reaction' signifies how the DNA fragments are copied, exponentially — one is copied into two, the two are copied into four, and so on.

So, the DNA from the patient's sample is collected and multiplied manifold using PCR which is then detected by a probe.

However, coronavirus is made of RNA (ribonucleic acid). They cannot be replicated directly using PCR. Therefore, to detect coronavirus, RNA is converted into DNA using a technique called reverse transcription. A 'reverse transcriptase' enzyme converts the RNA into DNA. Copies of the DNA are then made and amplified.

The sequencing of genomes of corona virus is well understood by experts and they have learnt to differentiate it from related viruses. Therefore, it was possible to prepare accurate tests to detect the virus relatively quickly, almost in the middle of a pandemic, and the RT-PCR tests began to be followed as the 'gold standard' in detecting the virus.

The only way such tests turn negative is if the actual sample does not have the virus or the swab was not properly administered and too little of the virus was gleaned.

ADVANTAGE OF PCR TEST OVER RAPID-ANTIBODY TESTING

- In case of PCR tests, it is the presence of an antigen in the infected patient that is tested for instead of the presence of antibodies which is done in case of Rapid Antibody testing
- Thus, detecting the presence of pathogen in the body before body's antibodies form can detect the infection early.

WHY ANTIBODY TESTS FOR COVID-19 ARE IMPERFECT?

- Not enough studies have been done on the antibodies and the profile of recovered patients.
- Sometimes the antibodies may be produced in response to a closely related pathogen
- Sometimes they may not be the right kind to counter the infection.

►ANTIBODY TEST

- The antibody test for COVID-19 will act as a screening process that will give quick results in a few hours.
- The antibody test detects the body's response to the virus. It gives an indication that a person has been exposed to the virus.
- If the test is positive, swab is collected & a Ribonucleic Acid (RNA) test is done using Polymerase Chain Reaction (PCR) kit. Therefore, this is a two-stage process.

However, the antibody test does not definitely indicate that a person is infected with COVID-19 infection. It is only for screening.

ANTIBODY VS RT-PCR TEST

- RT-PCR test detects the virus genetic material, which is the RNA.
- The antibody test detects the body's response to the virus.
- RT-PCR provides direct evidence whereas antibody kits provide the indirect evidence.

►RAPID ANTIGEN DETECTION TESTS (RADT)

- It is a test on swabbed nasal samples that detects antigens (foreign substances that induce an immune response in the body) that are found on or within the SARS-CoV-2 virus.
- It is a point-of-care test, performed outside the conventional laboratory setting, to quickly obtain a diagnostic result.
- Like RT-PCR, the rapid antigen detection test too seeks to detect the virus rather than the antibodies produced by the body.
- While the mechanism is different, the most significant difference between the two is time.
  - RT-PCR test takes a minimum of 2-5 hours including the time taken for sample transportation.
  - In a reliable rapid antigen detection test, the maximum duration for interpreting a positive or negative test is 30 minutes.

►FELUDA

- This has been developed by the CSIR-IGIB and approved by the Drug Controller General of India for a commercial launch.

- The test showed 96% sensitivity (% of positive results for positive samples) and 98% specificity (% of negative sample for negative result).
- This compares favorably to the ICMR's current acceptation criteria of RT-PCR kit of at least 95% sensitivity and at least 99% specificity.
- FELUDA kit takes 45 mins to give result. RT-PCR takes 1.5 hours. Rapid Antigen test takes 30-40 mins. TruNat gives result in 60 mins.
- It uses indigenously developed *CRISPR gene-editing technology* to identify and target the genetic material of SARS-CoV2, the virus that causes Covid-19.'Feluda' is also the *world's first diagnostic test to deploy a specially adapted Cas9 protein* to successfully detect the virus.

►RAPID BLOOD TEST TO PREDICT COVID-19 DISEASE SEVERITY

- It measures levels of mitochondrial DNA, a unique type of DNA molecule that normally resides inside the energy factories of cells.
- Mitochondrial DNA spilling out of cells and into the bloodstream is a sign that a particular type of violent cell death is taking place in the body.
- As per recent study mitochondrial DNA levels are much higher in patients who eventually were admitted to the ICU, incubated or died.
- The test could serve to predict disease severity as well as a tool to better design clinical trials, identifying patients who might, for example, benefit from specific investigational treatments.
- The test predicted outcomes as well as or better than existing markers of inflammation currently measured in Covid patients.

CONVALESCENT PLASMA THERAPY DEBATE

- India's largest randomised controlled trial, PLACID, has found Convalescent Plasma Therapy (CPT) ineffective in Covid-19.
- While the use of convalescent plasma improved resolution of shortness of breath and fatigue in patients with moderate Covid-19, it did not translate into a reduction in severity of disease or mortality.
- CPT uses blood from people who've recovered from an illness to help others recover. Blood donated by people who've recovered from COVID-19 has antibodies to the virus that causes it.

►VACCINE AND ITS TYPES

Type of vaccine	Description	Diseases covered
Live attenuated vaccines	It contain a version of the living microbe that has been weakened in the lab so it can't cause disease.	Measles, mumps, rubella (MMR combined vaccine) Varicella (chickenpox) Influenza (nasal spray) Rotavirus
Inactivated vaccines	The virus is first killed with chemicals, heat, or radiation and then used to make the vaccine. Inactivated vaccines usually don't require refrigeration, and they can be easily stored and transported in a freeze-dried form.	Hepatitis A, Influenza, polio, rabies
Sub-unit vaccine	A piece of the virus that is important for immunity, like the spike protein of COVID-19, is used to make the vaccine.	Hepatitis B Human papillomavirus vaccines
Toxoid vaccines	It contain a toxin or chemical made by the bacteria or virus. They make a person immune to the harmful effects of the infection, instead of to the infection itself.	Diphtheria and tetanus
Polysaccharide Vaccines	Polysaccharide vaccines are a unique type of inactivated subunit vaccine composed of long chains of sugar molecules that make up the surface capsule of certain bacteria.	Pneumococcal disease, meningococcal disease, and Salmonella Typhi
Biosynthetic vaccines	It contain manmade substances that are very similar to pieces of the virus or bacteria.	HIV
DNA vaccine	The gene that codes for the COVID-19 spike protein is inserted into a small, circular piece of DNA, called a plasmid. The plasmids are then injected as the vaccine.	No currently licensed vaccines use this approach.

m-RNA vaccine	The vaccine contains messenger RNA, called mRNA. mRNA is processed in cells to make proteins. Once the proteins are produced, the immune system will make a response against them to create immunity. In this case, the protein produced is the COVID-19 spike protein.	Covishield Covaxin

►VACCINES - HOW IT WORKS?

- When someone is infected with the COVID-19 virus (SARS-CoV-2), the reason it spreads in the body easily is because of the spikes on its surface. These spikes, known as the 'spike protein', allow the virus to penetrate cells and, thereafter, multiply.
- Certain vaccine (Ex. developed by Oxford and AstraZeneca) which belongs to a category called nonreplicating viral vector vaccines, tries to build the body's immunity against this spike protein. The idea is to create antibodies to fight this spiked surface so that the virus does not even have the chance to penetrate the cells.
- The vaccine uses a different virus — in this case, a weakened version of a common cold virus (adenovirus) that infects chimpanzees — to carry just the code to make the spike protein, like a Trojan horse.
- The adenovirus, genetically modified so that it cannot replicate in humans, will enter the cell and release the code to make only the spike protein. The body's immune system is expected to recognise the spike protein as a potentially harmful foreign substance and starts building antibodies against it.
- Once immunity is built, the antibodies will attack the real virus if it tries to infect the body.

►m-RNA VACCINE

Scientists have figured out the segment of the corona virus genome that encodes the spike protein and are using this sub-genomic genetic sequence as the vaccination product. Since the sequence resembles m-RNA, it is called messenger RNA or positive sense RNA.

The vaccine transfects molecules of synthetic RNA into immunity cells. Once inside the immune cells, the vaccine's RNA functions as mRNA, causing the cells to build the foreign protein that would normally be produced by a pathogen. These protein molecules stimulate an adaptive immune response which teaches the body how to identify and destroy the corresponding pathogen or cancer cells. The delivery of mRNA is achieved by a co-formulation of the molecule into lipid nanoparticles which protect the RNA strands and helps their absorption into the cells.

RISKS OF THE mRNA VACCINE

- Some mRNA-based vaccines are associated not only with inflammation but also potentially with autoimmunity.
- mRNA vaccines are new. Thus, there is the risk of unknown effects, both short and longer-term.
- mRNA sequence needs to be intact while it is transported and incorporated into the host cell cytoplasm. The m-RNA molecule and lipid nanoparticle transport molecule is very fragile, and thus the vaccine must be kept at very low temperatures (-70-to--80-degree Celsius) to avoid degrading.

ADVANTAGES

- As RNA vaccines are not developed from an active pathogen or an inactivated pathogen, they are non-infectious.
- RNA vaccines can be produced faster and its cheaper.
- It can be produced with fewer error rates.
- Replication mechanism can amplify antigen translation, decreasing the amount of starting material needed.
- According to preliminary trial results, these vaccines produce a reliable immune response and are tolerated by healthy individuals with few side effects.
- Biological-E, a company from India has been given m-RNA vaccine manufacturing technology by WHO's mRNA vaccine technology transfer hub.
- About mRNA vaccine technology transfer hub: WHO's initiative to build capacity in low- and middle-income countries to produce mRNA vaccines through a center of excellence and training. It is located at Afrigen, Cape Town, South Africa.

SPEED TEST – 3: SOLUTION

i. False; **ii.** False; **iii.** True; **iv.** True; **v.** True; **vi.** True; **vii.** True; **viii.** True; **ix.** False; **x.** True

DEFENCE TECHNOLOGY

MISSILE SYSTEM OF INDIA

CRUISE MISSILE	BALLISTIC MISSILE
A cruise missile is guided towards a preset land-based target using a navigation system.	A ballistic missile is a projectile shot up in the atmosphere.
Cruise missiles are known for low altitude flight and high mobility and hence the name.	Ballistic missiles are launched outside the atmosphere where its warheads detach and hit the target. (Uses gravity of earth and thus traces a parabolic path and hence the name)
Cruise missiles have short ranges of 300 to 1000 km Brahmos – 290 to 450 km Nirbhay – 700 to 1000	Ballistic missiles have long range up to 1000 km (ICBMs) Agni V – 5000 km
Easy to intercept because of high terminal speeds.	Difficult to intercept due to high terminal speeds of 5000 m/s
High precision due to navigation system	Low precision
Cheaper and thus suitable for firing conventional warheads	Expensive and thus suitable for firing nuclear warheads.

TSIRKON HYPERSONIC MISSILE: RUSSIA

- Tsirkon Cruise Missile will join Avangard glide vehicles and the air-launched Kinzhal (Dagger) missiles in Russia's hypersonic arsenal.
  - Cruise missiles differ from ballistic missiles in that they fly towards their target at lower altitudes, remaining within the Earth's atmosphere throughout their trajectory.
- It is one of the several missiles being developed in Russia that will arm up Russian submarines, frigates, and cruisers.
- Hypersonic Weapons are much harder to track and intercept than traditional projectiles because they can travel more than five times the speed of sound and maneuver in mid-flight.

HYPERSONIC TECHNOLOGY

- Speed: 5 or more times the Mach or speed of sound.
- Mach Number: It describes an aircraft's speed compared with the speed of sound in air, with Mach 1 equating to the speed of sound i.e., 343 m per second.
- Technology Used: Most hypersonic vehicles primarily use the scramjet technology, which is a type of Air Breathing propulsion System.
  - This is extremely complex technology, which also needs to be able to handle high temperatures, making the hypersonic systems extremely costly.

TYPES

- Hypersonic cruise missiles: These are the ones that use rocket or jet propellant through their flight and are regarded as being just faster versions of existing cruise missiles.

- Hypersonic Glide Vehicle (HGV): These missiles first go up into the atmosphere on a conventional rocket before being launched towards their target.

DEVELOPMENT OF HYPERSONIC TECHNOLOGY IN INDIA

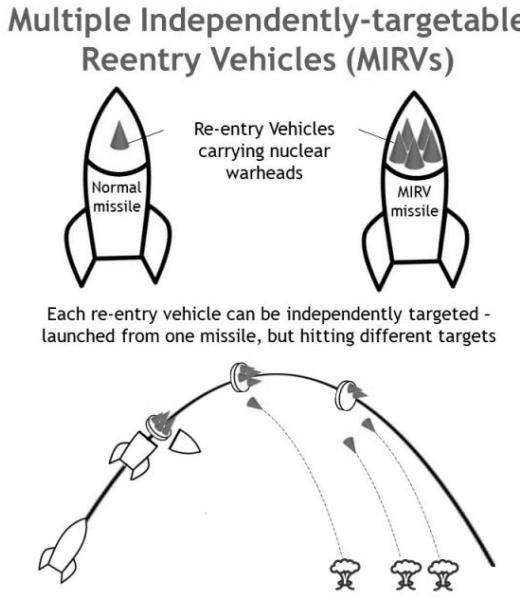
- India, too, is working on hypersonic technologies.
- As far as space assets are concerned, India has already proved its capabilities through the test of ASAT under Mission Shakti.
  - Hypersonic technology has been developed and tested by both DRDO (Defence research and Development Organisation) and ISRO (Indian Space Research Organisation).
  - Recently, DRDO has successfully flight-tested the Hypersonic Technology Demonstrator Vehicle (HSTDV), with a capability to travel at 6 times the speed of sound.
  - Also, a Hypersonic Wind Tunnel (HWT) test facility of the DRDO was inaugurated in Hyderabad. It is a pressure vacuum-driven, enclosed free jet facility that simulates Mach 5 to 12.

→ BALLISTIC MISSILES

►SURFACE-TO-SURFACE MISSILES

SHORT-RANGE BALLISTIC MISSILE	
NAME	**CHARACTERISTICS**
PRITHVI-I **Range:** 150 KM; **Weapon Payload:** 1000 kg	Short range surface-to-surface tactical ballistic missile
PRITHVI-II **Range:** 350 KM; **Weapon Payload:** 500 Kg	Airforce Version
PRITHVI-III **Range:** 350 KM; **Weapon Payload:** 1000 kg	
HANUSH **Range:** 350 KM; **Weapon Payload:** 1000 Kg	Naval Version of Prithvi I and Prithvi II class missiles
SHAURYA **Range:** 600-700 KM; **Weapon Payload:** 1000 Kg	• Hypersonic Canister-launched • Both conventional and nuclear warheads
PRAHAAR **Range :**150 KM; **Weapon Payload:** 250 Kg	• To replace Prithvi I • Weapons: High explosives, cluster munition, strategic nuclear weapon
AGNI-I **Range:** 700–900 km; **Weapon Payload:** 1000 Kg	• Single stage solid fueled • Nuclear capable missile

INTERMEDIATE-RANGE BALLISTIC MISSILE	
NAME	**CHARACTERISTICS**
AGNI-II (**Range:** 2000-3000 Km; **Weapon Payload:** 1000 Kg)	Two and a half stage, solid fueled missile with
AGNI-III (**Range:** 3200 Km; **Weapon Payload:** 2000-2500 Kg)	2-stage solid propulsion system
AGNI-IV (**Range:** 3500 Km; **Weapon Payload:** 1000 Kg)	2-stage missile powered by solid propellant

INTER-CONTINENTAL BALLISTIC MISSILE			
NAME	**RANGE**	**WEAPON PAYLOAD**	**CHARACTERISTICS**
AGNI-V	5000 Km	1500 Kg	3-10 Multiple Independent Targetable Reentry Vehicle (MIRV) warheads 
AGNI-VI	8,000–10,000 km (Under development)	1000 Kg	10 MIRV warheads
SURYA	10000 Km (Under development)	3000 Kg	10 MIRV warheads

SUBMARINE-LAUNCHED BALLISTIC MISSILE	
NAME	**CHARACTERISTICS**
K-15 → SAGARIKA **Range:** 750 km; **Weapon Payload:** 500 Kg	• Replica of land based Shaurya Missile. • K-15 Missile gets help from Indian Regional Navigation Satellite System. • The K-series missiles are much faster than Agni Missiles
K-4 **Range:** 3500 Km; **Weapon Payload:** 1000 Kg	• Nuclear-capable underwater missile • Meant for Arihant class submarines. • It is a solid-fuelled missile launched underwater capable of withstanding 50N of water pressure. • Submarine version of Agni 3. (Agni 3 – 17 m K-4 – 10 m)
K5 (UNDER DEVELOPMENT) **Range:** 5000 Km	
K6 (UNDER DEVELOPMENT) **Range:** 6000 Km	

►SHORT-RANGE SURFACE-TO-AIR MISSILES

NAME	CHARACTERISTICS
TRISHUL **Range:** 9-12 Km; **Weapon Payload:** 5 Kg	• Short range low-level surface-to-air missile
AKASH **Range:** 30 Km. **Weapon Payload:** 50 Kg	• Supersonic speed: Mach 2.5. • Medium range surface-to-air missile • Part of Air-defence system • It can simultaneously engage multiple targets in Group Mode or Autonomous Mode. • It has built in Electronic Counter-Counter Measures (ECCM) features. • Indigenous seeker technology.

MAITRI (QRSAM)
Range: 25–30 km.
Weapon Payload: 10 Kg
	• Developed by DRDO in collaboration with BEL and Bharat Dynamics Ltd.
	• Most effective in combating low flying Aerial targets faced by forward tactical battlefield area formations like
	  ○ Attack helicopters
	  ○ UAVs
	  ○ Armed drones
	  ○ Sub-sonic Cruise missiles
	• QRSAM is part of India's air defense system.
	• Capable of striking targets on-the-move.
	• It can strike targets at various altitudes from 30m to 6km.
	• It has a speed of 700-800 meters per second
	• RF seeker (Radio Frequency) as a part of terminal guidance to hit the target.
	• It has a truck-mounted canister.
	• It is capable of multiple-target engagement.
	• It is light-weight, has high-mobility and shorter-reaction time compared to Akash Air Defence Surface-to-Air Missiles.
	• It is equipped with electronic counter measures against the aircraft jammers to deceive enemy radar.

REVATI **Range:** 25–30 km. **Weapon Payload:** 10 Kg	**(Naval-Version of Maitri)**
ROHINI **Range:** 25–30 km. **Weapon Payload:** 10 Kg	**(Airforce-Version of Maitri)**
BARAK-8 **Range:** 70-100 Km. **Weapon Payload:** 60 Kg	• Indian Israeli Medium Range Surface-to-Air-Missile • Part of naval air defence system to be used aboard INS Vikrant (under construction) • maximum speed of Mach 2
IGLA-S	• Russia's Very Short-Range Air Defence Systems (VSHORAD)

Range: Maximum range of 6 km, altitude of 3 km	• Man-Portable Shoulder launched Air Defence System • It can aim at enemy targets using • Infrared signature • Laser targeting • Remote-controlled targeting

►AIR-TO-AIR MISSILE

NAME	CHARACTERISTICS
ASTRA	• It is a BvRAAM (Beyond Visual Range Air to Air Missile). • 1st air to air missile developed by India. • Capable of engaging targets at varying range and altitudes. • Both short range targets at 20 km and long-range targets up to 80-110 km.

►ANTI-TANK GUIDED MISSILE

NAME	CHARACTERISTICS
NAG **Range:** 3-7 Km. **Weapon Payload:** 8 kg	• 3rd generation anti-tank missile, best in its class for Indian conditions. • Fire and forget capability. • Imaging Infrared (IIR) guidance with day and night capability • Weight - 48 Kg and therefore fired from a BMP-2 vehicle called **Namica (Nag Missile Carrier)** **DIFFERENT VARIANTS** 1. Mounted on an infantry combat vehicle: NAMICA (Nag Missile Carrier) 2. Man Portable shoulder carried 3. HeliNa: (Helicopter-launched Nag) Rudra Helicopter, Dhruv and LCH.
HELINA **Range:** 7 Km. **Weapon Payload:** 8 Kg	Helicopter-launched Nag
SPIKE	• Israeli 4th generation anti-tank guided missile. • Fire-and-forget capability • Available in man-portable, vehicle-launched, and helicopter-launched variants. • Change the target mid-flight because of dual seeker. • Kill-probability of 95% • Better than Nag because Nag is facing seeker issues especially if the temperature of the target is high.
MILAN	• It is anti-tank guided missile for the Army. To be acquired from France.
SPICE 2000	• Israeli guided bombs for Indian Air Force.

→ CRUISE MISSILES

►NIRBHAY: SUBSONIC CRUISE MISSILE

Range: 750-1000 Km; **Weapon Payload:** 500 Kg

CHARACTERISTICS

- Long range sub-sonic cruise missile.

- 1st indigenously developed long range cruise missile flying at low altitudes.
- It will arm the army, navy and air force.
- **Speed**: Subsonic speeds of 0.7 mach. (speed of sound)
- **Range**: Long range of 700 to 1000 km.
- Can fly at tree-top altitudes as low as 10 m. (now tested for 5 m)
- Capable of delivering nuclear warheads of 200-300 kg.
- 2-stage solid fueled cruise missile.
- As a result, it has terrain-hugging capability and sea-skimming capability and thus go undetected by enemy radars.

►BRAHMOS: SUPERSONIC CRUISE MISSILE

Range: 290 Km.

Weapon Payload: 300 kg

CHARACTERISTICS

- Joint venture missile between India and Russia.
- **Speed**: Top speed of 2.8 Mach (speed of sound).
- **Range**: After India became a full member to MTCR export control regime, the range of BrahMos has increased from 300km to 450km.
- Fire and forget principle of operation
- Capable of being launched from land, water and air.

BrahMos NG

Low weight Air-launched version capable of being carried by Light Combat Aircraft, Tejas LCA

►BRAHMOS II: HYPERSONIC

Range: 290 Km; Weapon **Payload:** 300 Kg

CHARACTERISTICS

6 Mach

→INDIA'S MISSILE DEFENCE SYSTEMS

►BALLISTIC MISSILE DEFENCE SYSTEM

- 2-tier missile defence system
- Aimed at intercepting aerial threat from ballistic missiles that have ranges up to 5000km at altitudes both outside (exo) and inside (endo) the atmosphere
- **1st layer: Endo**
  - The single stage solid rocket-propelled **Advanced Air Defence (AAD) low-altitude interceptor** missile. (**Ashwin**)
  - AAD interceptor missile is primarily designed to intercept enemy missiles in endo-atmosphere at altitudes of 20-40 km.
- **2nd layer: Exo**
  - Prithvi Air Defense Vehicle known as Pradyumna Ballistic Missile Interceptor is designed to destroy missiles with ranges 300-2000 km at exo-atmosphere (about 80km altitude).
  - For higher altitudes up to 150 km, Agni-V-based ballistic interceptors would be used. (because of 5000km range)

►S-400

ALTERNATIVES: THAAD AND PATRIOT

- India has signed a deal with Russia to acquire S-400 Triumf multi-layered air defence system.
- S-400 is known as Russia's most advanced long-range surface-to-air missile defence system.
- S-400 layered defence system can intercept all types of aerial targets including aircraft, unmanned aerial vehicles (UAV), and ballistic and cruise missiles up to the range of 400km, at an altitude of up to 30km
- Capable of firing three types of missiles to create a layered defence.
- **Note**: USA is offering **THAAD** and **Patriot** as alternative to S-400 to India.

ADDITIONAL

Iron Dome: Israeli SHORT-RANGE AIR DEFENSE

►BARAK-8 LONG & MEDIUM RANGE SAM

- Medium-range surface-to-air missile system being developed jointly by India and Israel.
- It will have an interception range of 70-100 km.
- Part of naval air defence system to be used aboard INS Vikrant (under construction)
- Maximum speed of Mach 2

►AKASH MEDIUM-RANGE SURFACE TO AIR MISSILE SYSTEM

- India has 2 regiments of the indigenous Akash systems which are capable of multi-target engagement.

- It can strike targets up to a range of 25km and altitude of 18,000m.

►MULTI-LAYERED AIR DEFENCE SYSTEM FOR DELHI

- India is developing a multi-layered air defence system for its cities besides air defence system for tactical battle areas.
- First layer: 2-tier Ballistic Missile Defence System
- 2nd Layer: S-400 layered defence system
- 3rd Layer: Barak-8 long and medium range SAM
- 4th Layer: Akash medium-range surface to air missile system
- 5th Layer: NASAMS-2

►NASAMS-2

- India is acquiring NASAMS-2 from US.
- NASAMS 2 will form the inner-most layer of Delhi Area Air Defence Plan that has been conceived of.
- It will be deployed to protect vital assets and people in the National Capital region of Delhi including President's house, Parliament etc.
- It renders quick-reaction 3-dimensional protection at low altitudes of 5 km to various types of aerial threats ranging from drones to ballistic missiles.

FEATURES

- 12 multi-missile launchers to launch both advanced medium-range air-to-air missiles AMRAAMs and Stinger surface-air-missiles
- Sentinel X-band 3D radars
- 4 Fire distribution centers
- Advanced electro-optical/infrared sensor system vehicles.

→HYPERSONIC MISSILES

- Travels at Mach 5 or higher (more than one mile per second)
- They typically consist of a Supersonic Combustion Ramjet or Scramjet propulsion system to enable such high speeds.
- Scramjet engine collects oxygen from the atmosphere as it is travelling and mixes the oxygen with its hydrogen fuel, creating the combustion needed for hypersonic travel.
- India is developing a Hypersonic Technology Demonstrator Vehicle (HSTDV)
- It is an unmanned scramjet (allowing supersonic combustion) demonstration vehicle that can cruise to a speed of Mach 6 (or six times the speed of sound) and rise to an altitude of 32 km in 20 seconds. It has been developed by DRDO.
- There are 2 types of Hypersonic Weapon Delivery Systems
  1. Hypersonic Cruise Missiles (HCM)
  2. Hypersonic Glide Vehicle (HGV)

SIGNIFICANCE

- They are a mix of the speed of a ballistic missile and maneuvering capabilities of a cruise missile
- While cruise missiles achieve speeds of 550 mile per hour, the hypersonic missiles aircrafts can reach speeds more than 3500 miles per hour.
- Capable of penetrating any antimissile defence system currently available that are designed to intercept cruise and ballistic missiles.
- Specifically designed for increased survivability against modern ballistic missile defence systems.

IMPORTANT HYPERSONIC MISSILES

Only USA, Russia and China have hypersonic missiles

AVANGARD

- Russia's nuclear capable, hypersonic boost glide vehicle.
- Capable of hitting target more than 6000 km
- Can travel at a speed of 20 Mach (20 times the speed of sound).

KINZHAL

- Russia's nuclear capable air launched ballistic missile.
- It has a range of more than 2000 km.
- Can travel at speeds of 10 Mach.

STARRY SKY 2 HYPERSONIC AIRCRAFT

China's first hypersonic aircraft with waverider technology. Known as waverider for its ability to ride on the shock waves it generates.

DONGFENG MISSILES

China's Hypersonic Missile systems

►ARTILLERY WEAPON SYSTEM OF INDIA SIGNIFICANCE

- In the aftermath of the Kargil War of 1999 India announced its Artillery Rationalisation Program
- India has a 2-front porous border of 7000-odd kms and 4000-odd kms with China and Pakistan respectively.
- The operational requirement to fight a 2-front war is 3000-odd artillery guns in addition to aerial weapons, precision-guided weapons, multi-barrel rocket launches etc.
- The categories of artillery systems include
  - Long-range guns of towed variety
  - Self-propelled guns mounted on a high-mobility vehicle (K9 Vajra)
  - Light howitzers for difficult mountainous terrains. (M777 howitzers)

►DHANUSH

- 1st indigenously produced long-range artillery gun.
- The 155mm 45 caliber long-range artillery gun
- 2 varieties
  - Towed variety
  - Self-propelled mounted gun system variety
- 6-round magazine.
- Capable of firing 60 rounds in 60 minutes.
- Maximum firing range of 38 km in the plain areas

►K9 VAJRA T GUNS

- South Korean long-range artillery gun in the self-propelled mounted gun category.
- It has a range of 28-38 km.
- 155-mm, 52-calibre
- 1st ever-artillery gun that will be manufactured by private sector in India with L & T India manufacturing 90 of them.
- Capable of 'burst firing' meaning which it can fire 3 rounds in 30 seconds

►M777 ULTRA LIGHT HOWITZERS

- 155-mm, 39-calibre towed medium artillery gun.
- Maximum range of 30 km.
- Light artillery guns with a weight of 4 tons
- Capable of being air lifted by Chinook helicopters.
- Thus, M777 can be deployed in mountainous terrains devoid of roads & tracks.

►SHARANG

- Indigenous Artillery Gun
- 155 mm
- Range: Increased from 12 km to 39 km

►ADVANCED TOWED ARTILLERY GUN SYSTEM

- 155mm, 52-calibre gun-howitzer.
- It is capable of firing at both low angle like a gun and high angle like a howitzer
- Range: 45 Km
- World's only gun with a six-round automated magazine.
- High "burst fire" capability in that it can fire six-round burst in just 30 seconds.
- Other features
  - all-electric drive
  - high mobility
  - quick deployability
  - auxiliary power mode
  - Automated command and control system
- India's Artillery Combat Command and Control System is named '*SHAKTI*'

►INFANTRY WEAPON SYSTEM OF INDIA

- The infantry weapon system constitutes
  1. Assault rifles
  2. Carbines
  3. Light Machine Guns
- India is trying to modernize its infantry weapon system which includes acquisition of 7 lakh assault rifles, 44,000 light machine guns and 44,600 carbines.

►AK-203

- 3-generation upgraded modern variant of the AK-47 assault rifle.

- Light weight about 3.5 kg (as against 4.15 kg of INSAS)
- 7.62x39mm NATO grade ammunition (INSAS-5.56 mm)
- 30-round magazine
- It can fire at a rate of 600 bullets per minute
- Range: 500m on iron sight and 800m on 4X zoom.
- AK-203 has a high-grade poly hand grip and pistol grip. (AK-47 and INSAS has wooden grip)
- Adjustable foldable buttstock made of plastic and thus are easy to carry and transport. (Buttstock is back of the rifle)
- Equipped with optical scopes, night vision scopes with thermal infrared scopes, flashlight, red dot laser etc.

  Note: Will equip the infantry groups, paramilitary forces and police forces in 15-20 years
- India will be manufacturing AK203 at Korwa, Uttar Pradesh in a JV with Russia.

►SIG SAUER 716 ASSAULT RIFLES

- Replacement for ageing INSAS Rifles
- Range: 600m compared to requirement of 500 m range for counter-insurgency operations.
- Automatic rifles that are gas-operated i.e., they use gas generated by a fired cartridge to fire other bullets.
- Accurate, reliable thereby reducing fatigue of the ground soldier
- Note: SigSauer Assault Rifles are more advanced with greater firepower will equip the frontline infantry troops for counterinsurgency and counter-terror operations only at LOC.

►CARBINES

- India is signing a deal with UAE for acquiring 93,895 Close Quarter Battle (CQB) carbines.

AIRCRAFT CARRIERS OF INDIAN NAVY

►INS VIKRANT

- 1st aircraft carrier of India
- It was decommissioned in 1997 after serving for 37 years.

►INS VIRAAT

- 2nd and the longest serving aircraft carrier of India.
- It was recently decommissioned in 2017 after serving for 56 years. (26 years as HMS Hermes and 30 as INS Vikrant)

►INS VIKRAMADITYA

- India and Russia signed $1.5 billion for the acquisition the warship INS Vikramaditya inducted to the Indian Navy in 2013.
- INS Vikramaditya is the only aircraft carrier of Indian Navy in operation.

►INS VIKRANT (IAC-1)

India's 1st Indigenous Aircraft Carrier is set to be inducted to Indian Navy by 2020.

►INS VISHAL

The 65000 tonne Naval super carrier, INS Vishal on the lines of HMS Elizabeth will be built by India.

SUBMARINE ARM OF INDIA

→ CONVENTIONAL SUBMARINES OF INDIA

►PROJECT 75-I

- 6 Scorpene class submarines are being constructed with Transfer of Technology from France
- The 6 Scorpene class submarines will be the core of India's conventional attack submarine arm.

6 SUBMARINES OF PROJECT 75-I

- INS Kalavari – Inducted in 2017
- INS Kandheri – To be inducted in May 2019
- INS Karanj - Under trials, to be inducted by end of 2019
- INS Vela – To be launched for trials in 2019
- INS Vagir – Being manufactured and assembled.
- INS Vagsheer - Being manufactured and assembled.

SIGNIFICANCE

- The submarines built under the project will be capable of
  - Anti-submarine warfare

- Intelligence, Surveillance and Reconnaissance missions
- Underwater mining operations

Note: While the first four submarines will be conventional, the two will be equipped with the Air Independent Propulsion (AIP) system to stay underwater for longer duration

- The air-independent propulsion system will enable the submarines to stay submerged for longer duration and thus increase their operational range.

→ NUCLEAR-POWERED SUBMARINES

Nuclear submarines can be classified in to 2 categories namely SSN and SSBN

►SSN: (SUBMERSIBLE SHIP NUCLEAR)

- SSNs are attack submarines
- They are propelled by nuclear power.
- They can launch **conventional weapons** like torpedoes and cruise missiles

►SSBN: (SUBMERSIBLE SHIP BALLISTIC NUCLEAR)

- SSBNs are also propelled by nuclear power.
- They are usually equipped with nuclear weapons like ballistic missiles.
- Therefore, they are usually used as deterrents and not as attack submarines.

►NUCLEAR-POWERED SUBMARINE FLEET OF INDIA

→ SSN FLEET

►CHAKRA-I

1st nuclear-powered submarine to be inducted to Indian Navy.

►CHAKRA-II

- 2nd nuclear submarine to be inducted into Indian Navy.
- It was inducted in 2012
- It is an advanced version of Chakra I with following features
  - It can displace twice the amount of water compared to Chakra I, thereby higher operating depths.
  - Higher speed of 30 knots
  - The onboard nuclear reactor produces double the power.
  - It has more advanced weapon system including tube-launched missiles.
  - Chakra II is deployed with the Eastern Naval Command.

►CHAKRA-III

- India and Russia have signed agreement for leasing of Akula class nuclear powered submarine Chakra III for $3 billion for at least 10 years.
- Powered by 190 MW nuclear power

→ SSBN FLEET

►ARIHANT

- Under Advanced Technology Vehicle Program, India has indigenously built Arihant, SSBN.
- India's 1st nuclear-powered ballistic missile submarine
- Displacement capacity of 6,000 tons.
- Powered by an 83 MW pressurised light-water reactor with enriched uranium.
- Formally inducted in 2019 marking the Nuclear Triad capability of India.
- Capable of launching K-15 Missile with a range of 750 km and K-4 ICBM with a range of 3,500 km.

►ARIGHAT

- 2nd Arihant-class submarine built under Advanced Technology Vessel Program.
- Powered by a pressurised water reactor
- Maximum speed of 12–15 knots (22–28 km/h) when on surface and 24 knots (44 km/h) when submerged
- 4 launch tubes can carry up to 12 K-15 Sagarika missiles or 4 four of the under-development K-4 missiles.

IMPORTANT FIGHTER JETS OF INDIA

►TEJAS LCA

- 4th generation supersonic, single-seat, single-engine multirole light fighter aircraft.

- Conceived in the early 1980s to replace the Russia-made MIG 21 of the Indian Air Force.
- Designed and developed by the Aeronautical Development Agency.
- The combat-ready version of the fighter comprises of battle-time requirements such as mid-air refueling, AESA radar, electronic warfare suites, bombs and weapons etc.
- India does not have even a single squadron of the indigenously produced fighters.
- In contrast, both China has fifth generation fighters already in the test flying stage.
- Pakistan also has an operational indigenously built fighter jet, JF 17 developed with Chinese assistance.

►MIG 29

- India's premier Air Defense Fighter aircraft
- Light-weight air-superiority fighter aircraft developed by Russia.
- Twin-engine jet fighter inducted into Indian Air Force in 1985.
- With about 110 Mig-29s operated by Indian Air Force and Indian Navy combined, India is the second biggest operator of Mig-29s in the world after Russia.
- Played a key role during Kargil War, 1999.
- Three squadrons of 16-18 MiG-29s aircrafts each are deployed in the strategically important Adampur Air Force Station, which is around 100 km from Pakistan and 250 km away from China borders.
- The MiG 29s are far more superior to F-16s of the Pakistan Airforce with the capacity to launch Beyond Visual Range BVR missiles.

►SUKHOI-30 MKI

- Multirole combat fighter aircraft
- Jointly developed by Russia and India.
- India's answer to F-16 of Pakistan.
- Top speed of 2120 kph (Mach 1.7).
- Capable of launching up to 6 air-air, 6 air-to-surface missiles, 6 laser guided bombs and 8500kg of cluster bombs.
- Recently test fired the world's fastest supersonic cruise missile, BrahMos from Sukhoi-30MKI.
- This has provided a significant strategic deterrence against China and Pakistan in multi-mission roles, including precision strikes on terror camps across the LoC, against high-value naval targets, including aircraft carriers and nuclear bunkers.

►RAFALE

- Twin-engine medium multi-role combat aircraft, manufactured by French company Dassault Aviation.
- Can carry weapons more than 9 tons including air-air, air-ground and air-ship missiles.
- Main roles include missions including Air-defence/air-superiority, Reconnaissance, close air support dynamic targeting, Air-to-ground precision strike/interdiction, anti-ship attacks, and nuclear deterrence, buddy-buddy refueling.
- Can carry out both air-to-ground, as well as air-to-air attacks and interceptions during the same sortie.
- Maximum speed of 1.9 mach.
- Range of more than 3700 km vs 400-550 of Sukhoi-30
- Weapon systems include SCALP and METEOR missiles
- **SCALP:** a precision long range ground attack missile that can take out targets with extreme accuracy. Has a range of 300 km, capped by the missile technology control regime.
- **METEOR:** a beyond visual range air to air missile that is the best in its class. Can take out enemy aircraft at range of over 100 km.

►US-2 AMPHIBIOUS AIRCRAFT

Japanese amphibious aircraft that India is keen to import.

IMPORTANT HELICOPTERS

►LIGHT UTILITY HELICOPTER

- Developed as a replacement for Cheetah and Chetak helicopters
- New generation 3-Ton class helicopter.
- Being indigenously developed by Hindustan Aeronautics Limited (HAL).

►DHRUV

Utility helicopter developed and manufactured by HAL.

IMPORTANT ROLES

- Commuter Role
- Evacuation

- Rapid Deployment of Forces
- Logistic Air Support
- Search and Rescue

►CHINOOK

CHARACTERISTICS

- Acquired from USA under Foreign Military Assistance
- Heavy-lift Capability
- Modern heavy-lift helicopter woth payload lifting capacity of 10-12.5 ton
- Vertical-lift platform
- It has contra-rotating tandem rotors. (2 rotors rotating in opposite direction)
- Will replace the Mi-26 heavy-lift helicopters of IAF.

IMPORTANCE

- To ferry 4.2-ton M777 Ultra-Light Howitzer to high altitude forward areas with China and Pakistan which do not have road connectivity
- Will airlift artillery, light armored vehicles, troops and supplies to difficult Himalayan mountainous terrains
- It will assist Border Road Organisation to carry road construction and engineering equipments to difficult high-altitude terrains of Northeast.
- Deployed in disaster relief operations to carry and mass evacuation of disaster victims.

►APACHE

- Acquired from USA under Foreign Military Assistance
- It is a multi-role combat helicopter.
- All-weather helicopter that can engage both air and ground targets.
- Can approach enemy troops covertly with relative stealth and launch as close-range attack

KAMOV KA-226T

- Russia plans to deliver 10 Kamov Ka-226T military helicopters to India in a first tranche as part of a $1-billion deal, signed in Indo-Russia Summit in Moscow, 2015.
- A light weight, twin-engine multi-role chopper offers services for both military and civilian purposes.
- It will replace India's ageing fleet of Cheetah and Chetak.

►MH-60R (ROMEO) SEAHAWK HELICOPTERS

- Acquired from USA under Foreign Military Assistance
- Naval multi-role helicopter.
- Capable of being operated from various types of warships including frigates, destroyers, cruisers and aircraft carriers
- Equipped with state-of-art SONAR suite which provides navigation, situational awareness, target data and weapon guidance capabilities.

►KAMOV

The final deal on the 200 Kamov Ka-226 **light utility helicopters from Russia** is in advanced stages and expected to be signed soon.

SPACE WEAPONISATION

►ANTI SATELLITE TECHNOLOGIES

BACKGROUND

- Satellites form an integral part of a country's critical infrastructure.
- Intercepting satellites can halt various critical applications including navigation systems, communication networks, broadcasting, banking systems, surveillance etc.

WHAT IS A-SAT?

Anti-satellite technology is a counter-space capability of a country to neutralize space-based assets of enemy country.

TYPES OF A-SAT

1. **Missile-based A-SAT**: A missile is used to hit and destroy satellite using
   - **Direct-ascent** kinetic kill vehicle (Chinese A-SAT in 2007, India now, USA and Russia)
   - **Co-orbiting** missile (Russia has this type)
2. **Co-orbital drones**
   - Approach the target satellite and deviate it from its orbit. (China, UK, Russia is working on this technology)
3. **High-energy lasers**
   - Blind the sensors of the satellites.
4. **Interception and jamming** of signals from the satellites by sending more powerful radio signals.

HISTORY OF A-SAT MISSILE TESTS

- ASAT missile tests have been conducted by USA and Russia in the cold-war era.
- USA has the anti-satellite weapon since 1959 followed by Russia in 1960
- The cold war witnessed the anti-satellite weaponry tests till early 1980s.
- China conducted A-SAT weaponry test in 2007. (800km orbit)
- Russia has recently shot down satellite using ASAT weaponry as lately as 2018.

►TREATIES GOVERNING OUTER SPACE

OUTER SPACE TREATY 1967

- According to this treaty, outer space shall be used only for peaceful purposes.
- It prohibits countries from placing into orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction.
- It requires that celestial bodies shall be used by all parties exclusively for peaceful purposes and no weapon can be stationed on them.
- However Outer Space Treaty by itself does not prevent arms race in space.
- India is a party to Outer Space Treaty
- 50th anniversary of United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE+50) took place in 2018.

►UN RESOLUTIONS: PAROS TO TCBMS

PAROS

- The Prevention of an Arms Race in Outer Space (PAROS) is a UN resolution that advocates for a ban on the weaponization of space.
- It was conceived of during the Cold-war era.
- The PAROS resolution acknowledges the limitations of Outer Space Treaty in preventing of an arms race in outer space.
- However, US opposition has thwarted treaty negotiations in the UN General Assembly.

TCBMS AND PPWT

- Since 2005, the UNGA has adopted annual resolutions on "Transparency and Confidence-Building Measures in Outer Space Activities."
- China and Russia in 2008 submitted the following treaties to reiterate the importance of a weapon-free outer space.
- Treaty on the Prevention of the Placement of Weapons in Outer Space (PPWT)
- Treaty on threat or use of force against Outer Space Objects.

►MISSION SHAKTI

- Under Mission Shakti, India demonstrated the capability to destroy a satellite in the low earth orbit using an anti-satellite missile.
- India became only the 4th country to conduct an Anti-Satellite missile test after USA, Russia and China.

TARGET

- Microsat R was a military imaging satellite placed in an orbit 274 km above the Earth surface with an orbital velocity of 7.8km/s.

TECHNOLOGY: 'HIT TO KILL'

- The anti- satellite test involved the 'hit to kill' missile technology.
- Under the 'hit to kill' technology, a missile is shot at the satellite to hit and kill the satellite.

KILL VEHICLE TECHNOLOGY

- The A-SAT missile was based on the exo-atmospheric kill vehicle technology.
- It includes
  - an 18-tonne, 3-stage interceptor missile
  - with 2-stage solid propellants
  - with a long-range tracking radar and
  - Infra-red and radar frequency seekers to reach the target satellite and hit it.
- Accordingly, the anti-satellite missile used was an advanced version of 'Prithvi Defence Vehicle' of India's Ballistic Missile Defence system. This is because the target satellite was in the 300km orbit.

MISCELLANEOUS

►POSEIDON

- Anti-Submarine Warfare aircraft, which India plans to acquire from USA.
- It is a boost to maritime ISR capabilities (intelligence, surveillance and reconnaissance)

- Long-range maritime patrol aircraft capable of undersea surveillance from a height of up to 40000 ft.
- It has operational speed of 450 mph and a range of 4,500 nautical miles.
- It has an operational time of up to 10 hours.
- It is equipped with Active Electronically Scanned Array (AESA) radars capable of engaging multiple targets simultaneously.
- Magnetic Anomaly Detection (MAD) radar will help locate submarines in deep seas.
- The India-version of Poseidon 8 is equipped with Harpoon Block-II missiles, MK-54 lightweight torpedoes to enhance its anti-submarine warfare capability.

KEY OPERATIONAL REQUIREMENTS OF IAF

SHORT-TERM

The key operational requirements of IAF in the short-term for its new doctrinal focus towards counter-proxy wars include

- AWACS
- Close-in weapons for short-range battles
- Software Defined Radios (SDRs) to enhance inter-service communication

LONG-TERM

- IAF has been facing a severe shortage of fighter aircrafts with its current strength reduced to 32 squadrons against the sanctioned strength of 42.
- With MiG 21 and MiG 27 due to retire by 2025 the squadron strength will be reduced to 22 in the next 15 years.
- The efforts to augment the squadron strength with LCAs, Rafale and upgraded platforms of existing fighter jets are on.
- 40 Tejas Mk-1 will be delivered by 2023 and 83 Tejas MK-1A are ordered.
- 36 Rafale fighter jets to be delivered by April 2022

The premier Air Defence Fighter aircraft, MiG-29, has undergone major upgrades recently.

►HYPERSPECTRAL IMAGING PROGRAM

New-age aerial surveillance project of IAF expected to be operational by 2022 involving Hyperspectral Imaging.

FEATURES

- Sensors or cameras for hyperspectral imaging will be mounted on UAVs (Unmanned Aerial Vehicles) which will take images in 2 wavelengths of electro-magnetic spectrum, namely visible light and infrared
- The images so taken will be run through 'deep learning' algorithms to process them into usable data.
- The data so processed is then communicated to the IAF Air Warfare Strategy Cell.

APPLICATIONS

- New-gen aerial surveillance
- Can perform surveillance in areas under dense tree cover along the international borders. (Due to infrared sensors)
- Multi-sensor imaging helps to track adversary movement in day and night conditions.
- It works effectively in all-weather conditions, be it cloud cover, dense fog or snow cover.
- Crop monitoring, Drought monitoring, Mapping soil moisture, Mineral Prospecting etc.

►AWACS

- Indian Air Force has undergone a doctrinal shift from conventional warfare to sub-conventional warfare due to threats from proxy wars by Pakistan's Deep State post 1990s.
- Thus, India identified key operational requirements of IAF in the aftermath of Balakot airstrike I line with the counter-proxy war strategy.
- AWACS are one the short-term operational requirement identified by IAF.

ABOUT AWACS

- Known as 'eyes in the sky'
- Air-borne radar systems mounted on aircrafts for scanning and surveillance.
- With a 360-degree span, they are deployed to carry out surveillance on enemy Air Defence systems and to prepare an Air Situation Picture useful in aerial combats.

CURRENT FLEET OF AWACS IN IAF

India currently has 5 AWACS

PHALCON

- AWACS procured from Israel

NETRA

- Airborne Early Warning and Control (AEW&C) system indigenously developed by DRDO. (1st used in Balakot air strike)

- Mounted on an Embraer aircraft was for the 1st time used in an aerial combat by IAF in the Balakot airstrike

►DRONE FLEET OF INDIA

In the backdrop on the Kargil war of 1999, India felt the need for accurate real time intelligence.

IMPORTANCE OF UAVs

- UAVs can carry a diverse array of payloads for reconnaissance, surveillance, intelligence gathering and target acquisition.
- In the aftermath of the Doklam episode, it is important to keeping our borders under greater surveillance.
- Besides with capabilities like electro-optical/Infra-Red cameras, electronic and communication intelligence gathering, UAVs can act as excellent force multipliers.
- Thus, the UAVs have evolved from being a surveillance and reconnaissance asset to hunter - killer roles.

DRONE FLEET

SEARCHER 1 AND 2

- Israeli drone
- Acquired in 1998

HERONS

- Israeli drone for deployment by armed forces

LAKSHYA

- 1st indigenously built reusable aerial target system.
- Pilotless drone to serve as aerial target for the training of air defence artillery weapon crews
- Lakshya-2 is an advanced variant and has autonomous flight capability even at low level.
- It is suitable for training of crews for operating beyond visual range (BVR) and cruise missiles

NISHANT

- It is a 340-kg UAV, with endurance of 4.5 hours
- Indigenously developed by the aeronautical development establishment (ADE).

DAKSH

- Electrically powered and remotely operated wheeled vehicle
- Designed for the task of bomb disposal.
- Capable of being remotely controlled over a range of 500m line-of-sight (LOS) or even within buildings.

NETRA

- Netra is a lightweight, autonomous UAV for surveillance and reconnaissance especially useful for anti-terrorist and counter-insurgency operations.

RUSTOM SERIES

- 3 models of RUSTOM have been built with RUSTOM 2 testing done recently in 2017.
- The 3 models of RUSTOM include Medium Altitude Long Endurance (MALE) category, High Altitude Long Endurance family (HALE), and Rustom H with combat capabilities. (Rustom-I, Rustom-H and Rustom-C)
- Rustom UAVs are to be fitted with Helina missiles.

RUSTOM 2

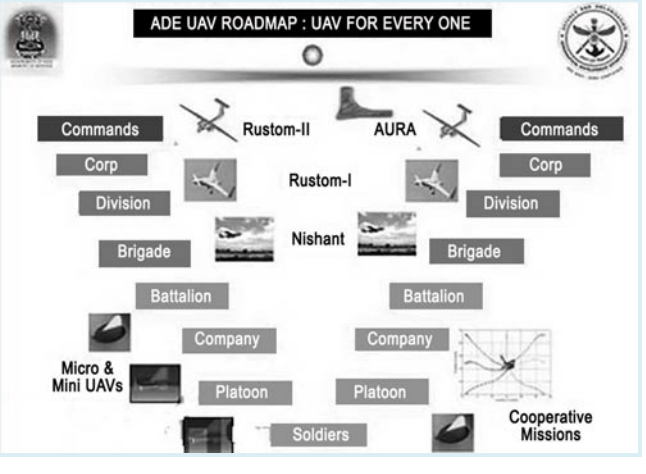
- Latest addition to the Rustom series of UAVs.
- Medium-altitude, long-endurance (MALE) unmanned aerial vehicle (UAV).
- Maximum speed is about 225 kmph.
- Endurance of more than 24 hours and it can operate up to an altitude of 35,000 feet above mean sea level.
- The unmanned aerial vehicle is designed to carry a variety of state-of-the-art payloads weighing up to 350kg.
- The payloads include electromagnetic intelligence (ELINT), communication intelligence (COMINT), synthetic aperture radar (SAR), maritime patrol radar (MPR), radio altimeter, transmitting and receiving antennae, and situational awareness payloads.

GHATAK

India's *1st stealth unmanned combat* aerial vehicle

PREDATOR-B

Weaponised version of Sea Guardian drones from the USA.



►LASER-BASED DIRECTED ENERGY WEAPON SYSTEM

- The laser-based weapons are the advanced directed energy weapon system that can be mounted on a truck, a vessel, used as close-in weapons on aircraft making up for the 6th generation fighters.
- They range from low-powered tactical beam emitters to a high-energy strategic weapons system.
- They can be used tactically to blind the enemy personnel, damage or destroy enemy's facilities, aircraft, anti-personnel weapon systems, missiles, even space assets.

HELIOS

- US Navy's high power laser weapon systems.
- Designed to counter unmanned aerial systems and small boats.
- Sensors that ensure long-range ISR (intelligence, surveillance and reconnaissance) capability
- A counter-UAS dazzler capability: A dazzler that can obscure adversarial UAS-based ISR capabilities.

LW-30

- China's vehicle-based laser defence weapon system.
- Usually truck-mounted, they are used to intercept aerial targets including UAVs, drones, guided bombs etc.

INDIA'S LASER WEAPON SYSTEM

- DRDO is developing a laser weapon system.
- High-powered laser weapon of 2KW

►INTEGRATED TRI-SERVICE AGENCIES

- India is set to form tri-service agencies in 3 critical domains of cyber security, space and special operations as per the recommendation of Naresh Chandra Committee.
- The 3 tri-service agencies that are being established include
  - *Special Operation Division*
  - *Defence Cyber Agency*
  - *Defence Space Agency*
- Note: India is also keen on restructuring the armed forces into 3 theatre-based integrated tri-service commands northern, western and southern on the lines on US (3) and China (5).

STRUCTURE

- The integrated tri-service agencies will draw staff from each service.
- They will be headed by a 2-star officer (Major General) and serve under the overall command of the Chairman, Chief of Staff Committee.

GLOBAL SPECIAL FORCES

United States Army Special Forces	Green Berets
Russian Special Forces	Spetsnaz GRU
German Special Forces	under the KSK Kommando Spezialkräfte

►DEFENCE SPACE AGENCY

COMPOSITION

- The Defence Imagery Processing and Analysis Centre (Delhi) and the Defence Satellite Control Centre (Bhopal) will be merged to form the Defence Space Agency
- It will be headed by an officer of the rank of air vice-marshal serving under the overall command of the Chairman, Chief of Staff Committee.

IMPORTANCE

- To protect India's space assets under the INSAT, IRS, IRNSS systems.
- The counter-space capability is much needed in response to China's offensive capabilities in the space which it has demonstrated.
- China is the second country after the US to have demonstrated this capability.

Note: USA has recently established a Space Force as a separate military branch

►CHIEF OF DEFENCE STAFF

4-star general

IMPORTANT FUNCTIONS

- Principal Military Advisor to the union Defence minister on all Tri-Services matters.
- Will not exercise any military command, including over the three Service Chiefs
- Act as the secretary of Department of Military Affairs
- Permanent Chairman of the Chiefs of Staff Committee

- Will command Tri-service agencies related to Cyber and Space
- Will be member of Defence Acquisition Council
- Military Adviser to the Nuclear Command Authority

►INFORMATION FUSION CENTRE-IOR

The IFC-IOR is established as a real time maritime information sharing hub for Indian Ocean region.

AIM

To keep track of both conventional and unconventional threats in our primary area of geopolitical interest spreading from the Persian Gulf to well beyond the Malacca Strait.

FUNCTIONS

- The IFC-IOR will help collate shipping data from
  1. Partner countries with whom we have white shipping agreements (US, UK, France, Australia, Brazil, Israel, Vietnam, Oman and Mauritius)
  2. Multi-national networks for exchange of shipping data (For instance, Trans Regional Maritime Network signed in December 2018)
  3. Other Maritime Information Centers
- It also facilitates dissemination of maritime security and safety information to partner nations, constructs and agencies.
- Now India has extended the facility to other participating countries of the Goa Maritime Conclave including Indian Ocean littoral countries, including Indonesia, Malaysia, Singapore and Thailand from Southeast Asia.

►BOLD-QIT (BORDER ELECTRONICALLY DOMINATED QRT INTERCEPTION TECHNIQUE)

- BOLD-QIT stands from Border Electronically Dominated QRT Interception Technique. This project was conceived in 2017 under Comprehensive Integrated Border Management System.
- It primarily involves installation of technical systems to equip border area with sensors.
- Under the project the entire span of riverine border is covered with a data network using various communication devices.
- The communication devices used in the data network include microwave communication, OFC cables, DMR communication, day and night surveillance cameras and intrusion detection system.
- The various devices under the data network feed signals to BSF control rooms.
- This ensures quick reaction teams (QRTs) from BSF in handling cross-border crimes.
- Since electronic communication devices are used to ensure quick reaction time from BSF in border surveillance, the project is named BOLD-QRT.
- Riverine border at Dhubri, Assam between India and Bangladesh is now secured with electronic surveillance with the formal launch of BOLD-QIT project.

►MILITARY EXERCISES

DOMESTIC EXERCISES		
NAME	**PARTICIPATING COUNTRIES**	**DETAILS**
Gagan Shakti	Indian Airforce	
TROPEX	Indian Navy, assets of the Indian Air Force, Indian Army and the Indian Coast Guard.	Short for (Theatre Level Readiness and Operational Exercise) Largest amphibious exercise of India Inter-service maritime theatre level war exercise
Cyberex	Major Cyber Exerciser	Army, Navy and AIrforce
Him Vijay	Indian Army	
Kharga Prahar	Indian Army	
Mission Reach out	Indian Army	

JOINT EXERCISES		
NAME	**PARTICIPATING COUNTRIES**	**DETAILS**
MILAN	Multi-lateral Naval Exercise Mostly Indian Ocean Region Countries, Southeast Asian Countries	India will host 2020 version Theme: Synergy across the Seas
MILEX	BIMSTEC	

MALABAR exercises	Trilateral naval exercise	India, US and Japan
Tiger-Triumph	1st Tri-Service (VVV Important)	India-USA
Vajra prahaar	Joint military exercise	India and US
Ex Cope India	Air Force	India and US
Ajeya Warrior	Joint Military	India and UK
Konkan	Navy	India and UK
Nomadic Elephant	joint military exercise	India-Mongolia
Ekuverin	joint military exercise	Indian Army and the Maldives
Sampriti	joint military exercise	India-Bangladesh
Sundarban Maitri	Navy	India-Bangladesh
Slinex	Navy	India-Sri Lanka
Mitra Shakti	Army	India-Sri Lanka
AUSINDEX	Naval	India-Australia
KAKADU exercise	Naval	Australia-led multilateral
Hand in Hand	Joint Military	India-China
Desert Eagle	Air Force	India-UAE
Gulf Star	Naval	India-UAE
Prabal Dostyk	Joint Training	India-Kazakhsthan
KAZIND	Joint Military	India-Kazakhsthan
Khanjar	Joint Training 'Exercise	India and Kyrgyzstan
INDRA	Joint Military	India-Russia
AVIAINDRA	Air Force	India-Russia
SIMBEX	Navy	India-Singapore
Bold Kurukshetra	Joint Military	India-Singapore
Maitree	Joint Military	India-Thailand
VINBAX	Joint Military	India-Thailand
CORPAT		India-Thailand
Harimau Shakti	joint training exercise	India-Malaysia
Samudra	Navy	India-Malaysia
Lakshmana		
Garuda Shakti	military exercise	India-Indonesia
Imbax	Bilateral Army Exercise	India-Myanmar
Lamitye	Navy	India-Seychelles
Varuna	Navy	India-France
Shakti	Army	India-France
Garuda	Airforce	India-France
SHINYUU Maitri	Airforce	India-Japan
Dharma Guardian	Army	India-Japan
AFINDEX	Army	India-Africa

►ARJUN MK-1A TANK

Recently, the Prime Minister of India has handed over the indigenously developed Arjun Main Battle Tank (MBT) MK-1A to the Indian Army.

The Arjun MBT Project was initiated by (DRDO) in 1972 with the Combat Vehicles Research and Development Establishment (CVRDE) as its lead laboratory.

The Arjun MBT is equipped with an indigenously developed 120mm main rifled gun with Fin Stabilised Armour-Piercing Discarding Sabot (FSAPDS) ammunition. FSAPDS can destroy all known tank armour up to direct shooting range.

The development of Arjun Mk1 was followed by improved variants - Mk1A and MkII.

- Arjun Mk1A, which features improved firepower and transmission systems, completed the final integration tests in 2019 and was cleared for production.
- Arjun MkII variant is a light-weight Futuristic Main Battle Tank (FMBT) with electro-optical sensors and high-power lasers.

►SOLID FUEL DUCTED RAMJET (SFDR) TECHNOLOGY

The Defence Research and Development Organisation (DRDO) recently successfully carried out a flight demonstration based on Solid Fuel Ducted Ramjet (SFDR) technology from Integrated Test Range Chandipur off the Odisha coast.

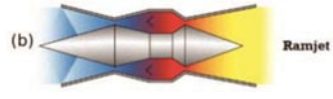
SOLID FUEL DUCTED RAMJET (SFDR)

- It is a missile propulsion technology jointly developed by India and Russia.

- It will improve the propulsion systems of future Indian long range air-to-air missiles. (Astra, air-to-air missile of India, has range of 80 km)
- The missiles which use such system are also able to carry larger payload due to absence of an oxidiser.
- Unlike solid-propellant rocket, the Ramjet takes up oxygen from the atmosphere during flight.
- Ducted rocket is Air-augmented rocket having a convergent-divergent nozzle. This ensures that combustion takes place at subsonic speeds, improving the range of vehicle speeds where the system remains useful.

SIGNIFICANCE

- Help both India's surface-to-air and air-to-air missiles to perform better and enhance their strike range.
- With it, India can have fastest long-range missiles in two categories, providing full-fledged and multi-layered aerial protection from hostile attacks.
- As per International Institute for Strategic Studies (IISS), this kind of propulsion system drastically enhances the range with higher average speed.
- Its successful use in missiles will mark India's entry into select club of nations that use next-generation missile technology against maneuvering targets, compromising effectiveness of conventional missiles.
- The Solid Fuel Ducted Ramjet is a missile propulsion system that includes a thrust modulated ducted rocket with a reduced smoke nozzle-less missile booster.
- The system utilises a solid fueled air-breathing ramjet engine.
- Officially, the technology is being developed to power future Indian air-to-air missiles. However, the technology can also be applied to surface-to-air missiles.

Criteria	Normal Missile	Missile with SFDR Technology
What it carries?	Propellant and Oxidiser	Only Propellant; Oxidiser not needed
Propulsion	Turbo Jet Engine	Ramjet Engines
How the Engine works?	 Burning of Propellant and Oxidiser → Releases → Trust	 Uses the engine's forward motion compress incoming air → Burning of Propellant → Releases Energy → Thrust
Amount of Payload	Relatively lower	Relatively higher
Range	Relatively lower (Astra Missile : 100 km)	Relatively higher (Astra Missile: 160km)
Speed of Missile	Relative lower	Relatively higher

Indian Naval Ship (INS) Pralaya visited at Abu Dhabi, UAE to participate in the NAVDEX 21 (Naval Defence Exhibition) and IDEX 21 (International Defence Exhibition). INS Mysore (an indigenously built guided missile destroyer deployed in the Persian Gulf) is also participating in the exhibition.

- INS Pralaya, a ship of the indigenously built Prabal Class Missile Vessels, was commissioned in the Indian Navy in 2002.
- Defence relations between India and UAE have been steadily growing since the upgradation of bilateral relations to a 'Comprehensive Strategic Partnership' in 2017.
- Sheikh Mohamed bin Zayed Al Nahyan, the Crown Prince of Abu Dhabi (capital of UAE), was a Chief Guest at India's Republic Day celebrations in 2017.

►MAAREECH

- The Indian Navy has inducted an advanced anti-torpedo decoy system called 'Maareech' that is capable of being fired from all frontline ships.
- It has been designed and developed indigenously by DRDO and it is capable of detecting, locating and neutralizing incoming torpedo.
- Bharat Electronics Limited, a Defence PSU, would undertake the production of this decoy system.

►AKASH PRIME MISSILE

DRDO has successfully tested a new version of the Akash surface-to-air missile Akash Prime from the Integrated Test Range at Chandipur, Odisha. It intercepted and destroyed

an unmanned aerial target mimicking enemy aircraft, in its maiden flight.

Akash Prime is based on the existing Akash surface-to-air missile (SAM) system.

- It is equipped with an improved active radio-frequency (RF) seeker for improved accuracy.
- Missile has also been optimized for low temperature and high-altitude operations with the modified ground system.
- It can intercept aerial targets mimicking enemy aircraft.

ABOUT AKASH MISSILE SYSTEM

- Akash is a medium-range mobile surface-to-air missile (SAM) system.
- It was developed by DRDO. Bharat Dynamics Limited (BDL) has produced these missiles.
- It can target aircraft up to 50–80 km away, at altitudes up to 18,000 m.
- These missiles can also neutralise aerial targets such as fighter jets, cruise missiles, air-to-surface missiles as well as ballistic missiles.
- It is in operational service with the Indian Army and the Indian Air Force.
- Akash-NG (new generation) missile: It is a new variant of the Akash missile which has a better range (60kms) compared to the original version (25 kms).

HEALTH & DISEASES

→ VIRAL DISEASES

BASICS OF VIRUS

- It depends on a host organism for its nutrients. Thus, it can metabolise and multiply only inside the living cells of other creatures.
- It is made up of a DNA or RNA genome.
- It lacks enzymes essential for the energy production
- It can infect animals, plants, and other microorganisms.

►CORONAVIRUS

- Large family of viruses, first identified in the 1960s.
- Can infect both animals and humans.
- It cause illness ranging from the common cold to more severe respiratory illness (like SARS & MERS)

NOVEL CORONAVIRUS – COVID-19

- A new strain that has not been previously identified in humans.
- First detected in Wuhan, China.
- Relative of SARS

TRANSMISSION

- These viruses are zoonotic – transmitted from animals to humans
- Human-to-Human: Mother to baby: Breastfeeding and placenta
- WHO has named the new coronavirus disease as Covid-19.
- Remdesivir: An anti-viral drug under trials in Wuhan 2019

►NIPAH

Zoonotic virus

TRANSMISSION

- Natural host – fruit bats.
- Intermediate host: Pigs
- It can also be transmitted through contaminated food or directly between people.

SYMPTOMS

- Like that of influenza: fever, muscle pain, and respiratory problems.
- Inflammation of the brain causing disorientation.
- Late onset of Encephalitis can also occur.
- **Note**: There are currently no drugs or vaccines specific for Nipah virus infection.

►YARAVIRUS

- Discovered in a lake in Brazil
- 'Yara', a water-queen figure in Brazilian mythology.

SIGNIFICANCE

  - Has genes that have not been described before.

- It could change how Deoxyribonucleic Acid (DNA) viruses are classified.
- It does not infect human cells.

►ROTAVIRUS DISEASE

- Leading cause of severe diarrhoea and death among children less than five years of age.
- Symptoms – fever, nausea, and vomiting, abdominal cramps and frequent watery diarrhoea.
- Transmitted by the faecal-oral route, contact with contaminated hands, surfaces and objects, and possibly by the respiratory route.

►MEASLES-RUBELLA

MEASLES

- **Introduction**
  - It is a contagious air-borne infection of the respiratory tract.
  - It is caused by a virus in the paramyxovirus family.
  - It can spread through direct contact or coughing, sneezing etc.
- **High-risk group**
  - It affects mostly children under the age of 5 years.
  - Unvaccinated groups including children, pregnant women
  - People with weak immune system
- **Symptoms**
  - High fever
  - Runny nose and cough
  - Red and watery eyes,
  - Small white spots inside the cheeks
  - Rashes in face, upper neck, hands and feet
- **Effects**
  - Severe respiratory infections such as pneumonia.
  - Serious complications include blindness, encephalitis (brain swelling), and diarrhoea.
- **Prevention**
  - WHO recommends routine measles vaccination for children and mass immunization campaigns as key public health strategies to reduce global measles deaths.
  - 2 doses of measles vaccine, either alone, or in a measles-rubella combination should be the standard for all national immunization programs.
  - Note: India, along with ten WHO South-East Asia Region member countries, plans to eliminate measles and control rubella/ congenital rubella syndrome (CRS) by 2020.

RUBELLA

- It is also known as German Measles
- Generally, a mild disease but can have serious consequences for pregnant women and their children as it may cause congenital rubella syndrome in the foetus.
- Both measles and rubella can be prevented by a highly effective Measles-Rubella (MR) vaccine, given under Universal Immunisation Program.

►ZIKA

- Zika is a viral infection spread by Aedes aegypti mosquito.
- Zika belongs to a group of viruses called the flaviviruses, which includes dengue, West Nile and yellow fever.
- Zika virus infect and replicate inside the cells of several species, including humans, monkeys, and mosquitoes.

►KYASANUR FOREST DISEASE OR MONKEY FEVER

- It is a tick borne (a tick which is found on monkeys) viral haemorrhagic fever. (haemorrhage is used to describe loss of blood)
- It is endemic to South Asia.
- The same family also causes yellow fever, dengue fever, chikungunya and Zika infection.

►YELLOW FEVER

- It is an acute viral haemorrhagic disease transmitted by infected mosquitoes.
- The 'yellow' in the name refers to the jaundice that affects some patients.
- Infected mosquitoes of the Aedes aegypti specie transmit the virus from person to person.

►ACUTE ENCEPHALITIS SYNDROME (AES)

- Characterized as acute onset of fever & a change in mental status.

- Viruses are the main causative agents in AES cases, although other sources such as bacteria, fungus, parasites, spirochetes, chemicals, toxins and non-infectious agents have also been reported over the past few decades.

►FLU

- There are three species of Influenza Virus viz. Influenza-A, Influenza-B, and Influenza-C.
- Influenza A infects birds and mammals.
- Influenza C Virus: Detected less frequently and usually causes mild infections, thus does not present public health importance.
- Influenza D virus: primary affect cattle and are not known to infect or cause illness in people.
- It has very high rate of mutation, and this is the reason that so many different strains of influenza virus are found.
- Various strains of Virus differ in certain proteins on the virus surface — hemagglutinin (HA) and neuraminidase (NA) proteins. This is the basis of naming viruses.
- The common Influenza outbreaks caused by Influenza-A strains include
  - H1N1 (swine flu)
- H5N1, H5N8, H2N9 (Bird Flu)

►AVIAN FLU

WHAT IS IT?

- Avian influenza refers to the disease caused by infection with avian (bird) influenza (flu) Type A viruses.
- These viruses occur naturally among wild aquatic birds worldwide and can infect domestic poultry and other bird and animal species. Avian flu viruses do not normally infect humans.
- However, sporadic human infections with avian flu viruses have occurred.

WHAT ARE DIFFERENT SUBTYPES DENOTED WITH H AND N?

- Influenza A viruses are divided into subtypes based on two proteins on the surface of the virus: hemagglutinin (HA) and neuraminidase (NA).
- There are 18 known HA subtypes and 11 known NA subtypes. Many different combinations of HA and NA proteins are possible.
- For example, an "H7N2 virus" designates an influenza A virus subtype that has an HA 7 protein and an NA 2 protein. Similarly, an "H5N1" virus has an HA 5 protein and an NA 1 protein.

DOES IT SPREAD EASILY TO HUMANS?

No, it does not. Generally, people coming in close contact with infected alive or dead birds have contracted the H5N1 bird flu, and it does not usually spread from person to person, as per the WHO. There is also no evidence, the WHO says, that the disease can be spread to people through properly prepared and cooked poultry food. The virus is sensitive to heat and dies in cooking temperatures.

THEN WHY THE SCARE?

- H5N1 is severe and deadly – around 6 out of 10 confirmed cases in humans have led to deaths (though the actual mortality rate may be lower due to under-reporting of asymptomatic cases).
- If the virus mutates and becomes easily transmissible from person to person, say by altering its shape to grab human cells much more effectively, it can potentially cause a pandemic.
- Also, flu viruses are more prone to mutation because they have a segmented genome. All known strains of flu – including the seasonal flu and the pandemic flu – have jumped from birds to humans in this way.

►WEST NILE FEVER

- It can cause fatal neurological disease in humans.
- Infection is most often the result of bites from infected mosquitoes

►AIDS

- Human Immunodeficiency Virus if left untreated, can lead to the disease AIDS (Acquired Immuno-Deficiency Syndrome).
- Unlike some other viruses, the human body can't get rid of HIV completely. So once one has HIV, he/she will have it for life.
- HIV attacks the body's immune system, specifically the T cells, which help the immune system fight off infections.
- If left untreated, HIV reduces the number of T cells in the body, making the person more likely to get infections or infection-related cancers.

►CRIMEAN-CONGO HAEMORRHAGIC FEVER

- Transmitted to humans from tick borne virus.
- No vaccine exists either for humans or animals.

►DENGUE

- Dengue virus is transmitted by female mosquitoes mainly of the species Aedes aegypti.
- The disease may develop into the life-threatening dengue haemorrhagic fever, resulting in bleeding, low levels of blood platelets and blood plasma leakage.
- Recently, Spanish health authorities confirmed world's first case of dengue being transmitted sexually, which until recently was thought to be transmitted only by mosquitos.

►JAPANESE ENCEPHALITIS

- Caused by a flavi virus that affects the membranes around the brain.
- A major cause of Acute Encephalitis Syndrome (AES) in India
- transmitted to humans through bites from infected mosquitoes of the Culex species.
- JE vaccination is also included under the Universal Immunization Program.

►BACTERIAL DISEASE

DISEASE	SPREAD	PARTS OF BODY AFFECTED	VACCINE/CARE
Maternal and Neonatal Tetanus	Unclean deliveries and umbilical cord care practices	Nervous system and causes muscles throughout the body to tighten	Can be easily prevented by hygienic delivery and cord care practices, and/ or by immunizing mothers with tetanus vaccine
Trachoma	Spreads through personal contact and flies that have contact with the discharge from the eye.	Eye (It affects the conjunctiva under the eyelids.)	Antibiotics treat early-stage trachoma. Surgery is required in later stages.
Leprosy	Slow-growing bacteria called Mycobacterium leprae (not very contagious)	Nerves, skin, eyes, and lining of the nose	Rifampicin and clofazimine are now combined with dapsone to treat multibacillary leprosy
Leptospirosis (rat fever)	Bacteria can be transmitted to humans through cuts and abrasions of the skin	Flu-like symptoms, such as headache, chills and muscle pain.	Antibiotics, such as doxycycline or penicillin
Tuberculosis	Mycobacterium tuberculosis	Mainly lungs	BCG living attenuated bacteria. Antibiotics e.g., streptomycin.
Cholera	Vibrio cholera	Alimentary canal (mainly small intestine)	Antibiotics
Typhoid	Salmonella typhi	Alimentary canal, then spreading to lymph and blood, lungs, bone	TAB vaccine
Yaws	Transmitted mainly through direct skin contact with an infected person.	skin, bones and joints	Benzathine Penicillin injection cures the disease.

►DIAGNOSING TUBERCULOSIS FROM URINE SAMPLES

Diagnosing TB usually involves using a sputum sample or a biopsy in the detection tests. This is not just time-consuming or expensive, there are also cases where getting a sputum sample is not easy or even possible, such as with small children or in the case of extrapulmonary TB.

IIT Madras researchers are developing a point-of-care platform for early-stage TB screening and detection using urine samples. The platform is yet to be tested in clinical trials.

HOW IT WORKS?

The glycolipid lipoarabinomannan (LAM), an integral component of the cell wall and cell membrane of Mycobacterium tuberculosis (Mtb), the disease-causing bacterium, has been explored as a biomarker for TB diagnosis.

Since it is known that LAM is released into the blood stream during active infection and passed out in urine, it can be viewed as a potential biomarker for even cases other than pulmonary TB.

In the test conducted by the group, the sample containing Mtb-LAM is mixed with gold nanoparticles and incubated for five minutes. Then a U-shaped fibre-optic sensor device with an LED and a photodetector attached to its two ends is dipped into the mixture. The results are generated in the next ten minutes, and the amount of Mtb-LAM present in the mixture can be read out.

TRUENAT TB TEST

- It is a small chip-based, portable, battery- operated device that was originally developed to detect Tuberculosis (TB).
- It can diagnose resistance to the drug Rifampicin as well.
- TrueNat is a cost-effective method to detect TB bacteria in the sputum sample in less than an hour.
- The World Health Organization approved it for testing TB bacteria as it showed 100% accurate results. Considered the miniature version of the PCR test, it can be used easily in a smaller setting and requires minimal training.
- Developed by Indian firm MolBio Diagnostics, Goa with funding from Bigtec Labs, India.

►MUCORMYCOSIS

- Mucormycosis or Black Fungus can be a cause of disease and death in transplant patients, and immunodeficient individuals.
- The rapid increase in cases seen in recovering COVID patients is causing grave concern. The frequency with which we are witnessing occurrence of COVID-triggered Mucormycosis with high morbidity and mortality has never been seen before.
- Symptoms of the disease include dry nose obstruction, swelling in the eye or cheeks, black dry crust in nose. one, you cannot one's nose and cheeks are numb.
- *Mucormycosis is not contagious* and the fungus targets immuno compromised people. Once one gets treated for COVID, he/she is *immunosuppressed*. One needs to eat immunity-boosting food after COVID treatment.
- Also, do not get exposed to polluted air and stay away from contaminated and damp surfaces. The fungus grows in such damp surfaces with black moulds.

►VECTOR BORNE DISEASE

- Vectors are organisms that transmit pathogens and parasites from one infected person (or animal) to another.
- Common in tropical and sub-tropical regions.
- Account for 17% of the estimated global burden of all infectious diseases.
- The deadliest vector-borne disease is malaria
- Fastest growing vector-borne disease is dengue.

►MOSQUITOES

AEDES

- Chikungunya
- Dengue fever
- Rift Valley fever
- Yellow fever
- Zika

→ ANOPHELES

MALARIA

- caused by the infectious Plasmodium
- Spread: Female Anopheles mosquitoes deposit parasite sporozoites into the skin of a human host.
- World's first vaccine against a parasitic disease: Mosquirix

CULEX

- Japanese encephalitis
- Lymphatic filariasis
- West Nile fever

TICKS

- Kyasanur Forest Disease or Monkey Fever
- Crimean-Congo hemorrhagic fever

SAND FLY

Kala Azar

►WOLBACHIA METHOD

- To control the spread of dengue and chikungunya naturally occurring *bacteria*, Wolbachia, is introduced in a strain of Aedes aegypti mosquito.
- Aedes aegypti mosquito is the main vector that transmits the viruses that cause dengue.
- Wolbachia inhibits viral infection. Even if people encounter mosquito bite, they will not be infected.
- Wolbachia bacteria do not allow the virus to replicate in the mosquito thereby minimising its number within the mosquito and hence virus won't be transmitted through a bite.

►DISEASES CAUSED BY WORMS

- Lymphatic filariasis
  - Caused by infection with parasitic worms living in the lymphatic system.
  - The larval stages of the parasite circulate in the blood and are transmitted from person to person by mosquitoes.
- Pinworm disease
- Hook-worm disease

GENETIC DISEASES

►SICKLE CELL ANAEMIA

- Genetic blood-disorder that results in deformation and break down of red blood cells in the blood.
- Most common inherited blood disorder that can be acquired from either or both the parents who carry the defective gene.
- Normally haemoglobin is smooth, round, disk-shaped and flexible allowing the RBCs to flow smoothly through our bloodstreams.
- In case of patients with sickle-cell disease, the gene that codes for haemoglobin is genetically mutated making the haemoglobin sticky.
- The mutation of haemoglobin-beta gene occurs on chromosome 11.
- The abnormal sticky haemoglobin forms rods that clump together distorting the shape of the RBCs.
- The distorted RBCs become curved and rigid taking the shape of a C-shaped sickle and hence the name.

►THALASSAEMIAS

Thalassemia is an inherited blood disorder that reduces the production of haemoglobin (oxygen carriers) in the RBCs of the blood. Thalassemia can cause anaemia, leading to fatigue.

►HAEMOPHILIA

- Haemophilia is a blood-related inherited disorder that restricts the ability of blood to clot.
- Males are most likely to be affected by Haemophilia.

EFFECTS

Prolonged bleeding

SYMPTOMS

- Skin bruises
- Pain and stiffness around joints due to internal bleeding
- Blood in urine, stool.

►TURNER'S SYNDROME

- Chromosomal disease affecting only females
- Occur when one of the X chromosomes (sex chromosomes) is missing or partially missing
- Medical and developmental problems, including short height, failure of the ovaries to develop and heart defects

►NATIONAL POLICY FOR RARE DISEASES, 2021

WHAT IS A RARE DISEASE?

- WHO defines rare disease as often debilitating lifelong disease or disorder with a prevalence of 1 or less, per 1000 population.
- In the US, rare diseases are defined as a disease or condition that affects fewer than 200,000 patients in the country (6.4 in 10,000 people).

- India, like many other developing countries, currently has no standard definition of rare diseases and data on prevalence.

So far only about 450 rare diseases have been recorded in India. The most common rare diseases include:

- Haemophilia
- Thalassemia
- Sickle cell Anaemia
- Primary Immuno Deficiency in children
- auto-immune diseases
- Lysosomal storage disorders such as Pompe disease, Hirschsprung disease, Gaucher's disease, Cystic Fibrosis, Hemangiomas, hunter syndrome.
- Certain forms of muscular dystrophies.

KEY FEATURES OF THE POLICY

- A patient registry of rare diseases is to be constituted under ICMR (Indian Council of Medical Research).
- According to the policy, rare diseases include genetic diseases, rare cancers, infectious tropical diseases, and degenerative diseases.
- Under the policy, there are three categories of rare diseases —
  - requiring one-time curative treatment - include osteopetrosis and immune deficiency disorders, among others.
  - diseases that require long-term treatment but where the cost is low, and
  - those needing long-term treatments with high cost.
- As per the policy, the assistance of Rs 15 lakh will be provided to patients suffering from rare diseases that require a one-time curative treatment under the 'Rashtriya Arogya Nidhi Scheme'. The treatment will be limited to the beneficiaries of 'Pradhan Mantri Jan Arogya Yojana'.
- For diseases listed under Group 2, State Governments can consider supporting patients of such rare diseases that can be managed with special diets or hormonal supplements or other low-cost interventions.
- Under the policy, certain medical institutes will be certified as Centre of Excellence for rare diseases. It includes AIIMS, New Delhi; Sanjay Gandhi Post Graduate Institute of Medical Science, Lucknow; King Edward Medical Hospital, Mumbai and four others.
- There are certain diseases such as Hurler Syndrome, Gaucher's disease, Wolman disease for which the annual treatment expenses may vary from Rs 10 lakh to Rs 1 crore. For such diseases, a digital platform is to be set up to raise donations and corporate funding.
- It proposes an inter-ministerial consultative committee is to be set up at national level. The committee will be led by MoHFW.
- It also aims to create Administrative Committee that will develop guidelines to determine which rare diseases to fund.

►HUNTER SYNDROME

Two brothers suffering from Mucopolysaccharidosis II or MPS II (Hunter Syndrome, Attenuated Type) have approached the Delhi High Court seeking direction to the Centre and AIIMS to provide them free treatment.

- MPS II is a rare disease that is passed on in families.
- It mostly affects boys and their bodies cannot break down a kind of sugar that builds bones, skin, tendons and other tissues.
- It is caused by mutations of the *IDS* gene that regulates the production of the iduronate 2-sulfatase (I2S) enzyme.
- This enzyme is needed to break-down complex sugars, known as glycosaminoglycans (GAGs), produced in the body.
- Lack of I2S enzyme activity leads to the accumulation of GAGs within cells, specifically inside the lysosomes leading to lysosomal storage disorders, causing many tissues and organs are enlarged in
- MPS II is inherited in an X-linked recessive pattern, which means that this condition occurs exclusively in males.
- In a family with more than one affected individual, the mother of the affected males must be a carrier. When a carrier female has a child, there is a 25% (1 in 4) chance that she will have an affected son.

►PARKINSON'S DISEASE

- It is a chronic, degenerative neurological disorder that affects central nervous system.
- It damages nerve cells in the brain dropping the levels of dopamine. Dopamine is a chemical that sends behavioral signals from the brain to the body.
- The disease causes a variety of "motor" symptoms (symptoms related to movement of the muscles), including rigidity, delayed movement, poor balance, and tremors.

- Medication can help control the symptoms of the disease but it can't be cured.
- Parkinson's disease (PD) is the second most common degenerative neurological disorder after Alzheimer's disease. It is estimated that PD affects 1 percent of the population over the age of 60.

►UMMID INITIATIVE

- UMMID (Unique Methods of Management and treatment of Inherited Disorders) has been launched to tackle inherited genetic diseases of newborn babies.
- Shifting of focus from "sick-care" to "wellness" by promoting the prevention of genetic diseases.
- NIDAN (National Inherited Diseases Administration) Kendra are established under the initiative to provide counselling, prenatal testing and diagnosis, management, and multidisciplinary care in Government Hospitals wherein the influx of patients is more.

►HAVANA SYNDROME

- Havana Syndrome refers to a set of mental health symptoms that are said to be experienced by US intelligence and embassy officials in various countries.
- It typically involves symptoms such as hearing certain sounds without any outside noise being present, nausea, vertigo and headaches, memory loss and issues with balance.

PLANT DISEASES

►FUSARIUM WILT TR4

- Recently, a novel fungus strain Fusarium wilt TR4 has started infecting the Banana plantations in India.
- It has been described as the equivalent of Covid-19 in Bananas. Like Covid-19, there is no treatment yet for the new fungal disease.

►YELLOW RUST

- It is a fungal disease which turns crop's leaves yellowish and stops photosynthesis activity.
- It is one of the three wheat rust diseases principally found in wheat grown in cooler environments (northern latitudes or cooler seasons)

►FALL ARMYWORM

- Invasive Species
- Spodoptera frugiperda is a species in the larval life stage of a fall armyworm moth.
- Native of America
- First detected in Karnataka this year (now has spread to W. Bengal and Gujarat)
- Attacks crops particularly maize.

►PINK BOLLWORM

- Infects cotton
- BT cotton grown in India is genetically modified for developing resistance to the pink bollworm pest in the crop.
- This is done by inserting 'Cry1Ab' and 'Cry2Bc' genes from the soil bacterium, Bacillus thuringiensis (Bt), into the cotton seed.

►LOCUST

- A locust is a large, tropical grasshopper with strong powers of flight (unlike ordinary grasshoppers)
- Under dry and stressful condition grasshoppers are getting stressed and transformed into locusts.
- Only four species of locusts are found in India
  - Desert locust
  - Migratory locust
  - Bombay Locust
  - Tree locust
- Locust adults can eat their own weight every day, posing huge threat to food security.

►SHEATH BLIGHT DISEASE

- Disease in rice
- Fungal disease
- Decreases the yield by 60%

►OTHER PLANT DISEASES

DISEASE	AFFECTED PLANT	CAUSE
Tutaabsoluta	Tomato	Tomato pinworm
Quick wilt,	black pepper vines	Black pepper vines
Stigmatomycosis	number of crops,	fungal disease

	such as cotton, soybean, pecan, pomegranate, citrus, and pistachio	
Rice blast	Rice	Fungus
Smut disease	Bajra	Fungus
Swollen shoot disease	Cocoa	Fungus
Brown rot	Cocoa	Fungus
White Stem Borer	Coffee	White stem borer pest
Red rot	Sugarcane	Fungus
	Sugarcane	White grub beetles
Late blight	potato	Fungus
Tikka disease (leaf spot disease)	Ground nut	Fungus
fire blight	Apple	Bacteria
Black rot	Cabbage	Bacteria
Canker	Lemon	Bacteria

►ANTIMICROBIAL RESISTANCE

- Anti-microbial resistance is the resistance acquired by any microorganism (bacteria, viruses, fungi, parasite, etc.) against antimicrobial drugs (such as antibiotics, antifungals, antivirals, antimalarials, and anthelmintics) that are used to treat infections.
- As a result, standard treatments become ineffective, infections persist and may spread to others.
- Microorganisms that develop antimicrobial resistance are sometimes referred to as "superbugs".
- Antimicrobial resistance is now regarded as a major threat to public health across the globe.

HOW IT HAPPENS?

- Some bacteria due to the presence of resistance genes are intrinsically resistant and therefore survive on being exposed to antibiotics.
- Bacteria can also acquire resistance. This can happen in two ways:
  - by sharing and transferring resistance genes present in the rest of the population or
  - by genetic mutations that help the bacteria survive antibiotic exposure.
- Once the resistance has been acquired, it can spread in the rest of the population of bacteria through reproduction or gene transfer.

REASONS FOR SPREAD OF AMR

- Antibiotic consumption in humans
  - Unnecessary and injudicious use of antibiotic fixed dose combinations could lead to emergence of bacterial strains resistant to multiple antibiotics.
- Social factors
  - Include self-medication.
  - Access to antibiotics without prescription.
  - Lack of knowledge about when to use antibiotics.
- Cultural Activities
  - Mass bathing in rivers as part of religious mass gathering occasions.
- Antibiotic Consumption in Food Animals
  - Antibiotics which are critical to human health are commonly used for growth promotion in poultry.
- Pharmaceutical Industry Pollution
  - The wastewater effluents from the antibiotic manufacturing units contain a substantial amount of antibiotics, leading to contamination of rivers and lakes.
- Environmental Sanitation
  - Untreated disposal of sewage water bodies - leading to contamination of rivers with antibiotic residues and antibiotic-resistant organisms.
- Infection Control Practices in Healthcare Settings
  - A report on hand-washing practices of nurses and doctors found that only 31.8% of them washed hands after contact with patients.

IMPACTS

- A threat to prevention and treatment of infections - medical procedures such as organ transplantation, cancer chemotherapy, diabetes management and major surgery (for example, caesarean sections or hip replacements) become very risky.
- The failure to treat infections caused by resistant bacteria also poses a greater risk of death.
- Antimicrobial resistance increases the cost of health care with lengthier stays in hospitals, additional tests and use of more expensive drugs.
- Without effective antibiotics for prevention and treatment of infections, the achievements of modern medicine are put at a risk.

- Without urgent action, we are heading to antibiotic apocalypse – a future without antibiotics, with bacteria becoming completely resistant to treatment and when common infections and minor injuries could once again kill.
- Antimicrobial resistance is putting the gains of the Millennium Development Goals at risk and endangers achievement of the Sustainable Development Goals.

AMR IN INDIA

- AMR is of particular concern in developing nations, including India, where the burden of infectious disease is high and healthcare spending is low.
- India is among the nations with the highest burden of bacterial infections.
- Consequently, the impact of AMR is likely to be higher in the Indian setting.
- The National Health Policy 2017 highlights the problem of antimicrobial resistance and calls for effective action to address it.
- The Ministry of Health & Family Welfare (MoHFW) identified AMR as one of the top 10 priorities for the ministry's collaborative work with WHO.
- In 2012, India's medical societies adopted the Chennai Declaration, a set of national recommendations to promote antibiotic stewardship.
- India's Red Line campaign demands that prescription-only antibiotics be marked with a red line, to discourage the over-the-counter sale of antibiotics.
- National Policy for Containment of Antimicrobial Resistance 2011.
- National Action Plan on AMR resistance 2017-2021.
- India has instituted surveillance of the emergence of drug resistance in disease causing microbes in programs on Tuberculosis, Vector Borne diseases, AIDS, etc.
- Since March 2014 a separate Schedule H-1 has been incorporated in Drug and Cosmetic rules to regulate the sale of antimicrobials in the country.
- The Food Safety and Standards Authority of India (FSSAI) banned the use of antibiotics and several pharmacologically active substances in fisheries.
- The government has also capped the maximum levels of drugs that can be used for growth promotion in meat and meat products.

SHORTCOMINGS IN FIGHTING AMR

- A cross-cutting program dealing with antimicrobial resistance across multiple microbes has been lacking.
- Absence of a One Health Approach in addressing AMR – which recognizes that human well-being is inextricably tied to the health of animals and the environment.
- The absence of stringently framed and implemented regulatory frameworks to limit the use of antimicrobials in livestock and food animals, especially for non-therapeutic purposes, has been one of the drivers of antibiotic overuse at the community level.
- In India, current effluent standards do not include antibiotic residues, and thus they are not monitored in the pharmaceutical industry effluents.

STEPS TO FIGHT AGAINST AMR

- Infection control in healthcare facilities.
- Creating awareness about the use and abuse of antibiotics.
- Vaccination can combat drug resistance by reducing the cases of infection and as a result reducing the need for antibiotics.
- Strengthening resistance tracking so that data on antimicrobial resistant infections and causes of infection can be gathered to enable formulation of specific strategies to prevent the spread of the resistant bacteria.
- Self-medication should be shunned.
- Antibiotics should be used only when prescribed by the doctor.
- Appropriate and safe use of antibiotics- taking antibiotics only when needed, choosing the right antibiotic and completing the full prescription.
- Invest in the search for new antibiotics to keep up with resistant bacteria as well as in new diagnostic tests to track the development of resistance.

WAY FORWARD

- AMR has the potential to return the world to a pre-antibiotic era when medicines could not treat even simple infections.
- Therefore, to contain AMR, there is need for a One Health Approach through coherent, integrated, multi sectoral cooperation and actions, as human, animal and environmental health are integrated.
- Development of antibiotic resistance breakers (ARBs) to restore effectiveness of older classes of antibiotics.

►ONE HEALTH APPROACH

- It focuses on a more integrated approach to tackle the challenges of human, animal and environmental health.

- Definition of One Health: One Health High Level Expert Panel has defined One Health as follows: *One Health is an integrated, unifying approach that aims to sustainably balance and optimize health of people, animals and ecosystems. It recognizes health of humans, domestic and wild animals, plants and wide environment (including ecosystems) are closely linked and inter-development. The approach mobilises multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective need for clean water, energy and air, safe and nutritious food, taking action on climate change and contributing to sustainable development.*
- One Health Approach was initially piloted by three bodies: FAO, WHO and World Organisation for Animal Health (OIE).
- Recently, UN Environment Program (UNEP) joined the other three to make it a four-member body driven.
- One of the four bodies will held annual rotating chair of One Health Secretariat.
- The four organisations are working to mainstream One Health so that humanity can be better prepared to prevent, predict and respond to global health threats and promote sustainability.
- One Health Joint Plan of Action includes 6 main action tracks:
    - Enhancing countries capacity to strengthen health system under a One-Health Approach.
    - Reducing risks from emerging or resurfacing zoonotic epidemics and pandemics.
    - Controlling and eliminating endemic zoonotic.
    - Neglected tropical or vector-borne diseases.
    - Strengthening the assessment, management and communication of food safety risks.
    - Curbing silent pandemic of antimicrobial resistance and better integrating environment into the One Health approach.

►NANOZYMES

- A research team at the Indian Institute of Science, Bengaluru has developed nanozymes that destroy the cell membrane of bacteria by directly targeting its phospholipids (a class of lipids that are a major component of all cell membranes).
- Nanozymes are nanomaterials that can disintegrate the cell membranes of a range of disease-causing bacteria. It also diminishes their resistance-building capacity.
- Nanozymes can replace the antibiotics that have become ineffective as several bacteria have developed resistance to them by producing their own enzymes.

COMMON SUPERBUGS

►STAPHYLOCOCCUS AUREUS

- Found on the mucous membranes and the skin
- It is extremely adaptable to antibiotic pressure.
- 1st bacterium in which penicillin resistance was found
- Consequently, Methicillin replaced penicillin as antibiotic
- MRSA (methicillin-resistant Staphylococcus aureus) first detected in 1961 is now common in hospitals.
- CA-MRSA (Community-acquired MRSA) has now emerged as an epidemic that is responsible for rapidly progressive, fatal diseases including pneumonia, severe sepsis etc.
- NDM-1 (New Delhi Metallo-beta-lactamase-1) is an enzyme that makes bacteria resistant to a wide range of powerful antibiotics used to treat multidrug-resistant infections.

►STAPHYLOCOCCUS EPIDERMIDIS

The superbug, identified as, is a type of bacteria commonly found on human skin.

►CANDIDA AURIS

- Multidrug-resistant fungus (yeast)
- Can cause many different types of infections such as bloodstream infection, wound infection, ear infection etc.

►SPREAD OF MULTI-DRUG RESISTANCE IN INDIA

- Self-medication
- OTC- Over the counter medication.
- Over-prescribing and unregulated use
- Incomplete antibiotic dosage.
- Antibiotic use in agriculture and livestock. (***Tylosin*** and ***Colistin*** used in poultry as growth promoters)

- Bad sanitation practices

►GLOBAL ANTIMICROBIAL RESISTANCE SURVEILLANCE SYSTEM (GLASS)

- WHO system launched in 2015
- **Aim**: Support global surveillance and research to strengthen the evidence base on antimicrobial resistance (AMR) and help informing decision-making and drive national, regional, and global actions.
- **India** has enrolled to GLASS system.

►AWARE

- Global campaign lead by WHO.
- Online tool to guide policymakers and health workers to use antibiotics safely and more effectively.

►REDLINE CAMPAIGN

Campaign to curb over-the-counter use of antibiotics in India

►NATIONAL ACTION PLAN TO COMBAT ANTIMICROBIAL RESISTANCE 2017

- **Adopted by Delhi declaration**
- **Objectives**
  - enhancing awareness
  - strengthening surveillance
  - improving rational use of antibiotics
  - reducing infections
  - promoting research
- In addition, support to neighbouring countries in collective fight against infectious diseases.
- Kerala & Madhya Pradesh have developed a state-level action plan to manage antimicrobial resistance.

►BIOSIMILARS

- They are 'similar biologic drugs', clinically equivalent, in terms of safety and efficacy, to biologic medicines.
- Cheaper versions of complex biologics such as vaccines, growth proteins, gene therapy usually developed from recombinant DNA technology.
- While generic medicines are chemically synthesized, biosimilars are developed in living cells using recombinant DNA technology.

DIFFERENCE BETWEEN BIOSIMILARS AND GENERIC

1. Biosimilars are 'similar', generics are 'identical'.
2. Biosimilars are only similar and must be equal to its'biologic counterpart' in terms of safety and efficacy.
3. Biosimilars need not work in the same way as the corresponding biologic; the only requirement being biosimilars should have the same effect as the corresponding biologic.

►TRASTUZUMAB

- First bio similar medicine prequalified by WHO.
- It is used to treat breast cancer.

►DENGVAXIA

- 1st ever vaccine licensed for dengue.
- Approved to treat patients in the age group 9-16 only.
- Recipients of the vaccine must have had a previous dengue infection.
- Live, attenuated dengue virus

►GV-971 / OLIGOMANNATE

- 1st ever carbohydrate-based drug for Alzheimer's disease.
- It is a seaweed-based drug, administered orally.
- Multi-target drug which hits several targets in the body.

►ALZHEIMER'S DISEASE

- Irreversible and progressive brain disorder.
- It slowly destroys memory, thinking ability and the capability to carry out simple tasks.

►MOSQUIRIX

- 1st ever vaccine against malaria
- **Note**: At the East Asia Summit in 2015, India pledged to eliminate the disease by 2030. Following this public declaration, India launched the five-year National Strategic Plan for Malaria Elimination. This marked a shift in focus from malaria "control" to "elimination".

►TYPBAR TCV

- World's 1st conjugate Typhoid vaccine.

- Pre-qualified by the World Health Organization's Strategic Advisory Group of Experts on Immunization (WHO-SAGE).

►BEDAQUILINE

An anti-TB drug to treat multi-drug resistant disease (MDR-TB)

►PRETOMANID

3rd new drug developed for the treatment of people with Extensively Drug-Resistant TB (XDR-TB) or Multi Drug-Resistant TB (MDR-TB) affecting the lungs.

►CAR-T

- A form of immunotherapy stimulating the body's immune system to help fight cancer.
- It is way to get immune cells, called T cells (a type of WBC) to fight cancer by genetically engineering them so that they can find and destroy cancer cells.
- T cells are taken from patient's blood and are changed in the lab by adding a gene for a man-made receptor (Called Chimeric Antigen Receptor). This helps the CAR-T cells to better identify specific cancer cell antigens. CAR-T cell therapy has been found particularly effective against leukemia.
- Since different cancers have different antigens, each CAR is made for a specific cancer. For ex. A CAR-T for leukemia based on CD19 antigen will not work for other cancers.

CHIMERIC PROTEINS

- They are proteins created through the joining of two or more genes that originally coded for separate proteins. Translation of this fusion gene results in a single or multiple polypeptides with functional properties derived from each of the original proteins.
- The genes are merged using recombinant DNA technology.

►MONOCLONAL ANTIBODIES

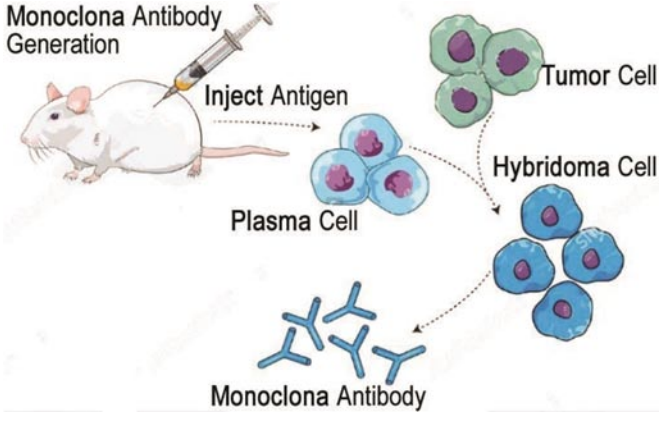
- They are antibodies are created in the lab. Like own antibodies, monoclonal antibodies recognize specific antigens and boost immunity against certain diseases.
- They are currently being used to treat a variety of conditions, including cancers, COVID-19, auto-immune diseases and other infectious diseases.
- They are administered through intravenous infusion (i.e., through a vein) or injection.
- Each Monoclonal antibody is made so that it binds to only one antigen. (Specificity).
- In contrast, polyclonal antibodies can also be manufactured.
- Naked monoclonal antibodies have no drug or radioactive material attached to them. They work by themselves.
- Conjugated monoclonal antibodies are combined with chemotherapy drug or radioactive particle.

PRODUCTION OF MONOCLONAL ANTIBODIES

- There are four different ways to make monoclonal antibodies:
- Murine: Made from mouse proteins
- Chimeric: Combination of mouse and human
- Humanised: Small parts of mouse proteins attached to human proteins
- Human: Fully human proteins

HYBRIDOMA TECHNOLOGY

- Monoclonal antibodies are produced by Hybridoma technology (most common) used to produce mouse and human hybrid cells.



►ENVIRONMENTAL DNA (EDNA)

- eDNA testing is a tool for monitoring the biodiversity of an area without physically collecting specimens.
- It is nuclear or mitochondrial DNA that is released from an organism into the environment.
- Sources include secreted faeces, mucous, gametes, shed skin, hair and carcasses.

►ALLOGRAFT

- It is the transplant of an organ or tissue or cells from one individual to another of the same species with a

different genotype (genetically non-identical donor) although of a compatible blood type.

- For example, a transplant from one person to another, but not an identical twin, is an allograft.

Allografts are commonly used in the transplants of skin, corneas, hearts, livers, kidneys, and bone and bone marrow, although transplants of the last often come from relatives.

►TRANS FAT LEVELS IN FOODS

- The Food Safety and Standards Authority of India (FSSAI) has capped the amount of trans fatty acids (TFA) in oils and fats to 3% for 2021 and 2% by 2022 from the current permissible limit of 5% through an amendment to the Food Safety and Standards (Prohibition and Restriction on Sales) Regulations.
- It was in 2011 that India first passed a regulation that set a TFA limit of 10% in oils and fats, which was further reduced to 5% in 2015.
- It has been suggested that the regulation must not be restricted to oils and fats but must apply to all foods. It is hoped that the FSSAI will address this as well before January 2022 to eliminate chemical trans fatty acids from the Indian platter.

TYPES OF TRANS FATS

- Naturally occurring trans fats are produced in the gut of some animals and foods made from these animals (e.g., milk and meat products) may contain small quantities of these fats.
- Artificial trans fats are created in an industrial process that adds hydrogen to liquid vegetable oils to make them more solid. Since they are easy to use, inexpensive to produce and last a long time, and give foods a desirable taste and texture, they are still widely used despite their harmful effects being well-known.

ASSOCIATED RISK OF TRANS FATTY ACIDS (TFA)

- TFAs pose a higher risk of heart disease than saturated fats. While saturated fats raise total cholesterol levels, TFAs not only raise total cholesterol levels but also reduce the good cholesterol which protect us against heart disease.
- It can lead to compromised foetal development.
- Trans fats are metabolized differently by the liver than other fats and interfere with normal liver functions.
- The risk of type 2 diabetes increases with transfat consumption. Trans fats are found to be associated with insulin resistance that pose a great risk to already diabetic patients.
- Trans fat may increase weight gain and abdominal fat, despite a similar caloric intake. TFAs enhance deposition of fat even in the absence of caloric excess.

STEPS TAKEN BY FSSAI

- Heart Attack Rewind - the 30 second public service announcement that will help support FSSAI's global target of eliminating trans-fat in India by the year 2022, a year ahead of the global target by the World Health Organization (WHO) for complete elimination of trans fat. It is a follow-up to an earlier campaign called "Eat Right cyclothon to engage citizens on issues of food safety, combating food adulteration and healthy diets.
- FSSAI has stated that the food establishments which use trans-fat free fats/oils and do not have industrial trans-fat more than 0.2 gms per 100 gm of the food can display 'Trans Fat Free' logo in their outlets and on their food".
- Eat Right Campaign - launched in 2018. Edible oil industries took a pledge to reduce the levels of salt, sugar, saturated fat and trans-fat content by 2% by 2022.
- Swasth Bharat Yatra, an initiative started under the "Eat Right" campaign is a Pan-India products.

Do you know, as part of the U.N.'s Sustainable Development Goals, the global community has committed to reducing premature death from non-communicable diseases by one-third by 2030. Global elimination of industrially produced trans fats can help achieve this goal.

In May 2018, the World Health Organization (WHO) launched the REPLACE action package to support governments to eliminate industrially produced TFA from the global food supply by 2023.

HEALTH RELATED PARTNERSHIPS

►GLOBAL ANTIBIOTIC RESEARCH & DEVELOPMENT PARTNERSHIP

- It has been created by the World Health Organization (WHO) and Drugs for Neglected Diseases initiative (DNDi).
- Global Antimicrobial Resistance (AMR) Research and Development (R&D) Hub: Berlin

►MERA INDIA INITIATIVE

- Launched by ICMR to eliminate malaria by 2030
- Malaria Elimination Research Alliance (MERA) India' – a conglomeration of partners working on malaria control – to prioritise, plan and scale up research to eliminate the disease from India by 2030
- Malaria is the deadliest vector-borne disease.
- Malaria is caused by a Plasmodium Parasites that is transmitted from one human to another by the bite of infected Anopheles mosquitoes.

►E-2020 INITIATIVE

It is part of the Global Technical Strategy for Malaria 2016-2030 endorsed by WHO.

►NEW INFLUENZA RESEARCH PROGRAM

- Indian and European Union collaborated for new influenza research program to develop Next Generation Influenza Vaccine.
- The program will get fund under EU funding program for research and innovation called **'Horizon 2020'**.

►SAANS CAMPAIGN

Social Awareness and Action to Neutralise Pneumonia - launched by Ministry for Health and Family Welfare

►3S PROJECT

- Smart Safety Surveillance or 3S project aims to optimize post-marketing surveillance of priority drugs and vaccines.
- Recommended by WHO.
- It aims to ensure the vaccines distributed under the universal immunization program are safe.
- As part of the 3S project rotavirus vaccines is being evaluated.

►GLOBAL FUND FOR AIDS, TB AND MALARIA

- International financing institution based on a unique partnership between governments, civil society, the private sector and affected communities.
- To fight three of the world's most devastating diseases (AIDS, Tuberculosis and Malaria)
- Secretariat – Geneva, Switzerland.
- The World Bank is the trustee of funds contributed to the Global Fund.

►NATIONAL HEALTH RESOURCE REPOSITORY PROJECT

- India's 1st ever healthcare establishment census to collect data of all public and private healthcare establishments.
- It is launched by the Union Ministry of Health and Family Welfare.
- Indian Space Research Organisation (ISRO) is technology partner for this project for data security.

HEALTH RELATED ORGANISATIONS

►NATIONAL PHARMACEUTICAL PRICING AUTHORITY

Independent, non-statutory body under Department of Pharmaceuticals under Union Ministry of Chemicals and Fertilizers.

IMPORTANT FUNCTIONS

- Fix/revise the controlled bulk drugs prices and formulations
- enforce prices and availability of the medicines
- Monitor the prices of decontrolled drugs

►STANDING COMMITTEE ON AFFORDABLE MEDICINES AND HEALTH PRODUCTS

- An autonomous body under Ministry of chemicals and fertilizers.

- Gives recommendation to the National Pharmaceutical Pricing Authority (NPPA)
- It decides list of drugs which should be under price control.

►DRUGS TECHNICAL ADVISORY BOARD

- DTAB is highest statutory decision-making body on technical matters related to drugs in the country.
- It is constituted as per Drugs and Cosmetics Act, 1940.
- It is part of Central Drugs Standard Control Organization (CDSCO) in the Ministry of Health and Family Welfare.

►CENTRAL DRUGS STANDARD CONTROL ORGANIZATION (CDSCO)

- CDSCO is the national regulatory body for Indian pharmaceuticals and medical devices.
- Within the CDSCO, the Drug Controller General of India (DCGI) regulates pharmaceutical and medical devices, under the gamut of Ministry of Health and Family Welfare.
- DCGI is advised by the Drug Technical Advisory Board (DTAB) and the Drug Consultative Committee (DCC).

►NATIONAL ORGAN & TISSUE TRANSPLANT ORGANISATION

- It functions under MoHFW and is an apex body for coordination and networking for procurement and distribution of organs/tissues and transplantation.
- At National level it creates awareness, promotion of organ donation and transplantation activities.

►NATIONAL ANTI-DOPING AGENCY

- National organisation responsible for promoting, coordinating, and monitoring the doping control program in sports in all its forms in India.
- It is formed by the Union Government under the societies Registration Act.
- NADA includes scientists and representatives from the Indian Olympic Association (IOA).

REPORT AND INDICES

World Drug Report	UN Office of Drugs & Crime
World Wildlife Crime Report	UN Office of Drugs & Crime
Global Burden of Disease Study	Health Metrics and Evaluation, Bill & Melinda Gates Foundation
India State-Level Disease Burden Initiative Report	ICMR, Public Health Foundation of India, Health Metrics and Evaluation, Ministry of Health and Family Welfare
Global Health Report	World Health Organisation
World Health Statistics	World Health Organisation
Global Health Expenditure Database	World Health Organisation
Tracking Universal Health Coverage	World Health Organisation
Universal Health Coverage Index	World Bank
Performance of Health Outcome Index	Niti Aayog
Global Nutrition Report	Expert Group of Global Nutrition Report, WHO is a partner

INFORMATION TECHNOLOGY

►SEMICONDUCTORS

- A semiconductor material has an electrical conductivity value falling between a conductor (such as metallic copper) and an insulator (such as glass). Lattice structure and atomic structure of constituent elements decide whether a particular material will be insulator, metal or semiconductor.

ENERGY BANDS

- There are two distinct band of energies (called valence band and conduction band) in which electrons in a material lie. Valence band energies are low as compared to conduction band energies. All energy levels in the valence band are filled while energy levels in the conduction band may be fully empty or partially filled.
- The electrons in the conduction band are free to move in a solid and are responsible for the conductivity. The extent of conductivity depends upon the energy gap between the top of valence band and bottom of conduction band.
- The electrons from valence band can be excited by heat, light or electrical energy to the conduction band and thus, produce a change in the current flowing in a semiconductor.

CLASSIFICATION OF SEMICONDUCTORS

I. On the basis of material:

(i) Elemental semiconductors: Silicon (Si) and (Ge)

(ii) Compound semiconductors:

a. Inorganic: CdS, GaAs, CdSe, InP etc.

b. Organic: Anthracene, Doped pthalocyanines etc.

c. Organic polymers: Polypyrrole, Polyaniline, Polythiophene etc.

Most of the currently available semiconductor devices are based on elemental semiconductors Silicon or Germanium (Ge) and compound inorganic semiconductors. However, after 1990s, a few semiconductor devices using organic semiconductors and semi-conducting polymers have been developed.

II. On the basis of purity:

(i) Intrinsic semiconductor: They are pure semiconductors with no impurities. They have no or zero conductivity at very low temperatures. However, as temperature rises, the conductivity of these materials increases.

(ii) Extrinsic semiconductor: When a small quantity of small impurity is added to pure semiconductor, the conductivity of the semiconductor is increased manifold. These semiconductors are called extrinsic or impurity semiconductors. The deliberate addition of a desirable impurity is called doping and the impurity atoms are called dopants.

Wide Bandgap semiconductor

- They are semiconductors 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:

- Permits devices to operate at much higher voltages and frequencies.
- Devices can operate at higher temperatures of the order of 300o 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

►WEB 3.0

- Web 3.0 is the next version of internet, where services will run on blockchain. It is a decentralized internet that runs on a public blockchain, which is also used for cryptocurrency transactions.
- It will be permissionless and democratic. For instance: Twitter will not be able to censor posts and Facebook will not be able to maintain a database of billions of users that can be potentially used to influence elections.
- In a Web 3.0 universe, people will control their own data and will be able to move around from social media to email to shopping using a single personalized account, creating a public record on blockchain of all that activity.
- Tim Berners-Lee, inventor of World Wide Web, intended that internet would be a collaborative medium, a place where all meet and read and write. But the current situation is entirely opposite, with big tech companies acting as gatekeepers to all that's on World Wide Web (W3).
- All data will be interconnected in a decentralized way, unlike current generation of internet (Web 2.0), where data is mostly stored in centralized repositories.
  - Key features of Web 3.0 are: Ubiquity, Semantic Web, Artificial Intelligence and 3D Graphics.
  - Examples of Web 3.0: Most recent example of Web 3.0 are the NFTs or non-fungible tokens.

EVOLUTION OF WORLD WIDE WEB

THREE STAGES OF INTERNET CONSUMPTION

	Web1	Web2	Web3
Time period	**1990-2005**	**2005-till date**	**2021 -**
Where data is stored	Server's file system	On-premise/Cloud	Blockchain, distributed across multiple networks
Examples	Static web pages	User generated content like Social media, and web applications like e-commerce etc...	NFTs, cryptocurrency transaction
Who owns data	Companies running the webpages	Companies that host application, cloud service providers	No one owns the data
Transacting	No transaction possible	Payment gateways for currency transactions	Transaction happens using crypto tokens

- Web 1.0 [1990 – 2000]: It is regarded as first generation of World Wide Web. Also known as Syntactic web or read only web. Mostly, Web 1.0 was limited to searching info and reading what's already there. There was little user interaction or content contribution. It was disorganized and overwhelming, and soon it came to be dominated by AOL, CompuServe, early Yahoo and other portals. These online service providers were gateway to Web 1.0. (HTML 1.0)
- Web 2.0 [from mid-2000s]: This phase was characterised by enhanced user experience and made internet interactive. Also known as Social Web or read-write web. It enabled users to participate

in content creation on social networks, blogs, sharing sites and more. Search engines (Google) and social media platforms (Facebook, Twitter) driven by user-generated content disrupted media, advertising and retail industries. Web 2.0's business model relies on user participation to create fresh content and resultant data being sold to third parties for marketing. Facilitated by HTML 2.0.

- Web 3.0 [yet to arrive]: Next stage of web evolution. It would make internet more intelligent, or process information with near-human-like intelligence through power of AI systems.

NEED FOR WEB 3.0

- Loss of privacy: Data is stored in servers of companies that people interact with. Intermediaries become custodians of user data and profit from. For such companies, more time consumers spend creating content, more data company can collect, helping it to improve its AI algorithm and its advertising engine, a key revenue model for the company. This gives rise to issues of privacy, wherein user data is shared for profit without their consent.
- Data ownership: Only centralized repositories are the ones that own user data and profit from it. In Web 3.0, users can own and be properly compensated for their time and data.
- Plagiarism: It's very easy to copy original content and build a following around it on social media. Plagiarism makes it harder for creators to get compensated. Web3 might help address that issue as transparent nature of blockchain makes it easy for anyone to track originator of content.

KEY DIFFERENCES BETWEEN WEB 2.0 AND WEB 3.0

- Any information that users share on Web 2.0 is stored with a cloud service provider whereas in Web3, all services are built on top of a blockchain.
- Cloud is controlled by internet giants and is centralized. In blockchain, data is distributed across networks and no single entity owns the information.

METAVERSE AND WEB 3.0

Metaverse is about creating digital avatars and interacting with others in virtual spaces. It does not have to be on a blockchain. The whole point of Web 3.0 is decentralisation.

EXAMPLES OF WEB 3.0

- Indian TikTok rival Chingari recently shifted from a Web 2.0 model of incentives for content creators to a Web 3.0 model and is building its token called '$GARI' on Solana blockchain.
- A range of Indian start-ups like Biconomy, Polygon, EPNS, Persistence, and Vauld are working to put together the technological building blocks to make Web 3.0's mass adoption a reality.

►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.
- OneWeb has launched around 400 satellites so far, while Starlink has launched over 2,000.
- It's worth mentioning that Starlink intends to deploy 42,000 satellites during the next ten years. Jio's adventure is just getting started.

WHY SPACE INTERNET SERVICES?

- This is primarily to guarantee that Internet services are stable and uninterrupted across the globe.
- 4 billion people, or more than half the world's population, does not have reliable Internet connection currently.
- That's because standard Internet delivery methods, such as fiber-optic cables or wireless networks, can't reach every corner of the globe.
- Cables or mobile towers are not practicable or viable in many isolated regions or places with severe terrain.
- Signals from orbiting satellites can readily pass this barrier.

ORBITAL DETAILS

- Space-based Internet networks have been in operation for several years, but only for a limited number of people.
- Most present systems rely on geostationary satellites.
- This orbit is 35,786 kms above surface of Earth, just over Equator.
- Satellites in this orbit travel at speeds of about 11,000 kms/hr, completing one Earth rotation in the same amount of time that the Earth turns on its axis.
- As a result, a satellite in geostationary orbit seems stationary to a terrestrial observer.
- Because of their reduced height, their transmissions only reach a narrow region. Therefore, many more satellites are required to transmit messages to all corners of the globe.

- To compensate for the effects of gravity, spacecraft in these orbits move at almost double the speed of satellites in geostationary orbit – around 27,000 kms/hr.

WHO CAN USE SATELLITE INTERNET?

- For a long time, militaries across the globe have relied on satellite communications.
- Many military experts, however, believe that this method is unreliable and too costly to be used as the main mode of communication.
- Satellite internet may still enable companies to create local branches and deliver digital services in distant places.
- If a bank has access to satellite internet, it may theoretically open additional ATMs in distant areas.

CURRENT REGULATORY FRAMEWORK FOR SATELLITE COMMUNICATION IN INDIA

- For operating satellite communication systems in India, be it Broadcasting Satellite (satellite to earth) Service or telecommunication (satellite to earth and earth to satellite) service, all entities, including government entities, need to obtain Service license and also Wireless operating license.
- For broadcasting satellite services (Ex. Direct to Home (DTH), TV Uplink, Digital Satellite News Gathering Service (DSNG) etc.) Ministry of Information & Broadcasting is the licensing authority. For interactive services like VSAT Services, DoT is the licensing authority. For any hybrid service, respective service license needs to be obtained from both these authorities.
- In addition to these above service licenses, entities need to obtain wireless licenses & uplink clearances from Wireless Planning & Coordination (WPC), DOT and Network Operation & Control Centre (NOCC), DOT, respectively, for the operations of the satellite network.
- Internet Service Provider (ISP)/Internet Protocol Television (IPTV) license is not alone sufficient to provide either Audio Visual or Broadband Wireless Access services through satellite.
- Even government agency engaged in Satellite Communication needs to obtain these licenses.

►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.
- They operate on Quantum principles of
  - Superposition
  - Entanglement
- The quantum computer was posited by Richard Feynman.

PRINCIPLES OF QUANTUM COMPUTING

Heisenberg's uncertainty principle which puts a fundamental limit to the knowledge an observed might have of a quantum system.

No-cloning theorem which states any arbitrary quantum state cannot be copied to generate replicas.

Quantum Entanglement which creates a non-classical correlation between two quantum entities.

Two protocols have been developed for Quantum Key Distribution:

- BB84 protocol which uses 4 different polarisation states of photons to encode key bits.
- B92 protocol is modified version of BB84 protocol which uses two polarisation states of photons.

►QUANTUM DOTS

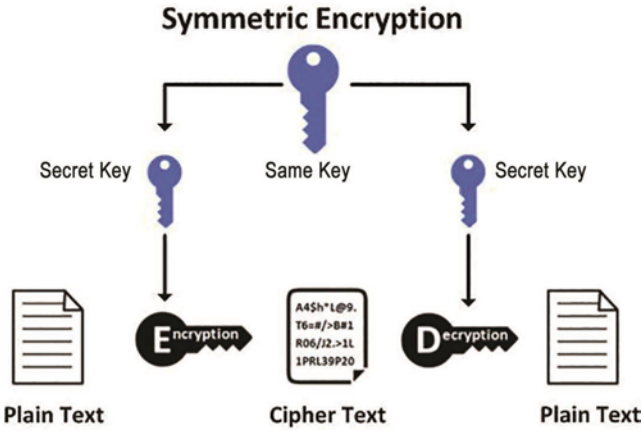
- It is a nanoparticle made of any semiconductor material such as silicon, cadmium selenide, cadmium sulfide, or indium arsenide.
- "Quantum dots" are more than 90% effective at wiping out antibiotic-resistant germs like Salmonella, E. coli and Staphylococcus.

HOW DOES IT WORK?

Bacteria rely on redox reactions, those involving the addition or removal of oxygen (reduction and oxidation, respectively). And when several Quantum dots are "excited" nearby, they produce chemicals that can be reduced or oxidized by reactive compounds within the bacteria. This effectively interferes with their intercellular processes, disrupts their cell growth, and kills them.

►QUANTUM KEY DISTRIBUTION

In traditional cryptography, security is usually because an adversary is unable to solve a certain mathematical problem.

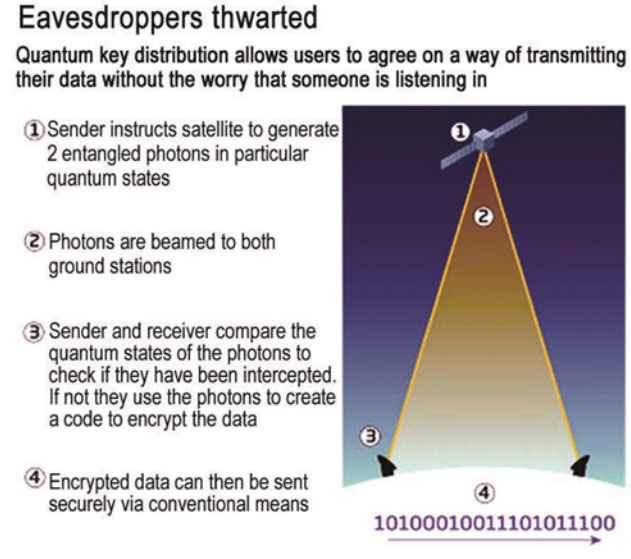


QUANTUM SUPREMACY

It's the point at which a quantum computer can complete a mathematical calculation that is beyond the reach of even the most powerful supercomputer.

Recently, Sycamore (Google's quantum computer) took 200 seconds to perform a calculation that the world's fastest supercomputer, Summit, would have taken 10,000 years to accomplish.

IN QKD, SECURITY IS ACHIEVED THROUGH THE LAWS OF QUANTUM PHYSICS



- Photons are generated randomly in one of two quantum states.
- Quantum Superimposition.
- The process of measuring a quantum system in general disturbs the system. You can't measure a quantum property without changing or disturbing it.

A satellite-based communication between two ground stations was activated by entangled-based quantum key distribution (QKD). This was achieved by Micius (also known as the Quantum Experiments at Space Scale), World's first quantum-enabled satellite. Micius was launched by China in 2016.

- Quantum key distribution (QKD) is a secure communication method which implements a cryptographic protocol involving components of quantum mechanics.
- It enables two parties to produce a shared random secret key known only to them, which can then be used to encrypt and decrypt messages.
- An important and unique property of quantum key distribution is the ability of the two communicating users to detect the presence of any third party trying to gain knowledge of the key.
- In QKD, security is achieved through the laws of quantum physics.

POST-QUANTUM CRYPTOGRAPHY

- This refers to cryptographic algorithms that are thought to be secure against a cyberattack by quantum computer.
- Currently, popular algorithms (non-quantum) for network security relies on one of the three hard mathematical problems: Integer Factorisation Problem, Discrete Logarithm Problem and Elliptic-curve discrete logarithm problem.
- All of these problems can be easily solved on a sufficiently quantum computer. Algorithm's for ex. Shor's Algorithm have been shown to easily break classical cryptographic strategies.

►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

India is the third most vulnerable country to Cyber-attacks according to Internet Security Threat report published by Symantec.

BASICS OF CYBER SECURITY

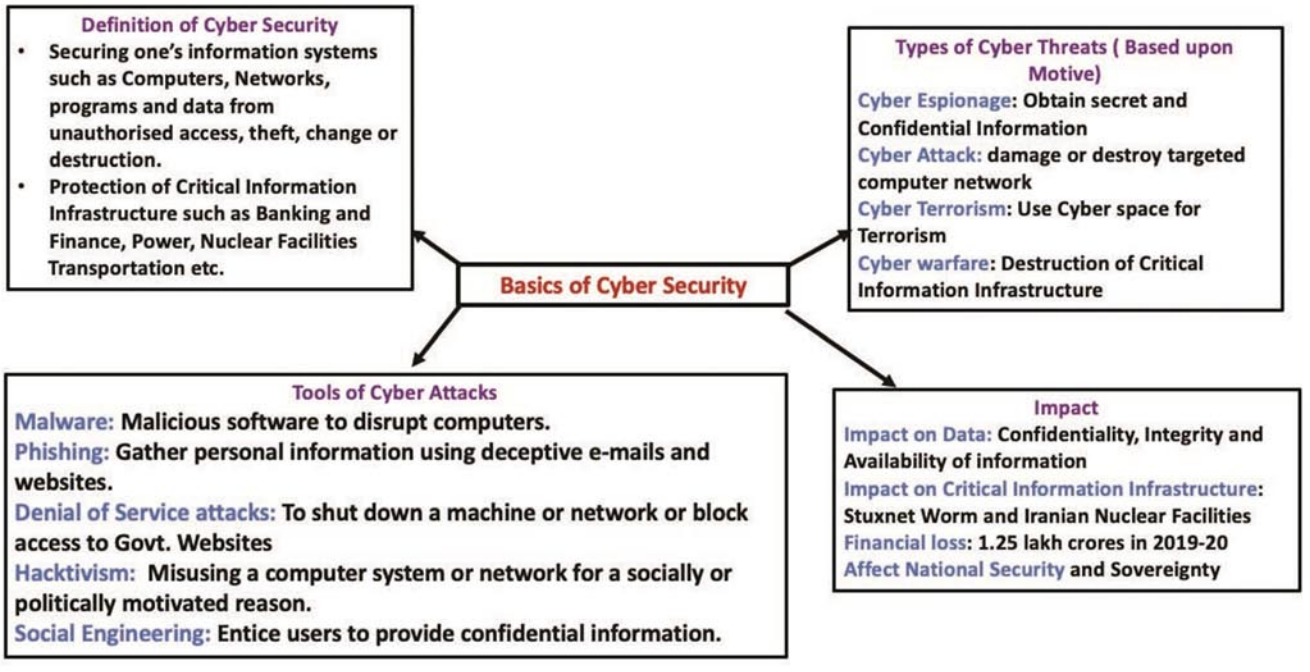
Based upon the motive, Cyber threats can be of 4 types:

i. Cyber Espionage: The act or practice of obtaining secret information i.e., personal, sensitive, classified nature from individuals, competitors or governments using malicious software such as Trojan horses and

spyware. Motive is to obtain secret information which could go against our National security.

ii. Cyber Attack: Targets computer information systems, infrastructures, computer networks. Motive is to damage or destroy targeted computer network or system. Impact: Destruction of Communication network.

iii. Cyber Terrorism: Convergence of terrorism and cyber space. Cyberspace has been used the by terrorists for number of purposes such as Planning terrorist attacks, recruitment of sympathizers, Spreading propaganda to radicalise people, to raise funding etc.



iv. Cyber warfare: Warfare conducted by a country or its proxies to attack the computer systems in other countries. Can Include- Theft, Vandalism (Defacing Web Pages), Destruction of Critical information infrastructure.

IMPACT

Impact on data: Confidentiality, Integrity and Availability of information

Impact on Critical Information Infrastructure: Presently, most sectors are critically dependent on use of ICT to execute their operations. Cyber-attacks on these critical information infrastructures can bring the entire country to a grinding halt. For example, the recent Chinese cyber-attack on the power system in Mumbai brought the entire city to a halt. The local trains, which are considered as Mumbai's lifeline stopped functioning and people got stranded. Similarly, the Stuxnet worm attack on the Iranian Nuclear facilities led to the destruction of the equipment which were controlled by the computers.

Financial loss: According to the *Data Security Council of India*, India has been the second most cyber-attacks affected country between 2016 to 2018.

Effect the National Security and peace and stability in a country.

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. Once activated following installation, Trojans can execute their malicious functions.
- Xafecopy
  - It is a Trojan Malware.

- It is disguised as useful apps and operates normally.
- Malware uses technology to bypass 'captcha' systems designed to protect users by confirming the action is being performed by a human.

- 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 consumes a lot of electricity. Crypto jacking is what some digital coin miners do to illegally gain access to many computers. The miners stealthily drop malware in an unsuspecting user's computer. These malware runs surreptitiously and turns devices into cryptocurrency-mining botnets.

Unlike most other types of malwares, crypto-jacking scripts do not use the victim's data. But they drain the CPU's resources, which slows down the system, increases electricity usage, and causes irreparable damage to the hardware.

HACKTIVISM

Misusing a computer system or network for a socially or politically motivated reason. For example, the hacktivists 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. For example, these days you must have come across some of the fake Facebook accounts which are opened in the name of your close friends. First, the cyber attackers send you the friend request in the name of your close friend. Once u accept it, they will ask to request you to transfer some money.

ADVANCED PERSISTENT THREAT

It is a type of cyber-attack in which an unauthorised 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 focussed on stealing data.

►CYBER SECURITY PREPAREDNESS

The International Telecommunication Union (ITU) released Global Cyber Security Index in 2017. This index measures the performance of the countries in terms of policies taken by them to improve cyber security. India was placed at 23rd rank among 165 countries. The relatively higher ranking of India shows that India has taken adequate measures for the protection of cyber space.

i. Section 66F of ITA: Specific provision dealing with the issue of cyber terrorism that covers denial of access, unauthorized access, introduction of computer contaminant leading to harm to persons, property, critical infrastructure, disruption of supplies, 'sensitive data' thefts. Provides for punishment which may extend to lifetime imprisonment.

ii. National Cyber Security Policy 2013: Policy document drafted by the Department of Electronics and Information Technology. Established National Critical Information Infrastructure Protection Centre (NCIIPC) to improve the protection and resilience of the country's critical infrastructure information; Create a workforce of 5 lakh professionals skilled in cybersecurity in the next 5 years.

iii. National Critical Information Infrastructure Protection Centre (NCIIPC): Established under *Information Technology Act, 2000* to secure India's critical information infrastructure. It is designated as the National Nodal Agency in respect of Critical Information Infrastructure Protection. It has been setup to enhance the protection and resilience of Nation's Critical information infrastructure. It functions under the National Technical Research Organization (NTRO).

iv. CERT-IN: Organization under the Ministry of Electronics and Information Technology with an objective of securing Indian cyberspace. The purpose of CERT-In is to respond to computer security incidents, report on vulnerabilities and promote effective IT security practices throughout the country. According to the provisions of the Information Technology Amendment Act 2008, CERT-In is responsible for overseeing administration of the Act. Sectoral CERT-Ins for dedicated sectors have also been mandated. For ex for finance, power sector etc.

v. Cyber Surakshit Bharat Initiative: It was launched in 2018 with an aim to spread awareness about cybercrime and building capacity for safety measures for Chief Information Security Officers (CISOs) and frontline IT staff across all government departments.

vi. Cyber Crisis Management Plan (CCMP): It aims at countering cyber threats and cyber terrorism

vii. National Cyber Coordination Centre (NCCC): It seeks to generate necessary situational awareness of existing and potential cyber security threats and enable timely information sharing for proactive, preventive and protective actions by individual entities.

viii. National Cyber Security Coordinator (NCSC) under National Security Council Secretariat (NSCS) coordinates with different agencies at the national level for cyber security matters.

ix. Cyber Swachhta Kendra: A platform for internet users to clean their computers and devices by wiping out viruses and malware.

- It is Botnet Cleaning & Malware Analysis Centre.
- Part of Digital India initiative under MEITY.
- It has been set up in accordance with the objectives of the National Cyber Security Policy.
- Operated by Indian Computer Emergency Response Team (CERT-In) under provisions of IT Act, 2000.

x. Information Security Education and Awareness Project (ISEA): Training of personnel to raise awareness and to provide research, education and training in the field of Information Security.

xi. S3WAAS

- Secure, Scalable and Sugamya Website as a Service
- It is a website generating and deployment product hosted on the National Cloud of NIC.
- It leverages technology to generate secure websites using GIGW compliant templates which are highly customizable and can seamlessly be deployed on a scalable software defined infrastructure.

XII. TECHSAGAR

- An online portal launched by National Cyber Security Coordinator's office in partnership with the Data Security Council of India (DSCI).
- It provides actionable insights about capabilities of the Indian Industry, academia and research across 25 technology areas like Internet of Things (IoT), Artificial Intelligence (AI), etc.

XIII. DATA SECURITY COUNCIL OF INDIA

- It is a not-for-profit premier industry body on data protection in India.
- It has been setup by NASSCOM

►CHALLENGES AND STRATEGIES IN INDIA'S CYBER SECURITY

- International Convention: Presently, Budapest Convention is the first international treaty seeking to address Internet and computer crime by harmonizing national laws, improving investigative techniques, and increasing cooperation among nations. This convention promotes greater cooperation between countries in fighting cybercrimes. However, India has not joined this convention. This is because the convention allows for cross border access to data to conduct investigation and India believes that such cross-border access to data can infringe on National Sovereignty.

  However, cyber experts have pointed out that, given the threats faced by us, India should accede to Budapest Convention at the earliest.

- PPP Framework for Cyber Security: Presently, most of the cyber security operations are carried out by the Government agencies such as CERT-In. Given the fast-changing nature and intensity of cyber threats, there is a need to leverage private sector expertise in combating cybercrimes through PPP framework.

- Shortage of Skilled Professionals

- Strengthen IT act and National Cyber Security Policy 2013: Experts have pointed out that the present legal and facilitative framework to fight cybercrimes i.e., IT Act and NCSP, 2013 are outdated and not well-equipped enough to manage technologically advanced cybercrimes. Prime Minister has said that

the Government is working on new Cyber security Policy 2020.

SECURING SECURE CYBER ECOSYSTEM:

- Appointment of Chief Information Security Officer in all the Organisations.
- Earmark funds towards enhancing cyber security
- Provide tax incentives to companies to upgrade information infrastructure
- Investment in R&D to improve Cyber Security- Big data, AI
- Enhancing Awareness among the people through the awareness campaigns

►INTERNET EXCHANGE POINT

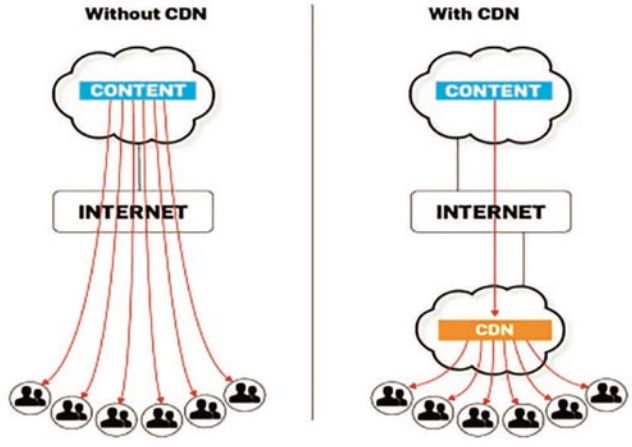
- IXP is a technical facility designed to route the traffic quickly and cost-effectively between different network members by enabling interconnection.
- They are essentially large local area networks that are built with interconnected Ethernet switches.
- IXPs allows ISPs and CDNs to interconnect their networks locally.
- This leads to flatter internet, improves international bandwidth utilisation and reduce the cost and latency of interconnections.
- Traffic exchange between two networks connecting at an IXP is facilitated by an exterior gateway protocol called Border Gateway Protocol (BGP).
- Current, Internet exchanges can be operated by both Private and Public Sector Players.
- National Internet Exchange of India is a non-profit company under Ministry of Electronics and Information Technology that operates internet exchanges in the public sector.

BORDER GATEWAY PROTOCOL

- Simply described, it is the Protocol that runs or makes the internet function.
- The BGP is the technology that binds the internet together, since it is a network of networks.
- When the BGP fails, the internet routers are unable to determine what to do, resulting in the internet becoming unavailable.

►CONTENT DELIVERY NETWORK

- It is a system of distributed group of servers and networks that deliver pages and other web content to a user, based on geographic location of the user, the origin of the webpage, and the content delivery server.
- CDN stores a cached version of its content in multiple geographic locations (points of presence or PoPs) which enables faster delivery of internet content.
- CDNs have emerged as overlay networks on the internet to provide better support for delivering commercial content than was available using basic, best effort internet packet transport services.



►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 TO 4G

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

- First launched in 1991.
- For the 1st time radio signals became digital rather than analog.
- 2G phones are used for data also along with voice.
- Thus, 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.
- With Enhanced Data Rates for GSM Evolution (EDGE) the speed went up to 1mbps

GPRS

- Launched in 2000
- Bridge between 2G and 3G.
- It marks the coming of data transmission besides voice communication
- General Packet Radio Service enabled mobile devices to send and receive e-mails and pictures.
- GPRS used EDGE and GSM standards for both voice and data transmission.
- GPRS had operating speeds of up to 115kbit/s.
- It increased to a maximum of 384kbit/s by using EDGE.

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.
- Further a 3G phone cannot communicate through a 4G network, but a 4G phone can communicate through a 3G or even 2G networks.
- Under both 2G to 3G technologies, data and voice transmission over the different networks using GSM or CDMA technology.

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.

	1G	2G	3G	4G
Period	**1980-1990**	**1990-2000**	**2000-2010**	**2010-(2020)**
Bandwidth	150/900MH2	900MHz	100MHz	100MHz
Frequency	Analog signal (30 KHz)	1.8GHz (digital)	1.6-2.0 GHz	2-8 GHz
Data rate	2kbps	64kbps	144kbps-2Mbps	100Mbps-IGbps
Characteristic	First wireless communication	Digital	Digital broadband, increased speed	High speed, all IP
Technology	Analog cellular	Digital cellular (GSM)	CDMA, UMTS, EDGE	LTE, WiFi

►5G TECHNOLOGY

- 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).
- The Steering Committee constituted for identifying the 5G deployment roadmap for India recently submitted report titled 'Making India 5G Ready'. As per government panel report with 5G data speed would be 2-20 Gbps.

FEATURES OF 5G

- High datarates (1Gbps for hotspots, 100Mbps download and 50Mbps upload for wide-area coverage)
- Massive connectivity (1million connections per square kilometre)
- Ultra-low latency (1milli second)
- High reliability (99.999% for mission critical 'ultra-reliable' communications).
- Mobility at high speeds (up to 500km/hr i.e., high-speed trains).

APPLICATIONS IN INDIA

- Will enhance infrastructure efficiencies like 'vehicle **platooning'.** Platooning can double vehicle density in roads promoting efficient and safer use of the limited road infrastructure.
- In manufacturing, 5G will enable use of robotics for precision manufacturing.
- 5G can also enable better logistics to track goods from raw materials to product delivery.
- In agriculture, 5G can enable improvement in the entire value-chain, from precision farming, smart

irrigation, improved soil and crop monitoring to livestock management.

- In the energy sector, 'smart grids' and 'smart metering' can be efficiently supported enabling growth of alternate energy technologies.
- In healthcare, 5G can enable more effective tele-medicine delivery, tele-control of surgical robotics and wireless monitoring of vital statistics.
- 5G will be used in in key government projects such as smart cities and Digital India.

►5G- MILLIMETER WAVE BAND

5G TECHNOLOGY

- The fifth generation (or 5G) of long-term evolution (LTE) mobile broadband networks is the most recent update.
- It's a single platform with much greater capacity, lower latency, quicker data delivery rates, and better spectrum utilisation than earlier mobile services.

5G SPECTRUM

5G primarily operates in three bands, namely the low, mid, and high-frequency spectrums, each of which has its own set of benefits and drawbacks.

LOW BAND SPECTRUM

- It has a lot of potential in terms of coverage and internet and data transfer speed; however, the maximum speed is just 100 Mbps (Megabits per second).
- The low band spectrum may not be ideal for specialised requirements of the business; thus, Telcos may utilise and deploy it for commercial cell phone customers who may not have need for extremely high-speed internet.

MID-BAND SPECTRUM

- It has faster speeds than the low band, however it has restrictions in terms of coverage area and signal penetration.
- This band might be utilised by companies and specialised production units to create captive networks that can be tailored to their specific demands.

HIGH-BAND SPECTRUM

- It has the fastest speed of the three bands, but its coverage and signal penetration intensity are severely restricted.
- Internet speeds in the 5G high-band spectrum have been tested to reach 20 Gbps (gigabits per second), although the greatest internet data speed in 4G has been reported at 1 Gbps in most circumstances.

MILLIMETRE (MM) WAVE BAND

- The millimetre wave band, or mmWave, is a portion of the radio frequency spectrum that spans 24 to 100 GHz.
- As the name implies, this spectrum has a short wavelength and is more likely to give higher speeds and shorter latencies.
- Since a result, data transport becomes more efficient and smoother, as existing networks are optimised for lower frequency bandwidths.

SIGNIFICANCE OF THIS MM BAND

- Lower frequency bands may be used to deliver 5G services.
- They can reach longer distances and have been demonstrated to perform well even in congested metropolitan areas.
- However, when it comes to data rates, these bands fall short of the maximum capacity required for a real 5G experience.
- So, mmWave is that key component in the 5G jigsaw puzzle for mobile service providers.

►INDIGENOUS 5G

Currently, Indian contribution is design ownership of telecom products is very limited and India has been significant importer of global products. TSDSI has been established to enable India industry to take lead in International standardization activities.

1. LMLC TECHNOLOGY

TSDSI in collaboration of IITs have been successful in getting the Low Mobility Large Cell (LMLC) use case accepted by ITU as one of the 5G requirements for rural areas.

Benefits:

a. Increases the distance between two base stations to 6 km against 1.7 km by other technology. This technology will be beneficial for rural India and other developing countries.

b. The base stations can be placed at Gram Panchayats and connectivity can be provided to neighboring villages and farms.

c. Reduction of Capex cost.

d. Increase in speed of internet access in rural areas.

e. These rural towers have to be located where BharatNet fiber ends in 2.5 lakh Gram Panchayats.

From these towers, neighboring villages numbering 3.5 lakhs have to be provided wireless coverage.

f. This is for the first time a global standard is emerging from India at ITU.

2. TSDSI RIT

IIT Madras along with other institutions has developed this standard as a variation to 3GPP standards for enhanced rural connectivity. This technology is also called 5Gi technology.

Benefits:

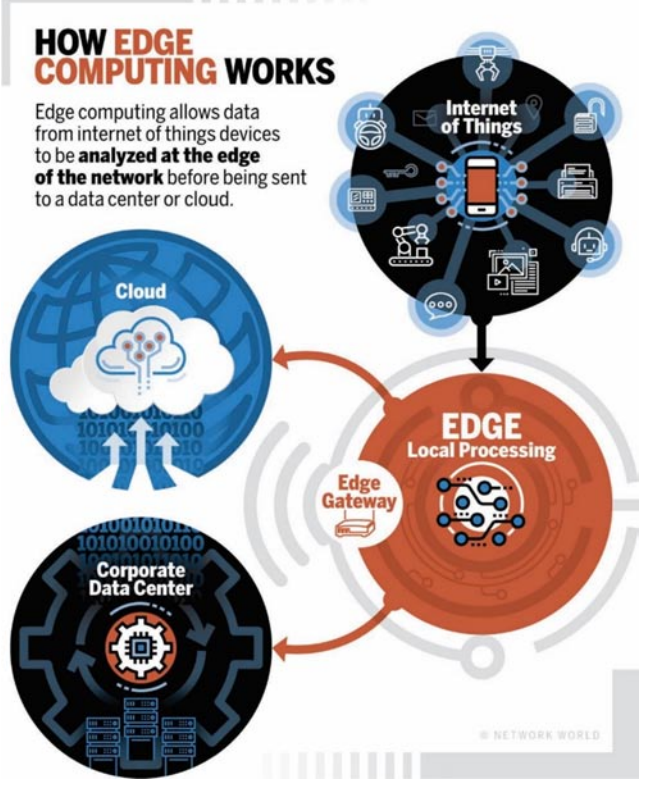
a. Enhanced coverage in rural areas

b. Reduced capex costs.

c. This standard however, has not been adopted by ITU and thus not globally harmonised.

►EDGE COMPUTING

- 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.



BENEFITS OF EDGE COMPUTING

- Useful for real time data processing applications.
- Very low or no latency.
- Cost effective: Saving of money as processing is done locally.
- Faster response time
- Interoperability between legacy and modern devices.
- Reliable operations with intermittent connectivity; low pressure on bandwidth
- Enhanced data security and privacy for users.
- Reduction of energy consumption
- Reduced amount of data that needs to be processed in a centralized or cloud-based location.
- Enables Internet of Things as it has scalability, low latency, longer battery life for devices, efficient data management
- 5G networks are expected to be 1000 times faster than 4G networks. Edge computing was developed due to the exponential growth of IoT devices, which connect to the internet for either receiving information from the cloud or delivering data back to the cloud. And many IoT devices generate enormous amounts of data during their operations.

HOW IS EDGE COMPUTING DIFFERENT FROM CLOUD COMPUTING?

The basic difference between edge computing and cloud computing lies in where the data processing takes place.

The existing Internet of Things (IoT) systems perform all their computations in the cloud using data centres.

Edge computing, on the other hand, essentially manages the massive amounts of data generated by IoT devices by storing and processing data locally.

►TECHNOLOGIES FOR INTERNET OF THINGS

NB-IoT technology operates on licensed spectrum, which is a subset of LTE brands. It stands for Narrowband Internet of Things. is a standards-based low power wide area (LPWA) technology developed to enable a wide range of new IoT devices and services. NB-IoT significantly improves the power consumption of user devices, system capacity and spectrum efficiency, especially in deep coverage. Battery life of more than 10 years can be supported for a wide range of use cases.

LoRa/LoRaWAN 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' to the internet in regional, national or global networks and targets key Internet of Things requirements such as

bi-directional communication, end to end security, mobility and localisation services.

Li-Fi: It is a wireless communication technology that utilises light to transmit data and position between devices. It is also called Light-Fidelity. It uses light from Light Emitting Diodes as a medium to deliver network. It is similar to Wi-Fi, the difference being Wi-Fi uses radio frequency to communicate. This technology can theoretically transmit at speeds of 100 Gbit/s.

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. (battery powered devices).

Sigfox: It is a standards-based low power wide area (LPWA) technology developed to enable a wide range of new IoT devices and services. NB-IoT significantly improves the power consumption of user devices, system capacity and spectrum efficiency, especially in deep coverage. Battery life of more than 10 years can be supported for a wide range of use cases.

►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.

►FREE SPACE OPTICAL COMMUNICATION

- FSO communication systems are where free space acts as a communication channel between transceivers that are line-of-sight (LOS) for successful transmission of optical signals.
- The channel can be atmosphere, space, or vacuum, whose characteristics determine the transmission and reception of optical signals for designing reliable and efficient communication systems.
- Using FSO technology data is transmitted by propagation of light through atmospheric or space communication channels, allowing optical connectivity.
- FSO communication offers a high data rate to meet the tremendous increasing demand of broadband traffic mostly driven by Internet access and HDTV broadcasting services.
- Compared to fiber optics technology, FSO offers much more flexibility in designing optical network architectures at very high speeds, at tens and hundreds of Gbit/s rates.
- However, FSO communication is affected by atmospheric effects, which limits sensitivity and achievable data rates with acceptable BER.
- Both point-to-point, point-to-multipoint, multipoint-to-point, and multipoint-to-multipoint FSO communications are possible, depending on the different scenarios of establishing optical links. FSO communication is the most practical alternative to solve the bottleneck broadband connectivity problem.

►GIGA MESH

- It is a wireless technology product that could enable telecom operators deploy quality, high speed rural telecom infrastructure at 5 times lower cost.
- Giga Mesh is based on millimeter wave multi beam technology.

►Wi-Fi CALLING

- It makes use of high-speed Internet connection, available via broadband, to make and receive high definition (HD) voice calls.
- This is not much different from a voice call using WhatsApp or any other over-the-top messaging platform, but here the call is from one number to another, and not using an app.
- Wi-Fi Calling can be configured on compatible smartphones by upgrading operating systems to the version that supports Wi-Fi Calling and enabling this in Settings.

►DATA PROTECTION BILL

- In the aftermath of the landmark decision of the constitutional bench of the SC on Right to Privacy in Puttuswamy case, Justice Sri Krishna Committee was constituted study issues relating to data protection in India and to recommend a suitable data protection law for India.
- Accordingly draft Personal Data Protection Bill, 2018 was framed covering various aspects of data protection.

ABOUT THE BILL

- The Bill deals with the broad guidelines on the collection, storage, and processing of personal data, the consent of individuals, penalties and compensation, and a code of conduct.
- Any entity that offers goods or services to Indian residents or processes the personal data of Indian resident is covered under the data protection law.

IMPORTANT PROVISIONS

The bill classifies personal data into 3 categories:

1. Critical personal data

- In case of certain critical personal data, the bill requires both storage and processing of data on servers located solely within the national borders.
- Central government is empowered to notify categories of personal data as critical personal data.

2. Personal data

- The bill allows some personal data to be stored and processed abroad without requiring a mirror of the data in India.
- However, all personal data can be processed outside only with the consent of the person.

3. Sensitive Personal data

- The draft Bill classifies 'sensitive personal data' as including passwords, financial data, health data, sex life, sexual orientation, biometric data, genetic data, transgender status, intersex status, caste or tribe, and religious or political belief or affiliation.

STORAGE

- "Sensitive" personal data shall be stored only in India.

PROCESSING

- This data can be processed abroad only under certain conditions, including the approval of a Data Protection Agency (DPA).
- Sensitive personal data can be processed only with the explicit consent of the person, and this consent needs to be informed, clear, and specific.

GOVERNMENT'S POWERS

Access to data

Government is empowered to gain access to any non-personal data — anonymised data like traffic patterns or demographic information — mainly for framing policy for better delivery of services and evidence-based policy.

DUTY OF INTERMEDIARIES

User Verification

- The Bill also requires social media companies, which are deemed "significant data fiduciaries" (SDF) to develop their own user verification mechanism.
- This is primarily to curb the menace of fake news in India

Processing of data without consent

- The Bill includes exemptions for processing data without an individual's consent for "reasonable purposes", including security of the state, detection of any unlawful activity or fraud, whistleblowing, medical emergencies, credit scoring, operation of search engines and processing of publicly available data.
- Personal data processed in the interest of prevention, detection, investigation and prosecution of any offence is exempt.
- In the interest of sovereignty, national security, preventing communal violence, we exempted some agencies from the law.

IN LINE WITH SOCIAL MEDIA REGULATION

- This is in line with proposed changes to Section 79 of the IT which centres around social media regulation.
- According to draft rule 3(9), the online platforms or "intermediaries" must "deploy appropriate technologies to proactively identify, remove or disable access to unlawful content.
- The unlawful content also include those that "threatens critical information infrastructure" in India.
- Further the online platforms would have to inform its users to refrain from hosting, uploading or sharing any content that is blasphemous, obscene, defamatory, hateful or racially, ethnically objectionable or those which threaten national security.

TRACEABILITY OF CONTENT

According to the Draft Rule 3(5), the intermediary shall enable tracing out of originator/source of unlawful content on its platform.

DATA PROTECTION AUTHORITY

- Data Protection Authority to ensure compliance with data protection norms.

- Permission of DPA for processing of sensitive information.

PENATIES

- In case of data leak of inaction - ₹5 crore or 2% of turnover, whichever is higher
- In case of sharing of data without consent – 15 crore or 4%

WHAT IT MEANS FOR CONSUMERS

- **DATA** can be processed or shared by any entity only after consent.
- **SAFEGUARDS**, including penalties, introduced to prevent misuse of personal data.
- **ALL** data to be categorized under three heads—general, sensitive and critical.

ROLE OF GOVERNMENT

- **GOVT** will have the power to obtain any user's non-personal data from companies.
- **THE** bill mandates that all financial and critical data has to be stored in India.
- **SENSITIVE** data has to be stored in India but can be processed outside with consent.

DUTIES OF INTERMEDIARIES

- **SOCIAL** media firms to formulate a voluntary verification process for users.
- **SHARING** data without consent will entail a fine of ₹15 crore or 4% of global turnover.
- **DATA** breach or inaction will entail a fine of ₹5 crore or 2% of global turnover.

DATA LOCALIZATION IN INDIA

- Reserve Bank of India has issued data localization rules for local storage of payments data.
- The draft Digital Information Security in Healthcare Act (DISHA) also has a provision for data localization of healthcare data.
- The draft National e-Commerce Policy by DIPP also has a provision for data localisation of consumer data.

GLOBAL PRACTICES

Individual rights centric

- **EU's GDPR**
  - According to EU's General Data Protection Regulation it is not mandatory to have local storage of data.
  - Besides cross-border flow of information is permitted if adequate data protection framework in there is the recipient country.
- **USA**
  - US does not even have a federal law for data protection

STATE-CENTRIC

China and Vietnam mandates strict data localisation norms.

MIDDLE PATH

Canada and Australia are selective in that they have provisions to protect their health data.

►PUBLIC DOMAIN NAME SERVER (DNS)

- The government will launch a public Domain Name Server (DNS) aimed at providing a faster and more secure browsing experience for Internet users in the country, while ensuring that citizens' data is stored locally.
- The main objective of bringing country's own public DNS is to ensure availability, particularly for smaller Internet Service Providers (ISPs) who don't have credible DNS.
- A user will be free to choose any DNS and they need not compulsorily need to shift to India public DNS.
- The National Informatics Centre (NIC) would configure the setup which would be offered to all citizens Domain Name System (DNS).

WHAT IS DNS?

- DNS is a system that translates domain names to Internet Protocol or IP addresses that allows browsers to load websites sought.
- Domain Name System translates human readable domain names (for example, www.google.com) to machine readable IP addresses (for example, 192.0.2.44).
- A domain name server is a computer that houses DNS zones of domain names.

►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.
- Aims to empower our national academic and R&D institutions spread over the country by installing a vast supercomputing grid comprising of 70 high performance computing facilities.
- These supercomputers will also be networked on the National Supercomputing grid over the National Knowledge Network.
- Phase III of the National Supercomputing Mission is aimed at taking computing speed in India to 45

Petaflops. Under the phase III, three systems of 3 Petaflop each and one system of 20 Petaflop will be developed as a national facility. These systems will provide High-Performance computing facility to researchers across the country through National Knowledge Network. Phase III will focus on increasing the indigenous content in supercomputers.

- Param Shivay: First supercomputer assembled indigeniously. 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.
- It is being designed for performance, power efficiency and support for large scale systems.

►SPINNAKER SUPERCOMPUTER

- It is the world's largest neuromorphic supercomputer that is designed and built to work in the same way a human brain does.
- Developed by the University of Manchester, UK.
- SpiNNaker is unique because, unlike traditional computers, it doesn't communicate by sending large amounts of information from point A to B via a standard network. Instead, it mimics the massively parallel communication architecture of the brain, sending billions of small amounts of information simultaneously to thousands of different destinations.
- It is funded by Human Brain Project of the EU.

►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.

►CRYPTO CURRENCY

- 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 CYPTOCURRENCIES

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

BENEFITS OF CRYPTOCURRENCIES

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

►DeFi

- Defi stands for decentralised finance.
- DeFi applications are platforms that facilitate crypto-denominated lending outside traditional banking, using as open-source code with algorithms that set rates in real time based on supply and demand.
- Many DeFi applications are embedded in the ethereum blockchain.

►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.

'Tokeninzing' 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.

Non-fungible tokens or NFTs are cryptographic assets on blockchain with unique identification codes and metadata that distinguish them from each other.

Unlike cryptocurrencies, they cannot be traded or exchanged at equivalency. This differs from fungible tokens like cryptocurrencies, which are identical to each other and, therefore, can be used as a medium for commercial transactions.

►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.
- It is a 54-qubit processor, solved a particularly difficult problem in 200 seconds.
- It could take years or decades for the technology to be freely available.

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.

►CLOUD NATIVE SCALABLE APPLICATIONS

- Cloud-native applications are a collection of small, independent, and loosely coupled services.
- They are designed to deliver well recognized business value, like the ability to rapidly incorporate user feedback for continuous improvement.
- In short, cloud-native app development is a way to speed up how you build new applications, optimize existing ones, and connect them all together. Its goal is to deliver apps users want at the pace a business need.

►OPEN API (APPLICATION PROGRAMMING INTERFACES)

- They provide an open architecture, allowing any business to access data and functionality without any association with the API providers.
- Open APIs can bring in the profound changes in the overall digital ecosystem. Open APIs basically allow data to be accessible to larger institutions.
- Government of India has open API policy for programs like Aadhaar, eKYC, eSign, and Unified Payments Interface (UPI) among others.
- Though Aadhaar data is handled by Unique Identification Authority of India (UIDAI) and banks have no control over the data, still banks can use the data. For instance, banks use Aadhaar-enabled biometric authentication to open bank accounts.
- An open API also gives banks the ability to monetise your data. But that doesn't mean all your information is made public. The data exchange in open APIs happens in a controlled manner.
- However, security does seem to be a concern with open APIs. Hence, not many banks currently offer them. But they are still works in progress and you can't rule out the possibility that someday, any bank would be able to fetch your data from any bank, of course, with your consent.

►UNIFIED MESSAGING PLATFORM

- MeitY has released Unified Messaging Platform for secure and efficient Government communications, envisages to provide email service to over 5 million officials of Central and State Government employees
- NIC is the implementing agency
- The service has been built through an open-source solution in accordance with the "Policy on adoption of Open-source software for Government of India". This gives strategic control of government over the solution.
- The service provides a multilingual platform comprising of 11 local languages with a go-live in English and Hindi initially, followed by other languages.

►GLOBAL CYBERSECURITY INDEX (GCI)

- The index measures the commitment of Member States to cybersecurity to raise awareness.
- The GCI revolves around the ITU Global Cybersecurity Agenda (GCA) and its five pillars (legal, technical, organizational, capacity building and cooperation).

►BROADBAND READINESS INDEX FOR STATES

- Department of Telecommunications and Indian Council for Research on International Economic Relations (ICRIER) have signed a MoU to develop a *Broadband Readiness Index* for Indian states and Union Territories (UT).
- The index will include indicators such *as* percentage of households using computers/ laptops with internet connection, percentage of households with fixed broadband connection, internet users as a percentage of the population, smartphones density, percentage of households with at least one digitally literate member, etc.

►NET NEUTRALITY

- Net neutrality is the principle that internet service providers and governments regulating the internet should treat all data on the internet the same, and not discriminating or charging differentially based on user, content, website, platform, application, type of attached equipment, or mode of communication.
- In 2016, TRAI took a revolutionary decision, prohibiting telecom service providers from levying discriminatory rates for data, thus ruling in favour of Net Neutrality in India. This move was welcomed by not just by millions of Indians but also by various political parties, businesspersons, and industry leaders.

►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.

►DIGITAL QUALITY OF LIFE INDEX, 2020

- This index ranks 110 countries on quality of digital wellbeing in in terms of e-infrastructure. It is released by Surfshark.
- Countries are ranked on five pillars: Internet Affordability, Internet Quality, Electronic Infrastructure, Electronic Security & Electronic Government.
- India ranks among the lowest in the world in terms of Internet quality. (59^{th})

►QR CODE

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

Features of QR Codes are:

1. High capacity of encoding of data
2. Small printout size
3. Dirt and Damage Resistant
4. Readable from any direction in 360 degrees
5. Structured Appending feature

QR Code has error correction capability to restore data if the code is dirty or damaged. Four error correction levels are available for users to choose according to the operating environment. Raising this level improves error correction capability but also increases the amount of data QR Code size.

►RFID TECHNOLOGY

- Radio Frequency Identification (RFID) refers to a wireless system comprised of two components: tags and readers.

- Reader is a device that has one or more antennas that emit radio waves and 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 are powered by the reader and do not have a battery. Active RFID tags are powered by batteries.
- RFID tags can store a range of information from one serial number to several pages of data. Readers can be mobile so that they can be carried by hand, or they can be mounted on a post or overhead.
- Reader systems can also be built into the architecture of a cabinet, room, or building.

ADVANTAGES OF RFID

- Automates data collection, reduces human effort & error
- Tag reading with no line-of-sight or item-by-item scans required.
- Multiple RFID tags can be read simultaneously.
- All RFID tags within range can be detected instantly and matched with information in your database.
- Assets can be cross-referenced against assigned locations & recorded as present, missing, or relocated.
- RFID can be integrated with active scanning and fixed readers for a totally automated tracking solution.
- Assets and employees can be tracked and located automatically for everything from supplychain & asset management, facility security & emergency planning.
- Available scanners support both RFID and barcoding so you can upgrade at your own pace.

►NEW EMERGING TECHNOLOGY

DRONE TECHNOLOGY

- The Ministry of Civil Aviation has suggested to the other Ministries to promote effective use of Drone technology. This suggestion was made as part of the initiatives to make India a global hub for drones under the Atmanirbhar Bharat Abhiyan and in the backdrop of the Union Government rolling out the liberalised Drone Rules 2021. Drones offer tremendous benefits to almost every sector of the economy, national defence, agriculture, law enforcement, and mapping, among others. It is also known as Unmanned Aircraft.
  - Originally developed for the military and aerospace industries, drones have found their way into the mainstream because of the enhanced levels of safety and efficiency they bring.
  - A drone's autonomy level can range from remotely piloted (a human controls its movements) to advanced autonomy, which means that it relies on a system of sensors and LIDAR detectors to calculate its movement.

APPLICATION OF DRONE TECHNOLOGY

- Defence: Drone system can be used as a symmetric weapon against terrorist attacks.
  - Drones can be integrated into the national airspace system.
  - Deployment of drones for combat, communication in remote areas, counter-drone solutions can be done.
- Healthcare Delivery Purposes: Recently, the Ministry of Civil Aviation has approved a project with the Telangana government for using drone technology to deliver vaccines in remote areas.
- Agriculture: In the agriculture sector, micronutrients can be spread with the help of drones.
  - It can also be used for performing surveys for identifying the challenges faced by the farmers.
- Monitoring: The drone technology in the SVAMITVA scheme launched by the Government of India, within less than a year, has helped about half a million village residents to get their property cards by mapping out the abadi areas.
  - Drones can be used for real-time surveillance of assets and transmission lines, theft prevention, visual inspection/maintenance, construction planning and management, etc.
  - They can be used for anti-poaching actions, monitoring of forests and wildlife, pollution assessment, and evidence gathering.
- Law Enforcement: Drones are also significant for the law enforcement agencies; the fire and emergency services wherever human intervention are not safe and the healthcare services.

ASSOCIATED ISSUES

- Increased Risk of Armed Attacks: Operation of drones without any adequate legal backing can pose several security threats.
  - Incidents of arms being dropped by drones are also there such as the recent Jammu drone attacks.
  - They can be put to destructive use, to slam into critical targets, destroy infrastructure and so on.

- Paramilitary Not Exempted from the Rules: The drone rules 2021 are not applicable to the army, navy or the air force.
  - However, it still includes paramilitary forces. BSF is suffering a lot of issues due to the drones coming across the lines.
- Cheaper Cost Enables a Larger Population to Procure Drones: Drones are cheaper in comparison to conventional weapons and yet can achieve far more destructive results which is the primary reason for increased number of drone attacks.
- Delivery of Mass Destruction Weapons: What makes combat drones most dangerous is the threat of them being used to deliver weapons of mass destruction.
  - Procurement of combat drones by non-state actors poses serious threats.

WAY FORWARD

- Training Programs: There must be training programs for drone pilots. The drone technology alone will not be enough, there must be a few more aspects to take care of for using the technology to its fullest.
- Balancing Security and Benefits: There is a need to ensure that the guidelines are in such a manner that the security concerns are not at all compromised, but the drone technology is also used to the maximum of its advantages.
- Developing Anti-Drone System: The DRDO has started developing an anti-drone system, one is already in place. There are soft kill and hard kill options available.
  - Soft kill options include jamming the drone.
  - Hard kill options include the laser technology, missiles or other drones to shoot down the drone.
- Increasing Investments: India needs to invest in its own Unmanned Aerial Vehicle (UAV) systems and counter-drone technology to detect and track threats, especially around critical assets.

►ARTIFICIAL INTELLIGENCE

- It describes the action of machines accomplishing tasks that have historically required human intelligence.
- It includes technologies like machine learning, pattern recognition, big data, neural networks, self-algorithms etc.
- The origin of the concept can be traced back to the Greek mythology, although it is only during modern history when stored program electronic computers were developed.
  - Example: Millions of algorithms and codes are there around the humans to understand their commands and perform human-like tasks. Facebook's list of suggested friends for its users, a pop-up page, talking about an upcoming sale of the favorite brand of shoes and clothes, that comes on screen while browsing the internet, are the work of artificial intelligence.
- A Complex Technology: AI involves complex things such as feeding a particular data into the machine and making it react as per the different situations. It is about creating self-learning patterns where the machine can give answers to the never answered questions like a human would ever do.

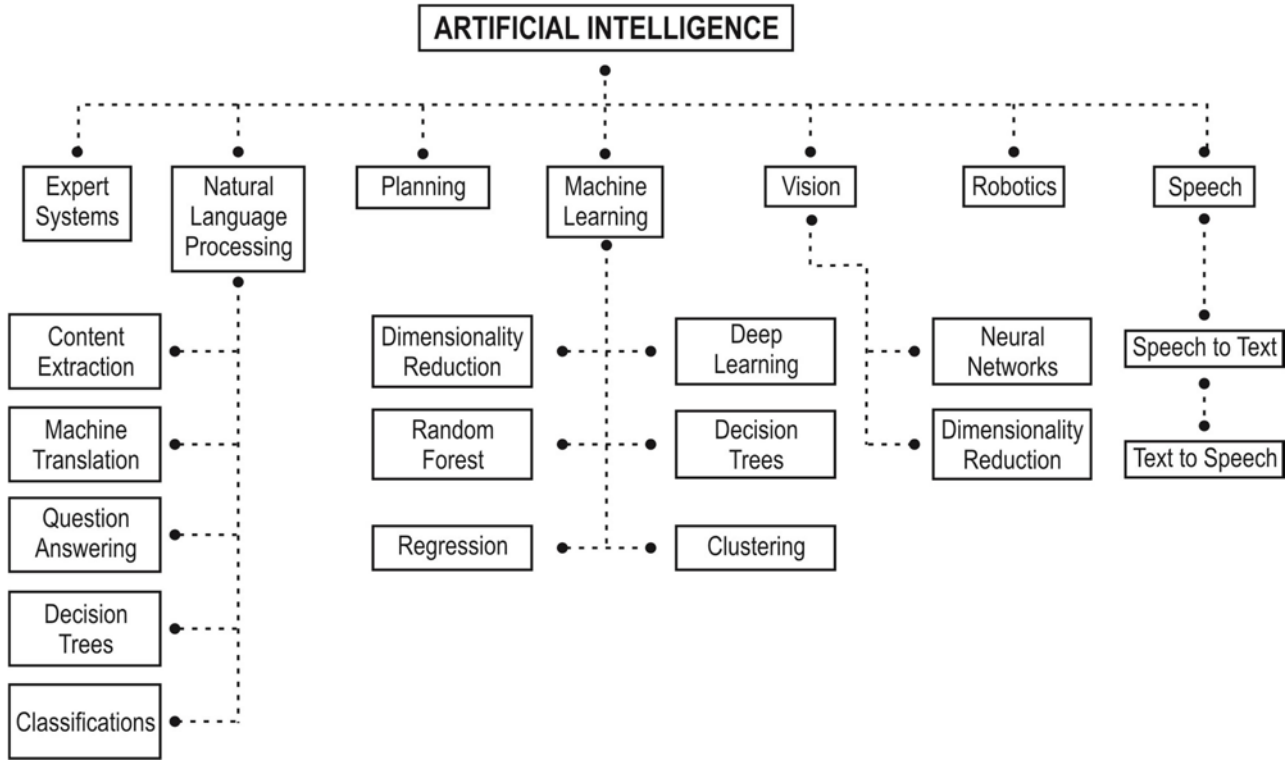
AI IS A DIFFERENT TECHNOLOGY

- AI is different from hardware driven robotic automation. Instead of automating manual tasks, AI performs frequent high volume computerised tasks reliably.
- AI is often misunderstood for machine learning. AI is a broader concept with a bunch of technologies that include machine learning and other technologies like natural language processing, inference algorithms, neutron networks etc.

EVOLUTION

- In the year 1956, American computer scientist John McCarthy organised the Dartmouth Conference, at which the term 'Artificial Intelligence' was first adopted. From then on, the world discovered the ideas of the ability of machines to look at social problems using knowledge data and competition.
- There used to be several dedicated projects on the same and the government was funding the research.
- Every aspect of science and especially when one starts looking at empowering machines to behave and act like human beings, the questions of ethics arise. About 70's and late 80's there was a time when the governments stopped funding research into AI.
- AI experienced a resurgence following concurrent advances in computer power and large amounts of data and theoretical understanding.
- AI techniques now have become an essential part of the technology industry helping to solve many challenging problems in computer-science. From Apple Siri to self-driving cars, AI is progressing rapidly.

AI METHODS



INDIA AND AI

- According to a Canada based company's report, Global AI Report 2019, India stood at the ninth position in terms of the number of the AI specialists working in the field. The US, China and the UK topped the list.
  - The top ranked countries in this report have many academic institutes with programs on AI. They have therefore a much greater number of people skilled to do research in the field.
  - India, on the contrary, lacks the opportunities in formal education in data science but is slowly trying to encourage the adoption of AI in educational institutes.
- Starting this year, the CBSE has AI as an elective subject for its ninth-grade classes.
- IIT Hyderabad has launched a full-fledged Bachelor of Technology (B Tech) program in AI becoming the first Indian educational institution to do so. It is also most likely the third educational institute in the world after Carnegie Mellon University and the Massachusetts Institute of Technology to have a full-fledged B Tech program on AI.
- IIIT Hyderabad is another educational institute that introduced popular executive programs on AI and machine learning and blockchain and distributed ledger technologies.
- Defence forces of India are now venturing into the products and technologies which will aid defence measures using the AI and technologies.
- In India, corporates and startups have started collaborating with academia on AI. IBM's Blue project is an example.
- It is estimated that AI will add 957 billion dollars to India's GDP by the year 2035 boosting India's annual growth by 1.3% points.

BENEFITS

- In Policing: India still has a conventional policing. AI based products open a new window of opportunity to do predictive policing in India. With the help of AI, one can predict the pattern of crime, analyze lot of CCTV footage which are available across the country to identify suspects.
  - Government is digitizing all the records, especially the crime records putting it into one single place called CCTNS where all the data including the image, biometrics, or the criminal history of a convict or suspect is available.
- In Agriculture: It has many uses, for example, it can help sense one how much water the crop needs.
- For solving complex issues like efficient utilization of available resources.
- Analyzing the Data: The AI technology helps in analyzing data and thus can improve the efficiency of

the systems like power management in cars, mobile devices, weather predictions, video and image analysis.

NEGATIVE IMPACTS OF AI

Steps taken by the Government

- In 2018-19 budget, the government mandated NITI Aayog to establish the National Program on AI with a view to guiding research and development in new and emerging technologies.
  - NITI Aayog then adopted a three-pronged approach undertaking exploratory proof of concept AI projects in various areas, crafting a national strategy for building a vibrant AI ecosystem in India and collaborating with various experts and stakeholders.
- NITI Aayog circulated the cabinet note to establish a cloud computing platform called AIRAWAT (Artificial Intelligence Research, Analytics and Knowledge Assimilation Platform.
  - The note circulated by NITI Aayog proposes that the government should pump in Rs. 7,500 crore rupees over 3 years as well as set up a high-level task force that will oversee the roll out and implementation of AI.
  - The move to create cloud computing platform is part of the government's goal of making India a pioneer amongst emerging economies with regards to AI and transform sectors like education, health, agriculture, urbanization and mobility.
- In Budget 2018, the government announced funds to support the country's AI, machine learning, robotics and IoT sector.
- As part of the initiative, NITI Aayog in the year 2018, published a draft National Strategy for AI, planning its scope for research, adoption and commercialization.
  - It envisioned AI use case clearly in the sectors like healthcare, agriculture, education, smart cities and infrastructure, smart mobility and transportation.
- The Commerce and Industry Ministry has also set up task forces to explore the use of AI and Big Data technologies in the country.
- In the Budget 2019-20, the government has announced setting up of a National Sports Education Board under Khelo India to prepare youth for new age skills, Artificial Intelligence, IoT, Big Data, 3D Printing, Virtual Reality etc.

AI IN CHINA

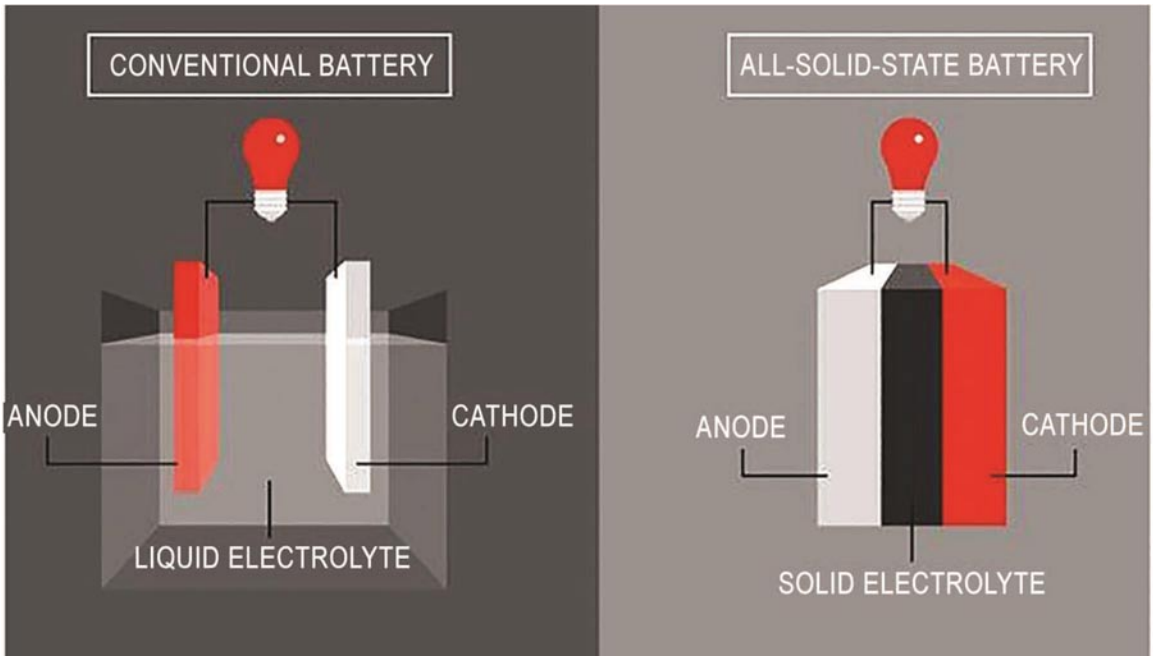
- China has been consistently building an ecosystem to fuel its ambition to become a world leader in AI by the year 2050.
- A report on China AI development released in the year 2018 said that from the year 2013 to the first quarter of the year 2018, the investment and financing in AI technology in China accounts for 60% in the world valued at 27 billion dollars in the year 2017.

►NEGATIVE ION TECHNOLOGY

- Authority for Nuclear Safety and Radiation Protection (ANVS), Netherlands issued a statement identifying various negative ion wearable products containing more Radioactivity than legally permitted.
- Negative ion technology embeds negative ions in personal products and is currently being advertised to maintain health, balance energy, and improve well-being.
- This technology is used in certain silicone wristbands, quantum or scalar-energy pendants, and kinesthesiology tape.
- Negative ions are also made when sunlight, radiation, air, or water break down oxygen.
- The minerals that produce these negative ions often include naturally occurring radioactive substances such as uranium and thorium.
- It is believed that negative ions create positive vibes and uplift the mood. They show the various mental and physical health benefits, such as stress reduction, better sleeping, respiration etc. whereas these ions may also act on pollutants, make them negatively charged and get them collected on surfaces.

►SOLID STATE BATTERIES

- A solid-state battery is a battery technology that uses solid electrodes and a solid electrolyte, instead of the liquid or polymer gel electrolytes found in lithium-ion or lithium polymer batteries.
- Such batteries can provide potential solutions for many problems of liquid Li-ion battery, such as flammability, limited voltage, unstable solid-electrolyte interphase formation, poor cycling performance and strength.
- A solid-state battery can increase energy density per unit area since only a small number of batteries are needed. For that reason, a solid-state battery is perfect to make an Electric Vehicle (EV) battery system of module and pack, which needs high capacity.



►ELECTRIC VEHICLES

- An EV operates on an electric motor instead of an internal combustion engine and has a battery instead of a fuel tank.
- In general, EVs have low running costs as they have fewer moving parts and are also environmentally friendly.
- In India, fuel cost for an EV is approx. 80 paisa per km. Contrast this with the cost of petrol which is today more than Rs 100/liter in Indian cities, or Rs 7-8 per km to operate a petrol-based vehicle.

PROSPECTS IN INDIA

- The private sector has appreciated the inevitability of the dominance of the EV.
- Companies like Amazon, Swiggy, Zomato and Ikea are deploying EVs for deliveries.
- Car manufacturers like Mahindra are partnering with consumers like Ola, while Tata Motors is partnering with Blu Smart Mobility in moves that will ensure more EV delivery and ride-hailing services.

ASSOCIATED CHALLENGES

- Lack of Charging Infrastructure: EVs are typically powered by lithium-based batteries. These batteries need to be charged usually every 200-250 kms or so for a car. So, there is a need for a dense proliferation of charging points.
- Issue of Slow Charging: It takes up to 12 hours for a full charge of a vehicle at the owner's home using a private light-duty slow charger. To compound this technological problem of slow charging at home, there are a few charging stations around the country.
    - This is woefully inadequate in a country as large and densely populated as ours.
- Lack of a Stable Policy for EV Production: EV production is a capital-intensive sector requiring long term planning to break even and profit realization, uncertainty in government policies related to EV production discourages investment in the industry.
- Technological Challenges: India is technologically deficient in the production of electronics that form the backbone of the EV industry, such as batteries, semiconductors, controllers, etc.
- Lack of Associated Infrastructural Support: The lack of clarity over AC versus DC charging stations, grid stability and range anxiety (fear that batteries will soon run out of power) are other factors that hinder the growth of the EV industry.
- Lack of Availability of Materials for Domestic Production: Battery is most important component of EVs. India does not have any known reserves of lithium and cobalt which are required for battery production. India is dependent on countries like Japan and China for the import of lithium-ion batteries.
- Lack of skilled workers: EVs have higher servicing costs and higher levels of skills is needed for servicing. India lacks dedicated training courses for such skill development.

WAY FORWARD

- Increasing R&D in EVs: The Indian market needs encouragement for indigenous technologies that are suited for India from both strategic and economic standpoint.
  - Since investment in local research and development is necessary to bring prices down, it makes sense to leverage local universities and existing industrial hubs.
  - India should work with countries like the UK and synergize EV development.
- Sensitizing Public: Breaking away the old norms and establishing a new consumer behaviour is always a challenge. Thus, a lot of sensitisation and education is needed, to bust several myths and promote EVs within the Indian market.
- Viable Electricity Pricing: Given current electricity prices, home charging may also be an issue if the generation is from thermal power plants run on coal.
  - Thus, a shift in the electricity generation landscape is what is required to facilitate the growth of electric cars.
  - In this context, India is on track to become one of the largest solar and energy storage markets by 2025.
  - A combination of solar-powered grid solutions that are organised with a general improvement in grid resilience will ensure adequate charging infrastructure for EV's being a green option.
- Creating the Closed-Loop Mobility Ecosystem: Subsidizing manufacturing for an electric supply chain will certainly improve EV development in India.
  - Along with charging infrastructure, the establishment of a robust supply chain will also be needed.
  - Further, recycling stations for batteries will need to recover the metals from batteries used in electrification to create the closed loop required for the shift to electric cars to be an environmentally sound decision.
- The largest suppliers of lithium-based EV batteries are reported to be the Chinese and the South Korean companies. If this is so, then a new global order is emerging to replace the Organisation of the Petroleum Exporting Countries (OPEC).
  - India must plan for its place in this order — with better-charging infrastructure, battery-making factories and smart incentives for car companies and consumers to go electric.

►AMMONIUM NITRATE

- Government has amended rules for Ammonium Nitrate to curb its pilferage, introduce fire-fighting provisions and improve ways to handle and store it.
- These rules have been amended after lesson learnt from Beirut Explosion in 2020. Nearly 3,000 tons of ammonium nitrate was stored at Beirut's port for six years that detonated in 2020.

ABOUT NEW RULES

- Ammonium nitrate received at ports be transferred to storage houses 500 m beyond the port area.
- Permit auction of seized ammonium nitrate to ensure safe and speedy disposal besides requiring that Ammonium Nitrate be imported in bagged form only.
- Provision for adequate fire-fighting facilities in storage and handling areas, improvement of flooring in storage and handling areas.
- Impact: Reduce handling of loose chemicals at port and therefore enhance safety.

ABOUT AMMONIUM NITRATE

- Ammonium Nitrate (NH_4NO_3) is a nitrogen-rich white, crystalline chemical which is soluble in water.
- Uses:
  - Manufacturing agricultural fertilizers.
  - Production anesthetic gases and cold packs.
  - Manufacturing of commercial explosives used in mining and construction.

AS EXPLOSIVE

- Main component of explosive composition known as ANFO- Ammonium Nitrate Fuel Oil.
- Pure ammonium nitrate is not an explosive. For Ammonium nitrate to be explosive, a primary explosive or detonator like RDX or TNT is required.
- Many Improvised Explosive Devices (IEDs) used by terrorists have ANFO as the main explosive.
- Stored ammonium nitrate is a fire hazard. It can explode in two ways: (a) Encounter some explosive mixture. (b) Oxidation process at large scale, heat may be generated starting a fire and explosion. This is probable cause of incident at Beirut port.

REGULATIONS

- Global: Classified as an oxidizing content under the UN classification of dangerous goods. UN Committee of Experts on Transport of Dangerous Goods categorizes types of dangerous goods, under nine classes like Explosive Materials, Inflammable liquids, easily oxidizing contents etc.

- India: In India, manufacture, conversion, bagging, import, export, transport, possession for sale or use of ammonium nitrate is covered under Ammonium Nitrate Rules, 2012 under Explosives Act, 1884.
  - Explosives Act, 1884, defines ammonium nitrate as the "compound with formula NH_4NO_3 including any mixture or compound having more than 45% ammonium nitrate by weight including emulsions, suspensions, melts or gels but excluding emulsion or slurry explosives and non explosives emulsion matrix and fertilizers from which the ammonium nitrate cannot be separated".
  - Storage of ammonium nitrate in large quantities in populated areas is illegal in India.
  - For manufacture of ammonium nitrate, an Industrial licence is required under Industrial Development and Regulation Act, 1951.
  - License under Ammonium Nitrate Rules, 2012 is required for any activity related to ammonium nitrate.

►SOILLESS CULTIVATION TECHNIQUES

Soilless Cultivation generally refers to any method of growing plants without soil as a rooting medium.

NEED FOR SOILLESS CULTIVATION

- Ensuring Food Security.
- Depletion of Resources for Traditional Farming.
- Helps maintain healthy root zones.
- Full potential of plant can be realized.

Easier to manage plant diseases during cultivation.

TYPES OF SOILLESS FARMING

1. Hydroponics

- Hydroponics is a method of growing plants in a water-based, nutrient-rich solution.
- In this method, root system is supported using an inert medium such as perlite, clay pellets, peat moss or vermiculite to provide access to oxygen which is essential for proper growth.

Advantages

- Hydroponic farming technology with closed water loop systems is a viable option for farmers with limited access to land and water.
- Significance of soilless systems increases for urban and peri-urban areas where arable land is polluted.
- Efficient resource consumption allows this alternative farming technique to be adopted by a variety of stakeholders.
- According to Food and Agricultural Organisation (FAO), vegetable yield of soilless systems is 20-25% higher than in traditional systems as number of plants per square meter is higher.

DRAWBACKS

- Water needs to be replaced at regular intervals as standing or re-circulating water makes it easier for plant disease to spread if pathogens enter water supply.
- Water and electricity are two major factors in Hydroponic farming, in absence of adequate water supply or stable electricity, it cannot function well.

2. Aeroponics

- It is a way of farming where roots are suspended in air & plants grow in a humid environment without soil.
- It is a variation of hydroponics where both growing medium and flowing water are absent. Roots of plants sprayed with water and nutrient solution. This technique enables farmers to control humidity, temperature, pH levels & water conductivity inside a greenhouse.

Advantages

- The water usage in the system reduces by 98% and fertilizer usage by 60%. Pesticides are fully eliminated as absence of soil reduces chances of diseases.
- Aeroponically grown plants can be harvested three times faster and yields are more consistent.
- As nutrients are sprayed onto plants and roots, there's plenty of oxygen and other gases in growing chamber for roots to absorb.
- Farming in a confined space gives farmer control over pest, locust attacks and sudden heat waves.

Drawbacks

- Aeroponics is far too dependent on technology. If any component of the system fails, it would render the entire system completely useless.
- One must be able to set up and run aeroponic System and be able to create perfect nutrient solution for plants otherwise the plant might die.
- Aeroponics is highly costly and not affordable for small and marginal farmers.
- Plants must receive constant attention to their pH levels & nutrient density ratio as there is no growing medium available to do this work.

3. Aquaponics

- Aquaponics is a system that combines hydroponics and aquaculture within a closed system.
- There are three biological components in aquaponics process: fishes, plants & bacteria. The

system represents a symbiotic relationship between plants and fishes; fish feces is used as fertilizer for plants, and plants clean water for fish.

Advantages

- Two agricultural products (fish and vegetables) are produced from one nitrogen source (fish food). Such a system prevents aquaculture waste from polluting nearby watersheds.
- Aquaponics farming doesn't involve pesticides or herbicides as these chemicals may kill fish. Here, fish feces are nutrient-rich fertilizer for plants.
- Huge water savings (80-90% water savings).
- An aquaponics system can be set on any scale. It can be as small as an aquarium and as big as a greenhouse commercial farm.

Drawbacks

- Supporting ideal environments for both plants and fishes make aquaponics a more complicated endeavor than hydroponics.
- Not suitable for tuberous plants & root vegetables as they perform most of their growth within soil and aquaponics uses water as a substitute for soil.
- In aquaponics, conditions where the system can fail are more; fish can die if they do not have right conditions and plants are also susceptible to pathogens.

SOIL-LESS FARMING OF TURMERIC

- Turmeric is grown in bags (large porous containers made of high-density polyethylene) packed with coco-peat (made from pith of coconut husk) instead of soil, set in shade houses.
- Turmeric grown by this technique has double content of curcumin as compared to turmeric grown by conventional methods.
- Curcumin is a bright yellow phenolic compound that has potential to fight cancer. Thus, there is a demand for high curcumin turmeric by pharmaceutical companies.

►ELECTRON BUBBLES IN SUPERFLUID HELIUM GAS

ELECTRON BUBBLE

- In a cryogenic gas or liquid, such as neon or helium, an electron bubble is the empty space generated around a free electron. At atmospheric pressure, they are quite tiny, measuring around 2 nm in diameter.
- A Single Electron Bubble (SEB) is formed when single electron is injected into a superfluid form of helium. It is a cavity that is devoid of helium atoms and contains just the electron. The form of the bubble is determined by the electron's energy state.
- When the electron is in the ground state, for example, the bubble is spherical (i.e., state of lowest energy). Thousands of electrons are contained in many electron bubbles.
- The frictionless flow and other strange behaviour seen in liquid helium at temperatures approaching absolute zero (273.15 °C), as well as the frictionless behaviour of electrons in a superconducting solid, is known as superfluidity. The strange behaviour is caused by quantum mechanical processes in each situation.

FEW-ELECTRON BUBBLES

- FEBs, on the other hand, are nanometre-sized cavities filled with just a few free electrons in liquid helium. The physical and chemical characteristics of materials are determined by the quantity, state, and interactions of free electrons.
- FEBs are a fascinating system because they have both electron-electron and electron-surface interactions.
- Researchers discovered that FEBs are stable for at least 15 milliseconds (quantum transitions generally occur on much shorter time periods), allowing them to be trapped and studied.

IMPORTANCE

- FEBs may be used to investigate how the energy levels of electrons and their interactions in a material affect its characteristics.
- FEBs may assist scientists understand a variety of phenomena, including turbulent flows in superfluid's and viscous fluids, as well as the movement of heat in superfluid helium.
- At extremely low temperatures, superfluid helium transfers heat effectively in the same way that current flows without resistance in superconducting materials.

MCQs

ANSWER KEY

Q1. Which of the following is/are the application(s) of the transparent ceramics?

1. Optical fibres
2. Infrared night vision
3. Thermal imaging

Select the correct answer using the code given below:

(a) 1 only (b) 1 and 2 only
(c) 1 and 3 only (d) 1, 2 and 3

Q2. Which of the following statements are correct about the Medicines Patent Pool (MPP)?

1. The Medicines Patent Pool (MPP) is a United Nations-backed public health organization.
2. The MPP's mandate is to accelerate access to affordable quality treatments for the people living with HIV, hepatitis C and tuberculosis.
3. COVID-19 treatments are included in the MPP's mandate.

Select the correct answer using the code given below:

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Q3. Consider the following statements:

1. Tricyclazole is a fungicide used in rice.
2. Buprofezin is an insecticide which is toxic to the aquatic organisms.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q4. Consider the following statements about Aflatoxins:

1. They are produced by the fungi present in the crops, such as maize.
2. They are associated with stunted growth and delayed development in children.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q5. Consider the following statements:

1. The term "hypersonic" describes any speed faster than four times that of sound.
2. Hypersonic cruise missiles are highly manoeuvrable and they fly at lower altitudes, making them more difficult to detect.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

Q6. Which of the following statements is/are correct about Laser Communications Relay Demonstration (LCRD)?

1. LCRD is a technology demonstration that will pave the way for future optical communications missions.
2. LCRD can only undertake one way communication from space missions to ground stations.

Select the correct answer using the code given below:

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q7. Consider the following statements about Solar Panels:

1. In hot climate, crystalline Silicon based solar modules degrade slower than in cold climates.
2. Roof mounted solar modules have lower degradation rate as compared to ground mounted solar modules.
3. Young solar modules have higher degradation rate as compared to old solar modules.

Which of the statements given above is/are correct?

(a) 3 only (b) 2 and 3 only
(c) 1 and 2 only (d) 1, 2 and 3

Q8. Consider the following statements:

1. An antineutrino has no electric charge.
2. The Glashow resonance is a way to identify an electron antineutrino.
3. IceCube Neutrino Observatory is buried under a huge mass of Antarctic ice and is designed to detect ultra-high-energy (UHE) neutrinos from outer space.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 and 3 only
(c) 1 and 2 only (d) 1, 2 and 3

Q9. Consider the following statements about Prime Editing:

1. It is a targeted gene editing technique that can focus on specific DNA sites.
2. It can facilitate gene editing without breaking both strands of DNA.
3. It has reduced incidence of unwanted or random by-products of genome editing as compared to CRISPR.

Which of the statements given above are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Q10. Consider the following pairs:

1.	TR-4 disease	Sugarcane
2.	Karnal Bunt	Rice
3.	Fall Armyworm	Maize
4.	Pink Bollworm	Cotton

Which of the above diseases are correctly matched with the crops affected by them?

(a) 1 and 2 only (b) 2 and 3 only
(c) 3 and 4 only (d) 1 and 4 only

Q11. Which of the following statements are correct?

1. The Gaganyaan Programme envisages undertaking the demonstration of human spaceflight to the geostationary orbit.
2. With the launch of the Gaganyaan Space Mission, India will become the fourth nation in the world to launch a human spaceflight mission, after the USA, Russia and China.

Select the correct answer using the code given below:

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q12. 'ICSI', 'ZIFT' and 'MESA' are the technologies related to which of the following?

(a) Space Exploration (b) Assisted Reproduction
(c) Nanotechnology (d) Artificial Intelligence

Q13. Which of the following statements is correctly related to the 'Epoch of Reionization' in cosmological history?

(a) It is the age of the universe from which the cosmic microwave background belongs.
(b) It is the age of the universe during which the universe was rapidly expanding, just after the Big Bang.
(c) It is the age of the universe during which the universe became opaque.
(d) It is the age of the universe during which the first stars and galaxies were formed.

Q14. With reference to the Border Gateway Protocol (BGP), which of the following statements is/are correct?

1. It is the Protocol that runs or makes the internet function.

2. When the BGP fails, the internet routers are unable to determine what to do, resulting in the internet becoming unavailable.

Select the correct answer using the code given below:

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither1 nor 2

Q15. With reference to the Linear No-Threshold (LNT) Model, which of the following statements is/are correct?

1. It is a dose-response model used in radiation protection.
2. It is based on biological responses at high radiation doses and dose rates.

Select the correct answer using the code given below:

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q16. Consider the following statements about the monoclonal antibodies:

1. They are artificially produced antibodies.
2. To produce the monoclonal antibodies, a culture of cancer cells with B cells of an infected mouse is fused to form hybridomas.
3. These antibodies can be used to treat cancer, infectious diseases and COVID-19.

Which of the statements given above is/are correct?

(a) 3 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Q17. Which of the following statements correctly relates to the goal of the Psyche Mission of NASA?

(a) It would allow studying of the core of the planets.
(b) It would allow the study of the presence of water in other planets.
(c) It aims to find the traces of extra-terrestrial life.
(d) It aims to study the blackholes and the dark matter.

Q18. Consider the following statements about the Chimeric Antigen Receptor T (CAR-T) Cell Therapy:

1. This cell therapy uses a person's immune system to fight cancer cells.
2. CAR-T cell therapy can treat all forms of cancer.
3. CAR-T cells are found naturally.

Which of the statements given above is/are correct?

(a) 1 only (b) 1 and 2 only
(c) 2 and 3 only (d) 1, 2 and 3

Q19. Consider the following statements about Small Satellite Launch Vehicle (SSLV):

1. The SSLV can carry satellites weighing up to 1000 kg to a low earth orbit.
2. SSLV is perfectly suited for launching multiple microsatellites at a time and supports multiple orbital drop-offs.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q20. Consider the following statements about the Hypersonic Technology Demonstrator Vehicle (HSTDV) developed by DRDO:

1. HSTDV is not a weapon itself but and is being developed as a carrier vehicle for hypersonic and long-range cruise missiles.
2. HSTDV can cruise at a speed of Mach 8.
3. The HSTDV uses atmospheric oxygen for propulsion.

Which of the statements given above are correct?

(a) 1 and 3 only (b) 1 and 2 only
(c) 2 and 3 only (d) 1, 2 and 3

Q21. With respect to "Pegasus", consider the following statements:

1. It is a spyware tool developed by a Russian firm, the NSO Group.
2. It is designed to enter a device, gather data and then forward it to a third party, without the consent of the user.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q22. With respect to "Viruses", consider the following statements:

1. Viruses are inert outside the host cell.
2. Viruses are able to generate energy.
3. The main purpose of a virus is to deliver its genome into the host cell to allow its expression by the host cell.

Which of the statements given above is/are correct?

(a) 1 and 3 only (b) 1 and 2 only
(c) 2 only (d) 1, 2 and 3

Q23. Recently, IIT-Hyderabad has created India's first AI-based employment portal for the persons with a disability. What is it called?

(a) Nukarita Portal (b) Shram Divyang
(c) Divyangkari (d) Swarajability

Q24. Which of the following statements are correct regarding the Young Scientist Programme (YUVIKA)?

1. It is launched by ISRO for the Indian University students.
2. The programme's main goal is to teach the students the fundamentals of space technology, science and applications.
3. It is planned that each state/UT picks 3 students to participate in this programme.

Select the correct answer using the code given below:

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Q25. Consider the following statements:

1. In adults, the red blood cells (RBCs) are generated in the red bone marrow.
2. Because of the presence of haemoglobin, leucocytes are often referred to as the RBCs.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q26. Which of the following statements is/are correct regarding the Nuclear Non-Proliferation Treaty (NPT)?

1. The Treaty is the only multilateral treaty that contains a legally enforceable commitment to the aim of nuclear disarmament by the nuclear-weapon states.
2. India is one of the only 5 countries that either did not sign or signed, but later withdrew from the NPT.

Select the correct answer using the code given below:

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q27. Magic Pit, Constructed Wetland and TADOX are the technologies related to which of the following?

(a) Wildlife conservation (b) Plastic waste remediation
(c) Fish farming (d) Wastewater treatment

Q28. Consider the following statements about the Ayushman Bharat Digital Mission:

1. It is implemented by C-DAC, under the Ministry of Electronics and Information Technology.
2. Unique identification number, called ABHA number, is provided to the persons.
3. A registry has been created for the healthcare professionals and health facilities across India.

Which of the statements given above is/are correct?

(a) 2 and 3 only (b) 1 and 3 only
(c) 3 only (d) 1, 2 and 3

Q29. Which of the following is/are the application(s) of Synthetic Biology?

1. Micro-organisms harnessed for bioremediation to clean pollutants from our water, soil and air.
2. Rice modified to produce beta-carotene.
3. Yeast engineered to produce rose oil, as an eco-friendly and sustainable substitute for real roses that the perfumers use to make luxury scents.

Select the correct answer using the code given below:

(a) 1 only (b) 1 and 2 only
(c) 3 only (d) 1, 2 and 3

Q30. Consider the following statements:

1. Gold Nano Particles show various useful properties, like changing colour with changing size of the particles.
2. Gold Nano Particles can enable the room temperature catalyst to break down volatile organic compound in the air.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q31. Consider the following statements:

1. Microgravity is the condition in which the people or the objects appear to be weightless.
2. Gravity becomes weaker with distance and it is possible for a spacecraft to go far enough from the Earth that a person inside would feel very little gravity.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q32. Consider the following statements regarding the LIDAR technology:

1. It is a remote sensing method that uses light in the form of a pulsed laser to develop three-dimensional maps of the surface of the Earth.

2. Satellites are the most commonly used platforms for acquiring LIDAR data over broad areas.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q33. Consider the following statements:

1. Ingenuity is a small robotic solar-powered helicopter that landed on Jupiter.
2. Ingenuity completed the world's first powered extraterrestrial flight.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q34. With reference to the Somatic Cell Nuclear Transfer (SCNT), consider the following statements:

1. The procedure involves implanting a donor nucleus from a somatic (body) cell into an enucleated oocyte (egg cell).
2. The most practical application of the SCNT is in the reproductive cloning of farm animals that have exceptional qualities, such as the ability to produce large quantities of milk.
3. The technique could also be used to revive extinct species.

Which of the statements given above is/are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 3 only (d) 1, 2 and 3

Q35. Which of the following reasons is/are correct regarding Rainbow formation?

1. A rainbow is always formed in a direction same as that of the Sun.
2. Refraction, reflection and dispersion play their role in rainbow formation.

Select the correct answer using the code given below:

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q36. With respect to 'Ribonucleic Acid (RNA)', consider the following statements:

1. It is a linear molecule composed of 4 types of smaller molecules, like adenine (A), cytosine (C), guanine (G) and uracil (U).
2. It employs thymine as a nitrogenous base, in place of the uracil used in DNA.
3. Unlike DNA, RNA is usually single stranded.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) 1 and 3 only (d) 2 and 3 only

Q37. Consider the following statements:

1. Waste materials, like livestock excreta, vegetable waste, domestic waste, sewage waste; straw and eradicated weeds are decomposed in pits as compost.
2. Vermi-compost is prepared by using bacteria and fungi to hasten the process of decomposition of plant and animal refuse.
3. Sun hemp or guar is grown and then mulched into green manure, which helps in enriching the soil in nitrogen and phosphorus.

Which of the statements given above is/are correct?

(a) 3 only (b) 1 and 2 only
(c) 1 and 3 only (d) 2 and 3 only

Q38. 'Xanthium', 'Parthenium' and 'Cyperinus rotundus' are examples of which of the following?

(a) Biofertilizers (b) Herbicides
(c) Viruses (d) Weeds

Q39. 'Apis cerana indica', '(A) dorsata', '(A) florae' and '(A) mellifera' are the varieties of which of the following?

(a) Mangroves
(b) Bees
(c) Primates
(d) Genetically modified variety of mustard

Q40. With respect to "Black hole", consider the following statements:

1. It is an object in the space that is so dense and has such strong gravity that no matter or light can escape its pull.
2. It can be observed with the telescopes that detect the X-rays, light, or other forms of electromagnetic radiation.
3. It was predicted by Einstein's Theory of General Relativity.

Which of the statements given above are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Q41. With respect to "Osmosis", consider the following statements:

1. It is the movement of a solvent across a semi-permeable membrane, towards a lower concentration of solute.

2. Absorption of water by the plant roots is an example of osmosis.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q42. With respect to "Mitochondria", consider the following statements:

1. The outer membrane of mitochondria is deeply folded, while the inner membrane is porous.
2. They release adenosine triphopshate molecules for chemical activities needed for life.
3. They have their own DNA and ribosomes.

Which of the statements given above are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Q43. Which of the following statements is/are correct regarding nuclear fusion-based energy generation?

1. It involves joining lighter nuclei to make a heavier nucleus.
2. It releases a tremendous amount of energy, as the mass of the product is little more than the sum of the masses of the original individual nuclei.

Select the correct answer using the code given below:

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q44. Which of the following statements is/are correct?

1. In a myopic eye, the image of a distant object is formed in front of the retina.
2. Presbyopia is the gradual loss of your eyes' ability to focus on nearby objects.

Select the correct answer using the code given below:

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q45. Which of the following reasons is/are correct regarding the scattering of the sunlight?

1. The longer the radiation travels through atmosphere, the lesser is the scattering.
2. Blueish colour of the sky and reddish colour of the Sun at sunrise and sunset is because of the scattering.

Select the correct answer using the code given below:

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q46. With reference to sex determination in the human beings, consider the following statements:

1. All children inherit an X chromosome from their mother, regardless of whether they are boys or girls.
2. A child who inherits a Y chromosome from her father will be a girl and the one who inherits an X chromosome from him will be a boy.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q47. With respect to the "GSLV Mk-III", consider the following statements:

1. It is a four-stage heavy-lift rocket with an indigenous cryogenic engine.
2. It can carry the satellites weighing more than 4 tonnes to the Geosynchronous Transfer Orbit (GTO).
3. It was the designated launch vehicle for Chandrayaan 2.

Which of the statements given above are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Q48. Consider the following statements:

1. Fly-bys are 'gravity assist' manoeuvres, which enable the interplanetary ships to either gain or lose momentum and modify their orbits around the Sun, without consuming large amounts of fuel.
2. BepiColombo uses them to brake, so that it falls towards the inner solar system.
3. A major focus for BepiColombo is water-ice deposits inside the permanently shaded craters in Mercury's Polar Regions.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 and 3 only
(c) 1 and 2 only (d) 1, 2 and 3

Q49. With respect to the "Stem cells", consider the following statements:

1. Stem cells are basically undifferentiated, primitive cells.
2. These cells do not have the ability of self-renewal.
3. Embryonic stem cell can produce a clone of the entire organism.

Which of the statements given above are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Q50. Consider the following statements:

1. The World Anti-Doping Agency annually updates the List of Prohibited Substances and Methods.
2. National Anti-Doping Agency (NADA) works towards a vision of 'Dope Free' sport in India.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

ANSWER KEY

1.	d	**11.**	b	**21.**	b	**31.**	c	**41.**	b
2.	d	**12.**	b	**22.**	a	**32.**	a	**42.**	b
3.	c	**13.**	d	**23.**	d	**33.**	b	**43.**	a
4.	c	**14.**	c	**24.**	c	**34.**	d	**44.**	c
5.	b	**15.**	c	**25.**	a	**35.**	b	**45.**	b
6.	a	**16.**	d	**26.**	c	**36.**	c	**46.**	a
7.	a	**17.**	a	**27.**	d	**37.**	c	**47.**	b
8.	d	**18.**	a	**28.**	a	**38.**	d	**48.**	d
9.	d	**19.**	b	**29.**	d	**39.**	b	**49.**	c
10.	c	**20.**	a	**30.**	c	**40.**	c	**50.**	c

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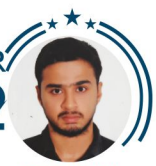
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