



TARGET PRELIMS 2024

BOOKLET-3; S&T-3

NUCLEAR SCIENCE AND TECHNOLOGY

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ACE CSAT
CSAT FOUNDATION COURSE
FOR CSE 2024

LET'S DEVELOP
CRITICAL THINKING

STARTS: 8TH JAN 2024

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**PRELIMS MASTER
PROGRAM** **BATCH 2.0**
FOR CSE PRELIMS 2024



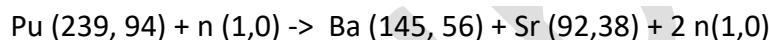
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2. NUCLEAR SCIENCE AND TECHNOLOGY

1) NUCLEAR ENERGY BASICS

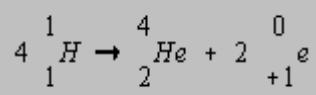
- What is nuclear energy?
 - Nuclear energy is the energy in the nucleus of an atom which is released during nuclear fission or fusion reaction.
 - During these reactions, a small amount of **mass is lost and gets converted** into energy according to Einstein's equation.
 - In **nuclear fission**, the nucleus of a heavy atom (such as uranium, plutonium or thorium), when bombarded with low - energy neutrons, can be split apart into lighter nuclei.
 - When this is done tremendous amount of energy is released, if the mass of the original nucleus is just a little more than the sum of the masses of the individual products.
- E.g. of fission reaction



In a nuclear fission, the difference in mass, Δm , between the original nucleus and the product nuclei gets converted to energy E at a rate governed by the famous equation,
$$E = \Delta m c^2$$
,

first derived by Albert Einstein in 1905, where c is the speed of light in vacuum. In nuclear science, energy is often expressed in units of electron volts (eV): $1 \text{ eV} = 1.602 \times 10^{-19} \text{ joules}$. It is easy to check from the above equation that 1 atomic mass unit (u) is equivalent to about 931 mega electron volts (MeV) of energy.

- E.g. of fusion reaction



- This is one of the common reactions taking place in sun.

2) FUSION REACTION (THERMONUCLEAR REACTIONS)

- **Introduction:**
 - **Fusion** is the energy source of the Sun and Stars.
 - At very high temperature and pressure in the core of the stars, hydrogen nuclei collide and fuse to convert into heavier helium atoms and release **tremendous amount of energy** in the process.
 - What is the **need of extremely high temperature** -> to **overcome the electrical repulsive force**

- Till date we don't have any stable fusion reaction.
 - **Development of thermonuclear energy power plants has been difficult:**
 - **Three conditions must be fulfilled** to achieve fusion in a laboratory:
 - **Very High Temperature** (of the order of 15 million degrees C)
 - **Sufficient Plasma particle density** (to increase the likelihood that collisions do occur)
 - **Sufficient confinement time** (to hold the plasma, which has the propensity to expand, within a defined volume)
- **Note:** Twentieth century fusion science identified the most efficient fusion reaction in the laboratory setting to be reaction between two hydrogen isotopes, deuterium (D) and tritium (T), as the D-T reaction produces the higher energy gain at the "lowest temperatures".
- **Why nuclear fusions are important as an energy source?**
 - Raw material easily available
 - Nuclear Fusion is a clean and green route to produce energy, as it doesn't involve any remnant waste products.
 - Long term energy security

A) USA'S ATTEMPT:

- In Dec 2022, an experiment at US National Ignition Facility (NIF), within the Livermore National Laboratory, Livermore, California, achieved a **fusion ignition** by successfully conducting a fusion test that produced 153% (1.53 gain) as much energy as went into triggering it.
- In July 2023, in a repeat of the above experiment, scientists were able to generate more energy with nearly a factor of 2 in gain compared with energy of the incoming lasers.
- **Types of Fusion Reactions:**
 - For fusion reaction to happen in reactors, the high temperature must be created artificially. There are two different ways of achieving this: **Inertial Confinement Method** and **Magnetic Confinement Method**:
 - 1) **Inertial Confinement Method:** In this method, high energy laser beams are focused onto a pellet of the fuel (D-T), which creates extreme temperatures required for fusion inside it. The outer mass of the pellet explodes and is responsible for confining the reaction.
 - E.g., **The NIF reactions**
 - 2) **Magnetic Confinement Fusion (MCF):** It uses a magnetic field to contain plasma, which prevents the particles from hitting the reactor walls which could otherwise cause them to slow down.
 - **Magnetic confinement** uses a torus-shaped reactor called tokamak, in which a hydrogen plasma is heated to a high temperature and the nuclei are guided by strong magnetic fields to fuse. **ITER** is a famous example of an experiment trying to achieve fusion using magnetic confinement.

- This is the method being used at ITER.

3) Some other variants also exist such as those which use a combination of these methods (Magnetized Target Fusion) and those that combine fission with fusion (**Hybrid Fusion**)

- **The NIF Breakthrough:**

- In Dec 2022, NIF was finally able to achieve ‘break-even’, or a net positive energy gain.
- In July 2023, it was able to replicate its efforts, but now with a bigger gain (almost 2)
- In both these achievements **inertial confinement was employed.**
 - In NIF’s set up, high-power lasers fire pulses at a 2 mm wide capsule inside a 1-cm-long cylinder called **hohlraum**, in less than 10 billionths of a second. The capsule holds deuterium and tritium atoms.
 - As the pulse strikes the hohlraum’s inside, the latter heats up and releases x-rays, which heat the nuclei to millions of degrees centigrade and compress them to **billions of Earth atmosphere**. This technique is called inertial confinement method because the nuclei’s inertia creates a short window between implosion and explosion in which the strong nuclear force dominates, fusing the nuclei.
 - Specifically, when two hydrogen-2 nuclei fuse, they yield a helium-4 nucleus, a neutron and 17.6 MeV of energy.

- **Significance:**

- **Fusion ignition** is one of the most impressive feats of the 21st century and is an engineering marvel beyond belief.

- **Some Caveats:**

- **First:** NIF experiment is highly sophisticated and required very high precision. Even small changes in the experiment may negatively impact the output. So, for long term use, they will have to reproduce these results again and again.
- **Second:** For fusion reaction to be truly gainful, the energy released by the reactions needs to be greater than the energy going into the lasers, about 300 megajoules, and not just the energy delivered to the hohlraum. This hasn’t been achieved yet. The energy transferred to plasma is just 1%, the rest is all lost in other processes. **“Future research will need to focus on reaching the next major milestone – a target gain of G > 100**, which is required to run a power plant efficiently.
- **Third:** The road to a power plant from the NIF’s current achievement isn’t well understood.

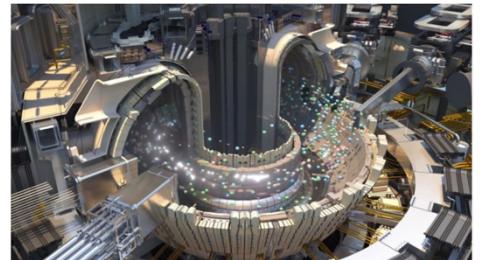
B) ITER (INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR (ITER))

- ITER is an international mega project which is aimed at creating nuclear energy through nuclear fusion reaction.
- **35 countries** are collaborating to build the world’s largest tokamak, a magnetic fusion device that has been designed to prove the feasibility of fusion as a large scale and carbon free source of energy.

- The **primary objective** of the ITER is the investigation and demonstration of burning plasma – plasmas in which the energy of the helium nuclei produced by the fusion reactions is enough to maintain the temperature of plasma, thereby reducing or eliminating the need of external heating.
- **What will ITER do?**
 - » Achieve a deuterium-tritium plasma in which the fusion conditions are sustained mostly by internal fusion heating ("burning plasma").
 - » Generate **500 MW** of fusion power in plasma.
 - » **Demonstration of the integrated operation of technologies** for a fusion power plant (superconducting magnets, remote maintenance, and systems to exhaust power from the plasma)
 - » **Test tritium breeding** – One of the missions for the later stages of ITER operation is to demonstrate the feasibility of producing tritium within the vacuum vessel.
 - » **Demonstrate the safety characteristic of a fusion device.**
 - ITER achieved an important landmark in fusion history when, in 2012, the ITER Organization was licensed as a nuclear operator in France based on the rigorous and impartial examination of its safety files.
 - One of the primary goals of ITER operation is to demonstrate the control of the plasma and the fusion reactions with negligible consequences to the environment.
- **India** is also participating in ITER. PM Modi while participating in the ITER assembly said that the ITER is perfect example of the age-old India belief – **Vasudhaiva Kutumbakam** – the entire world is working together for the betterment of humankind and that India stands proud with its fair share of contributions to the cooling water, cryogenic and cry-distribution systems, auxiliary heating devices using RF and beam technologies.

C) WHAT IS A TOKAMAK:

- The Tokamak is an experimental machine which is designed to harness the energy of a fusion. Inside a tokamak, the energy produced through the fusion of atoms is absorbed as heat in the walls of the vessel. (Heat -> steam -> rotate turbine)
- First developed by Soviet research in the late 1960s, the tokamak has been adopted around the world as the most promising configuration of magnetic fusion device. **ITER will be the world's largest tokamak**—twice the size of the largest machine currently in operation, with ten times the plasma chamber volume.
- **How does Tokamak Work -> Class discussion** (not very important for exam)



D) INDIA AND FUSION

- India has become one of the major players in fusion technology and has been one of the pioneers in its development.
- The **Plasma Physics Program** was initiated by the GoI in 1982 to conduct research at MCF, which later evolved into the **Institute for Plasma Research (IPR)** in 1986 and led to the creation of India's own tokamak, ADITYA, in 1989.

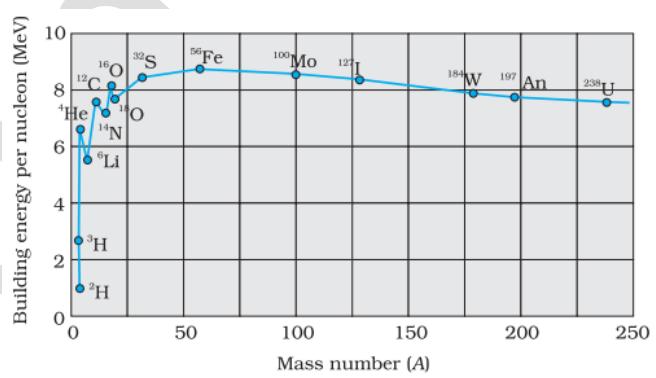
- Subsequently, it also developed a large semi-indigenous tokamak called the **Steady State Superconducting Tokamak (SST-1)** which was fully commissioned in 2013. IPR has also revealed its plans for a successor, the SST-2.
- In 2005, India became the 7th member to join the **International Thermonuclear Experiment Reactor (ITER) project**, a global initiative attempting to build the world's largest tokamak reactor.
 - ITER-India** has been set up under the supervision of IPR and is responsible for fulfilling India's commitment to the project. It has already provided the world's largest cryostat, a vacuum application stainless steel vessel, to house the reactor, along with a host of other equipment.
- Key Limitations for India:**
 - Lack of Private Investment: it is primarily because of Atomic Energy Act, 1962, which puts the brunt of developing and running nuclear power stations on the government.
 - However**, a recent government panel convened by NITI aayog has recommended overturning the ban of foreign investment and allowing greater participation of private players.

3) NUCLEAR BINDING ENERGY

The Nuclear mass M is always less than the mass of neutrons and mass of protons in the nucleus.

This **mass defect** will explain the energy required for breaking a nucleus containing protons and neutrons into individual protons and neutrons.

Similarly, if certain number of neutrons and protons are brought together to form a nucleus of certain charge and mass, an energy E_b will be released in the process. This energy E_b is called the **binding energy of the nucleus (Or Nuclear Binding Energy)**.



4) COMPONENTS OF NUCLEAR POWER REACTOR

Components of Nuclear Fission Reactor

- Fuel:** Uranium is the basic fuel. Usually pallets of **Uranium Oxide (UO_2)** are arranged in tubes to form fuel rods.
- Neutron Source:** In a new reactor with new fuel a neutron source is needed to get the reaction going. Usually this is beryllium mixed with polonium, radium or another alpha emitter. Alpha particles from the decay cause a release of neutrons from the beryllium as it turns to carbon-12. Restarting a reactor with some old fuel may not require this, as there may be enough neutrons to achieve criticality when control rods are removed.
- Moderator:** Material in the core which slows down the neutrons released from fission so that they cause more fission. It is usually water but may be heavy water or graphite.

- **Control Rods:** These are made of neutron absorbing material such as Cadmium, Hafnium or Boron, and are inserted or withdrawn from the core to control the rate of reaction.
- **Coolant:** A fluid circulating through the core so as to transfer the heat from it. In light water reactors, the water moderator functions also as primary coolant. Except in BWRs, there is secondary coolant circuit where the water becomes steam.
- **Steam Generator:** Part of the cooling system of pressurized water reactors (PWRs and PHWRs) where the high-pressure primary coolant bringing heat from the reactor is used to make steam for the turbine, in a secondary circuit.

5) TYPES OF REACTORS

A) BOILING WATER REACTOR

B) PRESSURIZED WATER REACTOR

C) PRESSURIZED HEAVY WATER REACTOR

D) ADVANCED GAS COOLED REACTORS

E) FAST NEUTRON REACTOR (FAST BREEDER REACTOR)

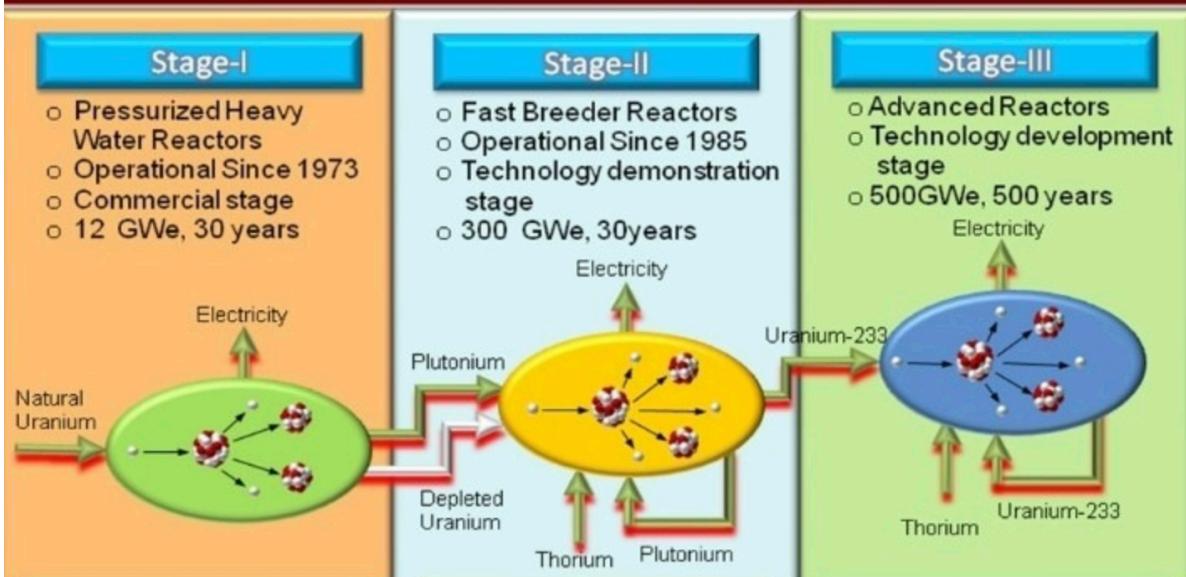
- Some reactors (**only one in commercial service**) do not have a moderator (they use a coolant that is not effective moderator, like liquid sodium). Although these fast neutrons are not good at causing fission, they are readily captured by uranium (U_{238}), which then becomes plutonium (Pu_{239}). This Plutonium isotope can be reprocessed and can be used as more reactor fuel or in the production of nuclear weapons.

- **Advantages:**
 - They get more than 60 times as much energy from the original Uranium compared with normal reactors.
 - Reduction in radioactive waste.
 - Safety -> closed fuel cycle would ensure safety
 - Energy security for India -> India plans third phase of its nuclear energy program on the success of FBR
- **Disadvantage:** Expensive and complicated to build and operate
- **Fast Breeder Reactors** - If FNRs are configured to produce more fissile material (plutonium) than they consume they are called Fast Breeder Reactors (FBR).
 - Breeder reactors are possible because of the proportion of uranium isotopes that exist in nature.
- **Problems associated with fast Breeder reactors / Fast Neutron Reactors**
 - Plutonium produced can be removed and used in nuclear weapons
 - To extract Plutonium the fuel must be reprocessed, creating radioactive waste and potentially high radiation exposure.
- **Use scenario globally**
 - US, UK, France and Germany have effectively shut down their fast breeder reactor plants
 - **India, Russia, Japan and China** currently have operational fast breeder reactor program.

6) INDIA'S 3-STAGE NUCLEAR POWER PROGRAM

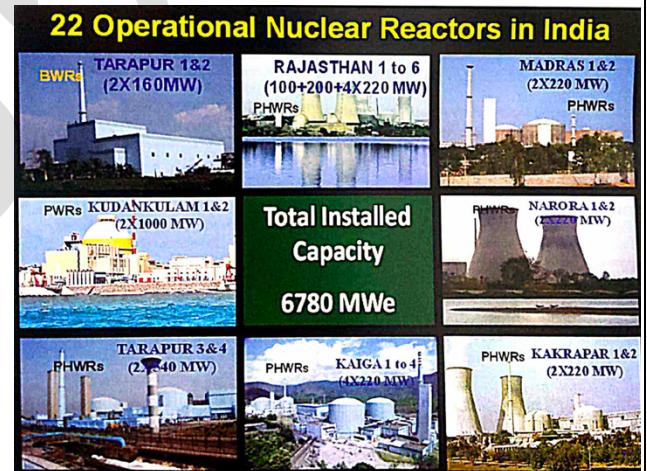
- The three-stage nuclear power production program of India had been conceived by the 'father of Indian Nuclear Power Program' Dr Homi J Bhabha, with the ultimate objective of utilizing the country's vast reserves of thorium-232.
 1. The first stage comprises setting up of **Heavy Water Reactors/Pressurized Heavy Water Reactors (PHWRs)** and associated fuel cycle facilities.
 2. The second stage envisages setting up of **Fast Breeder Reactors (FBRs)** backed by reprocessing plants and plutonium based fuels fabrication plants. Plutonium is produced by irradiation of U-238.
 3. The third stage is based on the thorium-232 -> Uranium 233 Cycle, Uranium-233 is obtained by irradiation of Thorium.

Indian Three Stage Nuclear Power Programme



Progress of the 3 Stages

- The first stage of Nuclear Power Programme is already in commercial domain. The Nuclear Power Corporation of India Ltd. (NPCIL), a public sector undertaking of DAE, is responsible for the design, construction and operation of nuclear reactors. The company presently operates 23 reactors with a capacity of 7.8 GW. In addition, the company is also engaged in construction of many other nuclear power reactors. In addition, 10 nuclear power reactors with a total of 8000 MW capacity are under construction. This include a 500 MW PFBR of the second stage nuclear power program. Further, government has accorded administrative approval and financial sanction of 10 indigenous PHWRs of 700 MW capacity each, to be set up in fleet mode. With completion of these projects, India's nuclear energy capacity is expected to go to 22.4 GW by 2031.



Nuclear power plant	State	Reactor
Tarapur atomic power station	Mha	Taps-1; taps-2 2*160 mw (BWR) Taps-3 and taps-4 (2*540) (phwr)
Rajasthan atomic power station	Rajasthan	Raps-1 to 6 (100 + 200 + 4*220)
Madras atomic power station	Tn	Maps-1; maps-2 (2*220) (phwrs)
Kaiga atomic power station	Karnataka	Kaps-1 to 4

		(4*220) (phwrs)
Kakrapara atomic power station	Gujarat	Kaps-1, kaps 2 (2*220) (phwrs) Kaps-3 (generating electricity from 30th Aug 2023) (700MW) Kaps-4 (attained criticality in Dec 2023)
Kudankulam nuclear power plant	Tn	Kknpp-1; kknpp-2 (2*1000 mw) pwrs
Naora atomic power stations	Uttar pradesh	Naps-1; naps-2 (2*220 mw) (phwrs)

- **Karappar-3** has been generating commercial electricity from 30th Aug 2023.
 - o The 700 MWe units are the largest indigenous nuclear power reactors to be built by the Nuclear Power Cooperation of India (NPCIL), a public sector undertaking of the Department of Atomic Energy (DAE)
- **Kakrapar-4 (KAPP-4)**, with 700 MWe capacity, started controlled chain reaction and thus became critical in Dec 2023.
- Both these reactors are PHWRs, which use natural Uranium as fuel and heavy water as coolant.

- **The Second Stage** of Nuclear power generation programme is geared towards setting up the Fast Breeder Reactors. These reactors produce more fuel than they consume. The fast breeder program is in technology demonstration stage.

▪ **Features of the Prototype Fast Breeder Reactor (PFBR)**

- **Fuel:** Plutonium Uranium Oxide (PuO_2 and UO_2)
- **Coolant:** Liquid Sodium
- **Liquid Sodium additional safety requirements**
 - o Since sodium explodes if it comes in contact with water and burns when in contacts with air, additional safety requirements are needed to isolate the coolant from the environment.
 - o Sodium also absorbs neutron to form Radioactive Na²⁴ isotope.

- **Advantages of FBR:**

- They can ensure upto 60 times as much energy from the original Uranium compared with normal reactors.
- Reduction in radioactive waste.
- Safety -> closed fuel cycle would ensure safety
- Energy security for India -> India plans third phase of its nuclear energy program on the success of FBR

- **The Third Stage:** of the Nuclear Power Programme is in **technology development stage**.
 - The ongoing development of 300 MWe Advanced Heavy Water Reactor (AHWR) at BARC aims at developing expertise for thorium utilization and demonstrating advanced safety concepts.
 - Thorium-based systems such as AHWR can be set up on commercial scale only after a large capacity based on fast breeder reactors, is built up.
 - Why Thorium based reactors are important for us
 - i. **Abundance:** India has the world's third largest reserve of thorium.
 - ii. **Less Enrichment requirement:** Thorium mining produces a single pure isotope, whereas the mixture of natural uranium isotope must be enriched to function.
 - iii. **Superior Nuclear Properties:** Superior physical and nuclear properties
 - iv. **Better Nuclear weapon resistant:** Better resistance to nuclear weapon proliferation
 - Weapon grade fissionable material (U-233) is harder to retrieve safely from a thorium reactor. It contains U-232, a strong source of gamma radiation that makes it difficult to work with. Further, its daughter product, thallium-208, is equally difficult to handle and easy to detect.
 - v. Reduced plutonium and actinide production. They have minuscule long lived radioactive waste.

7) THORIUM RESERVES IN INDIA

- As per the Department of Atomic Energy, India has reserves of thorium in sufficient quantity as compared to other parts of the world.
- As of 2014, the Atomic Mineral Directorate for Exploration and Research (AMD), a constituent unit of Department of Atomic Energy (DAE), has so far established 11.93 million tonnes of in situ resource Monazite (Thorium bearing mineral) in the country which contains about 1.07 million tonnes of thorium.
- **The state-wise details of the Monazite resources** (as of March 2021, as per Department of Atomic Energy):
 - » **Total: 12.73 million tonnes of Monazite** (More than 1 million tonnes of thorium in it)

State	No of Deposits	Resource (million tonne)	
		Monazite	Total Heavy Minerals
Odisha	12	3.16	332.44
Andhra Pradesh	24	3.78	333.45
Tamil Nadu	50	2.47	298.42
Kerala	35	1.84	242.88
Maharashtra	5	0.004	5.64
Gujarat	2	0.07	12.53
West Bengal	1	1.20	5.45
Jharkhand	1	0.21	1.12
Total	130	12.73	1,231.93

8) OTHER IMPORTANT ASPECTS

- Why most of the nuclear power plants are situated near the coast?

- India's n-facilities under IAEA's umbrella (Dec, 2014)
 - Paving the way for import of fuels for its nuclear reactors, India has completed the process of placing its civilian reactors under IAEA safeguards.
 - The reactors under the IAEA's umbrella are eligible to use imported uranium.
 - **Need of placing reactors under IAEA safeguards**
 - Enable India to use international fuel for civilian reactors.
 - A deal was signed under which India was to sign and ratify the Additional Protocol of the IAEA. A separation plan was chalked out after the deal, segregating the military and civilian reactors.

9) NUCLEAR WASTE MANAGEMENT

- Global Endeavours for Nuclear Waste Management:
 - » **On Site Storing:** Some nations go for onsite storing. But it carries the risk of radioactive leakage.
 - » In USA, for e.g., spent fuel is stored in a concrete and steel container called a dry cask.
 - » **India and a few other countries,** reprocess about 97-98% of spent fuel to recover plutonium and uranium. India also recovers materials like caesium, strontium, and ruthenium, which finds application as blood irradiators to screen transfusions, cancer treatment, and eye cancer therapeutics, respectively. The remaining 1-3% end up in storage facilities. India also immobilizes the wastes by mixing them with glass, which is kept under surveillance in storage facilities.
 - » **Deep geological Repositories:** Nations like Finland, Canada, France and Sweden are looking at deep geological repositories to tackle spent nuclear fuel wastes.
 - In Jan 2022, the Swedish government greenlit an underground repository for nuclear waste. Construction in Sweden will take at least 10 years.
 - » **About Onkalo Spent Nuclear Fuel Repository:** It is a deep geological repository for the final disposal of spent nuclear fuel. It will be world's first long-term disposal facility for spent fuel.
 - **Is geological repository safe?**
 - Experts associated with the project said that 40 years of theoretical and lab-based studies suggest that the geological repository is safe.
 - The bedrock provides a natural barrier to protect from radioactive release to the environment, such as water bodies and air.
 - The use of copper and clay provides a protective layer to ensure no release due to extreme conditions like earthquakes.

A) FUKUSHIMA AND THE ISSUE OF ITS WASTE DISPOSAL

- Why in news?
 - » In Aug 2023, in spite of backlash from public and neighbouring countries, Japan began the release of contaminated water from the Fukushima nuclear plant into the sea (Aug 2023)

- **Project to decommission the facility:**
 - » The decommissioning project got cabinet's approval in 2021 and could take three decades to complete. It will cost \$76 billion. Under this Japan plans to start flushing 1.2 million tonnes of water from the embattled nuclear power plant into the Pacific Ocean.
- » **Issue of water disposal into the Pacific Ocean:**
 - The water that the Japanese government wants to flush from the plant was used to cool the reactor, plus rainwater and groundwater. It contains radioactive isotope from the damaged reactor and is thus itself radioactive. Japan has said that it will release this water into Pacific over the next 30 years.
 - **Why release water in ocean?**
 - TEPCO is running out of room for the water tanks and that nuclear plants around the world regularly release water containing trace number of radionuclides into large water bodies.
 - **How was the water treated?**
 - The Tokyo Electric Power Cooperation (TEPCO) has treated the water using multiple techniques, notably the Advanced Liquid Processing System (ALPS), which removes 62 types of radioactive material.
- » **CONCERNS:**
 - ALPS technique doesn't remove Tritium which can be easily absorbed by the bodies of living creatures and rapidly distributed via blood. Removing tritium is quite impossible as it is chemically similar to Hydrogen. Since tritiated water can pass through the placenta, it could lead to developmental effects in babies when ingested by pregnant women.
 - Though Japanese government argue that the concentration of tritium doesn't exceed international standards, in particular, those of IAEA. It is six times less than the limit of tritium in drinking water.
 - As per TEPCO, the radiation emitted by Tritium is "extremely weak, and can be blocked with a single sheet of paper".
 - There is no safe limit of radionuclide and any number of radionuclides in water will increase the risk of cancer.
 - **Neighbouring countries** like China, South Korea and Taiwan have also expressed concerns over Japan's Plan

10) CLND, 2010

- This act has been deemed responsible for Nuclear energy deadlock within the country. The two most contentious have been **Section 17(b) and Section (46)**

- **Section 17(b)** : It contains provisions on **recourse liability on suppliers**. This allows a liable operator to recover compensation from a supplier in case the accident was caused by provisions of sub-standard services or defective or faulty equipment.
- **Section 46:** **Potentially unlimited liability** under this section. Section 46 provides that *nothing would prevent proceedings other than those which can be brought under the act, to be brought against the operator*. This is not uncommon as it allows criminal liability to be pursued where applicable.

11) NUCLEAR BOMB:

Basic Raw material for atomic bomb

- An atomic bomb can be made from two types of radioactive materials: Uranium and Plutonium. In both cases, the manufacturing starts with Uranium ore.
- **Highly enriched U-235** (more than 90%) and no control rod to extract neutrons.
 - **Uranium** mined from earth is less than 1% U-235, the isotope that can be used to fuel reactors and make bombs. Centrifuges are needed to separate the U-235 from the rest of the Uranium, in a process called **Enrichment**. **Bomb grade Uranium 90% U-235**.
 - The Other fuel that can be used to make a bomb, **plutonium**, is made by irradiating uranium in a nuclear reactor. The process transforms some of the Uranium into Plutonium.

A) UNDERESTIMATED FALLOUT OF THE TRINITY NUCLEAR TEST: NEW STUDY (JULY 2023)

- On 16th July 1945, in a nuclear test code named “**Trinity**”, a plutonium-based implosion device was set off a 100-foot metal tower. The irradiated mushroom cloud also went many times higher into the atmosphere than expected – Some 50,000 to 70,000 feet.
- **New Findings:** Using state of art modelling software and recently uncovered historical weather data, the study found that radioactive fallout from the Trinity test reached 46 states, Canada and Mexico within 10 days of detonation. How much of the fallout still remains is difficult to calculate.

B) J ROBERT OPPENHEIMER: FATHER OF ATOM BOMB

- **Why in news?**
 - » Christopher Nolan’s new film on the American Physicist who built most destructive weapon known to man was released on 21st July 2023.
- **J Robert Oppenheimer** (1904-1967) was an American physicist and one of the most prominent scientists of 20th century. He is best known for his role as the scientific director of the Manhattan Project, the top-secret US government program during WW-II that led to the development of the first atomic bomb.
- **Education:** He was born in 1904, in New York City. He attended Harvard University and studied Physics there. He completed his PhD in theoretical physics at University of Gottingen in Germany under the supervision of Max Born in 1927. Later he returned to USA, and taught in University of California,

Berkely, and the California Institute of Technology (Caltech). He made significant contribution to physics, especially in the area of quantum mechanics and quantum field theory, earning him the recognition as one of the leading theoretical physicists of his time.

- In 1942, he was appointed as the scientific director of the Manhattan Project. He played a crucial role in organizing and coordinating the efforts of various scientists and engineers to develop an atomic bomb. The project resulted in successful detonation of the first atomic bomb on 16th July 1945, in the New Mexico desert, in an area known as the Trinity Test Site.
- The use of Atomic Bomb over Hiroshima and Nagasaki in Aug 1945 led to the end of WW-II and raised profound ethical and moral questions about the use of nuclear weapons. Oppenheimer was deeply affected by the destruction caused by the bombs and became an advocate for arms control and international cooperation in the peaceful use of atomic energy.
- His political views and opposition to nuclear weapons led to him coming under scrutiny during the era of McCarthyism and the Red Scare. In 1954, his security clearances were removed, and he was also ostracized from the scientific community.
- Inspite of these controversies, he continued serving at Princeton from 1947 – 1966. In 1963, he received the Enrico Fermi Award, one of the highest honors in the field of nuclear science.
- He passed away in 1967, leaving behind a complex legacy of a brilliant physicist and a controversial figure in American History.

It was only in 2022, that the US government nullified its 1954 decisions, and affirmed his loyalty. President Joe Biden's Energy Secretary, Jennifer M Granholm, said the decision to revoke Oppenheimer's clearance was the result of a "flawed process", and that with time more evidence of his loyalty and love of country have only been further affirmed.

12) NUCLEAR ENERGY AND ENERGY SECURITY

- **Introduction:**
 - » Energy security means consistent availability of sufficient energy in various forms at affordable prices. When a country moves ahead on the path of development, it is necessary to utilize every energy resource available in the country.
 - » Currently, nuclear energy makes up about 3% of India's energy sources
- **Advantages of Nuclear Energy:**
 - a) Least carbon footprint (lesser than renewable energy)
 - b) Cost of nuclear power
 - c) Quantity of waste generated is also very less
 - d) Potential of self sufficiency
 - e) Depleting fossil fuels and import dependency: India is currently drawing around 63% of its total energy from thermal sources. A significant part of this is imported.

f) Limitations of Renewable Energy

- Renewable energy are subject to vagaries of weather; they are land intensive; dependence on import technology; energy storage handicaps;
 - Renewable energy is inevitable and nuclear option should be retained as insurance.

» Limitations

- a) Safety concerns in light of recent disasters
 - b) Nuclear waste disposal is a big concern
 - c) Potential of developing nuclear weapons
 - d) Security concerns
 - e) India is dependent on other countries both for raw material and technology
 - f) Ecological concerns
 - g) Long gestation period
 - h) More safeguards -> more costly

13) RADIOACTIVITY BASICS

▪ Introduction

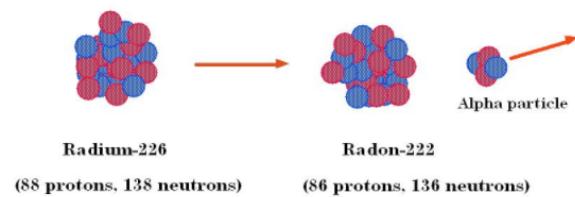
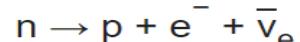
- Radioactivity is the tendency of unstable nuclei to emit particles in order to bring it closer to stability. There are four main types of radioactivity.

1. **Alpha Radiation:** The emission of a Helium nucleus.

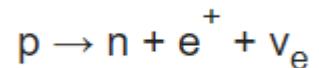
Alpha radiation is common when the nuclides of high atomic mass have a **lower neutron to proton ratio** than stable nuclide and ejects an alpha particle.

2. **Beta Minus (plus) radiation**: the emission of a high energy electron (or positron) from the nucleus.

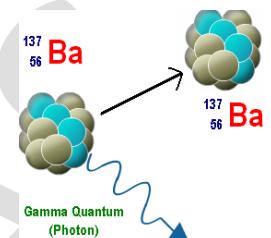
- Generally, an unstable atomic nucleus with an excess neutron undergo **Beta (-) decay**, where a neutron is converted into a proton, an electron and an electron anti-neutrino (the antiparticle of the neutrino).



- An unstable atomic nucleus with an excess of protons may undergo beta (+) decay, also called **positron decay**, where a proton is converted into a neutron, a positron, and an electron neutrino.



- Gamma Radiation:** These are penetrating electromagnetic radiation of a kind arising from radioactive decay of atomic nuclei.



- The decay of an atomic nucleus from a high energy state to a lower energy state, a process called gamma decay, produces gamma radiation.
- Gamma rays ionize atoms, and are thus biologically hazardous.

- Neutron Radiation:** It is a kind of ionizing radiation that consists of free neutrons.

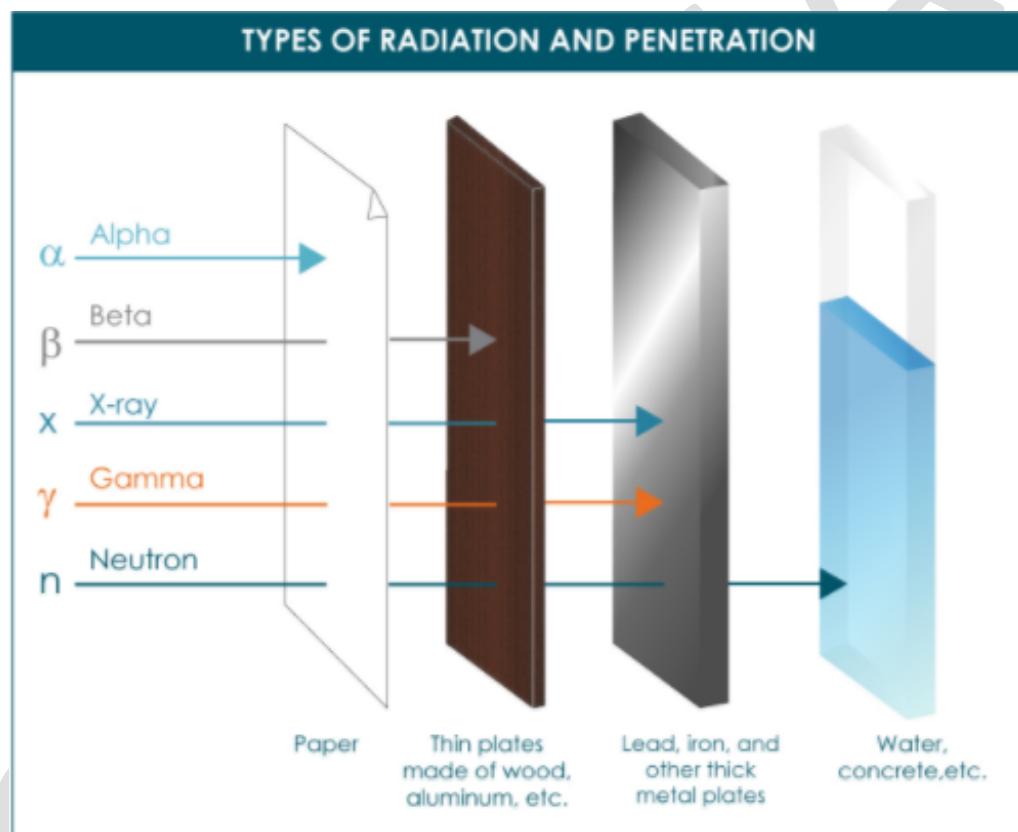
- This is generally a result of nuclear fusion and nuclear fission reaction.

- These particles (Alpha, Beta and Gamma) are available at an extremely low level in nature. Moderate to high rates of exposure to these particles can be severely detrimental to organic tissues and the life threatening to humans and rest of the ecosystem.

- Radiation can be ionizing or non-ionizing**, depending on how it affects matter.

- **Non-ionizing radiation** includes visible light, heat, radar, microwaves, and radio waves. This type of radiation deposits energy in the material through which it passes, but it doesn't have sufficient energy to break molecular bonds or remove electrons from atoms.
- **Ionizing Radiation** (such as x-rays and cosmic rays) is more energetic than non-ionizing radiation.
 - When ionizing radiation passes through material, it deposits enough energy to break molecular bonds and displace (or remove) electrons from atoms. This electron displacement creates two electrically charged particles (ions), which may cause changes in the cells of plants, animals, and people.
 - Ionizing radiation can be used for a number of beneficial purposes.

- For e.g. ionizing radiations are used in smoke detectors, medical purposes, etc.
- **Level of penetration of various ionizing radiations** (see the adjacent figure)
- **Sources of Radioactivity**
 - Minerals containing naturally radioactive elements (potassium, radium, uranium, thorium...)
 - Background cosmic rays
 - Solar Flux



- Nuclear power plants and nuclear fuel cycle plants
- Old Equipment (e.g. watches and clocks having radio luminescent paints) (radium, tritium)
- Nuclear labs
- Radioactive waste
- Nuclear Medicines
- Nuclear Bomb testing
- Radon gas

14) RADIOACTIVE DECAY

- Radioactive decay is the process through which radioisotopes lose their radioactivity over time. This gradual loss of radioactivity is measured in half-lives.
- **Law of Radioactive Decay:**
 - In any radioactive sample, which undergoes α , β or γ -decay, it is found that the number of nuclei undergoing the decay per unit time is proportional to the total number of nuclei in the sample. If N is the number of nuclei in the sample and ΔN undergo decay in time Δt then
 - $\Delta N / \Delta t \propto N$
or, $\Delta N / \Delta t = \lambda N$
- The **activity of a radioactive nucleus** (the rate of decay with time) can be described by the following equation:

$$A = \frac{dN}{dt} = -\lambda N$$

where λ is the 'decay' constant of the process in the equation.

- The **half-life** of a radioactive material is the time it takes one-half of the atoms of a radioisotope to decay by emitting radiation.
 $T_{1/2} = \frac{\ln 2}{\lambda}$ (note: $\ln 2=0.6931$)
 - The half-life of different elements can range from fractions of a second (for radon-220) to millions of years (for thorium 232).
 - **Note:** Half Life of Carbon-14 is **5,730** years.

15) RADIO-CARBON DATING

- Radiocarbon dating is a method by which age of an object is determined using radiocarbon, a name for the isotope Carbon-14.
- **How is Carbon-14 formed?**
 - It is created in the earth's atmosphere when cosmic rays – energetic streams of charged particles coming from sources in outer-space – slam into the atoms of the gases and release neutrons. When these neutrons interact with the nitrogen-14 nitrogen isotope, they can produce carbon-14. Since cosmic rays are constantly passing through earth's atmosphere, the carbon-14 is getting constantly created.
 - Carbon-14 readily combines with atmospheric oxygen to form radioactive CO₂ which enter the bodies of plants (during photosynthesis), animals (when they consume plants), and other biomass through the carbon cycle.
 - **Two key things which makes carbon-14 dating accurate:**

- The concentration of carbon-14 in the earth's atmosphere doesn't change across thousands of years. (if this wasn't true than radiocarbon dating – which dates organic materials by measuring the amount of carbon-14 they contain-wouldn't work).
- Carbon-14, in the form of carbondioxide and other carbon compounds, would have to be able to diffuse into the earth's various ecosystems such that the concentration of carbon-14 in the atmosphere was comparable to the concentration of carbon-14 in the planet's other biospheres.

- How does radiocarbon dating work?

- When an organism is alive, it constantly exchanges carbon with its surrounding by breathing, consuming food, defecating, shedding skin etc. Through these activities, carbon-14 is both lost and replenished in the body, so its concentration in the body is nearly constant and in equilibrium with its surrounding.
 - When the living organism dies, the C-14 is not replenished and it begins to reduce due to radioactive decay.
 - Radiocarbon dating dates an object by measuring amount of C-14 left, which scientists can use to calculate how long ago the body expired.
- Note: Since carbon-14 decays with a half-life of around 5,730 years, its presence can be used to date samples that are around 60 millennia old (i.e. 60,000 years old). Beyond that, the concentration of carbon-14 in the sample would have declined by more than 99%.

- Tools of Radiocarbon dating:

- Geiger Counter was used in 1940s when radiocarbon dating began. It consists of a Geiger-Muller tube connected to some electronics that interpret and display signals.
 - The Geiger-Muller tube contains a noble gas, such as helium or neon, and a rod passing through the centre. A high voltage is maintained between the tube's inner surface and the rod. The gas is insulating, so no current can pass between the two. But when energetic particles (including gamma radiation), such as those emitted during radioactive decay, pass through the gas, they can energize electrons in the gas's atoms and produce an electric discharge. The persistent voltage could also encourage these electrons to knock off electrons in more atoms, producing a bigger discharge (called the Townsend discharge). This electric signal is relayed to the electronics, where, say, a light may come on in response, indicating that radioactive decay is happening nearby.
- Today, more sophisticated devices are used. For e.g., one of the most sensitive dating setups uses accelerator mass spectrometry (AMS), which can work with organic samples as little as 50 mg.
 - Mass spectrometry is used to isolate ions that have the same mass-to-charge ratio. They begin with a sample – for e.g. a piece of bone – bombard it with electrons to ionize the atoms. Then they subject ions to different physical conditions that cause them to separate according to their mass-to-charge ratio.
 - For e.g. when deflected by electric or magnetic fields – Ions with different mass-to-charge ratios are deflected to different extents.

- **Impact of Radio-carbon dating on science and technology:** It was the first objective dating method to give numerical date to organic matter. Its impact on the field of archaeology and geology have come to be known as “**radiocarbon revolution**”

16) USE OF NUCLEAR RADIATION TECHNOLOGY FOR PROVIDING BETTER QUALITY OF LIFE TO ITS CITIZENS

1. Health: Care to Cure

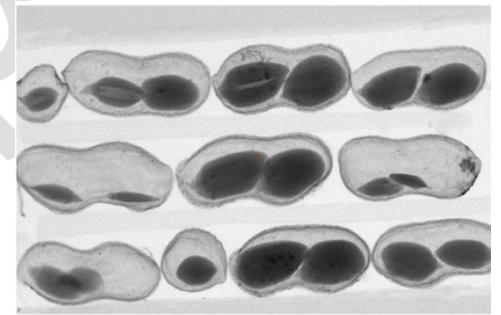
- Healthcare has grown into one of the most important peaceful uses of nuclear energy.
- **Nuclear Medicine - Diagnosis**
 - Radio pharmaceuticals can be administered by injection, inhalation, or orally and selectively localized and retained at sites of diseases. And thus, allow an image to be obtained of the loci using gamma scintigraphy or to deliver cytotoxic dose of radiation to specific disease sites without adversely affecting the surrounding normal tissues.
 - They help in identification of abnormalities in organ function even in early stages of a disease.
- **Radiation Therapy**
 - A treatment that involve use of high-energy radiation either by using special machines or from radioactive substance. The aim is to impart specific amount of radiation at tumours or parts of the body to destroy the malignant cells.
 - 1. **External Beam Radiation Therapy / teletherapy**
 - Radiation is delivered by using a machine outside the body.
 - A machine, either a ^{60}Co -teletherapy unit or linear accelerator is used
 - It can be used to treat Breast Cancer, Bowel Cancer, Head and Neck Cancer and Lung Cancer.
 - **Bhabatron** is a teletherapy machine developed by BARC and has been installed in 50 cancer hospitals.
 - It is cheaper than any imported telecobalt machine.
 - 2. **Internal Radiation Therapy or brachytherapy**
 - Radioactive material is placed in the body near cancer cells.
 - It makes it possible to treat a cancer with a larger dose of radiation that can't be given with external beam radiation therapy.

- Tiny titanium encapsulated Iodine-125 seeds have been developed by BARC and have provided an avenue to treat eye cancer.
2. **Food Security (1. Nuclear Agriculture 2. Food Preservation 3. Assessing the quality of output)**
- Use of ionizing radiation based technologies provide **safe hygienic and economically viable** solutions to address issue of agricultural productivity
1. **Nuclear Agriculture**
- Ionizing radiation is being used by BARC to induce mutation in plant breeding, and 42 varieties of different crops have been released to Indian farmers for commercial cultivation in the country.
 - e.g. groundnuts, mungbean, blackgram, pigeon pea, cowpea, mustard etc.
 - Advantages
 - Higher yield
 - Earliness
 - Large seed size
 - Resistance to biotic and abiotic stress
2. **Food Preservation - Produce and Preserve**
- Almost 30% of the food produced in India is lost due to spoilage because of pest attack, contamination and moulds infestation. These are encountered both during harvesting as well as post-harvest handling storage of the edible and cash crops.
 - **Limitation of using pesticides**
 - Health hazards
 - Disturbance to ecology
 - Development of resistance in pest
 - **Radiation Processing** can provide a viable, effective, and eco-friendly alternative to chemical fumigants and microbial decontamination, as the latter affect human health and environment adversely.
 - There is an utmost need to adopt and integrate the irradiated foods into the country's supply chains and promote the widespread use of this technology to ensure food safety and security.
 - **Advantages of using radiation processing**

- Disinfestation of insects, pests in cereals, pulses and grain.
- Microbial decontamination (hygienization) of dry species etc. for preservation/shelf life extension by applying pre-determined radiation doses.
- Increasing the exportability of Indian food produce.
- Elimination of parasites and pathogens of public health importance in food
- Delay in ripening and senescence in fruits and vegetables
- Inhibition of sprouting in tubers, bulbs and rhizomes
- **Radiation in no ways make production radioactive.**
 - Radiation therapy has been approved by WHO, IAEA, WTO, FSSAI etc.
 - As per the Department of Atomic Energy, as of Dec 2022, there are 25 irradiation facilities operational in the country in private, semi-government and government sector for food preservation.

3. X-Rays to assess the quality of food crops:

- Portable X-Ray imaging system can be very useful in grain value chains where the time needed to assess the economic value of grain by threshing or milling is a significant barrier.
 - » For e.g., a team comprised of scientists from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad and the Fraunhofer Development Center for X-Ray Technology (EZRT) in Erlangen, Germany have for the first time used x-Ray radiography to determine key market-related traits of peanuts while still inside the hull. (Sep 2022)
- X-Ray Radiography has the potential to be the right technology for in-field evaluation of farmers' produce which the International Committee for Food Value and Safety calls for.



3. Energy Security - Nuclear is Clean and Green

4. Societal Application: Sludge Hygenisation - from waste to wealth

5. Hydrogel - Healing the wound

- The process was developed by BARC scientists and technologically has been transferred for commercial purpose.

- Hydrogel is a thin transparent sheet of gel and is an excellent medical tool particularly useful for burn and injury dressings.
- **Production**
 - It is prepared by cross linking molecules of hydrophilic polymers like PVA either chemically or by Gamma/Electron beam irradiation.
 - A 3D network of gel like structure is formed which holds large quantities of water. Gamma Irradiation achieves gel formation and sterilization in one step.

6. Water Resources

1. Isotope Hydrology techniques
2. Measuring contaminants in water

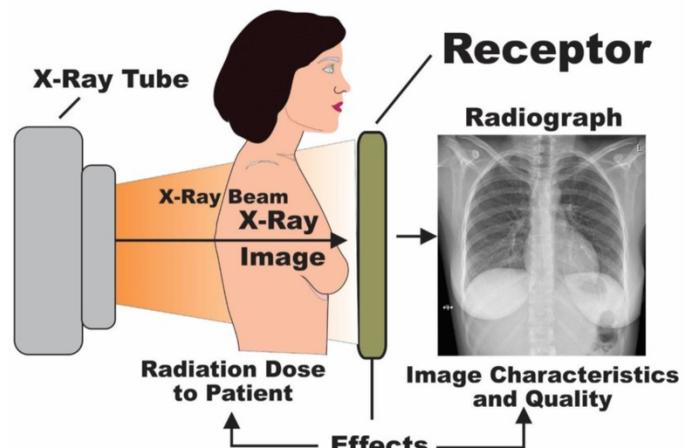
7. Industrial Applications

1. Radiation Sterilization of Medical Products
2. Radiography

- Radioisotopes which emit gamma rays are more portable than x-ray machines, and may give higher-energy radiation, which can be used to check welds of new gas and oil pipeline systems, with the radioactive source being placed inside the pipe and the film outside the weld.
- Radiography can also be used to gauge the thickness and density of materials or locate components that are not visible to other means.

1) X-RAY RADIOGRAPHY

- **X-Ray Radiography:** X-Ray radiography uses very small amount of ionizing radiation to produce pictures of the body's internal structure. These are amongst the oldest and most frequently used form of medical imaging. They are often used to help diagnosed fractured bones, look for injury or infection and to locate foreign objects in soft tissues.
 - » **How does it function?** During a radiographic procedure, an x-Ray beam is passed through the body. A portion of the X-Rays are absorbed or scattered by the internal



structures and remaining x-ray pattern is transmitted to a detector so that an image may be recorded for later evaluation.

- **Tomography:** It is any x-Ray technique in which shadows of superimposed structures are blurred out by moving x-Ray tube. Computational Tomography (also known as CAT Scanning), provides cross sectional imaging.
- **Details of Computerized Tomography (CT) Scan:** It combines a series of X-Ray images taken from different angles around your body and uses computational processing to create a cross-sectional image (slices) of the bones, blood vessels, and soft tissues inside your body. CT Scan can provide more detailed information than plain X-rays do.
- **Applications:** CT scan has many applications, but it is particularly suitable for quickly examining people who may have internal injuries from car accidents or other types of traumas.
- **Risks:** During a CT scan amount of radiation is greater than what you would get during a plain X-ray because the CT scan gathers more detailed information. The low doses of radiation in CT-Scan have not been shown to cause long-term harm, although at higher doses, there may be a small increase in your potential risk of cancer.

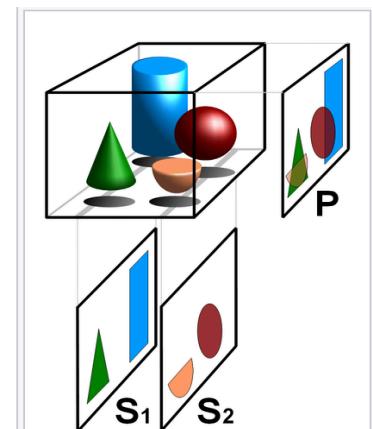


Fig.1: Basic principle of tomography: superposition free tomographic cross sections S_1 and S_2 compared with the (not tomographic) projected image P

A) CT SCANS ASSOCIATED WITH INCREASED RISK OF BLOOD CANCERS (DEC 2023: SOURCE – TH)

- **Radiation doses** at moderate (over 100 mGy) to high (over 1 Gy) values are known to cause hematological malignancies (blood cancers) in both children and adults and other cancers. However, there is uncertainty about risk at low doses (less than 100 mGy) that are typically associated with diagnostic CT examinations. A recent study published in Nature Medicine, (Nov 2023) suggests that even low doses of radiation have a small probability to cause blood cancer.
- **Analysis:** The results strengthened the body of evidence of increased cancer risk at low radiation doses and highlight the need for continued justification of pediatric CT examinations and optimization of doses.
- **Note:** gray (Gy) is the unit of ionizing radiation dose in the International System of Units (SI), defined as the absorption of one joule of radiation per Kg of matter. It measures the energy deposited by ionizing radiation in a unit mass of matter being irradiate and is used for measuring the delivered dose in radiotherapy, food irradiation, and radiation sterilization.

3. PYQS

1	In which one of the following areas did the Indira Gandhi Centre for Atomic Research make significant progress in the year 2005? [Prelims 2006] (a) Reprocessing the uranium-plutonium mixed carbide fuel of the Fast Breeder Test Reactor (b) New applications of radioisotopes in metallurgy (c) A new technology for the production of heavy water (d) A new technology for high level nuclear waste management
2	In which one of the following locations is the ITER project to be built? [Prelims 2008] A. Northern Spain B. Southern France C. Eastern Germany D. Southern Italy
3	To meet its rapidly growing energy demand, some opine that India should pursue research and development on thorium as the future fuel of nuclear energy. In this context, what advantage does thorium has over Uranium? [Prelims 2012] 1. Thorium is far more abundant in nature than Uranium. 2. On the basis of per unit mass of mined mineral, thorium can generate more energy compared to natural Uranium. 3. Thorium produces less harmful waste compared to Uranium. Which of the statements given above is/are correct? A. 1 only B. 2 and 3 only C. 1 and 3 only D. 1, 2 and 3
4	India is an important member of the ' International Thermonuclear Reactor '. If this experiment succeeds, what is the immediate advantage of India? [Prelims 2016] A. It can use thorium in place of Uranium for power generation. B. It can attain global role in satellite navigation. C. It can drastically improve the efficiency of its fission reactors in power generation. D. It can build fusion reactors for power generation.
5	In India, why are some of the nuclear reactors kept under "IAEA Safeguards" while other are not? [Prelims 2020] (a) Some use uranium and others use thorium (b) Some use imported uranium and others use domestic supplies (c) Some are operated by foreign enterprises and others are operated by domestic enterprises (d) Some are state owned, and others are privately owned



TARGET PRELIMS 2024

BOOKLET-4; S&T-4

COMPUTER, IT: AI, ML, CHATGPT ETC.

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2. ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

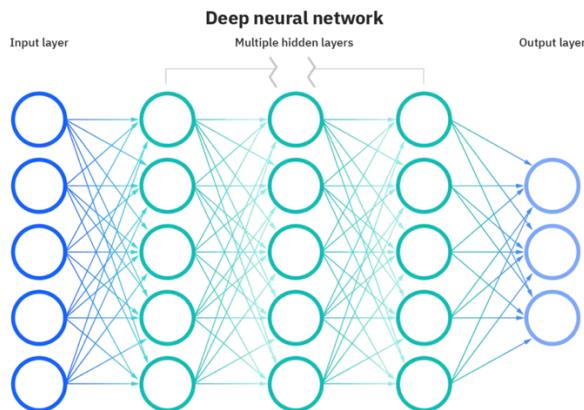
- » Intro
 - Artificial Intelligence is the science and engineering of making intelligent machines, especially intelligent computer programs which can complete tasks that typically require human intelligence.
 - » With the **explosion of available data and expansion of computing capacity**, the world is witnessing rapid advancements in AI, ML, and deep learning.
 - Machine learning is a science that involves **development of self-learning algorithms**. Machine learning uses statistics (mostly inferential statistics) to develop self-learning algorithm. It is a type of artificial intelligence.
 - » **Note:** All Machine Learning is AI, but not all AI is machine learning
 - » For e.g., symbolic logic (rules engines, expert systems, and knowledge graphs) as well as evolutionary algorithms and Bayesian statistics could all be described as AI, and none of them are machine learning.
 - » In Machine Learning the computer program should learn from experience "i.e., given data" such that the overall performance on doing a certain task increase.
 - i. Input data
 - ii. Model Training
 - iii. Output
- Applications of Artificial Intelligence and Machine Learning
 - Advertisements, Online shopping suggestions etc.
 - Spam filtering
 - Search engines
 - Fighting Black Money (e.g., Project Insight of India)
 - Space Exploration (e.g., identifying exoplanets from pictures)
 - Health Sector:
 - **Diagnosis:** E.g., a Bengaluru based startup has developed a non-invasive, AI-enabled technology to screen for early signs of breast cancer.
 - **Treatment:** AI powered Clinical Decision Support (CDS) tools can aid in developing appropriate and accurate diagnostic and treatment recommendations. E.g. Apollo hospital has launched Apollo Clinical Intelligence Engine, a CDS, open to use by all Indian doctors.
 - **Supply chain resilience:** By accurately predicting the demand and supply for medicines.
 - **Development of new Medicines/Molecules** – For e.g. AI can help in identifying and studying new molecules.
 - **Improvement in Governance:** E.g. For **COVID-19**, AI enabled chatbot was used by MyGov for ensuring communications.
 - Developing new materials (E.g. Google Deepmind predicted the structures of 2 million new materials)
 - Education (e.g., Personalized learning through adaptive tools; customizing professional development courses etc.)
 - Agriculture Sector:

- Tech like image recognition, drones etc can help farmers kill weeds more effectively to increase productivity.
- **Efficient resource utilization** – AI enabled solution for water management crop insurance etc are also being developed.
- **AI Powered decision making:** For e.g: ICRISAT has developed an **AI-power sowing app**, which utilises weather models and data on local crop yield and rainfall to predict and advise local farmers on when they should plant their seeds more accurately.
- **AI4AI (AI for Agriculture Innovation)** initiative has been launched by the WEF to transform agriculture sector in India. Under this, 'Saagu-Baagu' initiative has been launched in the state of Telangana.
 - **Disaster Management:** An AI-based flood forecasting system has been deployed in Bihar and is now being deployed throughout the country. It gives warnings 48 hours earlier about impending floods.
 - **Improve Ease of Doing Business**
 - Natural Language Processing (NLP)
 - Image Processing (Facial Recognition)

1) ADVANCEMENTS IN MACHINE LEARNING

A) NEURAL NETWORKS

- Neural network, also known as Artificial Neural Network (ANNs) or simulated neural networks (SNNs), are a subset of machine learning and are at the heart of deep learning algorithms. Their name and structure are inspired by the human brain, mimicking the way biological neurons signal to each other.
- A neural network can fine tune its output based on the feedback given to it during stages of training.
- ANNs consist of node layers, containing an input layer, one or more hidden layers, and an output layer. Each node, or artificial neurons, connects to another and has an associated weight and threshold. If the output of any individual node is above the specified threshold value, that node is activated, sending data to the next layer of the network. Otherwise, no data is passed along the next layer of the network.



- **Note:** ANN also rely on training data to learn and improve their accuracy over time.

- **Neural Networks vs. Deep Learning:**
 - Terms are sometimes used interchangeably. ‘Deep’ in deep learning is just referring to the depth of layers in a neural network. A neural network that consists of more than three layers – which would be inclusive of the inputs and output – can be considered a deep learning algorithm. A neural network that only has two or three layers is just a basic neural network.

B) DEEP LEARNING

- Deep learning is a machine learning technique that teaches computers to do what comes naturally to humans: learn by example. In deep learning, a computer model learns to perform classification tasks directly from images, text, or sound. It can achieve state of art accuracy, sometimes exceeding human-level performance. Models are trained by using a large set of labeled data and neural network architecture that contain many layers.
 - Most deep learning methods use neural network architecture, which is why deep learning models are often referred as Deep Neural networks. The term deep usually refers to number of hidden layers in the neural network.
- » Some Criticism of AI
- Idea of intelligent machines is obscene anti human and immoral.
 - Would make life more mechanical.
 - A lot of investment has taken place -> many AI companies going bankrupt
 - Taking away the human jobs

C) GENERATIVE ARTIFICATION INTELLIGENCE LIKE CHATGPT (CHAT GENERATIVE PRE-TRAINED TRANSFORMER)

ABOUT CHATGPT:

It is an AI tool developed by OpenAI.

OpenAI is a research institution and company that focuses on developing AI intelligence technology in a responsible and safe way. It was founded in 2015 by a group of entrepreneurs and researchers, including **Elon Musk, Sam Altman, and Greg Brockman**.

- ChatGPT is based on Generative Pre-trained Transformer Architecture.
 - It is trained on massive amount of text data from the internet. It used 570 GB of text data mined from the internet.
 - It is a type of neural network and was first introduced in 2017 in a paper titled “Attention is all you need”. A neural network can fine tune its output based on the feedback given to it during stages of training. This allows the model to better understand the context and meaning of the input and to generate conversational response.
 - Thus, we can say that ChatGPT is fine tuned to provide conversational responses, as against essay-type content. It is because the neural network behind it has been additionally trained on conversational transcripts with human feedback.

- But it is more than a chatbot. It can do tasks like writing software applications, new poems, stories etc.
- ChatGPT can become a powerful pedagogy tool on any topic to anyone, because we can instruct it to “explain it to me like I am a six-year-old”. It can explain in simple terms anything from philosophy to cooking recipes, including new recipes of its own.

It is a **Language Model** (rather than a chatbot) that can produce text that sound like human response in a conversation setting.

What is language model?

It is a software that prints out a sequence of words as output that are related to some words given as input with appropriate semantic relation. In practical terms, it means that it can perform tasks like answering questions and carrying on a conversation with humans. It is often used in Natural Language Processing (NLP) applications, such as speech recognition, automatic translation, and text generation.

It is also a **Neural Network**

It can be thought of as a large network of computers that can fine tune its output of words based on the feedback given to it during stages of training; this training process and the technology together are called **Reinforcement training**. The input data is typically huge corpus of text.

Another key idea of “Word embedding” has been used. It represents words as a matrix of numbers that can be manipulated inside computers. When a neural network processes these numbers, it can differentiate words according to different contexts: for example, when “shoot” appears with “gun” the neural network knows that the words that will follow may mostly be “bullets” or “victims”, whereas when “shoot” appears with “camera”, the neural network knows that the following words may be “picture” or “pixel”.

With a further refining technique called “Transformer”, a neural network can accurately understand the context of a sentence or a paragraph. This “comprehension” can be used for multiple purposes like answering a question, summarising a paragraph or an article, translating documents and so on.

GOOGLE BARD

Google’s Generative AI model

ABOUT GOOGLE GEMINI (DEC 2023)

- Google GEMINI is a new multimodal general AI model, which the tech giant calls its most powerful yet.
- It is now available to users through Bard, some developer platforms, and even the new Google Pixel 8 Pro phones.
- The flexible AI model comes in three sizes – Ultra (yet to be released), Pro, and Nano – is being seen as Google’s answer to ChatGPT, which has been ahead of the game so far when it comes to generative AI.

- Google claims that GEMINI Ultra is the first model to outperform human experts on massive multitask language understanding (MMLU), which uses a combination of 57 subjects such as math, physics, history, law, medicine, and ethics for testing both world knowledge and problem-solving abilities.
- So, IS GEMINI better than ChatGPT 4?
 - **Hard to say now.** But it does seem to be more flexible. Its ability to work with videos and on devices without internet, gives it some edge.
- **Some Concerns** about Generative AI:
 - **Teachers are unhappy about it** as they feel that it can be used to turn in plagiarized essays which could be hard to detect for invigilators. Recently, New York City's Education department banned ChatGPT in its public schools.
 - **Skilled white collar jobs** like that of computer programmers in the IT sector is at threat.
 - **India's IT services-based exports** may get impacted.

D) MULTIMODAL AI

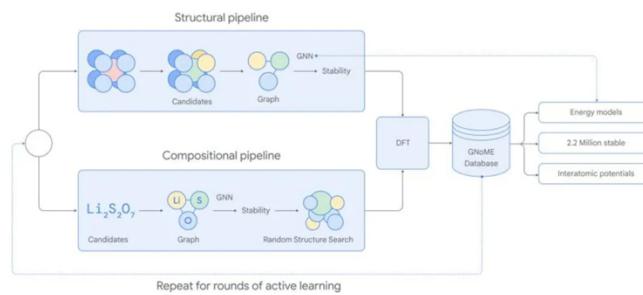
- **Definition:** Multimodal AI is a type of AI that can process and understand information from multiple types of sources like text, images, audio, and video. By integrating information from different sources, multimodal AI aims to enhance the system's ability to perceive and comprehend the world in a more holistic and human-like manner. It is like brain that can see, hear, and read all at the same time.
- **Advantages:** Multimodal AI can do several things which traditional AI can't:
 - **Understand the meaning of a video:** By combining audio and video, the multimodal AI will be able to tell you what is happening in the video, who the people are etc.
 - **Generate more realistic images:** This is because this AI will consider of things like lighting, shadows, reflections etc.
 - **Create more natural sounding speeches** – It is because the AI will be able to take into consideration the emotions and context of the conversation.
 - **Important areas where they can be used?**
 - **Processing CT scans or identifying rare genetic diseases** all need AI systems that can analyze complex datasets of images, and then respond in plain words.
- E.g. Gemini is Google's multimodal large language model.
- OpenAI is also reportedly working on a new project called **Gobi** which is expected to be a multimodal AI system from scratch, unlike GPT models.

E) GOOGLE DEEPMIND AI BREAKTHROUGH (NOV 2023)

- » **How are new materials discovered in Chemistry -> Trial and Errors -> Expensive and time-consuming process.**
- » **In last decades**, experimentation by humans has resulted in the discovery of the structures of some 28,000 stable materials, which are listed in the Inorganic Crystal Structure Database, the largest database of identified materials.

- » **What is DeepMind AI breakthrough?**
 - » Google DeepMind AI Tool known as **Graph Networks for Material Exploration (GNOME)** has successfully predicted the structures of more than **2 million new materials**. This was done with the help of AI.
 - » While these materials will still need to undergo the process of synthesis and testing, DeepMind has published a **list of 381,000 of the 2.2 million crystal structure that it predicts to be most stable**.

- » **How does GNOME actually work?**
 - » GNOME is a state of art **graph neural network model or GNN**, where the input data for the model takes the form of a graph that can be likened to connections between atoms.
 - » GNOME was **trained using active learning**, a technique to scale up a model first trained on a small, specialized dataset. Developers can then introduce new targets allowing machine learning to label new data with human assistance. This makes the algorithm well suited to the science of discovering new materials, which requires searching for patterns not found in original dataset.
 - » **GNOME** uses two pipelines to discover low energy (stable materials).
 - The **structure pipeline** creates candidates with structures similar to known crystals.
 - The **composition pipeline** follows a more randomized approach based on chemical formulas.
 - The output of both the pipelines are evaluated using established Density Function Theory (DFT) calculations and those results are added to the GNOME database, informing the next round of active learning.



- » **Significance:**
 - **Drastic increase in the number of 'stable materials' known to mankind by ten-fold.**
 - DeepMind claims its current research is equivalent to nearly 800 years of knowledge, given that 3,80,000 of its stable predictions are now publicly available to help researchers make further breakthrough in materials discovery teams.
 - **The breakthrough** has huge implications for sectors such as renewable energy, battery research, semiconductors, and computing efficiency which have been looking for new material to improve the efficiency in the sector.

F) PREDICTING PROTEIN STRUCTURE WITH AI

- The AI based program, **AlphaFold2**, from the company **DeepMind**, has stunned the world by accurately and quickly predicting the structure of proteins, starting from the sequence of amino acids that constitute them.

2) FACIAL RECOGNITION TECHNOLOGY (FRT)

- FRT is a type of biometric technology that identifies and verifies individuals by analysing and comparing patterns in their facial features.
- How does FRT Work?**
 - Data Acquisition:** It involves capturing a facial image or video of the person through cameras.
 - Feature Extraction:** In this phase, various features of the face is extracted (e.g. the distance between the two eyes, shape of the nose, width of the jaw etc.)
 - Feature Matching:** The extracted features are then matched with the database of existing pictures.
 - Identification or verification:** Based on feature matching, the FT technology identifies a person as someone in the database or verifies that the person is who he claims to be.
- Applications**
 - Security and Law Enforcement:** Criminals could be identified from the crowd.
 - Border Control:** FRT can be used to identify travelers at airports and border crossing.
 - Biometric Authentication:** For e.g. FRT can be used for unlocking of phones.
 - Marketing and Advertising:** FRT can be used to track users and user choices which can lead to better marketing
 - Social Media and Tagging:** Social media platforms use facial recognition for photo tagging and to enhance user experience.
- Concerns**
 - Excessive surveillance and violation of Privacy:** Widespread use of facial recognition could lead to mass surveillance and a loss of individual privacy. It may lead to unauthorized tracking, profiling, and potential misuse of personal data.
 - Technology challenges:**
 - FRT is prone to digital attacks or the use of physical or digital portraits, 3-D Models, such as deep-fakes etc.
 - Accuracy** concerns: Sometimes poor accuracy can lead to wrong authentication.

A) ASTR TOOL OF DOT

- why in news?**
 - Department of Telecommunication has developed an Artificial Intelligence-based facial recognition tool called **ASTR** (May 2023)
- About ASTR:**
 - Artificial Intelligence and Facial Recognition power Solution for Telecom Sim Subscriber Verification (ASTR)** can potentially bring down cyber frauds by detecting and blocking possible fraudulent mobile connections.
 - How does it function?**

- In 2021, DoT had ordered all telecom operators that they would have to share their subscriber database including users' pictures with the department. These images constitute the core database on which authorities are running their facial recognition algorithm using ASTR.
- **How ASTR Functions?**
 - Human faces in subscribers' images are encoded using Convolution neural network (CNN) models in order to account for the tilt and angle of the face, opaqueness and dark color or the images.
 - After that, a face comparison is carried out for each face against all faces in the database, and similar faces are grouped under one directory.
 - Two faces are concluded to be identical by ASTR if they match to the extent of at least 97.5%.
- The DoT allows an individual to take nine legitimate mobile phone connections using a single identity proof. In essence, what the ASTR does is -1) it looks up if there are more than nine connections against a single individual's photographs; 2) it runs a search through the database to see if the same person has taken SIMs under different names.
- **Results:**
 - According to the Ministry of Communication, an analysis of more than 87 crore mobile connections was carried out using ASTR in the first phase, where more than 40 lakh cases of people using a single photograph to obtain connections were detected. After "due verification", more than 36 lakh connections were discontinued.

B) DIGIYATRA: AIRPORTS USING FRT IN INDIA

- **What is DigiYatra?**
 - It is an initiative by GoI to make air travel and seamless and hassle free experience using digital technology. It envisages that travelers pass through various checkpoints at the airport through paperless and contactless processing, using facial features to establish their identity, which would be linked to the boarding pass.
- **How does it work?**
 - **Passenger Enrollment:** Passengers download the Digi Yatra app and link it to their Aadhaar card (a 12-digit unique ID). They can create a travel profile with their boarding pass and a self-image capture. These credentials are shared with airport authority.
 - **Facial Recognition:** At the airport, the passengers proceed to Digi Yatra Kiosk where their faces are scanned using a secure Facial Recognition tool. The system verifies the passenger's identity against their Aadhaar details stored in the app.
 - **Seamless Travel:** Once verified, passengers can simply walk through designated e-gates at various checkpoints without needing to show any physical document. The facial recognition system automatically grants them access.
- **Advantages:**
 - **Faster and smoother travel; Paperless travel.**
 - **Enhanced security**
 - **Data Privacy**
- **Who is running DigiYatra?**

- **DigiYatra Foundation:** It is a joint-venture company whose shareholders are the AAI (26%) and Bengaluru Airport, Delhi Airport, Hyderabad Airport, Mumbai Airport, and Cochin International Airport. These five shareholders equally hold the remaining 74% of the shares.

3) DEEPFAKES

- **Why in news?**
 - The Ministry of Electronics and Information Technology (MEITY) has sent an advisory to social media platforms on deepfakes (Dec 2023)
 - Earlier PM Modi had warned against Deepfakes calling on media to educate people on misinformation.
 - Following the controversy created by Deepfake videos of actress Rashmika Mandana and Katrina Kaif's deepfakes being circulated online, the GoI has asked social media companies to remove deepfake within 36 hours of a complaint being registered (Nov 2023)
- **Basics:** Deepfakes refer to manipulated media (audio, video, images etc) created using a form of Artificial intelligence called Deep Learning (or Deep Neural Network). This manipulated content uses lip syncing, swapping of face etc. – mostly without consent.
- **How does the Deepfake technology work?**
 - The technology involves modifying or creating images or videos using a machine learning technique called **Generative Adversarial Network (GAN)**. The AI driven software detects and learns the subjects' movements and facial expressions from the source material and then duplicates this in another video or image.
 - Larger the source material used, better will be the quality of deepfake. Therefore, highest number of deepfakes are made of public figures like politicians and film stars.
 - Through a collaborative work of two softwares, the fake video is rendered until the second software package can no longer detect the forgery. This is known as "unsupervised learning" when machine language models teach themselves. The method makes it difficult for other software to identify deepfakes.
- **Advantages:**
 - Synthetic Media/ Deepfakes can create possibilities and opportunities for all people, regardless of how people listen, speak, or communicate. It can give people voice, purpose, and ability to make an impact at scale and with speed.
 - It has been used by the ALS association in collaboration with a company to use voice cloning technology to help people with ALS digitally recreate their voices in future.
- **Concerns:**
 - Like most new technologies, it can also be weaponized to inflict harm to individuals, institutions, businesses or a country.
 - Crime against women can increase with malicious use of Deepfakes in pornography and can inflict emotional, reputational and in some cases violent outcome for some individuals. (for e.g. viral deepfake video of actress Rashmika Mandana incident)
 - **Endanger Social Harmony** – Communal/caste-based statements.

- Decrease trust towards institutions like government/media – by propagating false propaganda against them.
- **Undermine democracy and impair diplomacy** – false information about institutions, public policy, and politicians powered by a Deepfakes can be exploited to spin the story and manipulate belief.
- How to spot/identify a deepfake?
 - Look for unnatural blinking or lack of it.
 - **Lighting** that just don't sit right.
 - Sometimes, voice could be too robotic.
 - If the video sounds too sensational to be true, trust your gut.
 - Voices that miss the mark on lip synchronization
- Meity has sent another advisory to social media firms to comply with Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Rules, 2021 (Dec 2023)
 - The advisory was aimed at getting social media firms to crack down more forcefully on 'deepfake' clips of people.
 - It mandates that intermediaries communicate prohibited content, particularly those specified under Rule 3(1)(b) of the IT Rules, clearly and precisely to users.
- Recent Advisory released by Ministry of electronics and Information Technology (Nov 2023)
 - IT Rules, 2021 require that all content reported to be fake or produced using deepfake be taken down by intermediary platforms within 36 hours.
 - An advisory was sent to social media platforms in Nov 2023, reminding them that they may lose "safe harbour immunity" under the IT Act, if they fail to remove within 36 hours deepfake content that has been reported.

A) HOW VOICE CLONING THROUGH ARTIFICIAL INTELLIGENCE IS BEING USED FOR SCAMS (JAN 2024)

- Famous Examples:
 - » In April 2023, a family living in Arizona, USA, was threatened to pay ransom for a fake kidnapping pulled off by an AI cloned voice.
 - » In Dec 2023, a Lucknow resident was duped to transfer a substantial amount through UPI.
- India:
 - » A report, titled 'The Artificial Imposter' published in May 2023, revealed that 47% of surveyed Indians have either been a victim or knew someone who had fallen prey to an AI generated voice scam. Thus, numbers are almost twice the global average of 25%.
 - » In fact, India topped the list with the maximum number of victims to AI voice scams.
- How are voice clones done?
 - » Once a scammer finds an audio clip of an individual, there are host of online sites / applications like Murf, Resemble, and Speechify which can be used to generate voice clones.
- Various real time translation tools are also available:

- » For e.g. recently Meta released **SeamlessM4T**, an open-source multilingual foundational model that can understand nearly 100 languages from speech or text and generate translation in real-time.
- » Apple introduced a voice cloning feature in **iOS 7** intended to help people who may be in danger of losing their voice say to degenerative diseases.
- » On 2nd of Jan 2024, MIT and Tsinghua University in Beijing, China, and members of AI Startup MyShell released **OpenVoice**, an open-source voice cloning tool that is almost instant and offers granular controls to modify one's voice that isn't found on other such platforms.

4) GPAI (THE GLOBAL PARTNERSHIP ON ARTIFICIAL INTELLIGENCE)

- **Why in news?**
 - » Global Partnership on AI (GPAI) members unanimously adopt New Delhi Declaration on AI (Dec 2023)
- GPAI is an **international and multi-stakeholder initiative** to guide the **responsible development and use of AI**, grounded in human rights, inclusion, diversity, innovation, and economic growth.
 - » This is also a first initiative of its type for evolving better understanding of the challenges and opportunities around AI using the experience and diversity of participating countries.
 - » GPAI was first proposed by Canada and France in 2018 G7 summit, and was officially launched in June 2020 with 15 members (including India)
 - » **Currently** (as of Dec 2023), it consists of 29 members (28 countries and EU).
 - **China**, a major techpower is not a part of the grouping.
 - » It is supported by a Secretariat hosted by OECD, Paris.
- **Dec 2023 Meeting:**
 - » India hosted the summit and will also chair GPAI in 2024.
 - » This summit was important as it was the first summit after the explosive release of ChatGPT.
 - » The GPAI has unanimously adopted 'New Delhi Declaration'.
 - » **Key Highlights of the New Delhi Declaration:**
 - It underscores the need to mitigate risks arising from the development and deployment of AI systems. It flagged concerns emanating from such systems including misinformation, unemployment, lack of transparency, and fairness, protection of IP and personal data and threat to human rights and democratic values.
 - It also promotes equitable access to critical resources for AI innovation including computing and high quality diverse data sets.
 - It also fosters inclusivity so that countries outside the purview of GPAI can also reap AI benefits.
 - It also says that global framework for the use of AI should be rooted in democratic values and human rights; safeguarding dignity and well-being; ensuring personal data protection; the protection of IPR etc.
 - Members also agreed to support AI innovation in the agriculture sector as a new 'thematic priority'. Earlier GPAI themes include healthcare, climate action and building resilient society.

A) AI SAFETY SUMMIT AND BLETCHLEY DECLARATION (NOV 2023)

- **AI Safety Summit, 2023**
 - » AI Safety summit was an international conference discussing the safety and regulation of AI. It was held in the UK at Bletchley Park on 1st and 2nd Nov 2023.
 - » It was the first ever global summit on AI which is planned to become a recurring event.
 - » **27 countries** from across the globe including the US, the UK, China, Australia, and India, as well as EU, agreed on Bletchley Declaration on AI Safety.
- **Key Highlights: Bletchley Declaration**
 - » It aims to enhance global cooperation on (AI) safety.
 - » It has a twofold focus:
 1. **Identifying** shared AI-related risks and enhancing scientific understanding of these risks
 2. **Creating cross country policies** to address these risks.
 - » **Definition of Frontier AI:** Frontier AI refers to highly advanced generative AI models with potentially dangerous capabilities that can pose significant risk to public safety.
- **About Bletchley Park:** This is a site of historic importance in computing.
 - During WW-II, it played an important role in breaking the 'unbreakable' Enigma Code which was used by Nazis.
 - It also contributed to the development of the Colossus – often considered the world's first programmable electronic computer.

5) REGULATING ARTIFICIAL INTELLIGENCE

- **Why in news?**
 - » EU has reached a landmark agreement to regulate AI (Dec 2023)
- **Need of Regulating AI:**
 - » **Controlling Big-Techs:** Most of the advanced development in AI is taking place in the Big-Technology companies like Microsoft, Google, Meta etc who have access to immense data and computing power.
 - » **Controlling Misuse:** Frontier AI has led to increase in the risk of deepfakes, harmful information, and cyber frauds.
 - » **Negative impact on economy:** AI may pose a threat to jobs and inclusive development in future.
 - » **Preventing violations of Privacy, IPR etc.**
 - » **Model Collapse Scenario:** ML models train on Data sets. But AI generated Data sets may create discrepancies and incorporate mistakes of previous AI models.
- **EU has adopted the world's first law on regulating AI** in Dec 2023.
 - » The EU Parliament will now vote on the proposed act early next year (i.e. in 2024), but with the deal done, it's just a formality.
- **What does the EU law propose?**
 - » The law regulates the use of Artificial Intelligence (AI).
 - » It classifies AI systems in four categories based on the associated risks and provides for different level of regulation for each category.

- » It includes safeguards on the use of AI within the EU, including clear guardrails on its adoption by law enforcement agencies.
 1. The deal includes strong restrictions on facial recognition technology, and on Using AI to manipulate human behaviour.
 2. Government can only use real-time biometric surveillance in public areas only when there are serious threats involved, such as terrorist attacks.
- » **Provision for strong penalties:** The deal threatens stiff financial penalties for violations of up to 35 million euros or 7% of a company's global turnover.
- » **Consumers** have been empowered to launch complaints against any perceived violations.
- » The legislation also proposes to be "a launch pad for EU start-ups and researchers to lead the global AI race".
 1. The act works as a unique legal framework for the development of AI you can trust. It will help in development of technology which doesn't threaten people's safety and rights.

- **Significance:**

- » Strong and Comprehensive rules in EU can set a powerful example for many governments considering regulations.
- » **AI Companies** who follow these regulations in EU are also expected to extend some of these protections in other jurisdictions.

- **Comparing EU's approach with other regulations:**

- » EU has taken a tougher stance which segregates AI as per use case scenario based primarily on the degree of invasiveness and risk;
- » UK has seen regulation on the other end of the spectrum with a 'light-touch' approach that aims to foster innovation in this nascent field.
- » USA's approach lies in between that of EU and UK.

- **Leadership in tech regulation:**

- » Over the last decade, Europe has taken decisive lead over the US on tech regulation.
 1. EU has enforced the landmark **GDPR (General Data Protection Regulation)** since May 2018. It is an overarching law focused on privacy and requires individuals to give explicit consent before their data can be processed and is now a template being used by over 100 countries.
 2. EU has also passed a pair of sub-legislations – the **Digital Services Act (DSA)** and the **Digital Markets Act (DMA)**. These take off from GDPR's overarching focus on the individual's right over her data.
 - a. DSA focuses on issues like hate speech, counterfeit goods etc.
 - b. DMA has defined a new category of "dominant gatekeeper" platforms and is focused on non-competitive practices and abuse of dominance by these players.
- » On AI, though, the US has made an attempt to take a lead by way of the new White House Executive Order on AI, which is being offered as an elaborate template that could act as a blueprint for every other country looking to regulate AI. In Oct 2022, USA released a blueprint on an **AI Bill of Rights** – seen as a building block for the subsequent executive order.

A) AI REGULATION EFFORTS IN INDIA

- GoI plans to bring a Digital India Act to regulate AI.

- NITI Aayog has already released National Strategy on Artificial Intelligence which focuses on Responsible AI for all.

LevelupIAS



TARGET PRELIMS 2024

BOOKLET-5; S&T-5

COMPUTER & IT - 2

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2. SUPERCOMPUTERS

- A supercomputer is a computer with a high-level computational capacity compared to a general-purpose computer or Supercomputer is a computer with great speed and memory. They are usually thousands of time faster than ordinary personal computers made at that time.
- As per the 62nd edition of TOP500 released in Nov 2023, following are the **most powerful supercomputers currently:**
 - » **USA's Frontier** is the most powerful supercomputer in the world reaching 1194 petaflops (1.194 Exaflops)
 - » **USA's Aurora system** is at 2nd spot with a capacity of 585.34 PFlop/s.
 - **Note:** Aurora is currently being commissioned and will reportedly exceed Frontier with a peak performance of 2 EFlops/s when finished.
 - » **Eagle** (installed in the Microsoft Azure Cloud in the USA), is at 3rd Spot. This is the highest rank a cloud system has ever achieved. It has the capacity of 561.2 PFlop/s.
 - » **Fugaku (of Japan)** is now ranked 4th (it was ranked second till July 2023 and ranked one till Nov 2021). Its capacity is that of 441.02 PFlop/s.
 - » **LUMI (of European Union, Finland)** is ranked 5th with a capacity of 379.70 PFlops.
- **Uses:** Super computers are generally used for scientific and engineering applications that must handle very large databases or do a great amount of computation (or both). Some of the key areas where supercomputers contribute are:
 - » Weather forecasting
 - » Climate research (E.g. Pratyush at IITM, Pune)
 - » Code-breaking
 - » Genetic analysis
 - » Oil and gas exploration – Seismic processing in the oil industry: Supercomputers help to detect and accelerate deeper geological insights.
 - » Molecular modelling
 - » Other jobs that need many calculations including engineering, product design, complex supply chain optimization (actually any kind of optimization), Bitcoin mining etc.

1) SUPERCOMPUTING IN INDIA

- In India, Indigenous development of Supercomputers began in 1980s. India's first Supercomputer was Param 8,000 which was created in 1991.
- Currently, as per the 62nd edition of TOP500 released in Nov 2023, the most powerful supercomputer in India is **AIRAWAT – PSAI** which is ranked 75 with a total capacity of 13.17 Petaflops. Thus in **terms of supercomputing power** India is way behind the world leaders.

A) AIRAWAT – PSAI

- C-DAC has implemented AI Research Analytics and Knowledge Dissemination Platform (AIRAWAT) of 200 AI Petaflops at C-DAC, Pune under the initiative of Ministry of Electronics and IT, GoI.
- C-DAC has designed and commissioned the converged HPC-AI dense GPU infrastructure integrated with the existing PARAM SIDDHI AI (PSAI) system to make the cumulative compute capacity of **410 AI PF (13.17 PF DP)**.

- The system is installed under the **National Program on AI** by GoI.
- **Note:** AI FLOPS refers to the floating-point operations per second **specifically dedicated to AI workload**. It refers to **FLOPS** required for training an AI Model.

B) OTHER IMPORTANT SUPERCOMPUTERS OF INDIA

- **Param Pravega** (3.3 Petaflops); setup under National Supercomputing Mission
- **Param Siddhi AI** (4.6 petaflops) (210 AI Petaflops); Setup under National Supercomputing Mission
- **Pratyush (IITM)** and **Mihir** (National Centre for Medium Range Weather Forecasting) (NCMRWF), Noida are other fast super computers in India.

C) NATIONAL SUPERCOMPUTING MISSION (NSM)

- A visionary program, launched in 2015, to enable India to leapfrog to the league of world class computing power nations.
- The mission is jointly steered by DST and MEITY.
- **Implemented by** Centre for Development of Advanced Computing (C-DAC); Indian Institute of Science (IISc), Bangalore.
- **Super Computing Grid:** The mission envisages empowering our national academic and R&D institutions spread over the country by installing a vast supercomputing grid comprising of more than 70 high performance computing facilities.
- **Human Resource:** The mission also includes development of highly professional High-Performance Computing (HPC) aware human resource for meeting challenges of manpower scarcity in the sector.
- **Recent Developments**
 - **BullSEQUANA Super Computer:** French Company **Atos** have signed an agreement with C-DAC (Centre for Development of Advanced Computing) for designing, building and installing BullSequana – the super computer in India
 - The supply of Bullsequana XH200 will be used for creating the network of 70 high performance computing facilities under NSM.
 - The total computing power of the Bullsequena will be greater than 10 petaflops.

3. QUANTUM COMPUTER

- **Basics:** How classical computers work:
 - » **Classical Computers** have bit as a fundamental unit which can be **0 or 1**. These computers take a series of bits (e.g., 11001100110101) and switch some of these bits to give us output. Here a bit must be processed in an exclusive binary state at any point of time i.e., either 0 or 1. The **millions of transistors and capacitors at the heart of the computer can only be in one state at any point**. There is a limit as to how quickly these devices can be made to switch state.
- Classical computers have enabled the information revolution that we are part of today. But these **classical computers can't do a number of things** including Optimization, Simulation of large molecules, factoring of large numbers etc.

- **But** Quantum computing may help us solve the above problems someday.
- **Quantum computers are based on the principle of quantum theory.** They gain enormous processing power due to the ability of quantum computer to perform task using all possible permutations simultaneously.
- **Quantum Computers** use **qubit** (Quantum bit). These qubits can take values 0 or 1 or any of the infinite **superpositions** between 0 and 1. When Qubits are in superposition, it has some probability of being in state 0 and some probability of being in state 1.
 - » **Qubits** are usually made of things like electrons, photons or even a nucleus. In case of electron spin up correspond to state 0 and spin down correspond to state 1.
 - » According to quantum law, the particle then enters a superposition of states, in which it behaves as if it were in both states simultaneously. Each qubit utilized could take a superposition of both 0 and 1. **Thus, the number of computations that a quantum computer could undertake is 2^n** , where n is the number of qubits used
 - » Quantum computing also borrows inspiration from another property of quantum mechanics called entanglement, wherein the two qubits could be connected in such a way that the state of one qubit intrinsically affects the state of the other qubit.
 - » Each operation of a quantum computation is performed by a **quantum gate**, which like classical gate, changes the state the qubits are in.
- **Quantum Supremacy:** It refers to quantum computers being able to solve a problem that a classical computer cannot. The term was coined by theoretical physicist John Preskill of the Caltech in 2012.
 - » **Google** recently used a 53 Qubit processor (Sycamore) to generate a sequence of millions of numbers, that conform to an algorithm generated by google. A classical supercomputer checked some of these values and they were correct.
 - » **Google's Quantum computer claimed 'Supremacy'** because it reportedly did the task in 200 seconds that would have apparently taken a supercomputer 10,000 years to complete.
- **Some Problems faced by Quantum Computing Sector:** While the above concept sounds promising, but there are still tremendous obstacles to be overcome.
 - » **Interference:** During the computation phase of a quantum calculation, the slightest disturbance in the quantum system (a stray photon or a wave of EM radiation) causes the quantum computation to collapse, a process known as **Quantum Decoherence**.
 - » **Error Corrections:** Because truly isolating the quantum system has proven so difficult, error correction systems for quantum computing have been developed.
 - » **Output observance:** Observing the final output also risks corrupting the data.
- **The breakthroughs in the last 20 year** including the **quantum supremacy** achieved by Google have increased the chances of developing practical quantum computing mechanisms. However, it is not clear whether the practical application is less than a decade away or a hundred years into the future.
- **Examples of Quantum Computers:** While the idea governing quantum computers have been around since the 1990s, the actual machines have been around since 2011, most notably built by Canadian company D-Wave systems.

- The recent Google's **53 qubit Quantum computer** is called **Sycamore**. Google is also spending billions and targets to build its own working quantum computer by 2029.
- **IBM** plans to have a 1,000-qubit quantum computer. For now, IBM allows the use of its machines by those research organization, institutions etc which are part of its quantum network.
- **Microsoft** also offers companies access to quantum technologies via its Azure Quantum Platform.

- **Applications:** The potential that this technology offers are attracting tremendous interest from both the governments and the private sector. The quantum computers have the potential to easily tackle computational problems that may be tough for the classical computer. The basic advantage is speed as it can stimulate several classical computers working in parallel.
 - **Military Applications** include breaking of advanced encryption using brute force searches.
 - **Advanced Cryptography:** Quantum uncertainties could be used to create private keys for encrypting messages to be sent from one place to another.
 - **Climate Change and Weather Forecasting**
 - **Faster Data analysis in industrial science applications** will enable faster solution to business problems in the era of big data.
 - » **Improved Optimization** for complex problems like NP-hard problems. This may lead to faster optimization of very large-scale problems involving complex network structures, computational biological science, and physical sciences.
 - » **Transform Healthcare and Medicine:** Drug Development and Discovery
 - » **Other civilian applications** include **DNA Modelling** and **complex material science analysis**.
 - » **Improved Machine Learning Outcomes** by enabling more efficient optimization of these algorithms so that ML capabilities become more efficient, accurate and fast.
 - » **Teleporting the information from one location to another** without physically transmitting the information. Entangling of quantum particles allow us to achieve this.

- **India and Quantum Computing:**
 - » There are no quantum computers in India yet.
 - » **Cabinet Approves Rs 6003 Crore National Quantum Mission** (April 2023)
 - » In **Budget 2020-21**, government has announced **National Mission on Quantum Technologies and Applications** which will be allocated Rs 8,000 crore over the next 5 years.
 - » Although the amount is low to begin with but given the advances in technology and India's ability to create low-cost solutions, the money may suffice.
 - » In Aug 2021, India launched **QSim** to aid Quantum Computing research in India.

1) NATIONAL QUANTUM COMPUTING MISSION (APRIL 2023)

- NQM, planned during 2023-2031, will mainly work towards strengthening India's research and development in the quantum arena alongside indigenously building quantum-based computers.
- It entails development of satellite-based quantum communication between ground station and receiver located 3,000 kms away during the first three year.
- For long distance communication, tests will be conducted in coming years.
- Under NQM, there would be four broad themes:
 - » Quantum Computing

- » Quantum Communication
 - » Quantum Sensing and Meteorology
 - » Quantum Material and Devices
- **Thematic hub for each will be established** at research institutes and R&D centres who are already working in the field of research.
 - **Department of S&T (DST)** will lead the mission, supported by other departments.
 - The mission puts India among the top six leading nations involved in the R&D in quantum technologies. Presently, R&D work in quantum tech is underway in USA, China, Canada, France, Finland and Australia.

2) QUANTUM ENTANGLEMENT

- » **What is quantum entanglement?**
 - Two particles, having ‘interacted’ with each other at some stage, were found to have got ‘entangled’ in a way that the behaviour of one produced an instantaneous reaction in the other even if the two were no longer connected in any way and were separated by large distances.
- » **2022 Nobel Prize in Physics** has gone to Alain Aspect (France), John F Clauser (USA) and Anton Zeilinger (Australia). These three scientists over the last four decades, have conclusively established that the ‘entanglement’ phenomenon observed in quantum particles was real, not a result of any ‘hidden’ or unknown forces, and that it could be utilized to make transformative technological advances in computing, hack-free communication, and science fiction like concept of ‘teleportation’.
- » **Details of their contribution:**
 - The first half of the 20th century, saw the development of Quantum Physics which explained the seemingly bizarre behaviour of sub-atomic particles with remarkable accuracy.
 - Quantum theory explained many phenomenon of quantum particles such as Superposition and Entanglement which were completely against everyday experience.
 - **Albert Einstein**, in particular was very uncomfortable with this. His Special theory of relativity prohibited any signal from travelling faster than the speed of light. The seemingly instantaneous communication due to entanglement went against Einstein’s theory. Therefore, Einstein proposed that something was missing and the Quantum theory was incomplete.
 - **However**, experimentalists were discovering that almost every prediction made by quantum theory were being obeyed by sub-atomic particles. Till, that time, experiment to test entanglement didn’t appear feasible.
 - **In 1964**, John Bell showed how phenomenon of entanglement could be established by experimentalists.
 - » The famous Bell’s inequality, if maintained in the results of the experiment, would mean that Einstein was right. If violated, it would provide the predictions of quantum theory.
 - **John Clauser** was the first person to set up an experiment to test entanglement. In 1972, his experiments produced results that were clear violations of Bell inequality

- Alain Aspect is credited with vastly improving the set-up of Clauser and removing all the loopholes critics had found. His experiments also produced results that violated Bell's inequality.
 - Anton Zeilinger meanwhile had already started using entanglement property to open up new technological possibilities. He demonstrated that it was possible to teleport the quantum states of particles to another location without the particle moving anywhere and without a medium.
 - These experiments conducted by Clauser, Aspect and Zeilinger have decisively demonstrated that entanglement was real and in accordance with quantum theory and it was not being driven by any hidden forces as suggested by Einstein and others.
- » The satisfactory theoretical explanation of phenomenon, however, continue to elude scientists.

Application: The entanglement property is now being utilized to build the next generation of computers called quantum computers which exploit the quantum behaviour of particles to overcome the challenges considered unsurmountable. It is also being used for quantum cryptography.

3) QUANTUM GATES: DEVICES THAT TRANSLATE QUANTUM EFFECTS TO COMPUTING AWESOMNESS

- A gate (in traditional computer) is a circuit that changes the states of bits in a predictable way. The speed with which the gate works determine how fast the computer is.
- Understanding the limitation of these gates:
 - » Modern computers use semiconductor transistors to build circuits that function as gates. A semiconductor chip hosts more than 100 million transistors on 1 sq mm.
 - » As transistors become smaller, they become more susceptible to quantum effects. This is not desirable as this will make existing technology unreliable for computational tasks. So, there is a limit to how many transistors a computer can have.
- A Quantum gate is a physical process or circuit that changes the state of qubit or a collection of qubit.
 - » In quantum computers, quantum gates act on qubits to process information. For e.g., a quantum NOT gate changes the state of qubit from 0 to 1 and vice versa.
 - » It can be an electromagnetic pulse which changes the state of qubit.

LOGIC FUNCTION	LOGIC SYMBOL	BOOLEAN EXPRESSION	TRUTH TABLE	
			INPUTS	OUTPUTS
AND		$A+B=Y$	B 0 0	0
			0 1	0
			1 0	0
			1 1	1
OR		$A+B=Y$	0 0	0
			0 1	1
			1 0	1
			1 1	1
inverter		$A=\bar{A}$	0	1
			1	0
			0	1
			1	0
NAND		$\overline{A+B}=Y$	0 1	1
			0 0	1
			1 1	0
			1 0	1
NOR		$\overline{A+B}=Y$	0 1	0
			0 0	0
			1 1	0
			1 1	0

4) QSIM – (CLASS DISCUSSION)



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M.Sc. Mathematics, BITS Pilani

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4. CLOUD COMPUTING

- **Intro**
 - Cloud computing is a type of Internet-based computing that provides shared computer processing resources and data to computers and other devices on demand. It is a model for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources which can be rapidly provisioned and released with minimal management efforts.
 - E.g.
 - Computer networks, Storage (OneDrive, Google Drive etc.), Servers, applications, and services
 - **Advantages** – Reduced upfront cost; focus on core business; Faster deployment of application; Scalability and Elasticity; pay as you Go model; Agility; Device and Location independence; Maintenance, Multitenancy, Performance and Better Security.
- » **Concerns**
- Loss of control over certain sensitive data
 - Limited customization options
 - E.g., a restaurant with a limited menu is cheaper than a personal chef who can cook anything you want.
- **Technology behind cloud:** There are two vital technologies at the heart of Cloud Computing:
 - **Virtualization:** It lets computer resource to be shared through multiple virtual machines.
 - **Network:** It lets data requests flow to and from the datacenters or the Cloud through the Internet.

In cloud computing hardware resources are distributed across multiple locations and there is diverse choice of software that is available to consumers.
 - **Service Models:** IaaS, PaaS, SaaS etc represent various cloud service models. They offer different levels of service and control.
 - **Infrastructure as service (IaaS)**
 - It provides on-demand access to fundamental resources like Virtual Machines, storage, networking, and servers.
 - These are online services that abstract the user from the details of infrastructure like physical computing resources, location, data partitioning, scaling, security, back up etc.
 - E.g. AWS, Microsoft Azure.
 - It is ideal for companies with strong technical team and need for high customization.
 - **Platform as Service (PaaS)**
 - The provider typically develops toolkit and standards for development and channels for distribution and payment.
 - In PaaS model, cloud providers deliver a computing platform, typically including operating system, programming-language, execution environment, database, and web server.
 - E.g. **Google App Engine**.
 - **Software as a Service (SaaS)**

- User gain access to application software and databases (e.g. Google Photos – In this consumer pays based on the giga-bytes that is required to store photos, Gmail etc.)
- Cloud providers manage the infrastructure and platforms that run the applications.

5. EDGE COMPUTING (CLASS DISCUSSION)

6. WEB BROWSERS: HOW DO THEY FUNCTION?

- **Why in news?**
 - » How do web browser work? (Dec 2023: Source - TH)
- **Definition:**
 - » A web browser is software that allows you to find and view websites on the Internet. They translate code into the dynamic webpage that forms the backbone of our online experience.
 - » **Different Browsers over the years:**
 - » In 1990, the English Computer Scientist Tim Berners-Lee introduced the concept of World Wide Web and with it came the first web browser, also known as WorldWideWeb.
 - » The next watershed moment was Mosaic browser in 1993. It was developed by US National Centre for Supercomputing Application. It introduced the concept of displaying images alongside text. It revolutionized our interaction with the web and made internet visually engaging.
 - » In 1994 came the Netscape Navigator and it became the most popular browser of its time. It brought features like bookmarks and user-friendly URL bar. It simplified the navigation and made the web more accessible.
 - » Late 1990s saw the period of the 'Browser Wars'. Microsoft's Internet Explorer (IE) and Netscape Navigator were the primarily contenders. This competition led to a lot of innovation in various browsers. But, by 2,000 IE emerged as undisputed leader mostly on the back of the success of Windows operating system which generally shipped with IE as default browser which most of the people used. But this monopoly also led to stagnation and lack of innovation.
 - » In 2004-05, this monopoly was broken with the arrival of Mozilla's Firefox. Firefox was developed by a community of volunteers and was based on open-source principles. It introduced groundbreaking features like tabbed browsing, and pop-up blocking. It also allowed users to extend their personal browsers with add-ons.
 - » In 2008, Google launched Chrome, which swiftly gained in popularity for its speed and minimalist design. It also revitalized the browser market and encouraged innovation across the board.
 - » Today, the most popular browsers are Google Chrome, Firefox, Microsoft's Edge and Apple's Safari.

- **How do Browsers work?**

Modern web browsers have multiple core components, each of which is a complex technology in itself.

A) Request and Response

- When you enter a website's address (in the form of Uniform Resource Locator (URL)) into your browser's address bar (or when you click a link), you set in motion a sequence of digital communication. The browser sends a request to a server, asking for the contents of the specific web browser you're interested in. This request travels through a network of servers, like dispatching a letter through a series of post offices. Upon reaching the server, the request is received and processed.
- The server then formulates a response containing the information (or data) required to construct the web pages. This response embarks on its journey back to your browser, carrying the digital blueprint for the page you requested.

B) Deconstructing The Response

- The response from the server is an amalgam of various files. Typically, these files have information encoded in three languages: HTML, CSS, and JavaScript. Each set of information plays a pivotal role in shaping the final presentation of the web page.
- **HTML (Hyper Text Markup Language)** provides the architectural blueprint of webpage. It defines structure of the webpage, outline elements like headings, paragraphs, images, and links. HTML is the foundation on which browser construct a visual layout.
- **CSS (Cascading Style Sheets)** imparts style and aesthetics to the HTML structure by controlling attributes like color schemes, fonts, spacing, and positioning. CSS ensures that webpages come with its unique identity.
- **JavaScript** is a dynamic engine, making webpages interactive and responsive. It allows interactive elements like pop-ups, forms, animations, and Realtime updates, creating an engaging user experience.

C) Rendering

- With HTML, CSS and JavaScript in hand, a browser begins the process of rendering. This involves deciphering the HTML to understand the structural arrangement, applying CSS for stylistic finesse, and executive JS to infuse interactivity.
- The process is remarkably swift, assembling the final webpage and presenting it to user in a cohesive and visually appealing manner in much less than a second, depending on the amount of data.
- **Rendering engines** are in themselves a key piece of technology that enables screens to display graphics.

D) Managing Data

- Browsers serve as adept custodians for your digital footprint, so they also implement instruments like **cookies** and **cache** to enhance your online experience.
- **Cookies** are small snippets of data stored on your computer by websites you visit. They retain information such as login status, site preference, and shopping cart content. This allows you to navigate seamlessly, without having to re-login to a site when you close and reopen it in a short span of time.
- **Cache** is a repository of frequently accessed files. When you revisit a webpage, the browser checks its cache to see if it already has a copy of the required files. If so, it retrieves them from the cache itself rather than re-downloading them from the server.

E) Security

- Web browsers use an array of security measures to protect your data as they fly between your computer to various servers, via the internet, and even when they're stored on your computer. They do this by using **encryption protocols**, such as **HTTPS**, to create secure tunnels for data exchange shielding the information from prying eyes.
- Browsers also use **warning systems** to alert you about potentially malicious websites, preventing inadvertent exposure to threats.

Future of Internet Browsers:

- As technology hurtles forward, web browsers evolve in tandem. They are **embracing new technologies** like **Web Assembly**, a format that **enables near-native performance** within the browser environment.
 - o **Note:** Web Assembly is a type of code that can run on modern webbrowsers – it is low-level assembly-like language with a **compact binary format** that runs with near native performance and provides languages such C/C++ with a compilation target so that they can run on web. It is also designed to run along JavaScript, allowing both to work together.
- **Support for VR and AR** experience is also on the horizon, promising immersive online interactions.
- **Privacy features** are being bolstered, providing users a greater control over their digital footprint.

7. INTERNET OF THINGS (IOT)

- Introduction

- IoT is a network of physical objects embedded with sensors, software, and other technologies for connecting and exchanging data with other devices and systems via the internet.
- A **thing** on the internet of Things, can be a **person with a heart monitor implant**, a **farm animal with a biochip transponder**, an **automobile with a built-in-sensors to alert the driver when tire pressure is low - or any other natural or manmade object that can be assigned an IP address and provided with the ability to transfer data over a network**.
- This is achieved by **sensors** and finally fabricated **micro-controllers**.
 - o Microcontrollers are **small computers themselves** and are used internally by various single board computers like Arduino and Raspberry Pi.
 - o **Sensors** are used to detect and collect information and **micro controllers to transport information**.
 - o Together, they can **make anything to a thing in IoT**.

- **Movement from IPV4 (32 bit address) to IPV6 (128 bit address)** also played a **role in making IoT possible**.

- Advantages

- **Reduce waste, loss, and cost** -> by early detection of problems and taking corrective steps
- We would know **what things needed replacing, repairing, or recalling** and whether they were fresh or past their best. This helps in increasing the **reliability** of a device.

- **Applications**
 - a. **Health Care Sector:** IoT can improve the reliability and performance of the life-critical system. For e.g., the IOT based devices can be used in combination with cardiac monitor to raise an alarm to the doctors in case of abnormality.
 - b. **Agriculture Sector:** IoT can be used to gather live pedological data that can be used by scientists to improve the yield of the land. It can also help in implementing **precision agriculture**.
 - c. **Transportation Sector:**
 - **Early detection of wear and tear** (preventing accidents)
 - Self-Driving Cars – will need IOT for real time decisions
 - Traffic Management – real time traffic data -> better traffic management.
 - d. **Energy Management**
 - Managing temperature in a Nuclear Power Plant (using sensors and IoT)
 - Real time efficiency analysis of Solar Power panels.
 - e. **Research and Development:**
 - E.g. – Recent development of wireless communication system for satellites by NASA through which Satellites can communicate with each other.
 - f. **Safety and Security**
 - Real time tracking of criminals – using tagging and IoT.
- **Some Limitations of IoT**
 - » **High Initial cost of set up** -> Since IoT is based on expensive sensors
 - » **Increased cyber security concerns** -> with increased number of devices connected to internet
 - » **Compatibility issues** -> due to lack of the international standardization on IoT devices.

8. INDUSTRIAL REVOLUTION 4.0

- The **First Industrial Revolution** used water and steam power to mechanize production.
- The **Second** used electric power to create mass production.
- The **Third** used electronics and information technology to automate production.
- Now a **Fourth Industrial Revolution is building on the Third**. It is characterized by a **fusion of technologies that is blurring the lines between the physical, digital, and biological spheres**.
 - It is characterized by integration of advanced technologies such as AI, IOT, Robotics, big data, and more into various industries and aspects of society.
 - It combines Machine to Machine Communication, Industrial Big Data Analytics technology, cyber security, and automation. It's driving new levels of efficiency and productivity.
- **Three reasons** why 4th IR is not merely a prolongation of the 3rd IR, but rather the arrival of a Fourth and distinct one: Velocity, Scope and Systems impact.
 - The **speed** of current breakthroughs has no historical precedent. The 4th Industrial Revolution is evolving at an exponential rather than a linear pace.
 - It is disrupting almost every industry in the country.
 - The breadth and depth of these changes herald the transformation of entire systems of production, management, and governance.

- **Need of Industry 4.0:**
 - » Impetus to next surge of growth
 - » Harness the potential of Big Data, AI etc in every field.
 - » Improve governance by using new age tech.

9. BIG DATA

- **Intro**
 - » Big Data is a collection of data that is huge in volume (petabytes and exabytes of data) yet growing exponentially with time. It is a data with so large size and complexity that none of the traditional data management tools can store or process it efficiently. Big Data can be structured, semi-structured and Unstructured. But they generally have potential to be mined for information.
 - » **Examples of Big Data:**
 - BSE which generates Gigabytes of data per day
 - Social media – Around 500+ terabytes of new data get ingested into the database of social media site Facebook every day.
 - Data from search engines (like Google, Bing etc.) and Online portals like Amazon.
- **Challenges** include capture, analysis, data curation, search, sharing, storage, transfer, visualization, querying, updating, and information privacy.
- Big data is **characterized by 3 Vs** – Volume, Velocity and Variety.
- **Advantages – Accuracy, Better Correlation**
- **Key areas where it can be used**
 - » Internet
 - » Finance
 - » Urban Informatics
 - » Business informatics
 - » Meteorology
 - » Genomics and healthcare
 - Find new cures, optimize treatment, and even predict diseases before any physical symptoms appear
 - » Complex physical simulations
 - » Environment research
 - » Improve the performance of Individuals
 - (At sports, at home or work), where data from wearable sensors in equipment and wearable devices can be combined with video analytics to get insights that traditionally were impossible to achieve)
 - » Security Agencies
 - To prevent cyber attack
 - Detect credit card frauds
 - Foil terrorism

- Even predict criminal activity
- » Improve our homes, cities, and countries
 - Optimizing heating and lighting in our homes
 - Optimizing traffic flow in our cities
 - Optimizing Energy Grid across the country
- **Relation between cloud computing and big data**
 - » Cloud computing is very important in BIG data analytics due to its application sharing and cost-effective properties

10. NET NEUTRALITY

- **Why in news?**
 - » 120+ startups have written to TRAI opposing Telecom Service Providers (TSPs) push for regulating over the top (OTT) services (Oct 2023)
- Net Neutrality (also network neutrality, internet neutrality or net equality) is the principle that ISPs and Governments should treat all data on the internet equally, not discriminating or charging differentially by user, content, site, platform, application, type of attached equipment, or mode of communication.
- The term was coined by Columbia University media law professor **Tim Wu** in 2003 as an extension of the long-standing concept of a common carrier.
- **Arguments for Net Neutrality**
 - » **Free Flow of Data**
 - » **User Intolerance for slow loading sites**
 - » **Competition and Innovation**
 - » **Preserving Internet Standards**
 - » The advocates also argue that authorizing network providers to override a transport and application layer separation on the internet would signal the decline of fundamental internet standards and international consensus authority.
 - » **Preventing Pseudo Services**
 - » **End to End Principle**
 - Network neutrality is needed in order to maintain the end-to-end principle. It is this simple but brilliant end to end aspect that has allowed the internet to act as a powerful force for economic and social good.
- **Arguments against Net Neutrality**
 - » **Financing Infrastructure Improvements**
 - » **Counterweight to server-side non-neutrality.**
 - » **May prevent overuse of bandwidth.**
 - » **May prevent access to useless websites.**
- **Net Neutrality in India:**

- » In 2016, TRAI banned **Free Basics service (Internet.Org)** in India based on "Prohibition of Discriminatory Tariffs for Data Services Regulations".
- » In Sep 2020, TRAI recommended the creation of a multi-stakeholder body (MSB) to ensure that Internet access providers adhere to the provisions of net neutrality. TRAI also said that the net neutrality principles adopted by DoT were technology neutral and would apply equally to 5G technology.

11. TOPICS TO BE COVERED IN FUTURE BOOKLETS

- Encryption/Decryption – Public Cryptography, Digital Signature
- Quantum Cryptography
- BlockChain – BitCoin- Other Crypto Currencies
- NFTs
- AR/VR/Meta Verse
- Web 3.0
- Wireless Communication (5G/6G), Bluetooth, WiFi, NFC, RFID etc.
- Optical Fiber Communication / FSOC
- Electronics – Basics
- Semiconductor manufacturing in India
- LED; (OLED) (PMOLED), Flexible LED Display
- LASER and other optoelectronics
- Wireless Charging
- 3D Printing
- BarCode / QR Code



TARGET PRELIMS 2024

BOOKLET-6; S&T-6

COMPUTER & IT - 3

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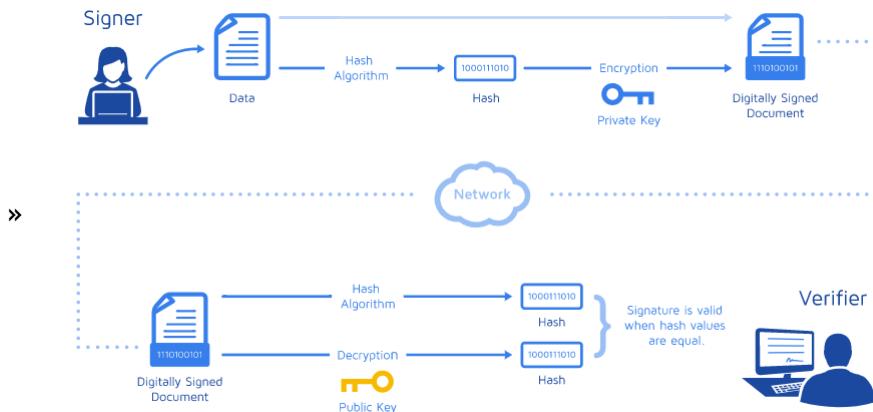
2. CRYPTOGRAPHY

- **Introduction**
 - » Encryption is conversion of electronic data into another form, called cipher text, which cannot be easily understood by anyone except authorized parties.
 - » **Key purpose:** Confidentiality, Authentication, Integrity and Non-Repudiation
- **Historical development**
 - » Spartans using stick of fixed diameter.
 - » **Symmetric Algorithms** (Same key for encryption and decryption)
 - Ceaser Shift cipher.
 - Polyalphabetic substitution -> which uses multiple substitute alphabets to limit the use of frequency analysis to crack a cipher.
 - Most famous example: Enigma electro-mechanic rotor cipher machine used by Germans during WW-2.
 - » All the above methods used the same key for encryption and decryption.
 - » **Limitations:** Requires secure channel for key transfer
 - » **Asymmetric Cryptography or Public Key Cryptography**
 - » It uses pairs of keys.
 - Public key that may be disseminated widely.
 - Private key which is known only to the owner.
 - » Public key algorithms, unlike symmetric key algorithms, do not require a secure channel for initial exchange of one (or more) secret keys between the parties.
 - » Famous examples: Digital Signature algorithm, RSA algorithm (based on the problem of factoring the product of two large prime numbers - the factoring problem), AES etc.
 - » **Where is Encryption used today?**
 - » Before coming of the Diffie-Hellman key exchange (public key algorithm) and RSA algorithm, governments and their armies were the only real users of encryption.
 - » Now, the broad use of encryption in **the commercial and consumer realms** to protect data both while it is being sent across a network (data in transit) and stored, such as on hard drive, smartphone, or flash drive.
 - » Other uses included uses in Modems, Set Top Boxes, Smart Cards, SIM Cards etc.

1) DIGITAL SIGNATURE

- Digital signature is a mathematical technique (cryptography mechanism) that is used to validate the authenticity and integrity of a message, software, and digital document.
- It offers security features like evidence of origin, identity, and Status of an electronic document, transaction or message and can thus acknowledge informed consent by a signer (i.e. nonrepudiation).
- **How Digital Signature Works?**
 - » It uses public key cryptography such as RSA. The individual who is generating the digital signature uses their own private key to encrypt signature-related data.

- » The only way to decrypt this data is with signer's public key. This is how signer's signatures are authenticated.
- **How to create digital signature?**
 - » To create a digital signature, signing software – such as an email program – creates a one-way hash of the electronic data to be signed. The private key is then used to encrypt the hash. The encrypted hash – along with other information, such as hashing algorithm is the digital signature.



- » **Note:** Digital signature technology requires all the parties to trust that the **individual creating the signature has been able to keep their own private keys secret**.
- **Uses of Digital Signature**
 - » **Government** publishes electronic versions of various **documents** such as budget, laws, bill etc. with digital signatures.
 - » **Various legal works** like processing tax returns, filing applications, verifying business to government transactions etc. use digital signature.
 - » Industries use the digital signature to **speed up the process**, including product design, quality assurance, manufacturing enhancements etc.

2) END TO END ENCRYPTION

- **Why in news?**
 - » The recent leaking of WhatsApp chats of several Bollywood celebrities has brought back questions around WhatsApp's privacy and security
- **Introduction**
 - » End to End Encryption (E2EE) is a method of secure communication that prevents third parties from accessing data while it's transferred from one end system or device to another.
 - » In E2EE, the data is encrypted on the senders' system or device and only recipient is able to decrypt it. Nobody in between, be they an Internet Service Provider, Application Service Provider, or hacker, can read or tamper with it.
 - » The cryptographic keys used to encrypt and decrypt the message are stored exclusively on the endpoints; a trick made possible through the use of public key encryption.
- **Whatsapp Encryption (started from April 2016)**
 - » **Step-1: Key Generation:** When you install Whatsapp, the app generates a pair of cryptographic key – a public key and private key.

- » **Step-2: Key Exchange:** When you communicate with someone, your device and recipient's device exchange each other's public key. The exchange happens automatically in the background using a secure Signal Protocol.
- » **Step-3: Message Encryption:** While sending a message, your device uses recipient's public key to encrypt so that only recipient will be able to decrypt. The encryption and decryption process happen locally on the devices involved meaning that Whatsapp servers don't have plaintext of your message. Therefore, even if Whatsapp servers are compromised, your messages are secure.
- » **Feature of Perfect Forward Secrecy:** It ensures that even if some malicious actor gets access to your private key, they would be able to decrypt messages sent after the compromise, past messages are secure.
 - This is done with the help of ephemeral (temporary) session keys.
- » **Feature of verification of identity through security codes:** Whatsapp allows users to verify the identity of their contacts by comparing security codes. These codes are unique to each conversation and help ensure that the keys used for encryption are not tampered with.

3) QUANTUM CRYPTOGRAPHY/ QUANTUM KEY DISTRIBUTION

- **About Quantum Cryptography:** It is a protocol to distribute secret keys using the principles of quantum mechanics. It is a new technique that ensures the confidentiality of information transmitted between two parties, by exploiting counter intuitive behavior of elementary particles called as photons.
 - » **How Quantum Mechanics is used – Heisenberg's Uncertainty Principle**
 - » The security of the quantum key distribution is guaranteed by the laws of quantum physics.
 - Following uncertainty principle, an eavesdropper cannot know everything about a photon that carries a bit and will destroy a part of the information. Hence eavesdropping causes errors in transmission line, which can be detected by Alice (sender) and Bob (Receiver).
 - If an eavesdropper, tries to determine the key, she will be detected. The legitimate parties will then discard the key, while no confidential information has been transmitted yet. If, on the other hand, no tapping is detected, the secrecy of the distributed key is guaranteed.
 - » **Other advantage of Quantum Cryptography/Quantum Key Distribution?**
 - It can distribute long key as often as possible between Sender and Receiver
 - » Long term secrecy of confidential data transmission

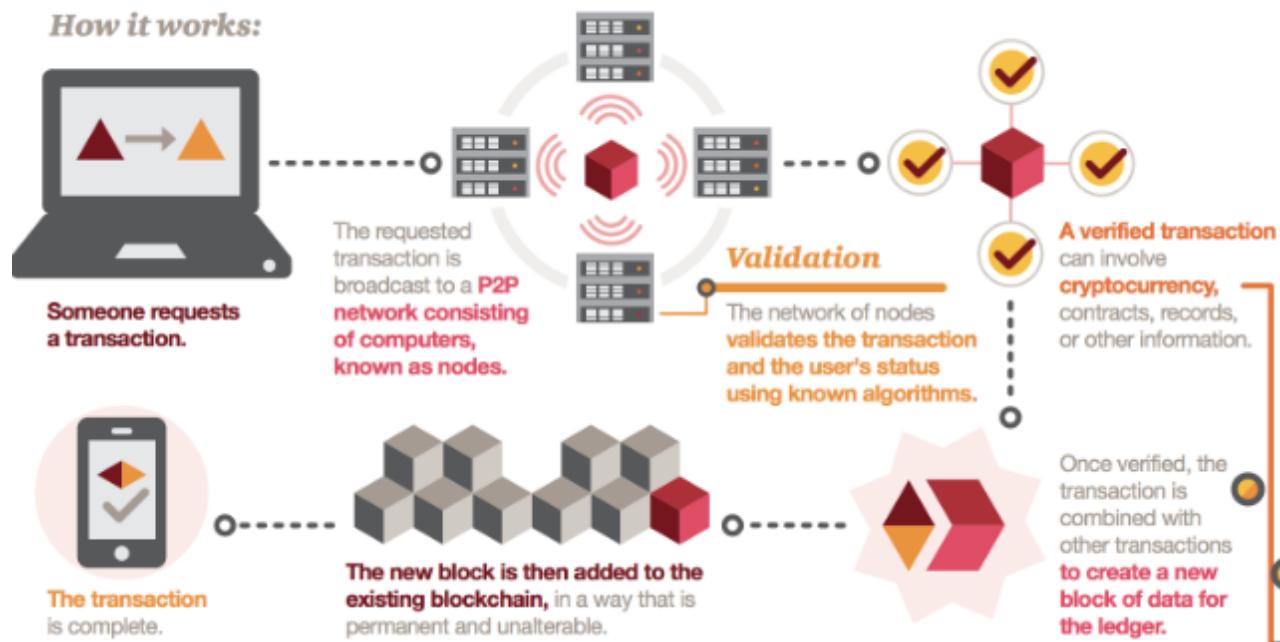
3. BLOCKCHAIN TECHNOLOGY

- **Introduction**
 - Blockchain is an incorruptible, decentralized, digital ledger of transactions that can be programmed to record not just financial transactions but virtually anything of value. Using this technology, participants can confirm transactions without the need of central certifying authority. In other words, blockchain is a distributed database that is used to maintain a continuously growing list of records/transaction, called blocks.
 - It was first used in the design and development of Bitcoin – Cryptocurrency in 2009 by **Satoshi Nakamoto**.

- It offers all parties involved in a business network a secured and synchronized record of transactions. It records every sequence of transaction from beginning to end, whether it is 100s of transaction in supply chain or a single online payment.
 - **Block:** As each transaction occurs it is put into a block.
 - **Chain:** Each block is connected to one before and after. Groups of transactions are blocked together, and a fingerprint of each block is added to the next thus creating an irreversible chain.
- **Data/Transactions** stored in the blocks are secured against tempering using cryptographic hash algorithm and are validated and verified through consensus (consensus protocol) across nodes of blockchain network.

- How blockchain transaction functions

How it works:



- Positives/Advantages

- **Security** -> Built in robustness -> no single point of failure i.e. no centralized points of vulnerability that hackers can exploit.
- **Trust** -> Increased Transparency and incorruptibility
 - Data is embedded within network as a whole, by definition it is public.
 - Altering any unit of information on the blockchain would mean using a huge amount of computing power to override the entire network.
 - In theory, this would be possible. In practice, it's unlikely to happen.
- **Permanent Ledger**
- Reduces the role of intermediary.
- Speeds up the process.
- Lowers transaction cost
- Applications in various sectors

- Applications (Current and Future Potential)

- **Economy and Finance** offers the strongest use cases for the technology.
 - **Financial transactions** are typically granted by third party and block chain could be used to automate the process, reducing overall costs, by cutting out the middleman with autonomous smart contract acting as trusted intermediaries between parties on the network.
 - **Faster, Cheaper settlements could** save billions of dollars from transaction costs while improving transparency.
 - **Stocks, mutual funds, bonds, and pensions** may one day be stored on blockchains as many financial organizations explore the technology.
- **Automotive:** Consumers could use the blockchain application to manage the fractional ownership in autonomous cars.
- **Public Ledger Information:** Many governments are looking to adopt this technology to store information about the citizens and census. A decentralized platform to safely store data regarding, birth, death crime etc. can contribute to effectively curbing fraudulent activities. Even our judiciary can benefit by using this platform to store court judgments, making our legal system more transparent and accessible to litigants.
- **Voting:** Using a blockchain code, constituents could cast votes via smartphone, tablet etc. resulting in immediately verifiable results. Voting by blockchain can eliminate election frauds by making each vote stored as a block on the block chain, rendering it impossible to tamper with.
- **Healthcare:** Patients encrypted information could be shared with multiple providers without the risk of privacy breaches.
- **Smart Contracts:** Every agreement, every process, every task, and every payment would have a digital record and signature that could be identified, validated, stored, and shared. Intermediaries like lawyers, brokers, bankers might not be necessary.
- **Secure File storage**
 - Distributing data throughout the network protects files from getting hacked or lost.
- **Identity Management:** Decentralized, used controlled digital identity holds the potential to unlock economic opportunity for refugees and others who are disadvantaged, while concurrently improving the lives of those simply trying to navigate cyberspace securely and privately.
 - There is definite need for better identity management on the web.
- **Supply chain auditing**
- **Protection of intellectual property**
 - Smart contracts can protect copyright and automate the sale of creative works online, eliminating the risk of file copying and redistribution.
 - Further, a blockchain storage can provide a consolidated platform where trademark and copyright filings can be stored. With entries that can't be tampered with and accurate time stamps, the number of disputes concerning IP may well decrease.
- **Anti-Money laundering and Know Your Customer (KYC)**
- AML and KYC practices have a strong potential for being adapted to blockchain

4. CRYPTO CURRENCY

- Cryptocurrency is a form of **digital cash** which uses **encryption technology** to make it secure. Since, this is a completely digital system, it doesn't exist in physical form.
- **Records of cryptocurrency transactions** have to be stored in a secure database. **Blockchain** serves the role of an incorruptible ledger for most of the cryptocurrencies.
- People can store their cryptocurrency in **virtual wallets** that resemble online bank accounts.

A) CRYPTO MINING

- Crypto mining refers to the process by which new units of cryptocurrency are created by solving complex mathematical problem.
- The miner who mines the cryptocurrency gets to add a new block of verified transactions to the blockchain.
- **Remember some key aspects:**
 - » **Resource intensive:** Solving mathematical problems consume a lot of processing power leading to environmental concerns.
 - » **Increasing Competition:** As coins keep getting mined, future coin becomes more difficult to mine.
 - » **Not all cryptocurrencies** may use mining.

BHUTAN TO EMERGE AS CARBON NEUTRAL HUB FOR CRYPTO MINING

- **In May 2023**, Singapore based mining company, Bitdeer (BTDR) announced a partnership with Bhutan to build a \$500 million closed end fund which will be used to build mining facilities powered entirely by carbon-free hydropower.
- The first phase of the project – Gedu data centre, with a total aggregate electrical capacity of 100 MW, has been operational since Aug 2023.

1) BITCOINS

- **Bitcoin** is the first cryptocurrency created and held electronically. It is a decentralized system (No one controls it). Bitcoins aren't printed, like Rupees or dollars - they are produced by people, and increasingly businesses, running computers all around the world, using software that solve mathematical problems.
- **Who created bitcoins -> Satoshi Nakamoto?**
- **Limited number bitcoins**
 - » The bitcoin protocol - the rules that make bitcoin work - say that only 21 million bitcoins can ever be created by miners. However, these coins can be divided into smaller parts (the smallest divisible amount is one hundred millionth of a bitcoin and is called a 'Satoshi', after the founder of bitcoin).
- **What is bitcoin based on?**
 - Bitcoin is based on **mathematics**. Around the world, people are using software programs that follow a mathematical formula to produce bitcoins. The mathematical formula is freely available, so that anyone can check it.
- **Advantages/Positive Characteristics of Crypto Currencies**
 - **Decentralized:** No central control and hence flexibility to use.
 - **Easy, Fast Set up:**
 - » Conventional banks -> complicated process to open bank account, merchant account for payment more complicated
 - » Bitcoin address can be set up in seconds, no questions asked, and with no fees payable.
 - **Protects Privacy/Anonymous**
 - » Users can hold multiple bitcoin addresses, and they are not linked to names, addresses, or other personally identifying information.

- **Completely Transparent**
 - » Bitcoin stores details of every single transaction that ever happened in the network in a huge version of a general ledger, called the **blockchain**. The blockchain tells all.
 - » If you have a publicly used bitcoin address, anyone can tell how many bitcoins are stored at that address. They just don't know that it's yours.
- **Transaction fee is minuscule and transaction is fast** (almost real time, even cross border)
- **It's non-repudiable.**
 - » When your bitcoins are sent, there's no getting them back, unless the recipient returns them to you. They're gone forever.

▫ Limitations/Disadvantages of Cryptocurrencies

- **Acceptance is limited** -> banned in countries like China and India
- **Loss of wallet -> no recovery option**
 - » If hard drive crashes, or wallet corrupts data. This can bankrupt a wealthy Bitcoin investor within seconds with no form of recovery
- **Volatile** -> no valuation guarantee
- **No grievance redressal/ No Buyer protection** in case of online purchase
 - » If seller doesn't send the bought goods, nothing can be done -> there is no provision of refund/reverse transaction
- Risk of **unknown technical flaws**
- **Built in deflation (in bitcoin)**
- **No physical form** -> Cannot be used in physical stores
- **Extremely high processing power/energy requirement** -> Environmentally unsustainable. According to a study by University of Cambridge, Bitcoin currently uses more energy than Argentina every year.
- Can be used for **criminal activities**
 - » Lack of centralized control allows its use for criminal activities such as by ransomware attackers.
- This may also be used by money launderers to launder black money.

2) LIBRA (DIEM) (PROJECT ABANDONED IN JAN 2022)

3) MOST FAMOUS CRYPTOCURRENCIES

- Bitcoin (BTC)
- Ethereum (ETH)
- Tether USDT (USDT)
- BNB (BNB)
- Solana (SOL)

4) CRYPTOCURRENCY AND INDIA

- In **April 2018**, RBI prohibited banks from providing services to firms and individuals who deal in bitcoin and other such virtual currencies. But, in **March 2020**, the **Supreme Court had set aside the RBI Ban on cryptocurrency transactions** by setting aside the April 2018 circular of the RBI prohibiting banks and entities regulated by it from providing services in relation to virtual currencies (VCs). The Court found the RBI circular "disproportionate" with an otherwise consistent stand taken by the Central Bank that VCs are not prohibited in the country. Further, the court held that the RBI didn't consider the availability of alternatives before issuing a circular.
- In 2019 **Inter-Ministerial Committee** (IMC) chaired by **Subhash Chandra Garg** that was setup to assess the viability of virtual currencies in India had also recommended that India should **ban private crypto currencies such as Bitcoin**. Through a **draft bill** they recommend a maximum of 10-year punishment for those who mine, trade, buy or sell cryptocurrencies.
 - » What is **IMC's view on Distributed Ledger Technologies (DLT)** and Cryptocurrencies?
 - i. IMC recognizes the potential of DLT and Blockchain.
 - ii. Therefore, it recommends the Department of Economic Affairs to take necessary measures to facilitate the use of DLT in the entire financial fields after identifying its uses.
 - iii. The IMC also **recommends that regulators – RBI, SEBI, IRDA, PFRDA, and IBBI – explore evolving appropriate regulations for development of DLT** in their respective areas.
 - » However, IMC has recommended a **ban on “private” cryptocurrencies**. It recommended the **introduction of a single cryptocurrency** for the whole country that is backed by Reserve Bank of India.
 - » **Why?**
 - i. Non-official virtual currencies can be used to defraud consumers, particularly unsophisticated consumers or investors.
 - ii. Further such currencies often experience tremendous volatility in their values.
 - iii. The scaling up of private blockchain based currencies require **crippling level of energy resources**. According to a report by Bank of International Settlement, Bitcoin processing already consumes as much energy as is used by Switzerland; it called this an environmental disaster.
 - iv. If the private cryptocurrencies are allowed to continue, **RBI would lose control over the monetary policy and financial stability**, as it would not be able to keep a tab on the money supply in economy.
 - v. Further, the anonymity of private digital currencies makes them **vulnerable to money laundering** and **use in terror financing activities** while making law enforcement difficult.
 - vi. Finally, there is **no grievance redressal mechanism** in such system, as all transactions are irreversible.

A) THE CRYPTOCURRENCY AND REGULATION OF OFFICIAL DIGITAL CURRENCY BILL, 2021

- **Yet to be officially approved by the Union Cabinet**
- It seeks to create a facilitative framework for creation of the official digital currency (to be issued by RBI)
- **Note:** RBI is looking at launching a pilot project for an official digital currency soon.
- It also seeks to prohibit all private cryptocurrencies in India. However, it allows for certain exceptions to promote the underlying technology of cryptocurrencies and its uses.

B) BUDGET 2022-23

- Virtual Digital Assets (VDAs) will be taxed at 30% (on the gain on the sale of such assets). Benefits of basic exemption limit is also not applicable. No deduction in respect of any expenditure other than cost of acquisition shall be allowed. Also, TDS of 1% shall be deducted on the transaction value from 1st July Subject to certain conditions.
- They mainly include Crypto currencies, NFTs etc. Prima facie, this excludes digital gold, central bank digital currency, or other traditional digital assets and hence aimed at specifically taxing cryptocurrencies.

5. NFT

6. WEB 3.0

- **Background: Understanding Web 1.0 and Web 2.0**
 - Web 1.0 is the world wide web or the internet that was invented in 1989. It became popular in 1993. The internet in the Web 1.0 was mostly static web pages. Here most of the users visited websites and read and interacted with the static material available there. It was a closed environment and users themselves couldn't create post content and reviews.
 - **Web 2.0** started in some form by late 1990s. By 2004, most of the features of web 2.0 was available for implementation. Here websites were more dynamic where users could create content, post comment, write reviews etc. They could also upload photos and videos. Primarily, a social media kind of interaction is the differentiating trait of Web 2.0.
- **Concerns of Web 2.0:**
 - Most of the data on internet is owned and controlled by a few behemoth companies. It has created issues related to data privacy, data security and abuse of such data. It has kind of disappointed experts that the original purpose of internet has been distorted.
- Web3 or Web 3.0 is a term used to describe the next phase of the internet.
 - It runs on the decentralized technology of blockchain and would be different from web 1.0 and web 2.0. Here, users have ownership stakes in platforms (unlike now where tech behemoths control everything). Here users will control their own data.
 - Thus, the need of intermediaries (like Amazon, Facebook, etc.) is removed. This will end data monopoly.
 - The **key concepts in Web3** seen so far are peer to peer transactions and block chain.
- The spirit of Web3 is **Decentralized Autonomous Organization (DAO)** which is that all business rules and governing rules in any transaction are transparently available for anyone to see and the software will be written conforming to these rules.
 - **Crypto-Currency and Blockchain** follow the DAO principle. With DAO, there is no need for a central authority to authenticate or validate.
- **Summarizing significance of web3.0:**
 - Prevents monopoly over data.
 - Promotes data privacy.

- Increase competition in fields like search engine businesses as control over content now restricted to just a few companies would end.
- New technology will give India an opportunity to innovate and develop.

- Future of Web 3.0: Will it take off?

- Tech honchos like Elon Musk and Jack Dorsey don't see a future for Web3.
- There are technological changes required: For e.g., it will require deviation from the current architecture where there is a front-end, middle layer and back-end. Web3's architecture will need backend solutions for handling block chain, persisting and indexing data in block chain, peer to peer communications and so forth. Similarly, middle layer would also need to change to handle block-chain based backend.

7. AUGMENTED REALITY/ VIRTUAL REALITY

A) AUGMENTED REALITY

- AR is the integration of digital information with the user's environment in real time. AR is a technology that layers computer generated enhancements atop an existing reality to make it more meaningful through the ability to interact with it.
 - AR is developed into apps and used on mobile devices to blend digital component in real world in such a way that they enhance each other but can also be told apart easily.
- **Boeing researcher Thomas Caudell coined the term in 1990.**
- **Current application of Augmented reality**
 - Google glass, heads-up displays in car windshields are perhaps the most-well known consumer AR products.
 - It is used in many industries including health care, public safety, gas and oil, tourism and marketing.

▪ VIRTUAL REALITY

- VR is an artificial, computer-generated simulation or recreation of a real-life environment or situation.
 - It immerses the user by making them feel like they are experiencing the simulated reality firsthand, primarily by simulating their vision and hearing.
- VR is typically achieved by wearing a headset like the Facebook's Oculus equipped with the technology and is used prominently in two different ways.
 - To create and enhance an imaginary reality for gaming, entertainment, and play.
 - To enhance training for real life environments by creating a simulation of reality where people can practice beforehand (such as flight simulators for pilots)

8. METAVERSE

- **Definition:**
 - » Metaverse is a digital place inhabited by the digital representations of people (Avatars) and things. It is a new vision of internet.
 - <https://youtu.be/Qw6UCwCt4bE>
 - » Metaverse is a network of 3D virtual worlds focused on social connections.
 - » It is often described as iteration of internet as a single, universal virtual world that is facilitated by the use of virtual and augmented reality.

- » Metaverse has its origin in the 1992 science fiction novel “Snow Crash” as a combination for “meta” and “Universe”. In this he envisioned lifelike avatars who met in realistic 3D buildings and other virtual reality environments.
 - » Some of the platforms already developed can be considered metaverse (e.g., “**second life**”).
- **E.g., applications of Metaverse:**
- » Meta envisions a virtual world where digital avatars connect through work, travel or entertainment using VR headsets. For e.g., it may include fake houses where you can invite all your friends to hang out in.
 - <https://youtu.be/Uvufun6xer8?t=237>
 - » Microsoft envisages that it could involve virtual meeting rooms to train new hires or chat with your remote coworkers.
 - » **Entertainment:** Attend a Concert virtually
 - <https://www.youtube.com/watch?v=Uvufun6xer8&t=775s>
- **Key Challenges:**
- » **VR headsets** are still very clunky, and most people experience motion sickness or physical pain if it is worn for too long.
 - » **Many Technological challenges** – For e.g., if the person would be wearing headsets, how the facial expressions would be scanned and made available in real time.
 - » **Lack of Common Standards:** Various big tech players are building their own versions of an extended virtual reality.
 - » **Cyber Security:** For e.g., by not limiting the number of avatars, Metaverse would allow users to create online representations of others without their consent or verification. While celebrities may be protected by various impersonation mechanisms. Common people would be more vulnerable.
 - Users are going to require regulatory support which integrates governments, industries, and other users.
- **What is being done and what is the way ahead?**
- » Mark Zuckerberg, the CEO of the newly named Meta (formerly Facebook), estimates it could take 5 to 10 years before key features of the metaverse become mainstream. But various components of metaverse already exist – Ultrafast broadband speed, virtual reality headsets and persistent always-on online worlds are already up and running.
 - » Open-Source Platforms like Web3D Consortium, World Wide Web Consortium, XR Association, and several other industry players have come together as the Metaverse Standards forum to build interoperability into the metaverse.
 - » It is important that the work on regulating metaverse starts parallelly. Here civil society, tech companies and government will need to work together to evolve appropriate rules and cybersecurity framework.

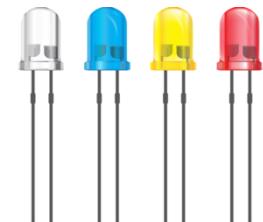
9. ELECTRONICS – BASICS

- 1) Semiconductors:** These are materials which have a conductivity between conductors (generally metals) and nonconductors or insulators (such as most ceramics).

- » They can be pure elements like silicon or germanium, or compounds such as gallium arsenide or cadmium selenide.
 - » In a process called **doping** small number of impurities are added to pure semiconductors causing large changes in the conductivity of the materials.
 - » They are crucial in the development of electronic devices and there would be no radio, TV, Computers etc. without semiconductors.
 - » An important property of semiconductors is that it has very high resistivity at 0K and its resistivity falls as the temperature goes up unlike metals which have high conductivity at 0K and whose resistivity increase as the temperature increase.
 - » Semiconductor devices also display other **useful properties** such as passing current more easily in one direction than the other, showing variable resistance and sensitivity to light or heat.
 - » Because **electrical properties** of a semiconductor can be modified by doping, or by the application of electric fields or light, devices made by semiconductors can be used for amplification, switching, and energy conversion.
- 2) **Diode:** It is defined as a **two-terminal electronic component** that only **conducts current in one direction**. An ideal diode will have **zero resistance** (negligible) in one direction, and **infinite resistance** (very large) in the reverse direction. It is effective like a valve for electric current.
- A **PN junction** is the simplest form of a semiconductor diode. In ideal conditions, this PN junction behaves like a **short circuit** when it is forward biased (current flowing in forward direction), and as an **open circuit** when it is in the reverse biased (current flowing in reverse direction).
- 3) **Transistor:** It is a semiconductor device used to **amplify or switch electronic signals and electric powers**. It is one of the basic building blocks of modern electronics. It is composed of semiconductor material usually with at least three terminals of connection to an external circuit.
- 4) **Amplifier:** It is an electronic device that can increase the power of a signal (a time varying voltage or current). It is a **two-part electronic circuit** that uses electric power from a power supply to increase the amplitude of a signal applied to its input terminals, producing a producing a proportionately greater amplitude signal at its output.

10. OPTOELECTRONICS

- Optoelectronics is a special discipline of electronics that focuses on light emitting or light detecting electronic devices.
- Light emitting devices **use voltage and current to produce electromagnetic radiation (i.e. light)**. These are commonly used for illumination or indication purposes.
 - » E.g. LEDs
- **Light Detecting Devices**, such as photo transistors, **convert received electromagnetic energy into electric current or voltage**. (e.g. photo resistors, solar cells etc.)
- **Light Bulbs** such as **incandescent lights**, are devices that convert electric current into visible lights. **Tungsten wire** has high resistivity and it converts light into heat which results into visible light (photons) to be emitted.



- **Halogen lamps** use a filament that resides inside a gas-pressurized bulb. The pressurized gas consists of an inert gas and a small amount of halogen element such as bromine or iodine. The combination of a halogen gas (small amount of iodine or bromine in inert gas) and tungsten filament produces a **halogen cycle** chemical reaction which **redeposits evaporated tungsten to the filament**, increasing its life and maintaining clarity of the envelope. This allows filament to operate at a higher temperature than a standard incandescent lamp of similar power and operative life;
- **Fluorescent bulbs** are very different. They consist of **mercury vapor filled glass tube** whose **inner wall** is coated with a material that fluoresces. When electrons which are emitted from the fluorescent bulb's inner cathode electrode, collide with the mercury atoms, UV radiation is emitted. This **UV radiation is absorbed by the lamp's fluorescent coating, which in turn releases a visible light.**
- **LEDs:** Discussed in detail below.
- **Laser diode** is a **semiconductor laser device** that is very **similar in both form and operation**, to a light emitting diode (LED). The laser diode is electrically equivalent to a **PIN diode**. A Pin diode is a diode with a wide undoped intrinsic semiconductor region sandwiched between a p-type semiconductor and an n-type semiconductor.
- **Photo Resistors** are light controlled variable resistors, also known as light dependent resistors (LDRs). **Generally**, when a photo-resistor is placed in dark, it has high resistance and when it is illuminated the resistance drops dramatically. They are used in **light sensitive switching devices**.
- **Photo diodes** are semiconductor devices that **convert light energy (i.e. photons) directly into electric current**.
- **Solar Cells** are photodiodes with exceptionally large surface areas.

11. LIGHT EMITTING DIODES

- **Introduction**
 - » A light emitting **diode** is a **semiconductor devise** that **emits visible light when an electric current passes through it.**
 - » The light is **not particularly bright** but, in most LEDs, **it is monochromatic, occurring at a single wavelength.**
 - » The **output from an LED can range from red** (at a wavelength of approximately 700 nanometers) to a blue violet (about 400 nanometers).
 - » Some LEDs emit infrared (IR) energy (830 nanometers or longer); such devices are known as **infrared-emitting diodes (IRED).**
- **Technical Details**
 - » An LED or IRED **consists of two elements of processed material** called the **P-type semiconductors and N-type semiconductors.** These two elements are **placed in direct contact**, forming a region called **P-N junction.** In this respect, the LED and IRED **resemble most other diode types** but there are important

differences. The LED and IRED had transparent package, allowing visible or IR energy to pass through. Also, the LED and IRED has a large PN-junction area whose shape is tailored to the application.

- » **Electrons in the semiconductor** recombine with electron holes, releasing energy in the form of photons.
- **Benefits of LED and IRED**, compared to incandescent and fluorescent illuminating devices, include:
 - » **Low Power Requirement**: Most can be operated with battery power supplies.
 - » **High Efficiency**: Most of the power supplied to an LED or IRED is converted into radiation in the desired form, with minimal heat production.
 - » **Long life**: when properly installed, an LED or IRED can function for decades
- **Other associated benefits**
 - » Climate change
 - » Power deficiency help
 - » Mercury pollution protection (CFLs)
- **Typical Applications include**
 - » **Indicator lights**: These can be two-state (i.e., on/off), bar graph, or alphabetical-numeric readouts.
 - » **LCD panel backlighting**: Specialized white LEDs are used in flat panel computer display
 - » **Fiber Optic Data Transmission**: Ease of modulation allows wide communications bandwidth with minimal noise, resulting in high speed and accuracy
 - » **Remote Control**: Most home entertainment "remotes" use **IREDs** to transmit data to the transmitter.
 - » **Optoisolator**: It is a semiconductor device that uses a short optical transmission path to transfer an electrical signal between circuits or elements of a circuit, while keeping them electrically isolated from each other.
 - » **Lighting**: LED bulbs
 - [Unnat Jyoti for Affordable LED \(UJALA Scheme\)](#)

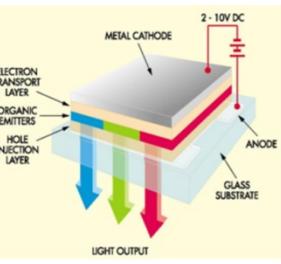
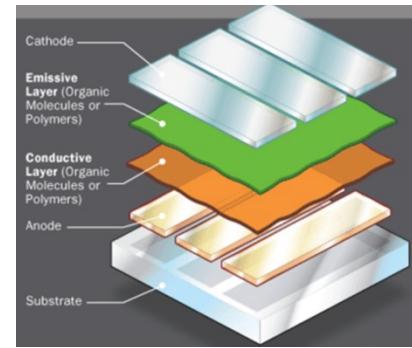
12. ORGANIC LEDs

- **OLEDs** are solid-state semiconductor devices composed of thin films of organic molecules that create light with the application of electricity. They are 100 to 500 nm thick or about 200 times smaller than human hair.
- **Advantages**: OLEDs can provide brighter, crisper displays on electronic devices and use less power than conventional LEDs and LCDs (liquid Crystal displays).
- **How OLEDs work?**

OLEDs have two layers or three layers of organic material. It consists of **following parts**:

 - **Substrate** (clear plastic, glass, foil): The substrate supports the OLED.
 - **Anode** (Positive Terminal) (transparent) – the anode removes electrons (adds electrons “holes”) when a current flows through the device.
 - **Organic Layers**: These layers are made of organic molecules or polymers:

- a) **Conducting Layers:** This layer is made up of organic plastic molecules that transport "holes" from the anode. One conducting polymer used in OLEDs is **Polyaniline**.



OLED Structure

- b) **Emissive Layers:** The layer is made up of organic plastic molecules (different ones from the conducting layer) that transport electrons from the cathode; this is where light is made. One polymer using in the emissive layer is **Polyfluorene**.
- c) **Cathode (negative terminal):** (may or may not be transparent depending upon the type of OLED) – The cathode injects the electron when a current flows through the device.

How OLEDs emit light?

Attach a voltage across cathode and anode.	
As the electricity starts to flow, the cathode receives electrons from the power source and the anode loses them (or it receives holes)	
Added electron is making the emissive layer negatively charged (similar to n-type layer in a junction diode), while the conductive layer is becoming positively charged (similar to p-type material)	
Positive holes are much more mobile than negative electrons, so they jump across the boundary from the conductive layer to emissive layer. When a hole (lack of electron) meets an electron, the two things cancel out and releases a brief burst of energy in the form of a particle of light – a photon.	

- The color of light depends on the type of organic molecule in the emissive layer. Manufacturers place several types of organic films on the same OLED to make colored display.

- **The intensity or brightness** of the light depends on the amount of electrical current applied: the more current, the brighter the light.
- Unlike LEDs, which are small-point light source, **OLEDs are made in sheets that are diffuse-area**. OLED technology is developing rapidly and there are handful of products offering with efficacy, lifetime, or color quality specs that are comparable to LEDs.

Types of OLEDs: They are several types of OLEDs:

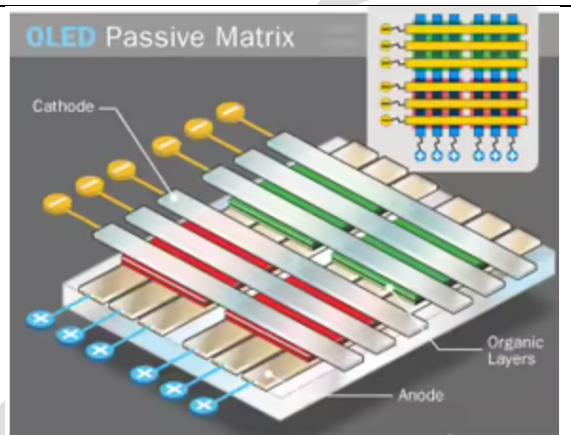
Passive-Matrix OLEDs (PMOLED): It consists of strips of cathode, organic layers, and strips of anodes. The anode strips are arranged perpendicular to the cathode strips. The intersection of the cathode and anode make up the **pixels** where light is emitted. External circuit applies current to selected strips of anode and cathode, determining which pixels get turned on and which pixels remain off. Brightness of each pixel is proportional to the amount of applied current.

Advantages: Easy to make

Limitations: Consumes more powers than other types of OLED, mainly due to power needed for external circuit.

Application: Suitable for text and icons and thus are best suited for screens (2 to 3 inch) such as those used in cell phones, PDAs, and MP3 players.

Note: Even with external circuitry, passive matrix OLEDs consume less battery power than the LCDs that currently power these devices.

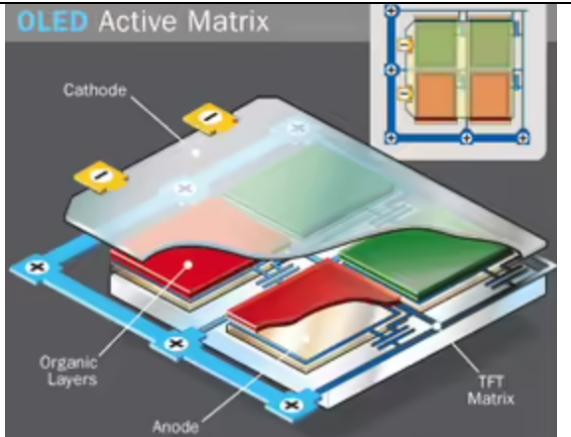


AMOLED (Active-matrix OLED): They have full layers of cathode, organic molecules and anode, but the anode layers overlay a thin film transistor (TFT) array that forms a matrix. The TFT array itself is a circuitry that determines which pixels get turned on to form an image.

Advantages:

- Consumes less power than PMOLEDs because TFT array requires less power than external circuitry, so they are efficient for large displays.
- They also have faster refresh rates suitable for videos.

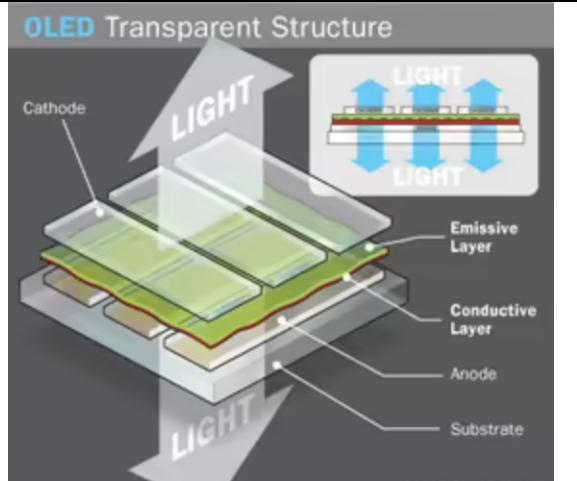
Applications: Computer Monitor, large-screen TVs and electronic signs or billboards.



Transparent OLEDs: They have only transparent components (substrate, cathode, anode) and, when turned off, are upto 85% as transparent as their substrate.

When a transparent OLED display is turned on, it allows light to pass in both directions.

It can be PMOLED or AMOLED. This technology may be used for heads-up displays.



Top Emitting OLEDs: They have substrate that is either opaque or reflective.

They are best suited to active-matrix design. Manufacturers may use top-emitting OLED displays in smart cards.

Foldable OLEDs: They have substrate made of very flexible metallic foils or plastics. They are lightweight and durable. Their use in devices such as cell phone and PDAs can reduce breakage, a major cause of phone repairs. They can also be used for making smart clothing.

White OLEDs: they emit light that is brighter, more uniform and more energy efficient than that emitted by fluorescent lights. They also have the true color quality of incandescent lighting. Because OLEDs can be made in large sheets, they can replace fluorescent lights that are currently used in homes and buildings.

Their use can reduce the energy cost of lighting.

Advantages of OLEDs:

- » OLEDs can be configured as large-area, more diffuse light sources whose soft light can be viewed directly. This eliminates the need of shades, diffusers, lenses, or parabolic shells.
 - This diffused light allows them to be used very close to the task surface without creating glare for the user.
- » OLEDs can be made very thin, increasing their eye appeal and allowing for easy attachment to the surface of walls and ceilings.
- » The Plastic, organic layers of an OLED are thinner, lighter, and more flexible than the crystalline layers in LED or LCD.
- » OLEDs are brighter than LEDs.
- » Because the organic layers of an OLED are much thinner than the corresponding inorganic crystal layer of an LED, the conductive and emissive layer of an OLED can be multilayered. Further, it doesn't require glass for support (which is needed by LED)

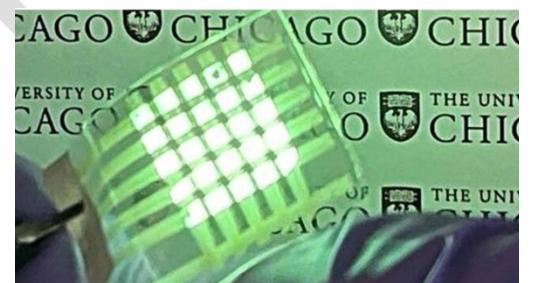
- » **OLEDs** are much more energy efficient.
- » OLEDs don't require backlighting like LCDs. LCDs work selectively blocking areas of backlighting to make the images that you see, while OLEDs generate light themselves. Because OLEDs don't require backlighting, they consume much less power than LCDs (most of the LCD power goes to the backlighting). This is specially important for battery-operated devices such as cell phones.
- » **OLEDs** are easier to produce and can be larger in size. Because OLEDs are essentially plastic, they can be made into large, thin sheets.
- » OLEDs have larger field view, about 170 degrees. Because LCDs work by blocking light, they have an inherent viewing obstacle from certain angles.
- » **OLEDs** can be made up of almost any shape and can be deposited on flexible substrates.

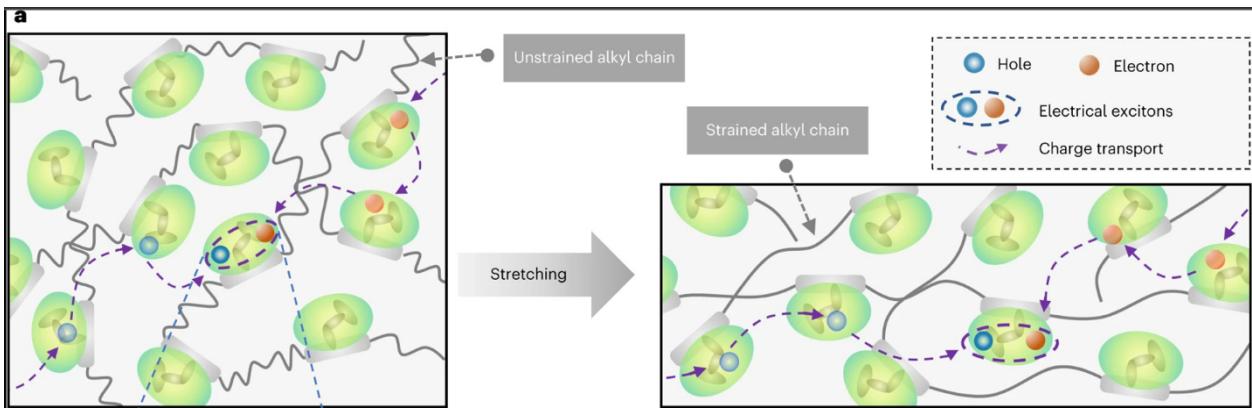
Limitations of OLEDs:

- » **Lifetime:** Blue organics currently have much shorter lifetime.
- » **Expensive manufacturing**
- » **Water can easily damage OLEDs.**

13. FLEXIBLE OLEDS

- **Why in news?**
 - Researchers have developed a stretchable OLED display technology that could power wearable electronics and other flexible form factors devices in future (April 2023)
- **Details**
 - Researchers at the University of Chicago have developed an OLED material that is so flexible that it can be bent in half or stretched to more than twice its original length while still emitting light.
 - It represents a new technology that could possibly be used to develop stretchable fabric-like displays in the future. It could be used in flexible displays for a variety of applications, including wearable electronics, health sensors, and even foldable devices, according to the University of Chicago.
- **Need:** The material that are currently used in OLED displays are very brittle and are not very stretchable. With this in mind, the researchers set out to create a material than maintained the light-emitting properties of OLED but was also stretchable.
- **Design Strategy:** Design strategy of inserting flexible, linear units into polymer backbones can greatly increase stretchability without affecting light-emitting performance.





14. LASER (LIGHT AMPLIFICATION BY SIMULATED EMISSION OF RADIATION)

- Introduction

- A laser is a device that generates an intense beam of coherent monochromatic light (or other electromagnetic radiation) by stimulating of photons from excited atoms or molecules.

▫ How does laser differ from normal light?

- **Monochromatic:** Same Wavelength/frequency (whereas normal light contains multiple wavelength)
 - This wavelength is determined by the amount of energy released when the excited electrons drop to a lower orbit.
- **Coherent** (ordinary light is not coherent): It means that all light waves are in phase with one another.
- **Very narrow, highly directional and doesn't diverge:**
- The laser beam is **extremely intense**.

- Uses: Lasers are used in

- Precision tools to cut through diamonds or thick metal.
- Laser surgery
- Skin treatment
- Optical disk drive
- Laser printers
- Barcode scanners
- Fiber optics
- Free space optical communication
- Drilling, cutting and welding materials
- Military and law enforcement devices
- Laser light display in entertainment
- Remote sensing

Lasers in India

India currently has two lasers that produce 100 Terawatt (10^{12}) beams.

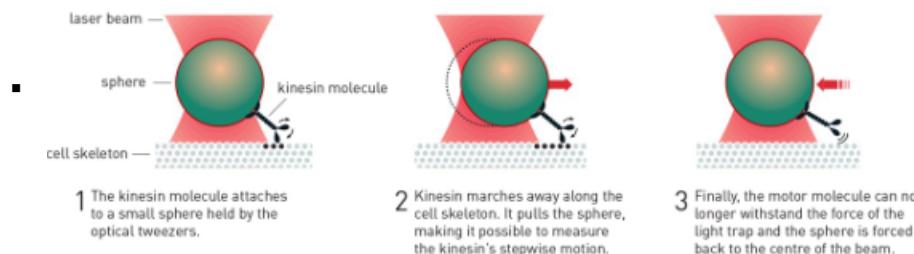
The Raja Ramanna Centre for Advanced Technology in Indore is in the process of installing two petawatt systems, while another is likely to be installed in Hyderabad.

- Nobel Prize in Physics, 2018 for LASER Physics Work

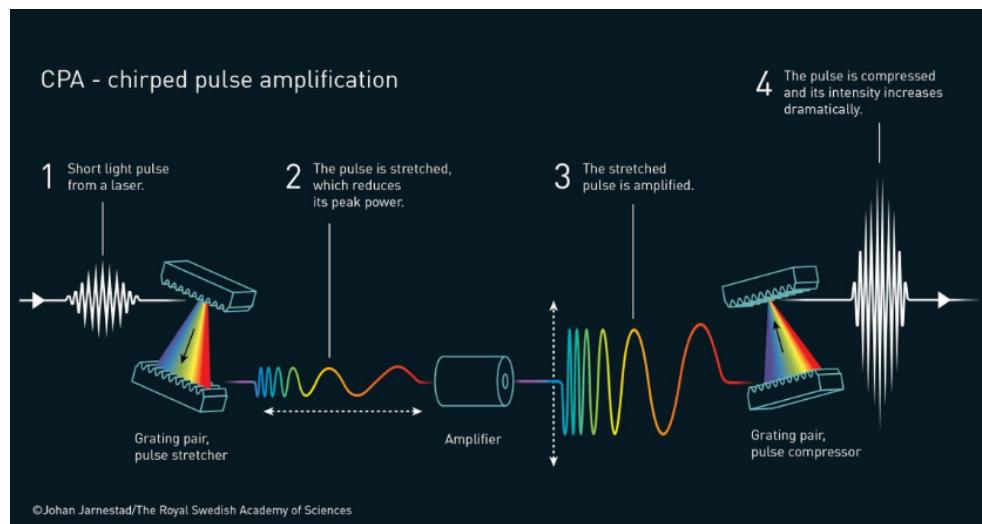
- Arthur Ashkin received the prize for the **optical tweezers** and their applications to biological system

- These optical tweezers are able to grab particles, atoms, viruses, and other living cells with **laser beam fingers**.

A motor molecule walks inside the light trap



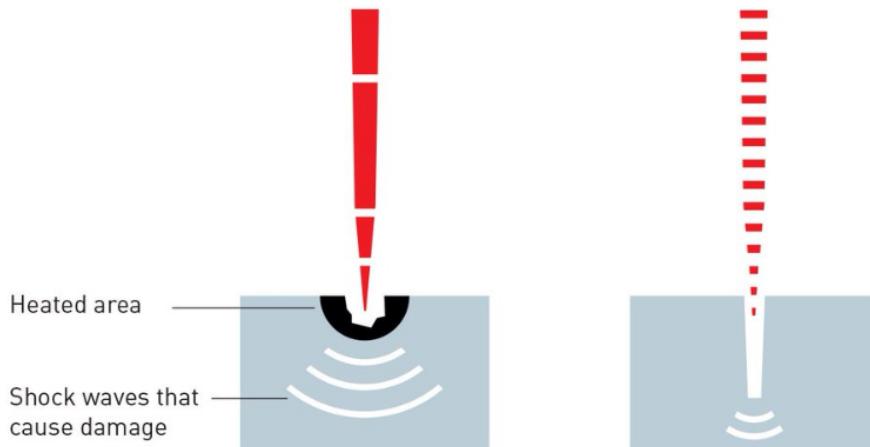
- These optical tweezers are widely used for isolating and examining very small particles, such as individual atoms, DNA strands, or biological cells.
- This helped scientists understand the behavior of single atom or cells, instead of studying the average behavior of an aggregation of such particles.
- The tweezers can capture living bacteria without harming them, a breakthrough achieved back in 1987.
- **Note:** Arthur Ashkin, at the age of 96, has become the oldest scientist ever to be awarded a Nobel Prize.
- **Gerard Mourou and Donna Strickland** were jointly awarded for their method of **generating high-intensity, ultra-short optical pulses**.
 - They created ultrashort high-intensity laser pulses without destroying the amplifying material, thus paving the way towards the shortest and most intense laser pulses ever created by mankind.
 - **Note: Donna Strickland** is only the third women to receive nobel prize in physics. Before her, **Marie Curie** had won it in 1903 and **Maria Goeppert-Mayer** in 1963.
 - **What was the problem earlier?**
 - Within a few years of the invention of laser, laboratory tabletop lasers had started achieving very high power of about a gigawatt. But after this state of peak power was reached, more intense pulses of power could not be produced without damaging the amplifying material.
 - **How the problem was solved?**
 - The two scientists increased the duration of the pulses before the light was amplified so that the intensity comes down.
 - The light could then be amplified normally.
 - This amplified pulse could then be compressed back to its original time duration, and thus increasing its intensity by several orders of magnitude.
 - Their innovative technique, known as '**chirped pulse amplification**' (CPA), has now become standard for high intensity lasers, including the ultra-sharp beam used in corrective eye surgeries. It allows to cut and drill very precisely in various matter.



- **How shorter high intensity laser pulse can be beneficial?**

Nanosecond laser

Femtosecond laser



- With ultrashort and intense laser pulses, we can see events that previously seemed instantaneous. Laser pulses shorter than 100 attoseconds reveal dramatic world of electrons.
- It has also made it possible to cut and drill holes in material and living matter incredibly precisely.
- This has allowed corrective eye operations for millions of users.

A) LIDAR

- It stands for Light Detection and Ranging. It is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distance) to the Earth.
- These light pulses - combined with other data recorded by the airborne system - generate precise, three-dimensional information about the shape of the earth and its surface characteristics.
- LiDAR instrument principally consists of a laser, a scanner, and a specialized GPS receiver.
- **Two types of LIDAR** are **topographic** and **bathymetric**.
 - Topographic LIDAR** typically uses a near-infrared laser to map the land, while
 - Bathymetric Lidar** uses water-penetrating green light to also measure seafloor and riverbed elevations.
- **Applications**
 - Used in projects related to roads, canals, surface transport, city planning, landslides, irrigation etc.

- The system can be brought to use for engineering designs, conservative planning, floodplain mapping, surface feature extraction (trees, shrubs, roads and building) and vegetation mapping (height and density).

15. WIRELESS CHARGING

- Inductive charging (also known as wireless charging) uses an electromagnetic field to transfer energy between two objects through electromagnetic induction.
- The **induction of an electromotive force (voltage)** by the motion of a conductor across a magnetic field or by a change in magnetic flux in a magnetic field is called '**Electromagnetic Induction**'.

- **Understanding Law of Induction in 1830:**

- **Michael Faraday** discovered **Law of Induction** in 1830.

- **First Law:** Whenever a conductor is placed in a varying magnetic field, EMF induces and this emf is called an induced emf and if the conductor is closed circuit than the induced current flows through it.

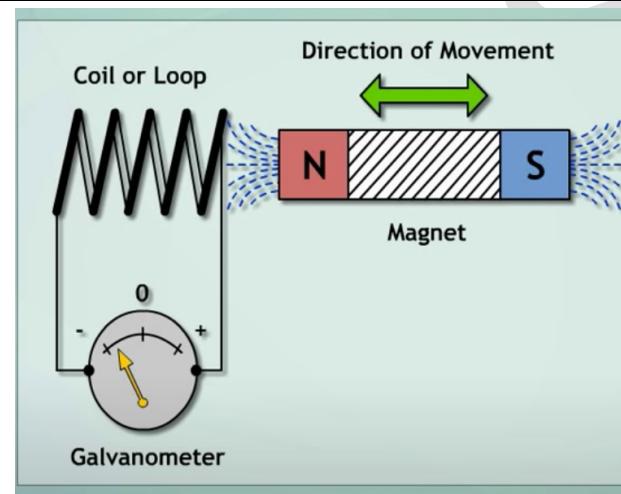
- **Second Law:** The **magnitude of EMF** id equal to the rate of change of flux linkages.

- The machines like generators, transformers, motors etc. work on the principle of electromagnetic induction.

- Similarly, while magnets can create magnetic fields, electric fields can also create magnetic fields.

- In fact, every time you change a magnetic field, you create an electric field. This is called Faraday's Law of Induction.

- Similarly, every time you change an electric field, you create a magnetic field. This is called the Maxwell-Ampere Law

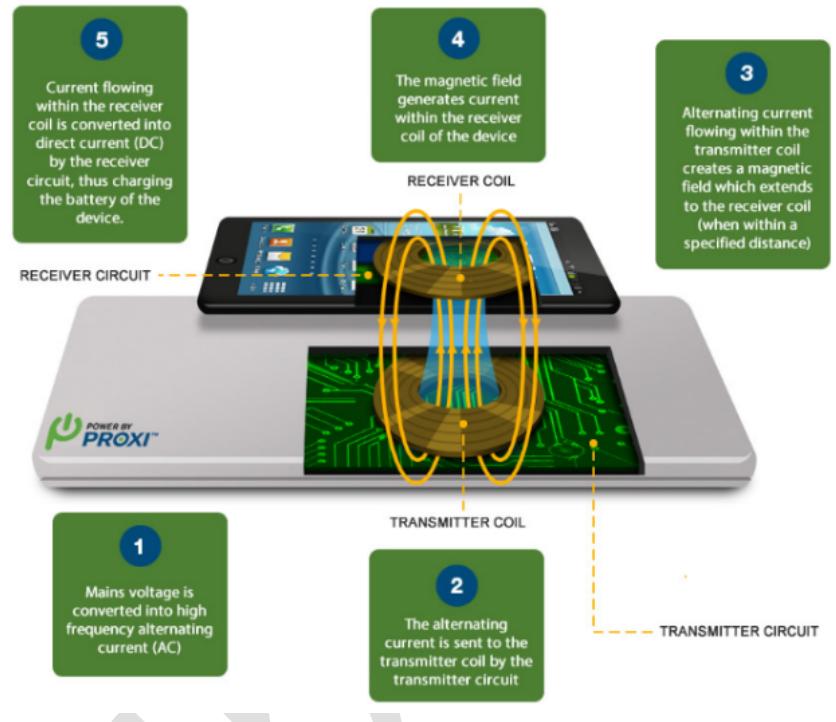


- **This is what happens in wireless charging.** Energy is sent through inductive coupling to an electrical device, which can then use the energy to charge batteries or run the device.
-
- **Advantages of inductive charging/wireless charging?**
 - **Protected Connection** -> No Corrosion, less risk of electric faults, short circuits etc.
 - **Low infection risk**
 - **Durability**

- Increased convenience and aesthetic quality

- Limitations
 - Less efficient
 - Slower Charging
 - More Expensive
 - Inconvenient

- Multiple Standards
 - Magne Charge, Qi etc are multiple standards being used in the market. This confuses the user and same charger cannot be used for all the devices.



16. FREE SPACE OPTICAL COMMUNICATION

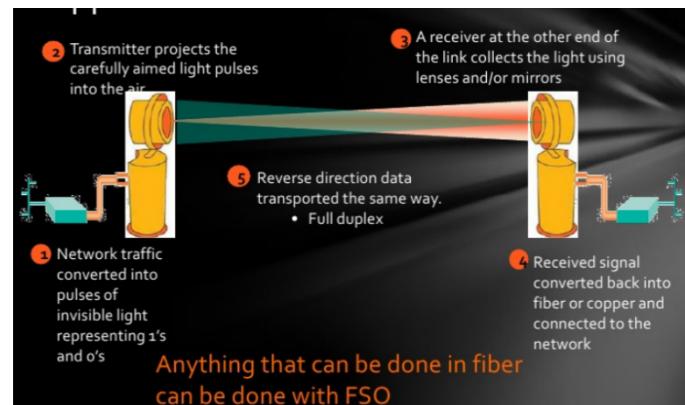
- Introduction

- It is a communication technology which uses light propagating in free space to wirelessly transmit data for telecommunications or computer networking.
- Most of the time laser beams are used, although non-lasing sources such as Light emitting diodes (LED) or IR-emitting diodes (IREDs) will serve the purpose too.
- “Free space” could mean air, outer space, vacuum etc.

- How does FSO work?

- The basic principle is similar to fiber optics transmission other than the fact that here the energy beam is collimated and sent through clear air or space, rather than guided through optical fiber.
- At the source, the visible or IR energy is modulated with the data to be transmitted. At the destination, the beam is intercepted by a photodetector, and data is extracted from the visible or IR beam (demodulated).
- Optical transceiver on both ends ensure bidirectional (duplex) capabilities.

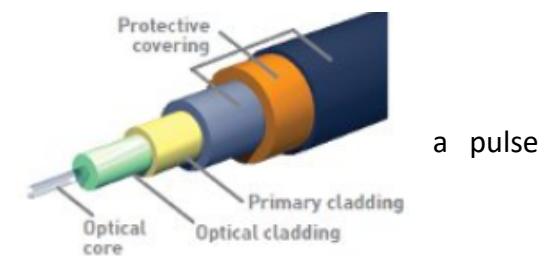
- Line of Sight Requirements



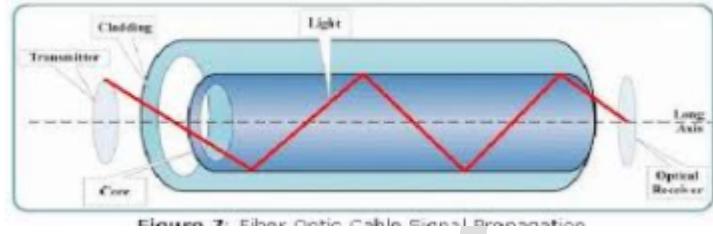
- Theoretically, FSO technologies can work over distance of several kms, as long as the source and the destination are in line of sight.
- **Uses**
 - The technology is very useful where physical connections are impractical due to high cost or other considerations.
 - It can be used for communication between spacecrafts. The first gigabit laser-based communication was achieved by the European Space Agency and called European Data Relay System (EDRS) in 2014. The system is still in operation.
 - LAN-to-LAN connections in campuses for very high-speed Ethernet access
 - To cross a public space (like road) which user doesn't own.
 - For temporary network installations, this is a better option as minimum infra set up is needed.
 - In disaster situation, it can re-establish data connections quickly
 - For high speed inter and intra chip communication.
- **Advantages**
 - Ease of deployment (very less infrastructure investment)
 - Can be used to power devices
 - License free long-range operations (as opposed to spectrum allocation licenses for microwave/radio wave communications)
 - Very high data bandwidth (very high speed of data communication)
 - Immunity from electromagnetic interference
 - Full duplex operation
 - Increased security when working with narrow beams (line of sight operation ensures security)
- **Limitations**
 - Stability and quality of the link is highly dependent on atmospheric factors such as rain, fog, dust and heat.
 - Doesn't work for non-line of sight senders and receivers

17. FIBER OPTICS COMMUNICATION

- **Introduction**
 - FOC is the method of transmitting information from one place to another by sending pulses of light through an optical fiber. Light basically forms the electromagnetic carrier wave that is modulated to carry information.
- **Key components**
 - Transmitter (light source) generates a light stream modulated to enable it to carry the data. Conventionally presence of light indicates "1" and absence of light indicates '0'.



▫ **Fibre Optic cable** is the very thin fibre of glass or other suitable material through which the modulated light stream travels to reach the destination. An optical fibre cable consists of a **core**, **cladding**, and a **buffer** (a protective outer coating). **Cladding guides the light along the core** by using the method of total internal reflection. The **core and the cladding (which is of lower-refractive index)** are usually made of high quality silica glass or plastic.



▫ **Optical repeater and amplifier:** In order to overcome the effects of attenuation of the cable, distortion of the light signal along the cable and to ensure that signal gets transmitted over long distances, repeaters and amplifiers are used.

▫ **Receiver (Detector)** converts the pulses of light into equivalent electrical pulses.

- Advantages of fiber optics over electrical cabling

- Lower Signal Attenuation
- Higher Bandwidth
- Can travel longer distances
- Fiber optics cables are much lighter than the coaxial cable (that might otherwise be used). This is very crucial in cases like that of aircraft
- No sparks – important for flammable and explosive gas environment
- Fiber optics do not suffer from stray interference pick up that occurs with coaxial cables.
- Further fiber optics transmission also doesn't suffer from cross talks in contrast to some type of electrical transmission signal.
- Resistant to corrosion due to non-metallic transmission medium.

- Limitations of fiber optics over electrical cable

- Fiber optical system are more expensive to install
 - The cost of cable, the transmitter and receiver is higher in case of fiber optics
- Electrical cable has the capability of carrying electrical currents as well as signals (in properly designated cables), whereas optical fibers can only be carrying signals.

- Applications

- Telecommunication (telephone signals, internet communication and cable tv)
- Due to lower attenuation and interference, optical fiber has large advantages over existing copper wire in long-distance, high demand applications and high-resolution content.

- India and Fiber Optic Communication

- The **National Optical Fiber Network (NFON)** is a project initiated in 2011 to provide broadband connectivity to 2.5 lakh gram panchayats of India (min bandwidth of 100 Mbps) at an initial cost of 20,000 crore rupees.
 - The project intended to enable government of India to provide e-services and e-applications nationally.

- **BharatNet** (rechristening of NOFN) is a project of national importance to establish, by 2017, a highly scalable network infrastructure accessible on a non-discriminatory basis, to provide on demand, affordable broadband connectivity of 2 Mbps to 20 Mbps for all households and on demand capacity to all institutions, to realize the vision of digital India, in partnership with states and private sector.
 - The entire service is being funded by Universal Service Obligation Fund (USOF), which was set for improving telecom services in rural and remote areas of the country.
 - The **objective** is to facilitate the delivery of e-governance, e-health, e-education, e-banking, Internet and other services to rural India.
 - **Implementation:** the project is a centre-state collaboration, with the states contributing free Rights of Way for establishing the Optical Fiber Network.

18.3D PRINTING

- **Intro**
 - 3D Printing (also known as additive manufacturing) is a process where an object is created by adding material layer by layer from a computer blueprint/design. It allows designers to create complex parts for machines, airplanes and cars at a fraction of cost and time of standard means like forging, molding and sculpting.
 - Now, smaller consumer friendly 3D printers are bringing additive manufacturing to homes and businesses.
- **Key steps involved in 3D printing**
 - **Create a blueprint** of the object that requires to be printed. **Modelling software like blenders, CADs etc.** can be used to create the design to be printed.
 - **Printing** works on the layering principle where layers of material is added till the final object is created. Most common material used in 3D printing is plastic, but other material can also be used.
- **Three key advantages of 3D printing are shorter lead time, design freedom, and lower costs.**
- **Main uses:** It's hard to find a sector where 3D printing hasn't had an impact.
 - **Manufacturing and other industrial sector** can now use 3D printing to develop prototype models and test new components.
 - It is also playing a significant role on **fashion industry** with fashion designers experimenting with 3D-printed clothes shoes etc.
 - **Medical Sector** has been one of the biggest beneficiaries of the technology
 - Doctors have been testing biomaterials for regenerative medicines. Some surgeons have even tested 3D printed organs for transplant.
 - **Cultural Heritage preservation, restoration, and dissemination**
 - Many museums in advanced countries have started using the 3D printing technology for actively creating missing pieces of relics.
 - **Homes and other buildings:** Recently a giant 3D printer in China printed 10 houses in just one day and at a cost of less than \$5,000 per house. It proved how cost and time efficient 3D printing can be.
 - **Food Industry:** 3D printing is being used for designing cakes on demand and other food items.
 - **Defence Sector:**
 - For e.g., the corps of Engineers used 3D printing to construct 22,000 temperatures controlled, relocatable, habitat in the high-altitude areas of LAC.

- In addition to 3D printing habitat, the Army's Corps of Engineers in consultation with IIT Gandhinagar, came up with **3D printed permanent defenses** for forward areas. Trials have shown that these 3D printed defences can take direct hit from T-90 tank from 100 meters away and can be constructed in a much shorter time frame compared to regular defensive bunkers.

- **Key Concerns**

- **Intellectual Property Rights:** Once 3D printing becomes very popular, it would be difficult to prevent the IPR violation by individuals at their homes and privately.
- **Health Issues:** Experts have raised concerns about potential health implications of the technology due to exposure to gases and other materials including nanomaterial. Particle emissions from a fused filament generally peaks during printing and may include a large number of ultrafine particles and volatile organic compounds.
- **Public Safety** may become an issue with 3-D printing advanced guns being available with anti-social elements, including terrorists.

19. BARCODE AND QR CODES

A) QR CODE (QUICK RESPONSE CODE) – A TYPE OF 2D BAR CODE

- **What is QR Code and how does it work?**
- Developed in 1994 by a Japanese Cooperation Denso Wave – a subsidiary of Toyota motors.
- QR Code, in full Quick Response Code, **is a type of bar code that consists of printed square pattern of small black and white squares that encode data which can be scanned into a computer system.**
- The black and white square can represent numbers from 0-9, letters A-Z, or characters in non-Latin scripts such as Japanese Kanji.
- The three corners of the QR code contain the finder pattern, a nested series of black and white squares that, when detected by an optical scanner and interpreted by software, allows the scanning device to determine the **orientation of the QR code**.
- **Advantages over barcode**
 - Store hundred times more information
 - Can be scanned from any direction for 360 degrees. This makes it easier for devices to read and lessens the possibility of background interference. Further, it doesn't need a special laser emitting device to read, camera of a smart phone or tablet computer is good enough for scanning the information.
 - Fewer errors – since QR codes have more storage, it can store same information multiple times to reduce the impact of physical damage of the code.
 - More Secure – as it is possible to encode the information in bar codes.
 - In **marketing**, the code's appearance is unique and interesting, increasing the likelihood of engaging the customers.
- **Uses:**
 - Used in advertising, to encode URL of a website that contain a coupon or information about a product.
 - Used in books to help students easily access the webpage.



B) BAR CODE

- Bar code is an optical, machine readable form of data. It is a printed series of parallel bars or lines of varying width that is used for entering data into a computer system. This data usually defines something about the product which carries the barcode.
- Barcodes represent data by varying the widths and spacing of parallel lines.
- **Uses:**
 - **Automation of supermarket checkout** is the most common place where we see bar code scanner. In fact, this use of barcode has almost become universal.
 - **Supply chain management**
 - **Advantages**
 - Speed of processing
 - Better tracking (in case of supply chain management)
 - Low cost and very accurate (compared to key entry)
 - **How does a bar code scanner work?**
 - Laser/LED is reflected back better from the white spaces (and not from the black bar).
 - This reflection is converted into on-off pulse in the binary digit by an electronic circuit attached to the scanner.



20. TOPICS TO BE COVERED IN FUTURE BOOKLETS

- Wireless Communication (5G/6G), Bluetooth, WiFi, NFC, RFID etc.
- VOLTE/ VoIP/ VoWiFi



TARGET PRELIMS 2024

BOOKLET-7; S&T-7

COMPUTER & IT - 4

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2. VARIOUS GENERATION OF CELLULAR WIRELESS COMMUNICATION TECHNOLOGY

1) DIFFERENCE BETWEEN 1G, 2G, 3G, 4G, AND 5G

- **G** in terms like 1G, 2G, 3G, 4G etc. refers to a generation of cellular wireless communication technology.
- When there is a change in generation, there is a change in:
 - The fundamental nature of service
 - Non-backwards compatible transmission technology
 - New Frequency bands.

Different Generations, key differences:

Features	1G	2G	3G	4G	5G
Year of introduction	1980s	1990s	Early 2000s	Late 2000s	Late 2010s
Core technology	Analog	Digital (CDMA , GSM)	CDMA2000	LTE	NR (New Radio)
Services	Voice calls	Voice calls, SMS, Basic mobile Internet;	Integrated high-quality audio, video and data	Dynamic information access, variable devices	Dynamic information access, variable devices with all capabilities
IP Protocol	N/A	Supported	Supported	Fully Supported	Fully Supported
Data Speed		Upto 384 Kbps	Several Mbps	100 Mbps to 1 Gbps	Upto 20 Gbps
MIMO technology	N/A	No	Yes	Yes	Yes

Note: Security keeps on improving with every generation; Latency keeps on decreasing with every generation; **Data Speed** keeps on improving with every generation.

MIMO Technology: (Multiple Input Multiple Output) (MIMO) is a wireless technology that uses multiple transmitters and receivers to transfer more data at the same time.

Note: Legacy wireless streams used Single-Input Single Output (SISO) technology. They can only send and receive only one spatial stream at a time.

2) VARIOUS 4G TECHNOLOGIES

- **4G phones are supposed to be faster, but there are many technologies and speed varies.**

- The International Telecommunication Union (ITU), a standards body, tried to issue requirements to call a network 4G but they were ignored by carriers, and eventually the ITU backed down.
- 4G technologies include.
 - 1. HSPA+ 21/42**
 - 2. WiMAX (now obsolete)**
 - 3. LTE (Long Term Evolution)**

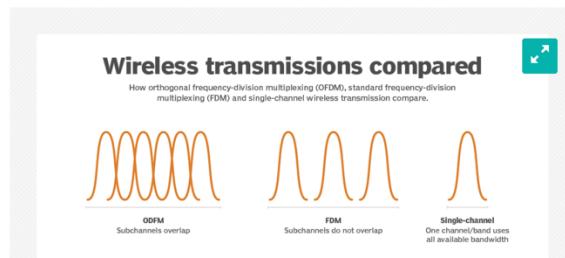
A) LTE

- » LTE is the most popular 4G tech. Some people consider it the only true 4G tech of the bunch and some others say that none of them are fast enough to be called 4G. The **key difference** between 4G LTE and other “4G” technologies is the upload speed.
- » **Other Details about LTE:** LTE only allows transmission of data. **Voice calls** are routed through telecom networks’ older 2G and 3G networks. Therefore, under LTE, we can’t access 4G data and services while on a call.

- » **Key Features of LTE:**

- **Orthogonal Frequency Division Multiplexing (OFDM):** It allows high data bandwidth to be transmitted efficiently while still providing a high degree of resilience to reflection and interference.

In a traditional single-channel modulation scheme, each data bit is sent serially or sequentially one after another. In OFDM, several bits can be sent in parallel, or at the same time, in separate substream channels. This enables each substream's data rate to be lower than would be required by a single stream of similar bandwidth. This makes the system less susceptible to interference and enables more efficient data bandwidth.



Multiple Input, Multiple Output: LTE-A uses MIMO antenna technology. MIMO and OFDM ensure a higher signal to noise ratio at the receiver ensuring good services even in dense regions.

B) VOICE OVER LTE (VoLTE)

- Voice over LTE is a **digital packet technology** that uses 4G LTE to route voice traffic and transmit data. VoLTE provides higher quality calls, better service, and the ability to simultaneously use voice and data.
- **NEED:** Why is VoLTE necessary?
 - » The technology is necessary because **LTE is a data-only networking technology**.
 - **Previous cellular networks** such as 2G and 3G, were designed to carry voice calls – services added cellular data support later through methods that basically “tunneled” data inside of voice-call connections.

- **LTE turns the network around** and uses Internet Protocol Packets for all communications. As such it doesn't support traditional voice call technology, so a new protocol and applications for voice over LTE are needed.
- **How does VoLTE work?**
 - » It is based on the **IP Multimedia Subsystem (IMS) framework**. This allows the service to deliver multimedia as data flows using a common IP interface.
- **Advantages of VoLTE**
 - » **VoLTE** uses the **spectrum more efficiently** than traditional voice calls. It uses less bandwidth because VOLTE's packet headers are smaller than those of unoptimized VoIP/LTE.
 - » It provides for increased battery life when compared to VoIP.
 - » Provides superior audio quality and a clearer calling experience.
 - » **Ends dependency** on the legacy circuit switched voice network to be maintained.
 - » Allows up to **six-way conference calls**.
 - » Ability to **simultaneously use voice and Data**. Eliminates the need to have voice on one network and data on another.
- **Limitations**
 - » Need volte capable smart phones
 - » **Strong 4G coverage** to make and receive calls over 4G network.
 - » For VoLTE call, both devices involved in communication must be compatible with VoLTE.
- **Services in India**
Reliance Jio and Airtel are the leading operator providing the VoLTE. Reliance Jio doesn't have spectrum in 2G or 3G and thus it places all its calls using 4G LTE only (unlike other operators which drop to 2G or 3G for sending and receiving calls).

3) 5G

- 5G refers to **the fifth generation of cellular wireless communication technologies**.
- **Key features of 5G technology** are:
 - **Higher speed; Lower latency; Greater network stability.**
 - **Device Intelligence:** Unlike 4G, 5G has the capability to differentiate between fixed and mobile devices. It uses cognitive radio techniques to identify each device and offer the most appropriate delivery channel. This will allow a much more customized internet connection – according to device capability and local reception environment.
 - **Other technical features of 5G**
 - 5G will use higher frequencies of wireless spectrum (~ **30 GHz to 300 GHz**) range when compared to 4G which uses frequencies below 6 GHz.
 - **Higher Frequency** -> Huge quantity of data; Shorter Wavelength -> smaller antenna sizes.
 - Building on the multiplexing technology of its predecessor, 5G ushers in a new standard called **5G New Radio (NR)**, which uses the best capabilities of LTE. **5G NR** will enable increased energy savings for connected devices and enhance connectivity.
 - These frequencies are **highly directional** and thus can be used right next to other wireless signals without causing interference.

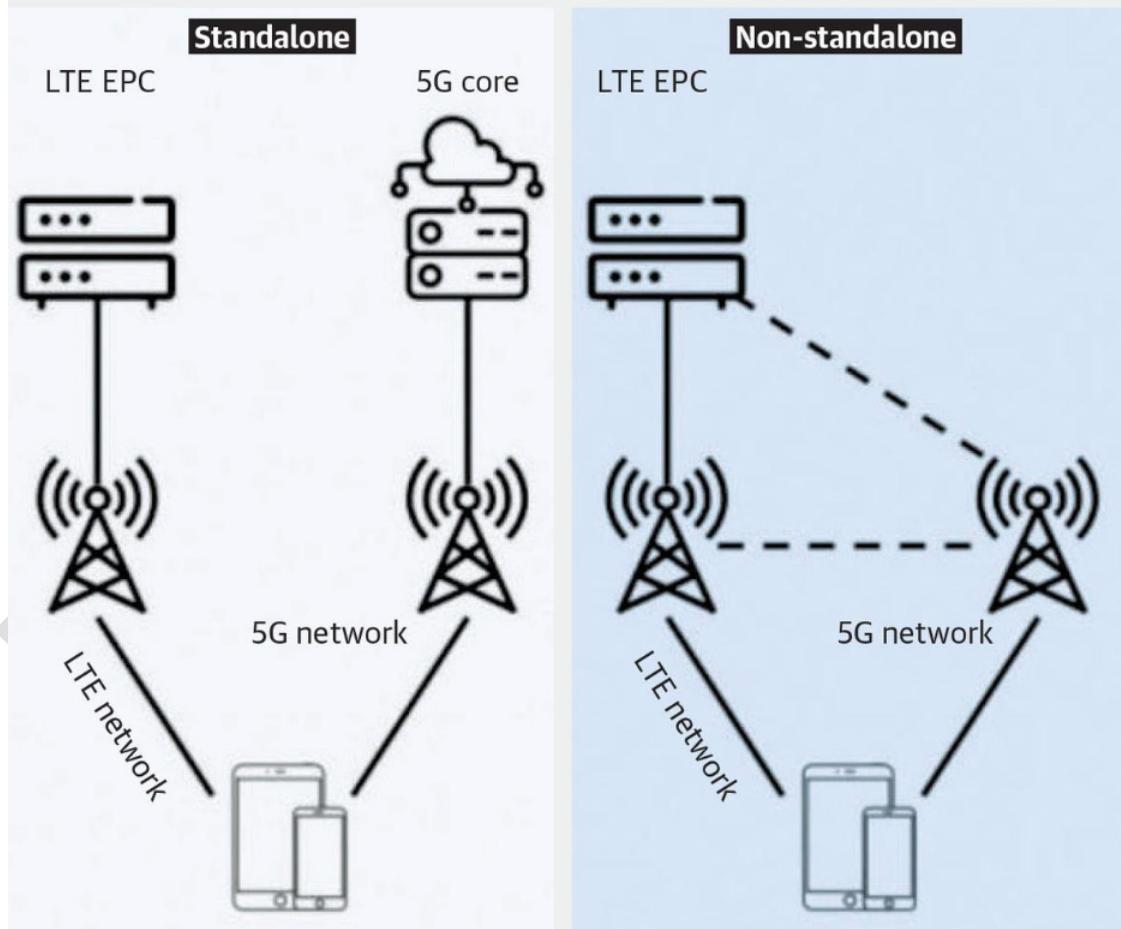
- Several hundreds of thousands of simultaneous connections for wireless sensors
- Spectral efficiency significantly enhanced compared to 4G
- Improved Coverage
- Enhanced signal efficiency

C) STANDALONE AND NON-STANDALONE 5G

- 5G networks are deployed on two modes: **standalone** and **non-standalone**.
- Each architecture has its advantage and disadvantages. The method used by the operators primarily reflect their view of the market for the new technology, and consequent rollout strategy.

5G architecture

When 5G is deployed through a non-standalone framework, the operator uses the existing installed capacities and LTE architecture. However, in a standalone model, the radio access network and the core will be completely new. It gives operators the full range of 5G's capabilities.



- **Standalone Mode:** In this mode, the 5G network operates with dedicated equipment and runs parallel to the existing 4G network. In this architecture, Radio Access Network (RAN) and the core are

completely new, and there will be a clear separation of different network functions in line with the 3GPP recommendations.

- Jio has chosen this method. It has committed an investment of Rs 2 lakh crore for its standalone 5G network.
- **Advantages:** Provides full 5G capabilities and new network functionalities such as slicing that provides greater flexibility to operators to efficiently use their spectrum holding; Simplify network operations; much faster than NSA 5G -> improved user experience; Long term solution.
- **Limitations:** High Initial Investment

- **Non-Standalone Mode (NSA):** In this, the 5G network is supported by the 4G Core infrastructure. The operators can use their existing capacities and LTE architecture to deploy 5G services while implementing a new radio access network (RAN). The operations in the core network will be supported by the existing evolved packet (EPC) from LTE. **Germany** for e.g., used the NSA model to roll out 5G services in 2019.
 - **Advantages:** Reduce initial cost/investment; Maximizes the utilization of existing network; Reduces time of deployment; first national coverage
 - **Limitation:** Only short term/medium term solution; Not as fast as pure 5G
- Given that the non-standalone networks are built on existing infrastructure, the initial cost and rollout times are significantly lower. It lets operators maximize the utilization of existing network infrastructure with relatively lower investment.

Compatibility with existing device ecosystems: Most smartphones today have compatibility to connect to non-standalone 5G network – which are essentially 5G airwaves transmitted through 4G networks. It will require software updates by their OEMs to be able to connect to standalone networks.

D) CHALLENGES OF FIBERIZATION AHEAD OF INDIA'S 5G DEPLOYMENT (CLASS DISCUSSION)

E) 5G SPECTRUM (LOW BAND, MIDDLE BAND, HIGH BAND)

- **5G** differs from previous cell phone standards, in having much wider spectrum than before. It is capable of tuning in many more types of frequencies – and multiple types of frequencies at the same time.
 - **Low Band 5G (600 – 700 MHz):** Low band tower can cover 100s of sq miles with 5G services that range in speed from **30 – 250 megabits per second (Mbps)**. It is the blanket layer for nationwide coverage. It will provide a base and services will not get worse than this. It uses the same frequency (600 MHz) that was once used for analog TV broadcasts. This ensures coverage in far flung rural areas.
 - **Note:** Even low band services are faster than 4G services.
 - **Middle Band 5G (2.5-3.5 GHz):** Mid band tower can cover several mile radii with 5G service that range in speed from **100 – 900 Mbps**.
 - **Note:** Some carriers will be skipping low band 5G, so their middle band 5G services will be the base service.

- **Note:** Cellular industry is considering the mid band 5G as the sweet spot for 5G distance and performance.
- **High Band** (millimeter wave/24-39 GHz) tower covers a one mile or lower radius while delivering superfast speeds (roughly 1-3 gbps speeds). It will be deployed in areas with “**dense urban**” environments and public gathering places that frequently save huge number of people.
- Each of these tiers would improve in performance over time.

F) PRIVATE 5G

- It is a cellular network technology that provides 5G connectivity for a specific, closed user group within a limited geographic area.
- Unlike public 5G networks, which are operated by mobile carriers and accessible to anyone with compatible device and subscription, private 5G networks are owned and operated by private entities, such as businesses, governments, or universities. This gives owner full control over the network, including who can access it, how it is used, and the quality of service.
- **How does it work?**
 - Same tech as public 5G, but they operate on licensed or unlicensed spectrum.
- **Advantages:**
 - **Increased privacy and security:** It allows organizations to implement their own security measures.
 - Improved reliability and performance (since it can be tailored to specific needs of the users)
 - Greater control and flexibility
 - Reduced cost

G) AIRLINES VS 5G IN USA AND SOME OTHER COUNTRIES (CLASS DISCUSSION)

- **what were the problems caused by deployment of 5G ‘C-Band’ spectrum (3.7 GHz – 3.98 GHz)?**
 - The C-band frequency range of 5G wireless technology is very close to the 4.2 to 4.4 GHz range used by altimeters on all aircrafts, something that was established long back

4) 6G

Successor of 5G

Frequency Bands – 95 GHz to 3 THz

It seeks to use Tera Hz band frequency which is still unutilized. Tera Hz band fall between infrared and microwaves. Though the waves have very small wavelength, there is a huge amount of free spectrum which would allow us very fast data rates.

Data rate – Upto 1 TBPS (100 times faster than 6G)

Latency < 1 milli seconds

Application and Advantages (Similar points as 5G)

6G also envisions to enable new applications such as holographic communication, brain-computer interface, quantum internet, and artificial intelligence.

Challenges for India:

Low R&D investments

Terahertz communication are blocked easily by barriers and signal also attenuates easily

5) BHARAT 6G ALLIANCE (B6GA)

Why in news?

DoT launches Bharat 6G Alliance to drive innovation and collaboration in Next-Generation Wireless Technology (July 2023)

Details about B6GA:

It is a collaborative platform consisting of public and private companies, academia, research institutions and standards development organization. It will forge coalition and synergies with other 6G Global Alliances, fostering international collaboration and knowledge network.

The **primary objective** of the B6GA is to facilitate market access for Indian telecom technology products and services, enabling the country to emerge as a **global leader in 6G technology**.

It aims to bring together Indian startups, companies, and the manufacturing ecosystem to establish consortia that drive the design, development and deployment of 6G technologies in India.

It also focuses upon accelerating standard related patent creation within the country and actively contributing to international standardization organizations such as 3GPP and ITU.

6) BHARAT 6G MISSION

- Aim of 6G service rollout by 2030.
- India has also launched a development test bed.
- **More about the Vision document**
 - » **Prepared** by the Technology Innovation Group on 6G (TIG) which was set up by Department of Telecommunication in 2021.
 - » **Mission divided into two phases:**
 - **Phase 1** (2023-2025): Ideation phase – understand various potentials and risks; test proof the concept
 - **Phase 2** (2025-2030): Delivering the potential technology solution
 - » **Constitution of an apex body** to oversee the mission and approve the budget of the mission
- **Significance** of the document:
 - » Assuming leadership in setting the 6G standards
 - » Not delaying adoption (as has happened in previous generations)
 - » Ensuring latest technology coming to India in the fastest way possible.

3. E-SIM

- **What is an eSIM (embedded Sim)?**
 - » An eSIM is a programmable chip that is built (embedded) into smartphones, tablets or other devices. An eSIM is a digital SIM that allows you to use a cellular plan from your carrier without having to use a

physical nano-SIM. The pre-installed (embedded) simcard is activated by installing the “eSIM profile” of a new operator.

- » **Technical Name:** The eSIM is called by its technical name, **eUICC** (Embedded Universal Circuit Card) or virtual SIM.

- **Advantages:**

- » This has very small physical footprint, even smaller than the nano sims available since 2012. Not having a removable sim slot also saves a lot of space. This is especially useful for smaller electronics like smartwatches. Further, not having the sim tray increases the scope of making the device water resistant.
- » It serves the same purpose as a physical SIM, but it is carrier independent and can be programmed via software instead.
- » **Same eSIM profile** can be activated on multiple device (e.g. phone, smart watches etc.) (traditionally, one physical sim card could be used only in one device)
- » **Switching providers is very easy:** Instead of getting a new physical SIM card, all you have to obtain is a configuration file and activate it on the device. Providers generally refer to it as an eSIM profile and offer it as a QR code that you can scan and download.
- » Further, eSIM allows storage of multiple carrier profiles on the smartphones and carrier can be switched between on the fly.
- » **Carriers also benefit** as they don't have to manufacture and provide a physical sim card thus reducing the cost.
- » **Environment friendly** – extra packaging of physical sim card, plastic waste, e-waste etc. could all be reduced.

- **Disadvantages/Limitations:**

- » **Not supported by all carriers yet.**

- In India, **Jio, Airtel, and Vi** all support eSIM. You need to send a message to the carrier asking them to activate eSIM and they usually send a code which has to be scanned via the device on which you intend to use the eSIM. Once done, the eSIM should work.

4. RFID COMMUNICATION

- RFID (radio frequency identification) is automatic recognition technology that uses wireless communication. Here, data is encoded in an RFID tag which might be read by the reader.

- **What is the most important advantage of RFID?**

- » Electronic devices generally need a power source. But, RFID tags use a mechanism where we can send power to device, whenever the device needs it. (Electromagnetic field coupling)
- » We don't need a power source on RFID tags.

- **Kinds of RFID: Passive and Active**

- » **Passive RFID:** RFID tags have neither an electric plug nor a battery. Instead, all of the energy needed to operate them is supplied in the form of radio waves by RFID readers. This technology is called passive RFID.
- » **Active RFID:** Here, there is a power source on the tag.

- **Advantages:**

- » Data can be read from longer distance. (for e.g., even if the tag is high, relatively inaccessible place) etc.
- » Multiple tags can be read at once -> it obviates the need to hold item one by one in order to read the data.
- » Data can also be read from outside the box unlike barcode/ QR code (without opening the box). It is also immune to things like dirt.
- » A passive type RFID can be used semi-permanently without a battery.
- » Since tag contains a memory, the data can be rewritten.

- **Applications:**

- » It enables efficient inventory count at logistics center, backyard, and storefront.
- » Incoming and outgoing record (e.g. FASTag at toll booths)
- » **Brand Protection:** It is a useful tool to prevent grey market and counterfeit products of luxury brands.
- » Tracking: Personnel, asset etc.
- » **Smart Keys** (for doors)

- **Disadvantages:**

- » It takes longer to program an RFID tag (compared to QRCode)
- » RFID can be intercepted easily, even if its encoded.
- » **Foil (2-3 layers of household foil)** can dam the radio waves
- » Privacy concerns: Anybody can access information about anything

5. NEAR FIELD COMMUNICATION

- **What is NFC and How does it work?**

- It is a short-distance wireless communication technology. When two NFC enabled devices are very close to each other (around 4 cm), then they can communicate with each other using radio waves.
 - » **Atleast one of the device should be active device** like smart phone, tablet, or post terminal. Please note that the active device would need an external power supply. The other device may be active or passive (for e.g. NFC tags). Passive device is powered by the electromagnetic field of the active device.
- **NFC supports three modes of communications:**
 - » **Peer to Peer communication mode**
 - E.g., when we share information between two smart phones.
 - In this mode, both devices are active devices. They can communicate with each other by generating radio waves alternatively. When one device transmits data, the other listens to it and vice-versa.
 - » **Reader/Writer Mode:**
 - E.g. when we access data from smart phones using NFC tags.
 - This mode is similar to RFID. Here the active device like smartphones and tablets reads or writes the data on NFC tag using the principle of electromagnetic induction. A time varying electromagnetic field generates the voltage in this passive tag. This voltage powers up the chip in this NFC tag. Once powered up the tag responds with its own information.
 - » **Card Emulation Mode**

- E.g. when smartphones are used for mobile payments.
- Both devices are active device. One device will be a smart phone and the second device is a payment terminal. Here, smartphone acts like a passive smart card and don't generate their own radio waves. They only respond back with the requested data by the payment terminal. Operating principle in this mode is similar to reader/writer mode.

- Applications

- **File sharing**
- **Contactless payments:** NFC is behind the cards that we have over card readers on shops
- **Mobile payments**
- **Pairing different devices**
- **Information sharing using smart posters and business cards**
- **Home automation**
 - » NFC tech is present in new age speakers, household appliances, and other electronic devices that we monitor and control through our smartphones.
 - » E.g. changing temperature of AC, ambient lighting etc.
 - » Automatic closing of doors
- **Healthcare:** NFC is used to monitor patients stats through NFC-enabled wristbands.
- **Library systems:** Keeping tabs on library books
- **Preventing Auto theft**
- **Personal usage**
- **Running unmanned toll booths**
- **Wireless charging**

- Advantages over other forms of communication.

- **NFC vs Bluetooth:** While Bluetooth provides for higher data rate sharing; But **NFC reduces the time required for pairing of devices**. In case of NFC the two devices can be set up in less than 0.1 seconds. Once the pairing between devices is done, for communications either Bluetooth or wifi can be used.
- **NFC vs RFID:** NFC is derived from RFID standards and the working principles are quite similar to RFID. But RFID works on large band of frequencies (LF: 125 kHz or 134 kHz) HF: 13.56 MHz; UHF: 860-960 MHz). But **NFC works on a particular frequency band** i.e. 13.56 MHz band. In case of RFID, the reader sends the request to the RFID tag and in response the RFID tag replies back to the reader. So, in case of RFID there is only one way communication. While in case of **NFC peer to peer communication is possible**.
- **NFC vs QR Codes:** In case of QR codes, scanning if required to access the information. In case of NFC, just by tapping mobile to NFC tag, information can be easily accessed. Therefore, access time required in case of NFC is less than that of QR code. Further NFC is more secure than the QR code. Because in case of QR code, wrong information may be provided by putting another QR code on top of the 1st QR code, while in case of NFC, if someone puts another NFC tag on top of the first one, then neither of the tags would be accessed. Thus, NFC tech is more secure than the QR code technology.

- How secure is this tech?

- Since NFC works at very close distance, it makes it difficult for attackers to record or communication between the devices compared to other wireless technologies.
- The user of the NFC-enabled device determines by the touch gesture which entity the NFC communication should take place with, making it more difficult for the attacker to get connected.

- Peer to Peer communication provides a mechanism to cipher all exchanged data to avoid external interpretation of recorded communication.
- When did NFC tech start?
- In 2004, consumer electronics companies, Nokia, Philips, and Sony together formed the NFC forum, which outlined the architecture for NFC technology to create powerful new consumer driven products.

A) 'TAP TO PAY' FOR UPI LAUNCHED BY GOOGLE PAY

- Google has recently launched a new feature in India, 'Tap to pay for UPI', in collaboration with Pine Labs. The feature makes use of Near Field Communication (NFC) technology.
- The functionality would allow users with NFC-enabled Android Smartphones and UPI accounts linked to Google Pay to carry out transactions just by tapping their phone on any Pine Labs Android point-of-sale (POS) terminal across the country. Till now, Tap to pay was only available for cards.
- Google Pay has been the first among UPI apps to bring Tap to Pay feature working on POS terminals.
- How will this work?
 - Once the users tap their phones on the POS terminal, it will automatically open the Google pay app with the payment amount pre-filled. Users can then verify the amount and merchant name and authenticate the payment, using their UPI PIN.
 - They will be notified when the payment is successful.
 - Advantage: The process is much faster compared to scanning a QR code or entering UPI-linked mobile number which has been the conventional way till now.
- Are other companies using NFC tech for payments using smartphones?
 - In Feb 2022, Apple introduced Tap to Pay on the iPhone. It will allow merchants across the US to use their iPhone to accept Apple Pay, contactless credit and debit cards, and other digital wallets through a tap on their iPhone without the need of any additional hardware or payment terminal.

At checkout, a customer just needs to hold their iphone or apple watch to pay with Apple Pay, their contactless credit or debit card, or other digital wallet near the Merchant's iphone to complete the payment using NFC technology.

6. BLUETOOTH COMMUNICATION

- Bluetooth is a wireless communication technology that can be used for close range of data transmission from one digital device to another. It relies on short-range radio frequency, and any device that incorporates the technology can communicate as long as it is within the required distance.
- It is essentially a one-to-one wireless connection that uses 2.4 GHz band radio waves. This is the same frequency which other wireless technologies in the home or office, such as cordless phones and WiFi routers use.
- Bluetooth creates a 10 meter (33 foot) radius wireless network, called a personal area network (PAN) or piconet, which can network between 2 to 8 devices.
- It is an electronics "standard", which means that manufacturers that want to include this feature have to incorporate specific requirements into their electronic device.

These specifications ensure that the devices can recognize and interact with other devices that use Bluetooth technology.

The "Bluetooth" name is taken from a 10th-century Danish king named Harald Bluetooth, who was said to unite disparate, warring regional factions. Like its namesake, Bluetooth technology brings together a broad range of devices across many different industries through a unifying communication standard.

- **Advantages:**

- Bluetooth offers a uniform structure for a wide range of devices to connect and communicate with each other.
- It has achieved global acceptance and almost any Bluetooth enabled device, anywhere in the world can connect to another Bluetooth enabled device nearby.
- Low power consumption when compared to wifi and other such wireless systems.
- It also costs much less to implement.



TARGET PRELIMS 2024

BOOKLET-8; S&T-8

BIOLOGY BASICS

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1. CELL: FUNDAMENTAL UNIT OF LIFE

1) WHY IS CELL THE FUNDAMENTAL UNIT OF LIFE?

- Cell is the fundamental structural and functional unit of living organisms i.e. it is the smallest living unit of an organism. Thus, it is also the basic fundamental unit of life.
- Every cell is capable of doing some basic things like respiration, obtaining nutrition, and clearing the waste material, or forming new proteins.

2) SHAPES OF CELLS

- With the discovery of electron microscope in 1940, it was possible to observe and understand the complex structure of the cell and its various organelles.
- The shapes and sizes of the cells are related to the specific function they perform. Some cells like Amoeba have changing shapes. Cells shape can be very peculiar. For example, nerve cells have a typical shape.
- **Some organism can have cells of different types**
 - For example, humans have different types of cells

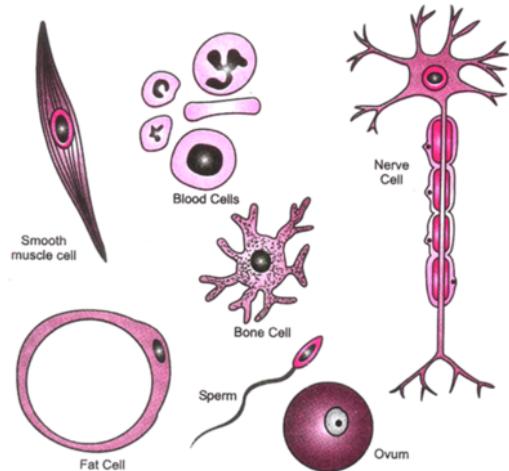


Figure : VARIOUS CELLS FROM THE HUMAN BODY

3) TWO BROAD CATEGORIES OF CELLS – EUKARYOTES AND PROKARYOTES

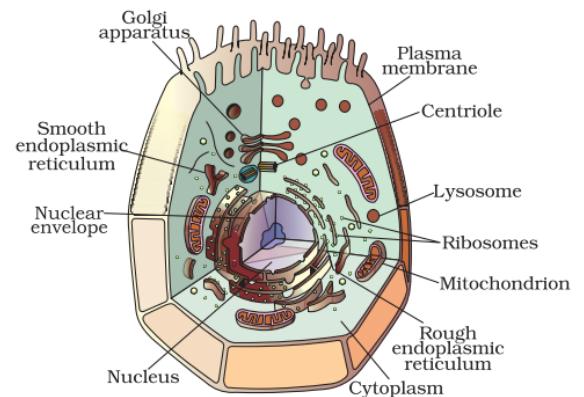
- The difference between the structures of Prokaryotes and Eukaryotes is so great that it is considered to be the most important distinction among group of organisms.
 - i. **Eukaryotic**
 - They have membrane bound organelles such as nucleus.
 - They are advanced cells found in plants and animals
 - They are usually found in multi-cellular animals. But there are a lot of unicellular Eukaryotes too.
 - ii. **Prokaryotic**
 - They don't have nucleus or other well-defined organelles. They do have genetic material, but it is not contained within a nucleus.
 - They are found in primitive cells like that of bacteria and Archaea.
 - Prokaryotic cells are always unicellular such as bacteria. But there is some evidence that some bacterial species can aggregate together and divide labor so that the "colony" is working more

efficiently. This is the characteristic of a multi-cellular organisms, but there is still a lot of resistance to the idea of calling these prokaryotes multi-cellular.

- Prokaryotes are usually much smaller than Eukaryotes.

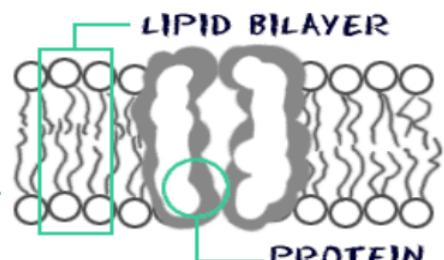
4) STRUCTURAL ORGANIZATIONS OF CELL

- Every living cell has the capacity to perform certain basic functions that are characteristics of all living forms. There is a division of labour seen within a single cell. The cell components called the cell organelles have specialized functions.
- These functions include making new material in the cell, clearing up the waste material from the cell and so on.
- These organelles together constitute the basic unit called the cell. It is interesting to note that all cells are found to have the same organelles, no matter what their function is or what organism they are found in.
- **Three Broad components of the cell**
 - **Plasma Membrane or Cell Membrane**
 - **Nucleus**
 - **Cytoplasm**



A) PLASMA MEMBRANE OR CELL MEMBRANE

- Cell membrane/Plasma membrane is the outermost covering of the cell that separates the contents of the cell from its external environment.
- It allows or permits the entry or exit of some materials in and out of the cells. It also prevents movement of some other materials. The cell membrane is therefore called **selectively permeable membrane**.
- Cell membrane is not a solid structure. Cell membranes are also described as lipid bilayers.
- There are two layers of phospholipids with protein embedded in the layers.
- **How does diffusion of substance take place into the cell?**
 - **Diffusion**
 - Continuous movement of a substance from a region of high concentration to a region where its concentration is low.
 - E.g.: O₂ enter the cell by the process of diffusion when the level of concentration of O₂ inside the cell decreases.
 - CO₂ moves out of the cell when the level of concentration of CO₂ inside the cell increases.



- Water also obeys the law of diffusion: **Osmosis** - the movement of water molecules through such selectively permeable membrane. It is basically movement of water from a region of high water concentration through a semi-permeable membrane to a region of low water concentration.
- **What happens when we put an animal cell or a plant cell into a solution of sugar or salt in water?**
 - **Hypotonic Solution:** If the medium has higher water concentration than the cell, meaning, outside cell is very dilute, the cell will gain water.
 - **Isotonic Solution:** Same concentration, no movement.
 - **Hypertonic Solution:** The medium has a lower concentration of water than the cell, meaning that it is a very concentrated solution, the cell will lose water by osmosis. Such solution is called a hypertonic solution.
- **Thus, osmosis is a special case of diffusion through a selectively permeable membrane.**
 - Unicellular freshwater organisms and most cells tend to gain water through osmosis. Absorption of water by plant roots is also an example of osmosis.
 - Only living cells, and not dead cells, are able to absorb water by osmosis.
- The flexibility of cell membrane also enables the cell to engulf in food and other material from its external environment. Such process is known as **Endocytosis**. Amoeba acquires its food through such processes.
- **Cell Wall**
 - Plant cells in addition to plasma membrane, have another rigid outer covering called the cell wall. The cell wall lies outside plasma membrane. The plant cell wall is mainly composed of cellulose. Cellulose is a complex substance and provides structural strength to plants.
 - **Plasmolysis:** When a living plant cell loses water through osmosis there is a shrinkage or contraction of the contents of the cell away from the cell wall. The phenomenon is known as plasmolysis.
 - **Plant cells can withstand much greater changes in the surrounding medium than animal cells. Why?**
 - **Animal cells never have a cell wall.**

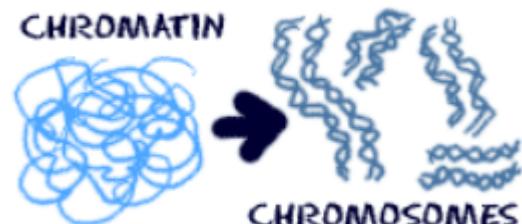
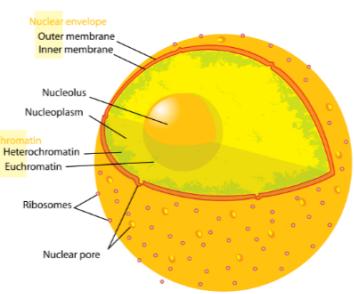
B) NUCLEUS

- Nucleus acts as **brain/control centre** of the cell. It stores DNA, the genetic information that tells a cell how to live its life. It controls basic activities like eating, movement, reproduction, basic characteristics etc.
- Sometimes there are more than one nucleus in certain cells. These are called **multi-nucleated cells**.
- Almost all human cells have one nucleus with identical DNA. Some human cells have no nuclei at all e.g. the Red Blood Cells. Some cells like liver cells and some muscle cells, are multinucleated, meaning they have multiple nuclei.

- **M multinucleated** cells are more efficient as they have two control centres. For instance – Liver cells – Hepatocytes do a lot of jobs. They make protein for digestion, help remove harmful stuff from your blood, produce enzymes to digest fats and carbohydrates and store carbohydrate energy for the body. Having two nuclei is like having two sets of blueprints, so the cells can build two proteins at the same time.
- **Nucleoid:** In some organisms like bacteria, the nuclear region of the cell may be poorly defined due to the absence of nuclear membrane. Such an undefined nuclear region containing only nucleic acids is called nucleoid.

▫ **Structure**

- Nucleus has a double layered covering called the **nuclear membrane**.
- The nuclear membrane has pores which allow the transfer of material (such as RNA and protein) from inside the nucleus to its outside, i.e. to the cytoplasm.
- **The nucleus contains**
 - **Chromosomes**
 - Chromosomes are composed of DNA and proteins.
 - It contains information for inheritance of features from parents to next generation in the form of DNA (Deoxyribonucleic Acid) molecules.
 - **DNA** molecules contain the information necessary for constructing and organizing cells.
 - Functional segments of DNA are called **genes**.
 - **Chromatin Material**
 - i. When the cell is in a resting state (not dividing) there is something called chromatin in the nucleus. It is made up of DNA, RNA, and nuclear protein.
 - ii. Chromatin material is visible as entangled mass of thread like structures.
 - iii. Whenever the cell is about to divide the chromatin material gets organized into chromosome (the rod shape structure)
- **Nucleolus**
 - It looks like nucleus inside a nucleus. It is made up of RNA and protein.
 - It is the structure where ribosomes are made.
 - After ribosomes leave the nucleus, they will have the important job of synthesizing proteins.



C) CYTOPLASM

- The cytoplasm is the fluid content inside the plasma membrane. It also contains many specialized cell organelles. Each of these cell organelles perform a specified function for the cell.

A. **Cell organelles** are enclosed by membranes to keep its own content separate from external environment.

B. In **Prokaryotes**, besides the absence of a defined nuclear region, the membrane-bound cell organelles are also absent. On the other hand, the **eukaryotic cells** have nuclear membrane as well as membrane-enclosed organelles.

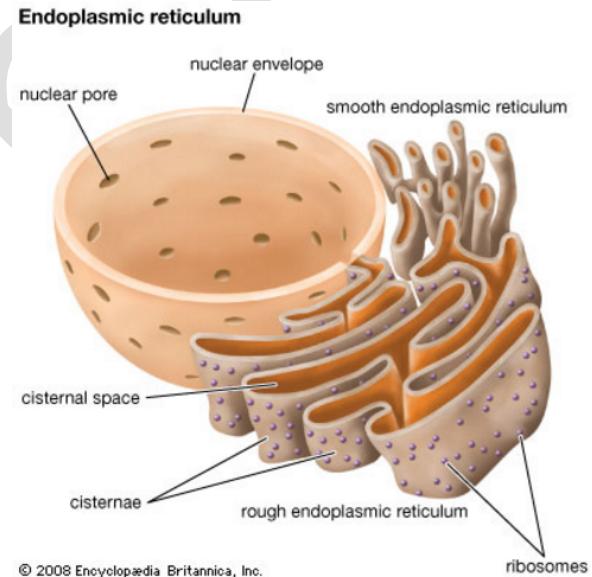
C. Significance of membranes

- i. Significance of membranes can be illustrated with the example of viruses.
- ii. Viruses lack any membranes and hence don't show characteristics of life until they enter a living body and use its machinery to multiply.

- Important Cell Organelles

A. Endoplasmic Reticulum (ER)

- ER functions both as a passageway for intercellular transport and as a manufacturing surface.
- It is a large network of membrane bound tubes and sheets to transport material. It looks like long tubules or round and oblong bags (vesicles). The ER membrane is similar in structure to plasma membrane.
- Some cells like Prokaryotes or RBCs **don't have** ER of any kind.
- Cells that synthesize and release a lot of proteins would need a large amount of ER. Cells from Pancreas or liver will have large number of ER structures.
- **Two types of ER**
 - **Rough Endoplasmic Reticulum (RER)**
 - RER looks rough under a microscope because it has particles called ribosomes attached to its surface. Ribosomes which are present in all active cells, are the sites of protein manufacture.
 - RER looks like sheets or disks of bumpy membranes while smooth ER looks more like tubes.
 - The manufactured proteins are then sent to various places in the cell depending on need, using the ER.
 - The RER are also attached to nuclear envelope that surrounds the nucleus. This attachment allows for movement of molecules through membranes.



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▪ Smooth Endoplasmic Reticulum (SER)

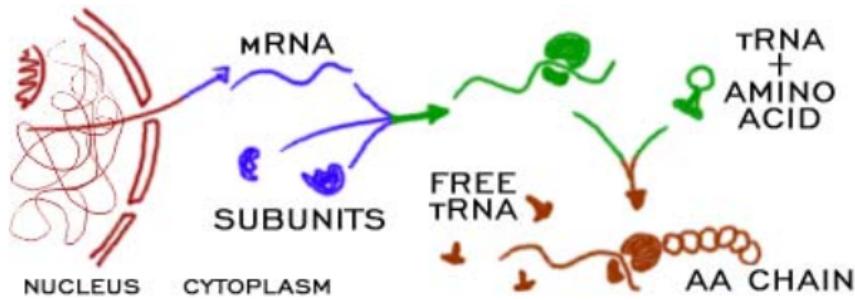
- SER help in manufacturing of fat molecules, or lipids, important for cell function.
 - They are mostly shaped like tubes.
 - Some of these lipids help in building of cell membrane. This process of known as membrane **biogenesis**.
 - Some other proteins and lipids function as enzymes and hormones.
-
- Although the ER varies greatly in appearance in different cells, it always forms a **network system**. Thus, one function of ER is to serve as **channels for the transport of materials** (especially proteins) between various regions of the cytoplasm or between the cytoplasm and the nucleus.
 - The ER also functions as a cytoplasmic framework providing a **surface for some of the biochemical activities of the cell**.
 - e.g.: In liver cells of vertebrates, SER plays a crucial role in detoxifying poisons and drugs

B. Ribosomes (not organelles)

- **Note:** Ribosomes are not organelles. They are not membrane-enclosed, instead they are macro-molecules made of both RNA and proteins.
- They are the protein factories of the cell. Composed of two subunits, they can be found floating freely in cell's cytoplasm or embedded within the endoplasmic reticulum.
- **Every cell needs Ribosomes**, so they are found in both prokaryotes and Eukaryotes.
- Using the templates and instructions provided by two different types of RNA, ribosomes synthesize a variety of proteins that are essential to the survival of the cell.
- There are two sub-units to every ribosome.
- **The Process of protein synthesis**
 - Protein synthesis starts when mRNA moves from nucleus to a ribosome on the surface of RER.
 - The two sub-units of ribosomes come together and combine with mRNA. They lock onto the mRNA and start the protein synthesis.
 - Ribosome builds the amino acid chain. The process is simple. First, you need an amino acid. Another nucleic acid that lives in the cell is **transfer RNA**. It is bonded to amino acids floating around the cell. With mRNA offering instructions, the ribosome connects to a tRNA and pulls off one amino acid. The tRNA is then released back into the cell and attached to another amino acid.
 - When the protein is complete RER pinches off a vesicle. That vesicle, a small membrane bubble, can move to the cell membrane or the Golgi apparatus. Some of the protein will

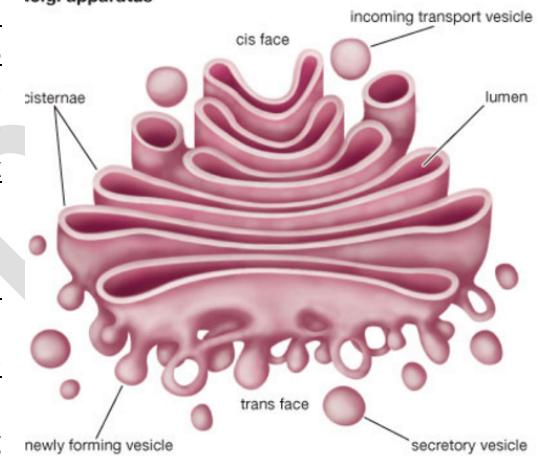
be used in the cell and some will be sent out into intercellular-space.

Mixing and Matching Amino Acids



C. Golgi Apparatus (pronounced 'GOL-JI')

- **Structure:** The Golgi apparatus, first described by Camillo Golgi, consists of system of membrane-bound vesicles arranged approximately parallel to each other in stacks called cisterns. These membranes often have connection to membrane of ER and therefore constitute another portion of a complex cellular membrane system.
- **Functions** of GA include storage, modification and packaging of products in vesicles.
 - Complex sugar can be made out of simple sugar
 - Turning protein into usable form by folding them into different shapes or adding other materials to protein such as lipids or Carbohydrates.
 - It is also involved in formation of lysosomes.
- After making these big molecules, Golgi apparatus packages them into vesicles, and either stores them for later use or sends them out of the cell.



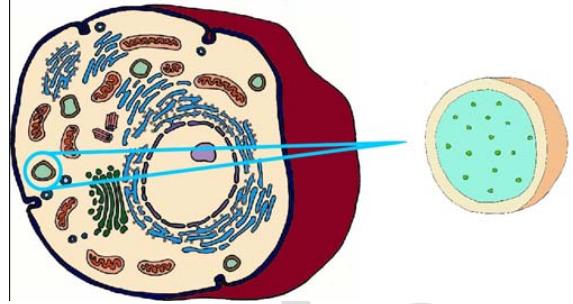
D. Lysosomes

- **Structure:** Lysosomes are membrane bound sacs filled with powerful digestive enzymes capable of breaking down organic material. These enzymes are made at RER. The membrane ensures that the internal enzymes don't digest the cell itself.
- **Functions**
 - It is a kind of waste disposal system of the cell. Lysosome help to keep the cell clean by digesting any foreign material as well as worn-out cell organelles.

Lysosome

- Suicide bags of cell

- During the disturbance in cellular metabolism, for example, when the cell gets damaged, lysosomes may burst, and enzymes digest their own cell. Therefore, lysosomes are also known as suicide bags of a cell.



- They are not commonly found in plant cells.
The tough cell walls keep out the foreign substance.

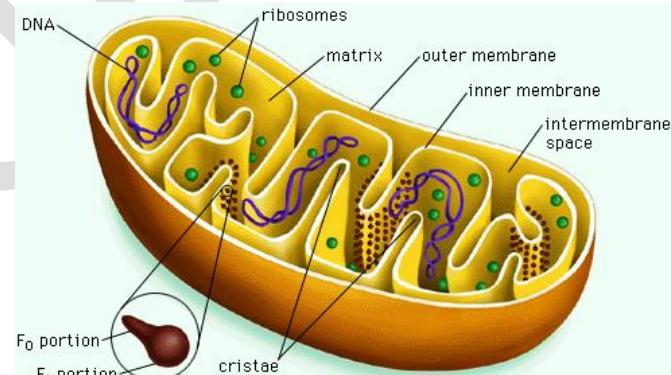
E. Mitochondria

- Structure:

- Mitochondria has two membranes covering instead of one.
- The outer membrane is very porous while the inner membrane is deeply folded. These folds create large surface areas for ATP generating chemical reactions.
- Mitochondria are **strange organelles** in the sense that they have their own DNA and ribosomes. Therefore, mitochondria are able to make some of their proteins.

- Functions

- Mitochondria are known as **powerhouse of the cell**.
- The energy required for various chemical activities needed for life is released by mitochondria in the form of **ATP (Adenosine Triphosphate)** molecules during a process called cellular respiration.
- ATP is known as the energy currency of the cell. It provides energy for all the cellular activities.
- Cells which need more energy have more mitochondria. (For e.g. muscle cells)
- The body uses energy stored in ATP for making new chemical compounds and for mechanical work.
- Mitochondria are also involved in controlling the concentration of Calcium (Ca^{2+}) ions within cell.



F. PLASTIDS (not found in animal cells)

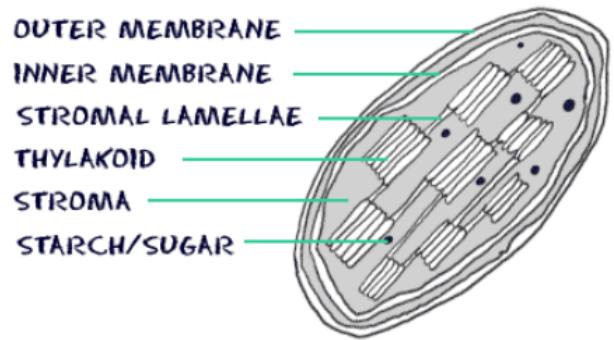
- Structures:

- The internal structure of plastids consists of numerous membrane layers embedded in a material called the Stroma.
- Plastids are similar to mitochondria in external structure.
- Like mitochondria, plastids also have their own DNA and ribosomes.

- Two types of plastids

- **Chromoplasts** (coloured plastids)

- **Leucoplasts** (white or colourless)-> these are organelles in which material such as starch, oil and protein granules are stored. Thus, primary purpose of leucoplast is storage.

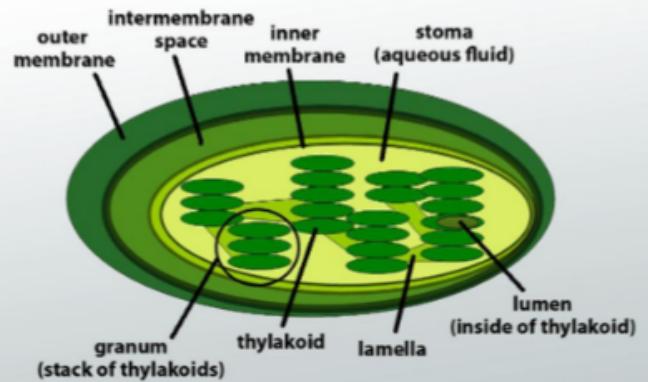


- **Chloroplasts:** Plastids containing the green pigment chlorophyll are known as chloroplasts.

- Chloroplasts are important for photosynthesis in plants and thus are food producers of the cell. They convert light energy of sun into sugars that can be used by cells. The entire process is called photosynthesis and it all depends on little green chlorophyll molecule in each chloroplast. In the process of photosynthesis, plants create sugar and release oxygen.

- Two membranes (named outer and inner membrane) surrounds the stroma and the grana (stacks of thylakoid).

One thylakoid stack is called grana. The stacks of thylakoid sacs are connected by stroma lamella. The lamella act like skeleton of the chloroplast, keeping all the sacs a safe distance from each other and maximizing the efficiency of the organelle.



- **Chlorophyll molecules sit on surface of each thylakoid** and capture light energy from sun. As energy-rich molecules are created by the light-dependent reactions, they move to the stroma where carbon (C) can be fixed and sugars can be synthesized. They also contain various yellow and orange pigments in addition to chlorophyll.

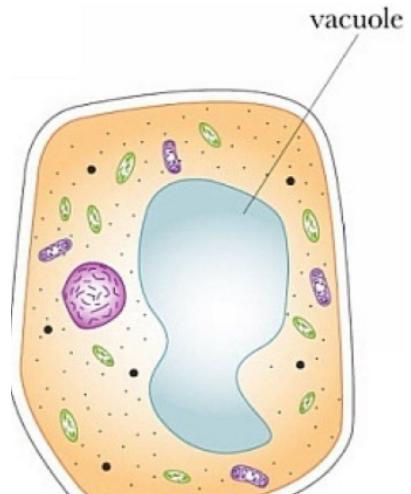
G. Vacuoles

- **Structure:**

- Vacuoles are of small size in animal cells while plant cells have very large vacuoles.
- The central vacuole of some plant cells may occupy 50-90% of the cell volume.

- **Functions**

- Vacuoles are storage sacs for solid and liquid contents. Many substances of importance in life of the plant cell are stored in vacuoles. These include amino acids,



sugars, various organic acids, some proteins and waste products.

- In plant cells vacuoles are full of cell sap and provide turgidity and rigidity to the cell.
- In single celled organisms like Amoeba, the food vacuole contains the food items that the amoeba has consumed.
- In some other unicellular organisms, specialized vacuoles also play important roles in expelling excess water and some wastes from the cell

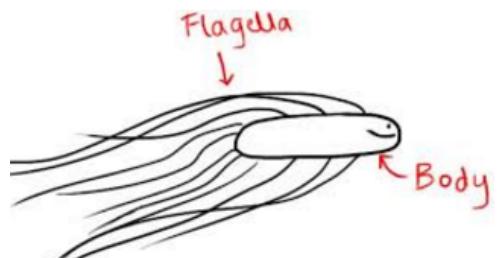
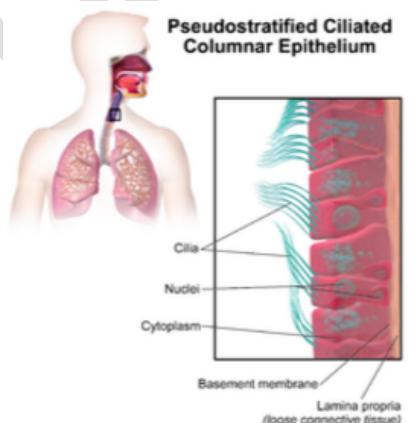
H. **Cytoskeleton** (Not organelles)

- It is the microscopic network of protein and tubules in the cytoplasm of many living cells, giving them **shape and coherence**.
- It is complex network of interlinking filament and tubules that extend throughout cytoplasm, from the nucleus to plasma membrane.



I. **Some unique structures which only some cells have**

- i. **Cilia:** In humans, the respiratory tract is lined with cells that have cilia. These are microscopic hair like projections that can move in waves. This feature help in trapping inhaled particles in the air and expels when you cough.
- ii. **Flagella:** Some bacteria have flagella. A Flagellum is like a little tail that can help a cell move or propel itself. The only human cell that have a flagellum is sperm cell.



5) SOME THINGS TO NOTE:

- Even every multi-cellular organism come from a single cell
- While observing a cell under micro-scope, we use iodine solution, safranin solution or methylene blue solution to stain the cells, so that different organelles are clearly visible.
- All cells have a cell membrane, cytoplasm, and genetic material.

6) IMPORTANT SCIENTISTS

- **Discovery of Cell (1665)**

- **Robert Hooke** (father of cytology - the branch of science which studies cell) while examining a thin slice of cork saw that the cork resembled the structure of a honey comb (hexagonal compartments). He in 1665 made the chance observation through a self-designed microscope. He called these boxes **cells**.
 - This was the very first time that someone had observed that living things appear to consist of separate units.
- **Discovery of a living cell (1674)**
 - Anton Von Leeuwenhock (father of bacteriology). He studied bacterial, protozoan cells etc.
- **Discovery of nucleus (1831)**
 - Robert Brown
- Term **Protoplasm** was coined by Purkinje in 1839 for the fluid substance of the cell.

2. TISSUES

1) INTRODUCTION

- In a unicellular organism, a cell performs all basic functions. For example, in Amoeba, a single cell carries out movement, intake of food and respiratory gases, respiration and excretion.
- But in multicellular organism there are millions of cells. Most of these cells are specialized to carry out a few functions. Each specialized function is taken up by a different group of cells. A group of cells that are similar in structure and/or work together to achieve a particular function forms a tissue.
- Tissues are the fabric of your body. (Infact, the term tissue literally means woven)
- When two or more tissues combine, they form organs. Kidneys, lungs, liver etc are all organs which are made of different kind of tissues.
 - Function of an organ depend on the kinds of tissues it is made of.
- **Histology:** The study of tissues.

2) FOUR PRIMARY TYPES OF ANIMAL TISSUES

A) NERVOUS TISSUES

- All cells possess the ability to respond to a stimulus. However, cells of a nervous tissue are highly specialized for being stimulated and then transmitting stimulus very rapidly from one place to another within the body.
- **Two big functions of nervous tissues**
 - Sensing stimuli
 - Sending electrical impulse through the body often in response to stimuli.
- The brain, spinal cord and nerves are all composed of the nervous tissue.
- **Nervous tissue is made of two different types of cells**
 - Neurons
 - Glial cells
- **A neuron** consists of a cell body with a cytoplasm and nucleus, from which long thin hair-like parts arise.

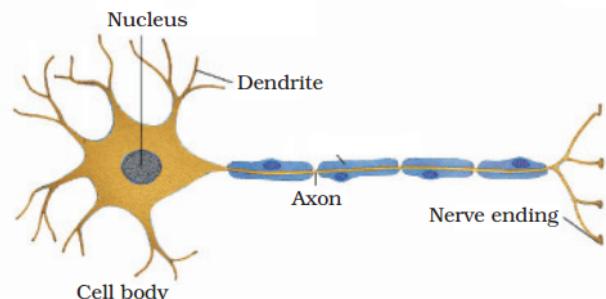
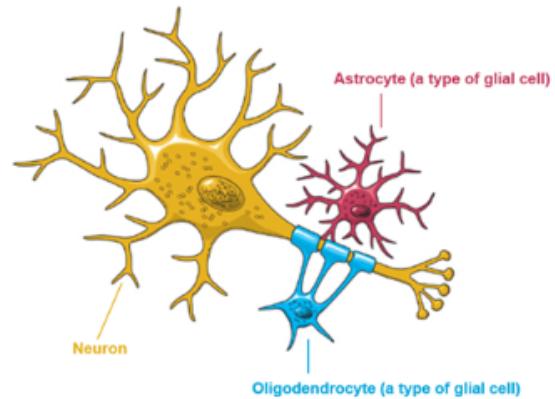


Figure 2.1: A neuron unit of nervous tissue

- Usually each neuron has a single long part, called the **axon** and many short, branched parts called dendrites.
- An individual nerve cell may be upto a meter long.
- **Cell body (soma)** is the neurons life support. It contains all the necessary things like nucleus, mitochondria etc.
- **Dendrites:** They collect signals from other cells to send back to soma. Thus, they are the listening end.
- **Axon** works like a transmission cable and carries messages to another neurons, muscles and glands.
- Neurons are present all over the body.
- **Glial Cells:** These are other types of nervous cells which provide support insulation, and protection and tethering them to blood vessels.

Simplified View of a Neuron and Glial Cells



B) MUSCLE TISSUES/ MUSCULAR TISSUES

- Muscular tissues consist of elongated cells, also called muscle fibres. This tissue is responsible for movement in our body.
- Muscles contain special protein called contractile protein, which can contract and relax to cause movement.
- Unlike your nervous tissues, your muscle tissues can contract and move.
- It is well vascularized meaning it has a lot of blood coming and going.
- **Two types of Muscle tissues**
 - 1. Voluntary Muscles/Skeletal Muscles**
 - Can be moved by conscious will.
 - e.g. Muscle in our limbs
 - Also called skeletal muscles as they are mostly attached to bones and help in body movement.
 - Under microscope, these muscles show alternate light and dark bands or striations when stained appropriately. As a result, they are also called striated muscles.
 - The cells of this tissue are long, cylindrical, unbranched and multinucleate (having many nuclei).

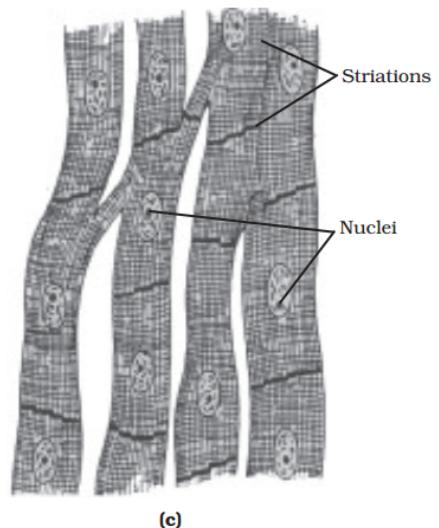
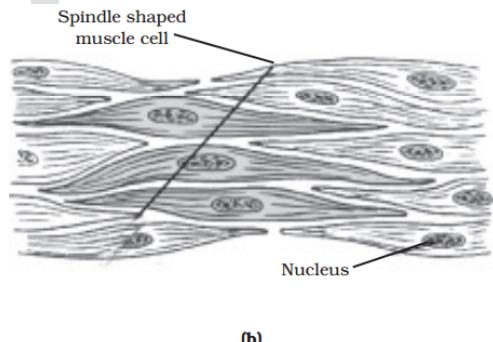


Figure 2.3: Striations

2. Involuntary Muscles

- It is not in our control. Movement is involuntary. We cannot really start them and stop them simply by wanting to do so.
- The movement of food in the alimentary canal or the contraction and relaxation of blood vessels are the examples of involuntary movement.
- **Smooth muscles** (a type of involuntary muscles) control such movements.
- They are also found in iris of the eye and in the bronchi of the lungs.
- The cells are long with pointed ends (spindle shaped) and uninucleate (having a single nucleus). They are also called unstriated muscles.
- The muscles of heart show rhythmic contraction and relaxation throughout life. These muscles are called cardiac muscles (another type of involuntary muscles). Heart muscles cells are cylindrical, branched, striated and uninucleate.
 - Cardiac muscle is only found in heart.

C) EPITHELIAL TISSUES

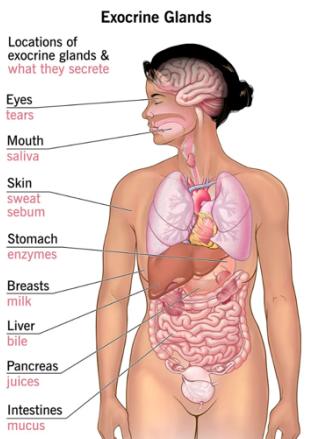
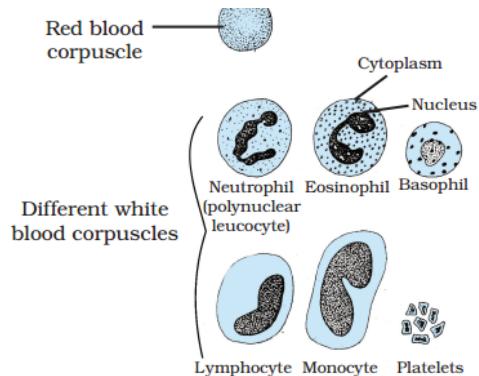
- The covering or protective tissues in animal body are epithelial tissues.
 - It covers most organs or cavities within the body.
 - **This protects** our deeper layers of tissues from injury or infection
 - E.g.: Lining of stomach with epithelial cells that produce mucus -> we don't digest our stomach along with our food.
 - It also forms barrier to keep different body systems separate.
 - Permeability of cells of epithelia play an important role in regulating the exchange of materials between the body and the external environment and also between different body parts.
 - Tissues lining small intestine allows you to absorb nutrients through diffusion and active transport.
 - Urinary waste gets filtered through different epithelia lining the kidneys
- E.g.
 - **The skin**, the lining of mouth, the lining of blood vessels, lung alveoli and kidney tubules are all made of epithelial tissues.
- They are tightly packed and form a continuous sheet. They have a very small amount of cementing material between them and almost no intercellular spaces.
- All epithelium is usually separated from the underlying tissues by an extracellular fibrous basement membrane.
- **Avascular:** All of our epithelial tissues are avascular - meaning they don't have blood supply.
 - Instead, they rely on the blood supply in the supporting connective tissues around them for the material they need.
- **Polar:** All of our epithelial tissues are polar - meaning that they have distinct sides.
 - **Apical Side** or the upper side is exposed to outside of the body of whatever internal cavity it is lining.
 - **Basal Side** or inner side is tightly attached to the basement membrane.
- **Epithelium can also be divided into following groups**

1. Proper Epithelium

- **Discussed above**
- **Covers most organs and cavities and separates various organs**

2. Glandular Epithelium

- Epithelial cells often acquire additional specialization as gland cells, which can secrete substances at the epithelial surface. Sometimes a portion of the epithelial tissues folds inward, and a multicellular gland is formed. This is **glandular epithelium**.
- **Glandular epithelium forms two different kinds of glands**
 - **Endocrine Glands**
 - Secrete hormones right into your blood stream or to nearby cells
 - e.g.1: Hormone thyroxine is secreted by endocrine gland: **Thyroid**
 - It needs to be distributed throughout the body so that it can stimulate the metabolism in all of our cells
 - E.g.2: Pancreas is an endocrine gland which releases Glucagon (raised blood sugar) and Insulin (lowers blood sugar; stimulates metabolism of glucose, protein, fat).
 - E.g.3: Testes is an endocrine gland which releases testosterone (it develops and maintains male sexual characteristics and maturation)
 - **Exocrine Glands**
 - Secrete their juices into tubes or ducts that lead to the outside of the body or inside of the tube, rather than right into the blood.
 - E.g.
 - Sweat, Saliva, Mucus, stomach acids, milk (if you are lactating)
 - **Note:** The Pancreas is a unique dual gland that has both exocrine and endocrine function. It consists of 95% of exocrine and less than 5% of endocrine functions.



D) CONNECTIVE TISSUES

- Connective tissue is almost everywhere in the body. How much of it is there depends on organ to organ.
 - e.g. Skin is mostly connective tissue while the brain has very little of this since it is almost all nervous tissues
- Cells of connective tissues are loosely spaced and embedded in an intercellular matrix.

- The matrix can be jelly like, fluid, dense or rigid.
 - The nature of matrix differs in accordance with the function of the particular connective tissues.
- **Blood** has a fluid (liquid) matrix called plasma, in which RBCs, WBCs and platelets are suspended.
 - The plasma contains proteins, hormones and salts.
 - Blood flows and transport gases, digested food, hormones and waste materials to different parts of the body.
- **Bones**
 - Another example of connective tissue. It forms the framework that supports the body. It also anchors muscles and support the main organs of the body.
 - It is also strong and inflexible tissue.
 - Bone cells are embedded in a hard matrix that is composed of calcium and phosphorus compounds.
- **Ligament**
 - Two bones can be connected to each other by another type of connective tissue called ligament. The tissue is very elastic.
 - Ligament contains very little matrix.
- **Tendons**
 - They connect muscles to bones and are another type of connective tissue.
 - Tendons are fibrous tissues with great strength but limited flexibility.
- **Cartilage**
 - Another type of connective tissue cartilage, has widely space cells. The solid matrix is composed of proteins and sugars.
 - Cartilage smoothens bone surface at joints and is also present in the nose, ear, trachea and larynx.
- **Areolar Connective tissue** is found between the skin and muscles, around blood vessels and nerves and in the bone marrow.
 - It fills the space inside the organs, supports internal organs and helps repair of tissues.
- **Adipose tissue**
 - Fat storing adipose tissues is found below the skin and between internal organs.
 - The cells of this tissue are filled with fat globules. Storage of fat also lets it act as an insulator.
- **Four Major Classes of Connective Tissues**
 - Proper Connective Tissues
 - Cartilage Connective Tissues
 - Bone Connective tissues
 - Blood Connective tissues
- **How connective tissues contribute**

- Binding and supporting
 - Protecting
 - Insulating
 - Storing reserve fluid and energy
 - Transporting substances within the body
 - Movement
- **E.g.**
- **Fat** which is a type of proper connective tissue provides insulation and fuel storage. It also serves structural purposes like holding your kidney in place etc.
 - **Bones, Tendons, and Cartilage** bind, support, and protect your organs and give you a skeleton so you can move with purpose.
 - **Blood** transports hormones, nutrients and other materials all over the body. It is a type of connective tissue.
- **All connective tissues have three factors in common** that sets them apart from other tissue types
- **Common Origin**
 - They all develop from **MESENCHYME** a loose and fluid kind of embryonic tissue.
 - **Degree of vascularity**
 - Connective tissues have a different degree of vascularity or blood flow
 - E.g. most cartilages are avascular meaning no blood vessels, while other types of connective tissues like dense irregular tissue in our skin is brimming with blood vessels.
 - **Mostly composed of non-living material**
 - All connective tissues are mostly composed on non-living material called the extracellular matrix.
 - While other tissue types are mainly made of living cells.
 - Extracellular matrix is mostly made of two components
 - i. **Ground Substance**
 - Watery, rubbery, unstructured material that fills in spaces between the cells and protects the cells from their surroundings
 - It is made of starch and protein molecules mixed with water.
 - ii. **Fibers**
 - It provides support and structure to otherwise shapeless ground substances
 - E.g. Collagen fibre

3) PLANT TISSUES

- Plants and animals are not made of same kind of tissues.
 - i) Different structure
 - Most tissues are supportive, which provide them with structural strength
 - Most of these tissues are dead
 - Since dead cells can provide mechanical strength as easily as live ones, and need less maintenance.

ii) Different functions

- Plants are stationary, whereas animals are mobile
- The growth of plant is limited to certain regions, while this is not so with animals
- There are some tissues in plants that divide throughout their life. These tissues are localized in certain regions
 - Meristematic tissues -> always growing
 - Permanent tissues
- Animal tissues -> no such demarcation in dividing and non-dividing tissues
- Structural organization of organs simple in plants and far more complex in animals

iii) **Because of above differences it is clear that plant tissues must be very different than animal tissues**

- **Types of Plant Tissues**

1) MERISTEMATIC TISSUES

- Growth of plants occur only in certain specific regions. This is because the dividing tissue, also known as meristematic tissues, is located in this point.
- Depending on the region where they are present, meristematic tissues can be classified as
 - **Apical**
 - Present at the growing tips of stems and roots and increase the length of the stem and the root.
 - **Lateral**
 - The girth of the stem or root increases due to lateral meristem (cambium).
 - **Intercalary meristem**
 - It is the meristem at the base of the leaves or internodes (on either side of the nodes) on twigs.
- As the cells of the tissue are very active, they have dense cytoplasm, thin cellulose walls and prominent nuclei. They lack vacuoles.
- New cells produced by meristem are initially like those of meristem itself, but as they grow and mature, their characteristics slowly change and they become differentiated as components of other tissues.

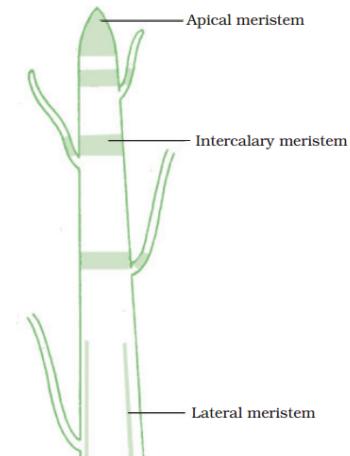


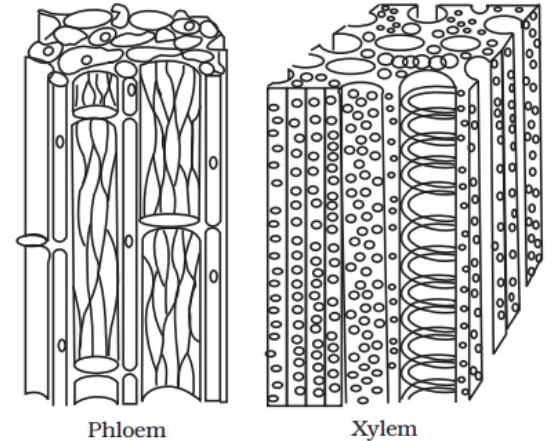
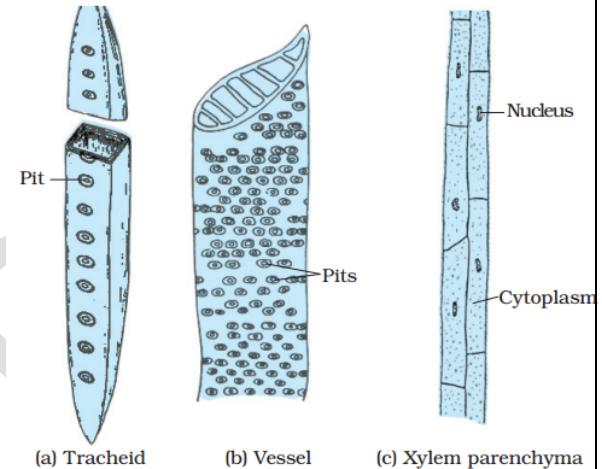
Fig. 6.2: Location of meristematic tissue in plant body

2) PERMANENT TISSUES

- After cells are formed by meristematic tissue, they take up a specific role and lose the ability to divide. As a result, they form permanent tissues.
- This process of taking up a permanent shape, size, and a function is called the differentiation to form different types of permanent tissues.
- **Types of Permanent Tissues**
 - (i) **Simple Permanent Tissues**
 - They are made of one type of cells. A few layers of cells form the basic packaging tissue.

(ii) Complex Permanent Tissues

- Complex permanent tissues are made of more than one type of the cells. All these cells coordinate to perform a common function.
- **Xylem and Phloem** are examples of such complex tissues.
 - They are both conducting tissues and constitute a vascular bundle.
 - Vascular or conductive tissues are distinctive feature of complex plants, one that has made possible their survival in the terrestrial environment.
- **Xylem**
 - It consists of tracheid's, vessels, xylem parenchyma and xylem fibres.
 - Tracheid and vessels are tubular structures. This allows them to transport water and minerals vertically.
 - The parenchyma stores food and helps in the sideways conduction of water.
 - Fibres are mainly supportive in function
- **Phloem** is made up of four types of elements:
 - Sieve tubes
 - Tubular cells with perforated walls.
 - Companion cells
 - Phloem fibres
 - Phloem parenchyma
- **Phloem is unlike xylem in that material can move in both directions in it.**
 - Phloem transfers food in leaves to other parts of the plant.
 - Except for phloem fibres, phloem cells are living cells.



3. BLOOD TYPE AND RELATED ISSUES

- Introduction

- Blood consists of red blood cells (and other cells not relevant here) floating in fluid called Plasma. The RBCs carry on their surface a set of markers with which plasma interacts. The compatibility and cross talk between the RBC and the plasma is what makes each blood type special.
- The markers on the cell are determined by a master type called H, out of which are generated types A, B, AB and O.
- In addition to A and B antigen, there is a third antigen called Rh factor, which can either be (+) or (-)
 - Rh- patient can only be given Rh- blood
 - Rh+ patient can get either Rh- or Rh+ blood
- **A blood type** (also called a blood group) is defined as the classification of blood based on the presence or absence of inherited antigenic substances on the surface of red blood cells (RBCs).
- A series of related blood types constitutes a **blood group system**, such as the Rh or ABO system. The frequencies of the ABO and Rh blood types vary from population to population

- ABO System

Blood Group	Antigen
A	Has only A antigen on red cells (and B antibody in the plasma)
B	Has only B antigen on red cells (and A antibody in the plasma)
AB	Has both A and B antigens on red cells (but neither A nor B antibody in the plasma)
O	Has neither A nor B antigens on red cells (but both A and B antibody are in the plasma)

- The universal red cell donor has Type O negative blood type
- The universal plasma cell donor has Type AB positive blood type.

- Donating blood by compatibility type

- In a blood transfusion, a patient must receive a blood type compatible with his or her own blood type. If the blood types are not compatible, red blood cells will clump together, making clots that can block blood vessels and cause death.

Blood Type	Donate Blood To	Receive Blood From
A+	A+ AB+	A+ A- O+ O-
O+	O+ A+ B+ AB+	O+ O-
B+	B+ AB+	B+ B- O+ O-
AB+	AB+	Everyone
A-	A+ A- AB+ AB-	A- O-
O-	Everyone	O-
B-	B+ B- AB+ AB-	B- O-
AB-	AB+ AB-	AB- A- B- O-

- **Blood types are inherited just like the eye colour.** The chart below shows possible blood type of a child according to their parents blood group

Parent 1	AB	AB	AB	AB	B	A	A	O	O	O
Parent 2	AB	B	A	O	B	B	A	B	A	O
O					●	●	●	●	●	●
A	●	●	●	●	●	●	●	●	●	●
B	●	●	●	●	●	●	●	●	●	●
AB	●	●	●		●					

- **RH Factor Inheritance**

- We inherit one Rh factor from each parent, either Rh+ or Rh-. Everyone has 2 Rh "factors" in their blood cells. They can be either positive (+) or negative (-). The only way to be Rh negative is for both parents to have at least 1 negative (-) factor and for you to receive it from both of them.
- If you receive one Rh+ factor you are Rh+. **Only those people with two Rh negative "factors" are considered Rh- blood type.**
- **Possible Rh Factor combinations are**
 - a. ++ = Rh positive
 - b. +- = Rh positive
 - c. -- = Rh Negative
- **Examples**
 - a. If both parents are ++, then the child must be ++
 - b. If both parents are --, then child must be --
 - c. If one parent is ++ and the other parent is +-, there is 50/50 chance of the child being either ++ or +-.

A child who is (--) cannot come from a parent who is (++) , because the child must inherit at least one of those (+'s). Both parents must have at least 1 Negative (-) "setting" to have a Rh-Negative Child.

- **Bombay Blood**

- It is a blood type called (hh)- , a rare one (1 in 10,000 Indians) first discovered in 1952).

▪ **Biology behind Blood types**

- The markers on the cell are determined by a master type called H, out of which are generated types A, B, AB and O.
- The Bombay doctors found that the **hh type (Bombay type people)** can accept only from other hh type, and also can receive only from the hh types. This makes the Bombay Blood types a very special and rare category of people.
- **How did this happen and why are these people so rare?** It is largely because of extensive inbreeding within the same lineage or close-community marriages, often consanguineous, such that the 'blood type' or the gene pool is greatly restricted. Such intra-community marriages have happened in small isolated communities such as the gypsies, Russian Jewish or Parsi communities. It is thus likely that the Bombay Blood types have common ancestral origins.

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BIOTECHNOLOGY

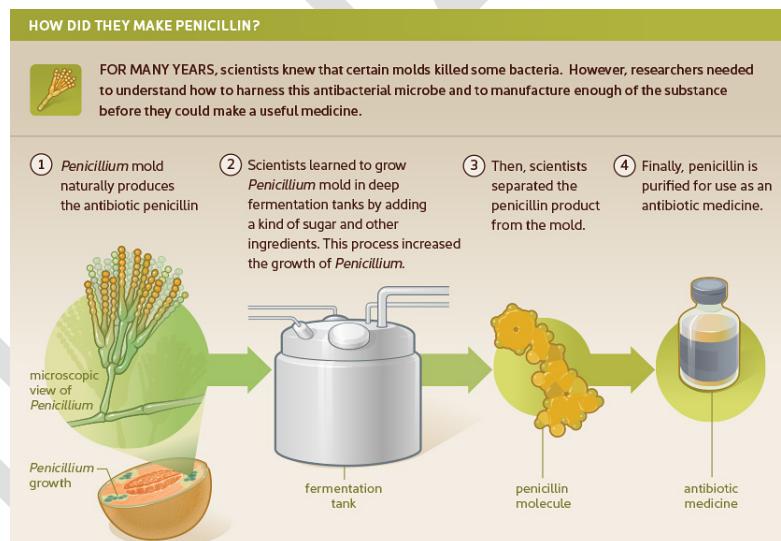
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1. INTRODUCTION

- **Definitions**
 - Biotechnology is the use of biological processes, organisms, or systems to manufacture products intended to improve the quality of human life.
 - E.g., Curd, Alcohol, GM crops, test-tube baby, developing a DNA vaccine or correcting a defective gene, are all part of Biotechnology.
 - Depending on the tools and applications, it often overlaps with the (related) fields of bioengineering, biomedical engineering, bio manufacturing, molecular engineering etc.
- **Two Sections of Biotechnology:** The entire field of Biotechnology can be divided into two sections
 - **Classical/traditional/Old Biotechnology**
 - E.g.
 - Curd being prepared with the help of microbes
 - Brewing alcohol
 - Cheese, bread and vinegar
 - Penicillin
 - In all the above product only natural capabilities of the microorganisms and cells were exploited.



▫ Modern Biotechnology

- Modern biotechnology refers to manipulation of genome or innate capabilities of organisms for making it more desirable or to synthesis a valuable product.
- E.g.
 - Genetic Engineering
- Tissue/Cell Culture (it refers to growth of tissue or cells in an artificial medium separate from the organisms)

2. BASIS OF BIOTECHNOLOGY

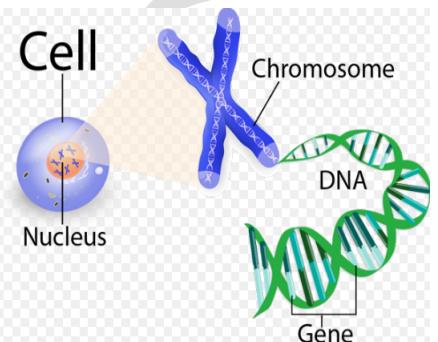
- Most living organisms have DNA as genetic material, DNA (Deoxyribonucleic Acid).
 - Some viruses have RNA as genetic material (e.g. Tobacco Mosaic viruses, QB bacteriophage, etc.)

- Now since all living organisms have DNA, it is possible to make changes, mix and match and this gives rise to possibility of the use of biotechnology.

1) BASICS UNDERSTANDING OF GENETIC MATERIAL

A) GENE

- It is basic physical and functional unit of heredity. It contains the code for a molecule that has a function. They act as instructions to make molecules called proteins
- Genes are located on DNA. It is a short section of DNA. DNA can be cut and separated, forming a sort of 'bar code' that is different from one person to the next.
- In humans, genes vary in size from a few hundred DNA bases to more than 2 million bases.
- The Human Genome Project has estimated that humans have between 20,000 and 25,000 genes.

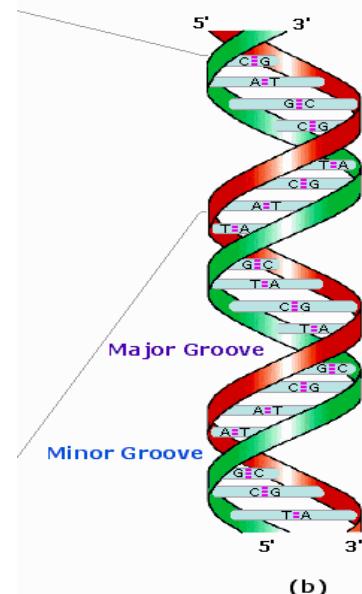


Gene Mapping

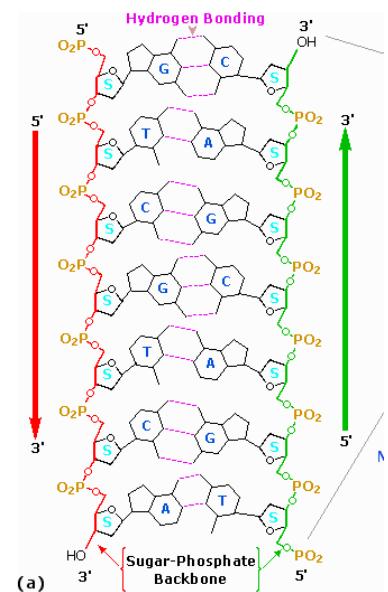
- Determining the gene's functionality and position of the gene in the chromosome is called gene mapping.

B) DNA (DEOXYRIBONUCLEIC ACID)

- DNA is the hereditary material in humans and almost all other organisms. Nearly every cell in a person's body has the same DNA. Most DNA is located in the cell nucleus (where it is called nuclear DNA), but a small amount of DNA can also be found in the mitochondria (where it is called **mitochondrial DNA** or mtDNA)
- DNA is long polymer of deoxyribonucleotides. I.e. a deoxyribonucleotide is the monomer, or single unit, of DNA, or deoxyribonucleic acid.
- The length of the DNA is usually defined as number of nucleotides (or a pair of nucleotides referred to as base pairs) present in it.
- Human DNA is **3.3×10^9 base pairs**.
- Structure of Polynucleotide Chain**



- A nucleotide has three components - a nitrogenous base, a pentose sugar, (deoxyribose in case of DNA), and a phosphate group.
- There are two types of nitrogenous base.
 - Purines** (Adenine and Guanine)
 - Pyrimidines** (Cytosine, Uracil and Thymine)
- Note: Thymine is only found in DNA and Uracil only in RNA
- DNA bases pair up with each other, A with T and C with G, to form units called base pairs.
- The bases in two strands are paired through hydrogen bond (H-bonds) forming base pairs (bp). Adenine forms two hydrogen bonds with Thymine from opposite strand and vice-versa. Similarly, Guanine is bonded with Cytosine with three H-bonds.
- The structure of double helix is somewhat like a ladder, with the base pairs forming the ladder's rungs and sugar and phosphate molecules forming the vertical sidepieces of the ladder.
- The two chains are coiled in right-handed fashion.



a) WHAT IS DNA FINGERPRINTING?

- DNA fingerprinting, also called DNA typing, DNA profiling, genetic fingerprinting, genotyping, or identity testing is a method of isolating and identifying variable elements in the base pair sequence of DNA.
- This technique was developed in 1984 by British geneticist **Alec Jeffreys**, after he noticed that certain sequences of highly variable DNA (known as **minisatellites**), which don't contribute to the function of genes, are repeated within genes.
- It was also noticed that each individual has a unique pattern of minisatellites (the only exceptions being multiple individuals from a single zygote, such as identical twins).
- DNA fingerprinting is a technique** that simultaneously detects lots of mini satellites in the genome to produce a pattern unique to an individual. This is a **DNA Fingerprint**.
- How is DNA fingerprint created?**
 - Obtaining a sample of cells:** such as skin, hair, or blood cells which contain DNA.
 - Extract** and purify DNA from these cells.
 - PCR** is used to amplify the desired fragments of DNA many times over creating thousands of copies of the fragments.
 - Once an adequate amount of DNA has been produced using PCR, the exact sequence of nucleotide pairs in a segment of DNA can be determined by using one of several **biomolecular sequencing methods**.

- **Application of DNA Fingerprinting:**
 - **Identification:** It is a forensic technique used to identify individuals/ dead bodies by characteristics of their DNA.
 - **Solving legal disputes:**
 - **Physically connect a piece of evidence to a person** or rule out someone as a suspect.
 - To determine **paternity and other relationships**
 - **Medical applications:**
 - Match tissue of organ donors with those of people who need transplant
 - Identify diseases that are passed down through your family
 - Help find cure for those diseases, called hereditary diseases.
- **Problems:**
 - **Sources of errors:** Sample contamination, faulty preparation procedures, and mistakes in interpretation of results are major sources of error.

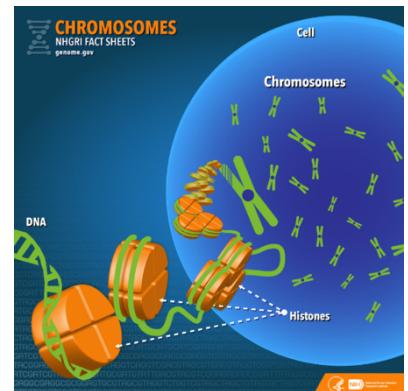
b) DNA BARCODING

- **DNA Barcoding** is a tool for **rapid species identification** based on DNA sequence. It uses as short section of DNA from a specific gene or genes.
 - The way barcodes on a product, uniquely identifies a commercial product, in the same way, short gene segments – known as **DNA barcodes** – are unique for each species.
 - DNA barcoding has emerged as a global standard for fast and reliable genetic species identification of animals, plants and fungi.
- **Different gene regions are used to identify the different organismal groups using barcoding:**
 - For e.g., for animals (birds, butterflies, fish) and some protists – a short DNA sequence of COI gene found in mitochondrial DNA is used.
 - Similarly, Species identification of land plants is enabled by the combination of two different chloroplast gene regions – matK and rbcL.
 - Fungi species can be determined by the ITS region.
- **The ultimate goal of DNA barcoding is to build a publicly accessible reference database** with species-specific DNA barcode sequences.
- **Various methods of DNA Barcoding:** Barcoding can be done from tissue from a target specimen, from a mixture of organisms (bulk samples), or DNA present in environmental samples (e.g. water or soil). The methods barcoding will differ in each of these cases:

- **Tissue Samples**
- **Bulk Samples:** This sample contains several organisms from the taxonomic group under study.
 - E.g. – Aquatic macroinvertebrate samples collected by kick-net, or insect samples collected with a Malaise trap.
- **eDNA samples:** The environmental DNA (eDNA) method is a non-invasive approach to detect and identify species from cellular debris or extracellular DNA present in environmental samples (e.g., water or soil).
 - The main difference between bulk samples and environmental samples is that the bulk sample usually provides a large quantity of good-quality DNA.
- **Applications of DNA Barcoding:**
 - Identifying plant leaves (even when flowers and fruits are not available)
 - Identifying pollen collected on the bodies of pollinating animals
 - Identifying insect larvae which may have fewer diagnostic characteristics than adults
 - Investigating the diet of an animal based on its stomach content

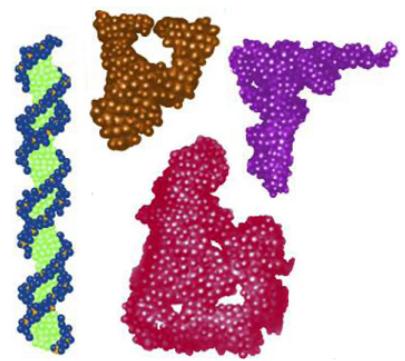
C) CHROMOSOMES

- In the nucleus of each cell, the DNA molecule is packaged into thread-like structure called chromosomes.
- Each chromosome is made up of DNA tightly coiled many times around protein called histones that support the structure.
- The adjacent figure shows the relation between chromosome and DNA molecule



D) RNA

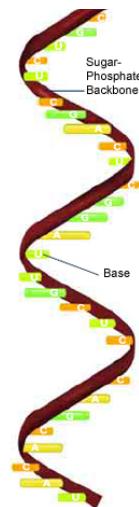
- RNA stands for ribonucleic acid. It is a molecule with long chain of nucleotides. A nucleotide contains a nitrogenous base, a ribose sugar, and a phosphate.
- Like DNA, RNA is also vital for living cells.
- **Shape and structure**
 - It comes in a variety of different shapes.
 - Unlike double-stranded DNA, RNA is a single-stranded molecule in many of its biological roles and has a much shorter chain of nucleotides.



- However, RNA can, by complementary base pairing, form intra-strand (i.e., single-strand) double helixes, as in tRNA

- **Functions of RNA**

- Carrying **genetic material** in some viruses
- The main job of RNA is to **transfer the genetic code needed for the creation of proteins from the nucleus to the ribosome**. The process prevents DNA from having to leave the nucleus. This keeps the DNA and genetic code protected from damage. Without RNA, proteins could never be made.
- Some RNAs act as enzymes. Such RNA enzymes are called ribozymes and they exhibit many of the features of a classical enzyme.



Ribonucleic acid (RNA) has the bases adenine (A), cytosine (C), guanine (G), and uracil (U). Image Credit: National

- **mRNA, rRNA, and tRNA**

- RNA is central to protein synthesis.
 - First a type of RNA called messenger RNA (mRNA) carries information from DNA to structure called ribosomes.
 - These ribosomes are made from proteins and ribosomal RNA (rRNAs).
 - These all come together and form a complex that can read messenger RNAs and translate the information they carry into proteins. This requires the help of transfer RNA or tRNA.
- RNA is formed from DNA by a process called transcription. This uses enzymes like RNA polymerase.
- **Transcriptome** is the set of all messenger RNA molecules in one cell or a population of cells.
 - Because transcriptome includes all mRNA transcripts in the cell, the transcriptome reflects the genes that are being actively expressed at any given time.

Biotechnology makes it possible to move gene which is responsible for some particular feature from one organism to another.

a) RNA INTERFERENCE TECHNOLOGY

- » RNA Interference Technology (RNAi) is a biological process in which RNA molecules inhibit gene expression or translation, by neutralizing targeted mRNA molecules.
- » It is also known as **co-suppression, post-transcriptional gene silencing (PTGS), and quelling**.
- » Here mechanisms are developed to degrade mRNA molecules. This decreases their activity by preventing translation, via gene silencing.
- » **Functions/Applications**
 - » RNA interference is a vital part of the immune response to viruses and other foreign genetic material, especially in plants where it may prevent the self-propagation of transposons.

- » RNA interference has an **important role** in defending cells against parasitic nucleotide sequences – virus etc.
- » It can be useful to **study the function of a gene** in experimental biology in cell culture.

3. TWO CORE TECHNIQUES THAT ENABLED BIRTH OF MODERN BIOTECHNOLOGY ARE:

1) GENETIC ENGINEERING

- » Technique to alter the chemistry of genetic material (DNA and RNA), to bring about desired modifications into host organisms and thus change the phenotype of the host organisms.
Jelly fish glow at night. If we want other living organism to glow at night, we can extract the gene which is responsible for this glow and put it in the new host organism.
- » **Advantage of genetic engineering over traditional hybridization process**
 - » Traditional hybridization processes -> can lead to inclusion and multiplication of undesirable genes along with desired genes.
 - » Genetic engineering solves the above problem by isolating and introducing only one or a set of desirable genes without introducing undesirable genes.

2) MAINTENANCE OF STERILE (MICROBIAL CONTAMINATION-FREE) AMBIENCE IN CHEMICAL ENGINEERING PROCESS

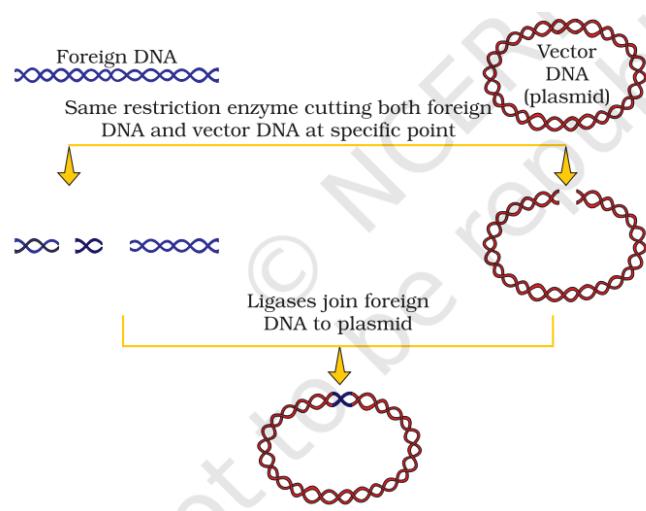
- » To enable growth of only the desired microbe / eukaryotic cell in large quantities for the manufacture of biotechnological products like antibiotics, vaccines, enzymes etc

4. TOOLS OF RECOMBINANT DNA TECHNOLOGY

Genetic engineering or recombinant DNA technology can be accomplished only if we have key tools, i.e., **restriction enzymes, polymerase enzymes, ligases, vector and the host organisms.**

1) RESTRICTION ENZYMES

- A restriction enzyme or restriction endonuclease is an enzyme that cuts DNA at a near specific recognition nucleotide sequence known as restriction sites.
 - To cut DNA, all restriction enzymes make two incisions, once through each sugar-phosphate backbone (i.e. each strand) of the DNA double helix.



- **Restriction endonuclease** are used in genetic engineering to form 'recombinant' molecule of DNA, which are composed of DNA from different sources/genomes.
- When cut by same restriction enzyme, the resultant DNA fragments have the same kind of 'sticky-ends' and, these can be joined together (end-to-end) using **DNA ligases**.

2) CLONING VECTOR

- They are used to transfer the foreign DNA to host DNA.
- Vectors used at present are engineered in such a way that they help easy linking of foreign DNA.

3) DNA LIGASE

- » It is a specific type of enzyme, a ligase that facilitates the joining of DNA together by catalyzing the formation of a phosphodiester bond.

4) HOST ORGANISMS

- The organism where the gene would be inserted.
- Techniques such as micro-injection are used. Here recombinant DNA is directly injected into nucleus of an animal cell.
- In other methods suitable for plants, the cells are bombarded with high velocity microparticles of gold or tungsten coated with DNA in a method known as **biolistic or gene gun**.
- Another method is using 'disarmed pathogen' vectors, which when allowed to infect the cell, transfer the recombinant DNA into the host.

5. CRISPR-CAS9

- What is **(CRISPR/CAS9)**?
 - CRISPR-CAS9 is a new genome editing tool, which is simpler, faster, cheaper, more versatile and more accurate than the previous techniques of editing DNA and has wide range of potential applications.
 - **Background: The inspiration for CRISPR:**
 - The inspiration of developing CRISPR CAS9 came from the **CRISPR system used by several bacteria** to fight against bacteriophages.
 - CRISPR (Clustered Regularly Interspaced Short Palindromic Sequence) are short DNA sequences found in the genome of Prokaryotic organisms such as bacteria, which are reminders of various bacteriophage (virus) attacks that the bacteria successfully defended against. Cas9 enzyme (part of the bacteria's defence mechanism) uses these

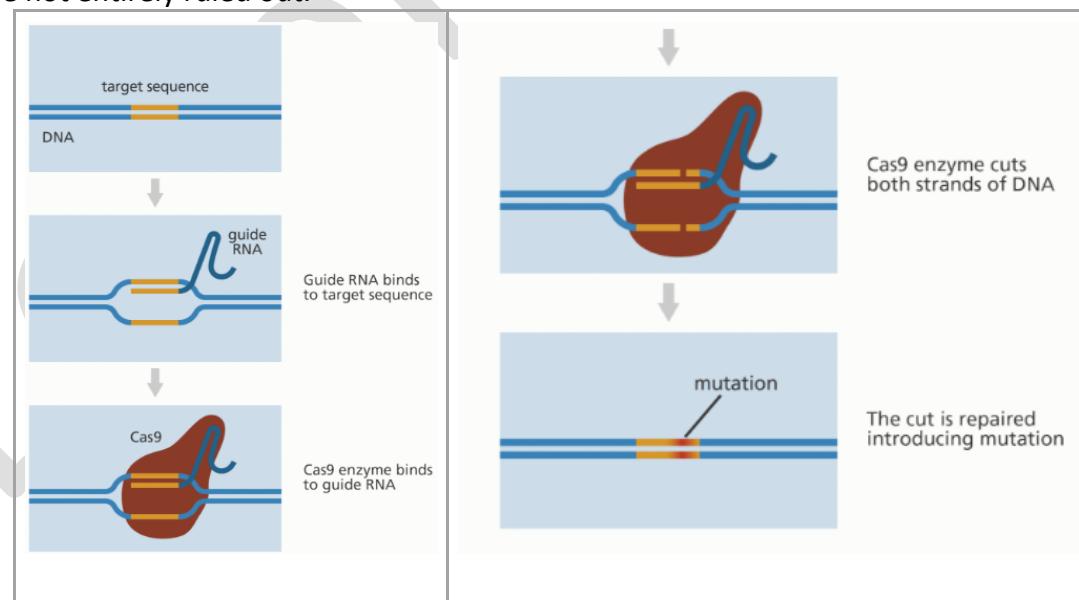
flags to precisely target and cut any foreign DNA, thus protecting the bacteria from future attacks by similar bacteriophages.

- Emmanuelle Charpentier of France and Jennifer Doudna of the US won the Nobel Chemistry Prize in 2020 for developing CRISPR-Cas9. This was the first time a Nobel Science prize has gone to a women-only team.

NOTE: Prof. Charpentier, 51, and Prof. Doudna, 56, were just **the sixth and seventh women to receive the Nobel Prize in Chemistry.**

- **How does CRISPR-CAS9 work? (Clustered Regularly interspaced short palindromic repeats)**

- https://www.youtube.com/watch?v=UKbrwPL3wXE&ab_channel=MayoClinic
- The first task is to identify the particular sequence of genes that is cause of problem and thus have to be deleted.
- Once this is done, an RNA molecule (called guideRNA) is programmed to locate this sequence of DNA stand, just like the 'find' or 'search' function of a computer.
- After this, a special protein called Cas9 (CRISPR associated Protein 9), which is often described as 'genetic scissors / molecular scissors', is used to break the DNA strand at specific points so that bits of DNA can then be added or removed.
 - A DNA strand, when broken, has a natural tendency to re-attach and heal itself. But if the auto-repair mechanism is allowed to continue, the bad sequence can regrow. So, scientists intervene during the auto-repair process by supplying the correct sequence of genetic codes, which attaches to the broken DNA strand.
- The entire process is programmable, and has remarkable efficiency, though chances of error are not entirely ruled out.



- **Applications of CRISPR-CAS9**

- The technology has had a **revolutionary impact** on life science.

- Its applications include:
 - **Curing diseases genetic in nature** – i.e., the diseases are caused by unwanted changes or mutations in genes. These include common blood disorders like sickle cell Anaemia, eye diseases including color blindness etc.
 - **Deformities arising out of abnormalities in gene sequences** – like stunted or slow growth, speech disorders, or inability to stand or walk can also be treated by CRISPR.
 - **Developing GM crops and animals.**
 - For e.g., Japan has already approved the commercial cultivation of a tomato variety that has been improved using CRISPR-based intervention.
 - In India, several research groups are working on CRISPR-based enhancements for various crops including rice and banana.

- **Limitation**

- **Potential of misuse:** (bioterrorism; designer babies)
- **Collateral Damage (Knock-on Effect):**
- **Ethics of CRISPR** – Should humans be allowed to modify how the nature works?

4) HOW GENE THERAPY USING CRISPR CAN CURE CANCER (DEC 2022: SOURCE THE HINDU)

- **What is T-cell acute lymphoblastic leukaemia (T-ALL)**
 - It is a type of cancer where the T-cells, which are a class of white blood cells, equipped to hunt and neutralize threats to the body, turn against the body and end up destroying healthy cells that normally help with immunity. The disease is rapid and progressive and is usually treated by chemotherapy and radiation therapy.
- **How gene therapy treated this?**
 - Alyssia, a teenage girl, had tried several of the standard treatments including chemotherapy and radiation. But the treatment wasn't successful.
 - Then she enrolled in an experimental trial conducted by doctors and scientists at the University College, London and Great Ormond Street Hospital. She was the **first patient to receive experimental gene therapy that relied on a new technique called 'base-editing'**.
 - **What is base editing?**
 - When a misarrangement in the sequence of nitrogen bases (ATCG) is edited to arrange it properly, it is called base editing. David Liu, of the Broad Institute, Massachusetts has improvised on the CRISPR-cas9 to be able to directly change certain bases: thus, a C can be changed into G and T into an A. While still a nascent technology, **base editing is reportedly more effective at treating blood disorders**

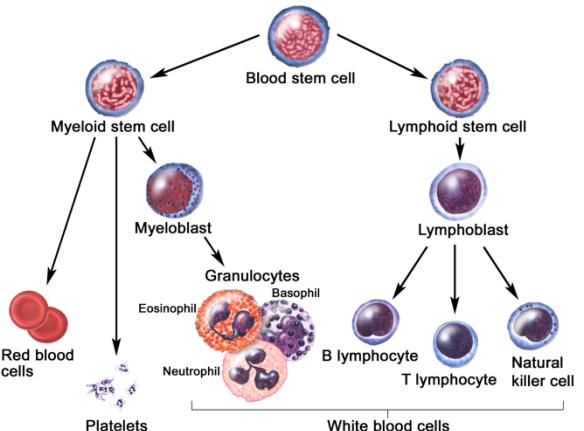
which were caused by so-called single point mutations, or when a change in a single base pair can cause terminal disease.

- Alyssia's case:

- In Alyssia's case, her T-cells – perhaps because of a misarrangement in the sequence of bases – had become cancerous. The objective of the gene therapy in the case of T-cell leukemia was to fix her immune system in a way that it stops making cancerous T-cells.
- First, healthy T-cells were extracted from a donor and put through a series of edits.
 - The first base edit blocked the T-cells targeting mechanism so it would cease attacking Alyssia's body.
 - The second removed a chemical marking, called CD7, which is on all T-cells.
 - Third prevented the T-cells from being killed by a chemotherapy drug.
 - Finally, the T-cells were programmed to destroy all cells – cancerous or protective – with CD7 marked on it.
 - After spending a month in remission, she was given a second donor transplant to regrow her immune system that would contain healthy T-cells.
- How effective was the treatment?
 - Her cancer doesn't seem to have re-surfaced.
- More verification needed:
 - It has been 1.5 years since she was first diagnosed with the disease and whether the treatment has reliably and entirely fixed her immune system, remains to be established.

A) UNDERSTANDING T-CELLS IN MORE DETAILS

- T cells are a type of white blood cells. They are part of immune system and develop from **hematopoietic stem cells** (blood stem cells) present in bone marrow. They help protect body from infection and may help fight cancer. They are also called T Lymphocyte and thymocyte.
- After getting born from blood stem cells, they migrate to thymus gland to develop. T-cells derive their name from the thymus. In thymus, the precursor cells mature into several distinct type of T cells. This differentiation continues after they have left the thymus.



- One of the important functions of T-cells is immune mediated cell death – it is carried out by two major subtypes – CD8+ “Killer” and CD4+ “helper” T cells. These are named for the presence of the cell surface proteins CD8 and CD4.
- T cells, also known as “Killer T-cells”, are cytotoxic – this means that they are able to directly kill virus-infected cells, as well as cancer cells.
- T-cells can be distinguished from other lymphocytes by the presence of a T-cell receptor (TCR) on their cell surface.

6. DARK DNA – CLASS DISCUSSION

7. SOMATIC CELL NUCLEAR TRANSFER

- In genetics and developmental biology, somatic cell nuclear transfer (SCNT) is a **laboratory technique for creating an ovum with a donor nucleus.**
 - In SCNT the nucleus, which contains the organism's DNA, of a somatic cell (a body cell other than a sperm or egg cell) is removed and the rest of the cell discarded.
 - At the same time, the nucleus of an egg cell is removed.
 - The nucleus of the somatic cell is then inserted into the unnucleated egg cell.
 - After being inserted into the egg, the somatic cell nucleus is reprogrammed by the host cell.
 - The egg, now containing the nucleus of a somatic cell, is stimulated with a shock and will begin to divide.
 - **After many mitotic divisions in culture**, this single cell forms a blastocyst (an early stage embryo with about 100 cells) with almost identical DNA to the original organism

It can be used in embryonic stem cell research, or in regenerative medicine where it is sometimes referred to as "therapeutic cloning." It can also be used as the first step in the process of reproductive cloning.

8. APPLICATIONS OF BIOTECHNOLOGY

2) GM CROPS

- **GM Crops, Advantages and Controversies**

- Crops whose DNA has been altered are known as GM crops. This genetic modification of crops can add or remove certain characteristics from the plant and thus can bring many advantages.
 - Make crops **more tolerant to anti-biotic stresses** (cold, drought, salt, heat) etc.
 - E.g., GM Rubber developed by Rubber Research Institute of India
 - Make plants **Pest Tolerant**.
 - Reduces reliance on chemical pesticides.
 - E.g. BT cotton, BT Brinjal (in Bangladesh)
 - Help to **reduce post-harvest losses**
 - Enhance the **nutritional value** of food, e.g., Golden Rice (Vitamin A enriched rice)
 - Tailor-made plants to supply **alternative resources** to industries, in the form of starches, fuels, and pharmaceuticals.

A) BT COTTON

- Specific BT Toxic gene (*cry1Ac*) were isolated from *Bacillus thuringiensis* and incorporated into several crop plants such as cotton. This produces proteins that kill certain insects such as lepidopterans (tobacco budworm, armyworm), beetles, etc.
- It has been grown in India since 2002 and over the years have given increase productivity and area under crop cultivation. It has also led to decrease in insecticide which fought bollworms by 97%.
- **Note:** **Bollgard® Bt Cotton** (single gene technology) is India's first biotech crop technology approved for commercialization in 2002, followed by Bollgard® II – double gene technology in mid-2006, by the GEAC.
 - **Bollgard® cotton** provides in-built protection for cotton against destructive American Bollworm *Heliothis Armigera* infestations, and contains an **insecticidal protein from a naturally occurring soil microorganism, Bacillus thuringiensis (Bt)**.
 - Bollgard® II technology contains a superior double-gene technology - Cry1Ac and Cry 2Ab which provides protection against bollworms and *Spodoptera caterpillar*, leading to better boll retention, maximum yield, lower pesticides costs, and protection against insect resistance.
 - Both, Bollgard® II and Bollgard® insect-protected cotton are widely planted around the world as an environmentally friendly way of controlling bollworms.
- But it has also raised concerns like increased water consumption, and emergence of pesticide resistant pests (e.g., pink bullworm), and increased use of insecticide for controlling pests like sucking pests.

B) BT BRINJAL

- Transgenic Brinjal created by inserting a **crystal protein gene (Cry1Ac)** from the soil bacterium Bacillus thuringiensis into the genome of various brinjal cultivar. It gives resistance against lepidopteron insects in particular the Brinjal fruit and shoot border (BFSB), the most common pest which affects 30-50% of the Brinjal crops.
- The crop also cleared the GEAC's biosafety test in 2009. But, government yielded to anti-GM activists and declared a moratorium in 2010 on the crop.
- But some cases of illegal BT Brinjal cultivation was observed in Haryana in 2019

- **Why are some groups are calling for allowing of BT Brinjal in India?**
 - It had cleared the GEAC's biosafety test in 2009.
 - **Increased benefit for farmer**
 - When GM Crops are not officially available, farmers turn to **unapproved knock offs** that may not conform to accepted biosafety standards.

- **Why is BT Brinjal not allowed in India? Why is it opposed by various activists?**
 - There are fears that it may **impact India's plant biodiversity**.
 - Further, **cross pollination** may lead to **herbicide resistant super weeds** that can further threaten environment and biodiversity.
 - **Health Impact** is something that needs to be studied more.
 - **Not so obvious benefits:** A recent study from surveys of farmers indicate that 2/3rd of the farmers who moved to BT Brinjal have had a 'bad' or 'very bad' experience.

C) GM MUSTARD

- **What is GM Mustard?**
 - DMH-11 (Dhara Mustard Hybrid) is a genetically modified (GM) mustard Hybrid.
 - GM mustard is the country's first genetically modified food crop.
 - It was developed by a team of scientists led by former Vice Chancellor Deepak Pental, of DU at Center for Genetic Manipulation of Crop Plants (CGMCP), Delhi University by crossing Indian mustard cultivars with juncea lines of East European origin like 'Early Heera' and Donskaja.

- **Claim of higher yield:**
 - Claims around 30% more yield than the traditional varieties

- **What genetic modification was achieved and what are its benefit?**
 - **Barnase gene and Barster gene** from *Bacillus amyloliquefaciens*
 - Barnase impairs pollen production

- Barster blocks the function of Barnase
 - Hybridization becomes possible:
 - This method was used to developed DMH-11 by crossing a popular Indian mustard variety 'Varuna' (the barnese line) with an East European 'Early Heera-2' mutant (barstar).
- **Arguments for and against approval of GM mustard**
- » **For**
 - **Higher Production**
 - **Reducing Import Dependency**
 - **Saving Forex**
 - **Keeping India Scientifically relevant**
 - » **Against**
 - The main contention is that the GM mustard incorporates three alien genes - barnase, barstar, and bar - rendering it inherently unsafe for human and animal health.
 - But these genes have already been deployed in Canola, and we import it freely.
 - Mustard is a food crop unlike cotton, so both should not be compared
 - All health effects not properly known yet
 - Environmental damages should be studied properly first.
 - Yield claims have been challenged by many organizations
 - » **GEAC Approval (Oct 2022)**
 - In Oct 2022, GEAC approved commercial cultivation of genetically modified mustard yet again. The approval allowed environmental release of two varieties of genetically engineered mustard, so that it can be used for developing new parental lines and hybrids under the supervision of ICAR. The environmental release of DMH-11 will allow for its seed production and testing as per existing ICAR guidelines and other extant rules/ regulations prior to commercial release. The field demonstration studies on the effect of GE mustard on honeybees and other pollinators was also allowed to be conducted.

D) GM RUBBER – DEVELOPED BY KERALA BASED - RUBBER RESEARCH INSTITUTE OF INDIA

- Rubber Research Institute of India have developed a plant tailored for the climatic conditions in the Northeast.
- Rubber board research farm at Sarutari on the outskirts of Guwhati now sports world's first GM rubber plant, tailored for climatic condition in the north-east.

- **Genetic Modification:** The GM rubber has additional copies of the gene MnSOD, or manganese-containing superoxide dismutase, inserted in the plant, which is **expected to tide over the severe cold conditions during winter** – a major factor affecting the growth of young rubber plants in the region

E) INCREASING THE NUTRIENT CONTENT – GOLDEN RICE

▫ Golden Rice

- What is Golden Rice?

- The IRRI and its national research partners have developed golden rice to complement existing interventions to address vitamin A deficiency (VAD). It is a serious public health problem affecting millions of children and pregnant women globally.
- Golden rice is variety of rice produced through genetic engineering to biosynthesize beta-carotene. Beta-carotene is a nutrient similar to what is found in orange colored fruits and vegetables and is converted into Vitamin-A as needed by the body.
- Thus, golden rice can help south and south-east Asian countries, where two-thirds or more of daily calorific intake is obtained from rice. Research has indicated that the golden rice can provide upto 50% of the daily requirement of an adult for vitamin A.



- Golden rice was one of the 7 winners of the 2015 Patents for Humanity Awards by the United States Patent and Trademark Office
- **Safety Evaluation by International Rice Research Institute**
 - The safety evaluation of Golden rice has shown that it is as safe and nutritious as conventional rice but comes with added benefit of beta-carotene.
- **About International Rice Research Institute:**
 - IRRI is the world's premiere research organization dedicated to reducing poverty and hunger through rice science; improving the health and welfare of rice farmers and consumers; and protecting the rice growing environment for future generation.
 - It is an independent, non-profit, research and educational institute, founded in 1960 by the Ford and Rockefeller foundations with support from the Phillipines government.
 - The institute is headquartered in Los Banos, Philippines and has offices in 17 rice-growing countries in Asia and Africa.
 - It works with in-country partners to develop advanced rice varieties that yield more grain and better withstand pests and disease as well as flooding, drought, and other harmful effects of climate change.

F) ISSUE OF ILLEGAL CULTIVATION OF GM CROPS:

- **BT Brinjal** Illegal cultivation in Haryana Rajasthan etc.
- **Sale of Illegal HTBt (Herbicide tolerant Bt) cotton seeds** has doubled this year(June 2021)
 - The HTBt cotton variant adds another layer of modification to BT cotton, making the plant resistant to the herbicide glyphosate, but has not been approved by regulators.
 - **Support for HTBt:** Groups like Shetkari Sangathan are demanding the legalization of HTBt cotton.
 - **Saves cost:** Weeding labour cost reduces, only one round of glyphosate spraying is needed to deal with the weed.
 - **Illegal sales** reduce accountability, hampers government revenue and farmers are at risk of getting wrong information.
 - **Concerns/Fears:**
 - Glyphosate have carcinogenic effect
 - Unchecked spread of herbicide resistance to nearby plants through pollination, creating a variety of superweeds etc.

G) SCIENTISTS ARE ENGINEERING PLANTS TO PRODUCE INSECT 'SEX PERFUME' TO REPLACE PESTICIDES (APRIL 2023)

- Researchers are engineering tobacco plants to produce moth pheromones that could potentially be used to create traps that can lure insects as a replacement for harmful pesticides.
- **Note:** Pheromones are chemicals that are produced and released by animals. When they are released by an individual of a species, they effect the behaviour of other individuals. Animals secrete these pheromones to trigger different kinds of behaviour. The pheromones that trigger sexual arousal can be thought of as a kind of 'sex perfume', attracting other individuals of the same species.
- The researchers engineered plants to produce chemicals that mimic these pheromones.
- **Note:**
 - Chemically produced insect pheromones are already used for pest control and have been for some decades. Some insect traps contain pheromones to attract the insect to them, for use in the house garden, and in food production systems.
 - **Disadvantages of these chemically produced pheromones:** It is not possible to make complex pheromones by this mechanism. Moreover, chemical manufacturing process produces a number of other pollutants.
- **GM Crop Route:**
 - Researchers used Nicotiana benthamiana, a species of tobacco.
 - Note: The same plant has been engineered to produce ebola antibodies and even coronavirus like particles for use in COVID vaccine.

- Here, scientists built a sequence of DNA in the lab that mimic moth's genes and also put in place a few molecular switches that can precisely regulate how the molecules are formed. The switches can turn the manufacturing process on and off.
- **Advantages of using pheromones:** They are highly species specific and unlike broad spectrum pesticides don't kill other species of pollinators.

3) REDUCED HEIGHT GENES (RHT): ADVANTAGES AND LIMITATIONS

Introduction

- Since the 1960s and the Green Revolution, **reduced height (Rht) genes have increased global yields** because the short-stemmed wheat they produce puts more investment into the grains rather than into the stems and has improved standing ability. It leads to reduced risk of lodging, increase in partitioning and assimilation of grains, more fertile florets per spriglet and higher harvest index (the proportion of plant weight in grains).
- The high yielding wheat variety developed by **Borlaug**, which required higher use of fertilizers and pesticides, produced bigger grains. However, the heavier grains caused the plants to become unstable and prone to lodging. Therefore, **Borlaug introduced dwarfing genes** into wheat giving plants a stronger, shorter stem that resisted lodging.
 - i) **21 reduced height genes** in wheat Rht1 – Rht21, have been described so far.
 - ii) In India, the presently available semi-dwarf varieties, which were explored during the Green Revolution, carry conventional Rht1 dwarfing alleles (variant form of a given gene) and produce optimum yields under high-fertility irrigated conditions.
- **Limitations of Dwarf wheats:**
 - a) Dwarf wheats are not well adapted to deeper sowing conditions. This is due to shorter coleoptiles, and low early vigor often results into reduced seedling emergence. Further shorter coleoptiles lead to crop residue posing a problem for seedling emergence.
 - b) These wheats also don't work in drought conditions they can't be planted deep inside the soil to access moisture. They will fail to reach the surface of the soil.
- **Key Research to solve the issue:**
 - Scientists at Agharkar Research Institute (ARI), an autonomous institute of DST, have mapped to alternative dwarfing genes of Rht14 and Rht18. These genes are associated with better seedling vigor and longer coleoptiles (sheath protecting the young shoot tip).
 - **Advantages:**

- a) The new wheat variety will be suitable for sowing under rice stubble retained condition and in **dry environments**. It would thus reduce the need of water and also contribute to reduction in crop stubble burning.
 - b) It also diversifies the genetic base of dwarfing genes considering diverse wheat growing zones in India.
2. Recent research published in the *Proceedings of the National Academy of Sciences (PNAS)* journal on 23rd Nov 2022 says that Scientists at the John Innes Centre, in collaboration with an international team of researchers, have discovered **the new “reduced height” or semi dwarf gene called Rht13**. The varieties of wheat with Rht13 gene could be rapidly bred into wheat varieties to enable farmers to grow reduced-height wheat in **drier soil conditions**.
- Rht13** overcome this problem of seedling emergence because the **gene acts in tissues higher-up in the wheat stem**. So, the dwarfing mechanism only takes effects once the seedling has fully emerged. This gives farmers a significant advantage when planting deeper in dry conditions.

3) BIOTECHNOLOGICAL APPLICATION IN MEDICINES

The recombinant DNA technological processes have had a great impact in the area of health care by enabling mass production of safe and more effective therapeutic drugs.

- Further, the recombinant therapeutics do not induce unwanted immunological responses as is common in case of similar products isolated from non-human sources.
- At present, more than 30 recombinant therapeutics have been approved for human-use the world over.
 - In India, around 12 of these are presently being marketed.

A) VACCINES (COVERED SEPARATELY WITH HEALTH SECTION)

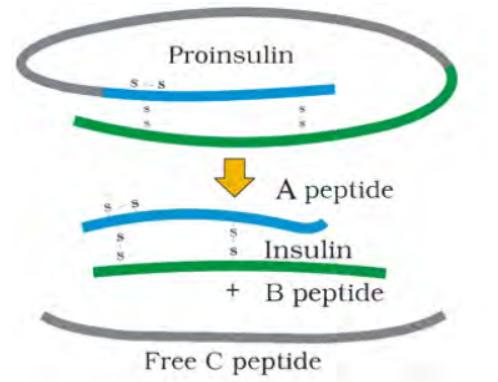
- For e.g., various vaccines for COVID-19 were developed with the help of biotechnology – mRNA vaccines, vaccines with attenuated virus

B) MASS PRODUCTION OF EFFECTIVE THERAPEUTICS

- The recombinant DNA technological processes have had a great impact in the area of health care by enabling mass production of safe and more effective therapeutic drugs.
- **Advantages of recombinant therapeutics:** Further, the recombinant therapeutics do not induce unwanted immunological responses as is common in case of similar products isolated from non-human sources.
- At present, more than 30 recombinant therapeutics have been approved for human-use the world over.
- In India, around 12 of these are presently being marketed

C) GENETICALLY ENGINEERED INSULIN

- Earlier, Insulin used for diabetes was extracted from pancreas of slaughtered cattle and pigs.
 - » Caused patients to develop some kind of allergies or other kinds of reactions to the foreign protein.
- Structure of Insulin
 - » Insulin consists of two short polypeptide chains: Chain A and Chain B, that are linked together by disulphide bridges.
 - » In Mammals, including humans, insulin is synthesized as a pro-hormone (like a pro-enzyme, pro hormone also needs to be processed before it becomes a fully mature and functional hormone) which contains an extra stretch called C peptide.
 - » This C peptide is not present in the mature insulin and is removed during maturation into insulin.



- The main challenge for production of insulin using rDNA technique was getting insulin assembled into a mature form.
- How this was achieved through Biotechnology
 - In 1983, Eli Lilly an American company prepared two DNA sequences corresponding to A and B, chains of human insulin and introduced them in plasmids of E. coli to produce insulin chains.
 - Chains A and B were produced separately, extracted and combined by creating disulphide bonds to form human insulin.

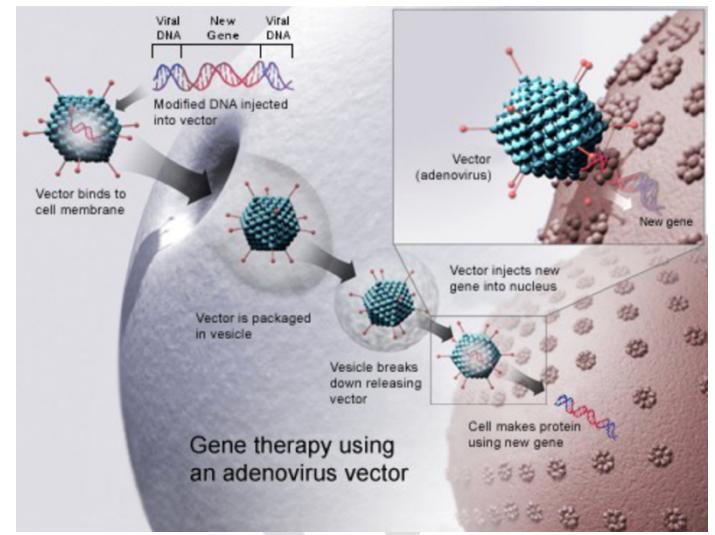
D) GENE THERAPY

- Introduction

- » If a person is born with a hereditary disease, can a corrective therapy be taken for such disease? Gene therapy is an attempt to do this.
- » Gene therapy refers to the process of introduction, removal or change in the content of an individual's genetic material with the goal of treating the disease and a possibility of achieving long term cure.

» **Gene Therapy Products (GTPs)** include the mechanisms to deliver nucleic acid components by various means for therapeutic benefit to patients. They include entities that are used for things like gene augmentation, gene editing, gene silencing, synthetic or chimeric gene augmentation etc.

- **Note:** Not all medical procedures that introduce alterations to a patient's genetic makeup can be considered a gene therapy. For e.g.: Bone Marrow transplantation and organ transplants in general have been found to introduce foreign DNA into patients.



- Advantages of promoting gene therapy

- **Permanent result may be a possibility:**
- **High burden of rare genetic diseases in India:** Around 7 crore of India's population suffers from rare genetic diseases. Gene therapy can prove to be a turning point in treatment of such genetic diseases.
- **Worldwide market for the gene therapy products** is expected to go to \$250 billion by 2025.

- Concerns/Limitations

- Promotion of development of gene therapy also brings along with it unique technical risks and ethical challenges.
- **Technical Challenges**
 - The gene therapy may be associated with **unwanted immune system reactions**. For e.g., when vectors (viruses) are attacked by the immune system of the body.
 - Current gene therapy mechanisms can sometimes **target the wrong cells**.
 - **The delivery viruses may mutate** and become harmful.
- **Ethical Challenges**
 - For e.g. creation of GM babies using germline gene editing by a Chinese scientist attracted global criticism and fueled debate on ethical concerns regarding applications of gene therapy technologies.
 - **Playing god** debate.

- National Guidelines for Gene Therapy Product Development and Clinical Trials – Released by ICMR in Dec 2019: Key Highlights

- » The guidelines are **aimed** at ensuring that **gene therapies are introduced in India** and **clinical trials for gene therapy can be performed in an ethical, scientific and safe manner.**
- » They provide the **general principles for developing gene therapy products (GTPs)** for any **human ailment and provide a framework** for all areas of GTP production including **pre-clinical testing, clinical administration, human clinical trials, as well as long term follow up.** These must follow the established general principles of biomedical research.
- » They **apply to all stakeholders** involved in the field of gene therapy including **researchers, clinicians, oversight/regulatory committees, industry, patient support groups and any other involved in GTP development** or their application in humans and their derivatives.
- » The guidelines will serve as a **roadmap** for those in the field trying to develop gene and cell **therapies** and will thus **contribute to accelerating the development** of advanced therapeutic options
- ICMR has also proposed setting up of **task force to promote gene technology research in the country.**

a) CAR-T CELL THERAPY

- **Why in news?**
 - The CDSCO has granted **market authorization for NexCAR19**, India's first indigenously developed CAR-T cell therapy, to ImmunoACT (Nov 2023)
- **Background: How Cancer has been treated before CAR T-Cell Therapy:**
 - **Surgery** (removing the cancer)
 - **Radiotherapy** (delivering ionizing radiation to the tumour)
 - **Systematic Therapy** (administering medicines that act on tumour)
 - The **earliest form** of systematic therapy was **chemotherapy**. It **preferentially acts on cancer cells** because of the latter's rapid, unregulated growth and poor healing mechanisms. These drugs have **modest response rate** and **significant side effects** as they effect numerous cell types in the body.
 -
 - The next stage in its evolution was **targeted agents** a.k.a. **immunotherapy**: The drugs bind to **specific target on the cancer or in the immune cells** that help the tumour grow or spread. This method often has **less side effects** as the impact on non-tumour cells is limited. However, it is **effective only against tumours that express these targets.**
- **CAR-T Cell Therapy** has emerged as a **new development in this front.**
 - It is a revolutionary therapy that **modifies immune cells**, specifically T-Cells, by **turning them into potent cancer fighters known as CAR-T Cells.**
 - **How it works?**
 - In CAR T-cell therapy, **the patient's blood is drawn to harvest T-cells** – immune cells that play a major role in **destroying tumour cells.**

- Researchers modify these cells in the laboratory so that they express specific proteins on their surface, known as **chimeric antigen receptors** (CAR): they have an affinity for proteins on the surface of tumour cells. This modification in the cellular structure allows CAR T-cells to effectively bind to the tumour and destroy it.
- These modified cells are then infused back into the patient's blood stream after conditioning them to multiply more effectively.
- The cells are even more specific than targeted agents and directly activate the patient's immune system against cancer, making the treatment more clinically effective. This is why they are called '**living drugs**'.
- **Advantages of CAR-T Cell therapy over other Cancer fighting methods:**
 - It is very accurate and only targets cancer cells.
 - It makes the treatment easier with onetime therapy (unlike several sessions of chemotherapy)
 - It can also fight non-responsive cancer patients.
 - It is designed to cure and provide lifelong benefits.

- **Where is it being used today?**

- CAR T-cell therapies are approved for **Leukaemias** (cancers arising from the cells that produce white blood cells) and **Lymphomas** (arising from the lymphatic system)
- It is also being used among patients with cancers that have returned after an initial successfully treatment or which haven't responded to previous combinations of chemotherapy or immunotherapy.

- **CAR T-Cell Therapy in India:**

- The first major clinical trial showing they were effective was published almost a decade ago. The first indigenously developed therapy in India was successfully performed only in 2021.
- **In Oct 2023, the Central Drugs Standard Control Organization (CDSCO) granted market authorization for **NexCAR19**, India's first indigenously developed CAR-T cell therapy, to **ImmunoAct**, a company incubated by IIT Bombay. This paves the way for commercial launch of this therapy in India.**
 - It is designed to target cancer cells that carry the CD19 protein. This protein acts like a flag on cancer cells, which allows CAR-T cells to recognize and attach themselves to the cancer cells and start process of elimination.
 - **Who can get the NexCAR19 therapy?**
 - The therapy is for people with B-Cell lymphomas who didn't respond to standard treatments like chemotherapy, leading to relapse or reoccurrence of the cancer.
 - **B-Cell leukaemia is most common among children. Are they also eligible?**
 - » For now, therapy's approval is only for patients aged 15 years and above.
 - » The pediatric trial phase is currently underway at the **Tata Memorial Hospital**, in collaboration with IIT-Bombay.

- **Significance:**
 - India is one of the first developing country to have its own Car-T therapy. Even some developed nations don't have their own CAR-T therapies and they import from USA or Europe.
 - This reduces the cost of treatment to about 1/10th of the cost abroad and has the potential of boosting medical tourism in India. It costs around Rs 3.3 crores abroad while in India it will cost somewhere between 30-40 lakh rupee.
 - Lab and animal studies have shown that **NexCAR19** lead to significantly lower drug-related toxicities. For e.g., it causes minimal damage to neurons and the central nervous system, a condition known as neurotoxicity. The therapy also leads to minimal Cytokine Storm Syndrome (CRS), which is characterized by inflammation and hyperinflammation in the body due to the death of a significant number of tumour cells, as CAR-T cells are designed to target and eliminate cancer cells.

b) WHAT IS B-CELL LYMPHOMA

- B-Cell Lymphoma is a form of cancer that starts in a white B-cell called a **Lymphocyte**. B-Cell Lymphocytes make antibodies, the proteins in the immune system that help fight infections. They are often found in lymph nodes or other lymphoid tissues such as the spleen.
- **In B-Cell Lymphoma**, some lymphocytes are no longer healthy and don't fight infections. Instead, they grow out of control, crowding out the normal cells and causing the Lymph nodes to get bigger.

c) GENE THERAPY TO TREAT SICKLE CELL ANAEMIA AND THALASSEMIA (NOV 2023) (WILL BE COVERED WITH HEALTH BOOKLET)

d) PFIZER'S HEMOPHILIA B GENE THERAPY SUCCEEDS IN LATE-STAGE STUDY (DEC 2022: SOURCE – THE HINDU)

- **About Haemophilia B:**
 - It is a hereditary bleeding disorder. It hampers body's ability to make a blood-clotting protein called factor IX.
 - **What happens when you bleed?**
 - At the time of bleeding, a series of reactions take place in the body that helps blood clots to form. This process is called coagulation. It needs various proteins called coagulation, or clotting factors. A person has higher chances of bleeding if one or more of these factors are missing and are not functioning like they should.
 - **Factor IX (nine)** is one such coagulation factor. **Haemophilia B** is the result of the body not making enough factor IX. It is caused by an inherited X-linked recessive trait, with the defective gene located on the X chromosome.
 - **Most people with haemophilia B are male.** (Reason – Class discussion)

- **Pfizer's haemophilia B gene therapy succeeds in late-stage study:**
 - The study showed that a single dose of the therapy was superior to the current standard of care in helping reduce the bleeding rate in patients with moderately severe to severe forms of haemophilia B.
 - Pfizer's therapy, fidanacogene elaparovec, is designed to help patients produce factor IX themselves after a one-time treatment, as opposed to current treatments, which focus on regular infusions of the protein.
- **Pfizer is also testing other experimental gene therapies in late-stage trials as potential treatments for the bleeding disorder haemophilia A and muscular disorder Duchenne muscular dystrophy.**

e) NOTE: HAEMOPHILIA A

- It is also called factor VIII(8) deficiency or classic haemophilia. It is a genetic disorder caused by missing or defective factor VIII (FVIII), a clotting protein.

f) DUCHENNE MUSCULAR DYSTROPHY

- **About muscular dystrophy:**
 - It is a group of diseases that cause progressive weakness and loss of muscle mass. In muscular dystrophy, abnormal genes (mutations) interfere with the production of proteins needed to form healthy muscle.
 - There are many kinds of muscular dystrophy. The Symptoms of most common variety begin in Childhood, mostly in boys. Other types don't surface until adulthood.
 - **Sign:** The main sign of muscular dystrophy is progressive muscle weakness. Specific signs and symptoms begin at different ages and in different muscle groups, depending on the type of muscular dystrophy.
- **About Duchenne muscular dystrophy:**
 - Most common type of muscular dystrophy.
 - Although girls can be carriers and mildly affected, it's much more common in boys.
 - **Signs and symptoms** which typically appear in Childhood are:
 - Frequent falls
 - Difficulty rising from a lying or sitting position
 - Trouble running and jumping
 - Walking on the toes
 - Large calf muscle
 - Delayed growth

- Learning disabilities.
- Other types of muscular dystrophy include: Becker Muscular Dystrophy

E) MOLECULAR DIAGNOSIS

- For treatment of any disease, early diagnosis and understanding its pathophysiology is very important. Using **conventional methods** of diagnosis (**serum and urine analysis**, etc.) early detection is not possible.
- Recombinant DNA technology, Polymerase Chain Reaction (PCR) and Enzyme linked Immuno-Sorbent Assay (ELISA) are some of the techniques that serve the purpose of early detection.
 - PCR is a technique used in molecular biology to amplify a single copy or a few copies of a piece of DNA across orders of magnitude, generating thousands to millions of copies of a particular DNA sequence.
 - It is now routinely used to detect HIV in suspected AIDS patients. It is being used to detect mutations of genes in suspected cancer patients too.
 - ELISA is based on the principle of antigen-antibody interaction. Infection by pathogen can be detected by the presence of antigens (proteins, glycoproteins etc.) or by detecting the antibodies synthesized against the pathogens
- E.g. Tests During COVID-19
 - RT-PCR Test
 - The test detects the presence of viral RNA in human samples.
 - In this test first the viral RNA is converted into DNA (reverse transcription)
 - PCR is a process where a few copies of DNA are amplified to produce millions of copies.
 - This is done with the help of enzymes, primers, and probes.
 - Rapid Anti-Body Test
 - A rapid test is conducted to determine if there has been any kind of recent viral infection in a person's body. When a pathogen enters a human body, specific anti-bodies are released as a response to the virus. A rapid test can detect the presence of such anti-bodies in blood, serum or plasma samples question.
 - This is a simple test and can give results in 10-30 minutes.
 - It should be noted that it is not a confirmatory test for COVID-19. It is only a preliminary screening for diagnosis of coronavirus infection.
 - Further, a negative test doesn't rule out COVID-19 infection. A rapid test comes positive after 7-10 days of viral infection and remains positive for several weeks after that.

F) DISEASE CONTROL THROUGH GENETICALLY MODIFIED ORGANISMS

- By introducing sterile mosquitoes (genetically formed). (concept - not done yet)
- Synthetic vector genome which is incapable of hosting the parasite and/or virus.

G) PERSONAL GENOMICS

- It is the branch of genomics concerned with sequencing and analysis of the genome of an individual. The genotyping stage employs different techniques, including single-nucleotide polymorphism (SNP) analysis chips (typically 0.02% of the genome), or partial or full genome sequencing.
- **Uses**
- Once the genotypes are known, the individual's genotype can be compared with the published literature to determine likelihood of trait expression and disease risk.
- Personalized medicines
 - It is a medical method that targets treatment structures and medicinal decisions based on patient's predicted response or risk of disease.
 - Various subcategories of personalized medicines
 - Predictive Medicines
 - Precision Medicines
 - Stratified Medicines
- It predicts the right kind of treatment
 - Efficacy of toxicity of chemotherapy, or radiotherapy etc.

4) TRANSGENIC ANIMALS

- Animals that have their DNA manipulated to possess and express an extra (foreign) gene are known as transgenic animals.
 - Transgenic rats, rabbits, pigs, sheep, cows and fish have been produced, although over 95% of all existing transgenic animals are mice.
 - **Why so much medical research on mice, rat?**
 - **Genetic, biological and behaviour characteristics** closely resemble that of humans and many symptoms of human conditions can be replicated in mice and rats.
 - We share between 95% of the same genes, and our immune system are even more compatible.
 - Therefore, the result of mouse experiment often correlates to human biology
 - Further, mice can be genetically manipulated to mimic virtually any human disease or condition.
 - **Convenience**
 - Rodents are small, easily housed and maintained, and adapt well to the new surroundings.
 - **Reproduce quickly and short lifespan:** Reproduce quickly and have short life span of 2-3 years - so several generations of mice can be observed in sort span of time.

- **Relatively Inexpensive**
 - Can be brought in large quantities from commercial producers
- **Mild tempered and docile**
 - Rodents are also generally mild tempered and docile, making them easy for researchers to handle.
- **How transgenic animals are helpful?**
 - **Normal physiology and development**
 - Experimenting on how alteration of genes would affect humans.
 - **Study of disease**
 - Many transgenic animals are designed to increase our understanding of how genes contribute to the development of disease.
 - **Biological Products**
 - Some medicines might require some biological products which are often expensive to produce.
 - Transgenic animals that produce useful biological products can be created by the introduction of portion of DNA (or genes) which code for a particular product.
 - E.g. : Human protein (α -1-antitrypsin) used to treat emphysema.
 - In 1997, the first transgenic cow - Rosie, produced human protein-enriched milk (2.4 grams per liter).
 - The milk contained the human alpha-lactalbumin and was nutritionally a more balanced product for human babies than natural cow milk.
 - **Vaccine Safety**
 - Transgenic mice are being developed for use in testing of safety of vaccines before they are used on humans.
 - Transgenic mice are being used to test the safety of the polio vaccine.
 - **Chemical safety testing**
 - This is known as toxicity safety testing.
 - The procedure is same as used for testing toxicity of drugs.

5) BIOTECHNOLOGY AND ENVIRONMENT

H) GM ALGAE, CROPS ETC. CAN PROVIDE MORE BIOMASS FOR BIOFUEL.

B) BIODIVERSITY CONSERVATION

- a. E.g. -> De-extinction of species; **Colossal** is a new bioscience and genetics company, with the idea of bringing many extinct species back to life. Scientists at Harvard University in the USA would insert

the Giant Woolly mammoth's (extinct 4,000 years ago) genes responsible for tiny ears, subcutaneous fat and hair length and color into living elephant skin cells. Once they are successful in bringing these hybrids back to life, Colossal will proceed with the ultimate goal of reviving the ancient extinct animals by producing more such hybrids.

Criticism: Immoral; revival of these species may threaten the existing ecosystem and disturb the food chain which has evolved over the years; Rather than focusing on revival of long extinct species, biotechnology should focus on protecting the existing ones.

C) TO DETECT INVASIVE SPECIES:

- Environmental DNA based assay to detect invasive catfish in waterbodies (Nov 2022 – Source: DTE)
 - Conventional methods to detect invasive species like using nets, traps, and visual observations, are cumbersome, the researchers from CCMB now have developed Environmental DNA (e-DNA) based molecular methods to provide a time and cost-effective alternative.
 - eDNA is defined as “genetic material obtained directly from environmental samples (soil, sediments, water etc.) without any obvious signs of the biological source material. It is an efficient, non-invasive and easy-to-standardize sampling approach. It can be obtained from ancient as well as modern environment. With scientific advancements in DNA sequencing technologies, the technique is increasingly being used for biodiversity monitoring.
 - CSIR-CCMB has designed a molecular assay utilizing eDNA to specifically detect this invasive catfish in Indian ecosystem, which is affordable and quick, and will be very useful tool in conservation management. They use a reliable eDNA-based quantitative PCR assay to detect the African Sharptooth Catfish from water samples in the aquatic system.

5) GM INSECTS

- A genetically modified (GM) insect refers to insects whose DNA has been engineered through various genetic engineering tools like CRISPR CAS9.
- Various GE insects are available globally today. The development and application of GE insects offers applications in various fields:
 - **Improving Human Health:**
 - **Vector Management** in human and livestock health: GE mosquitoes for e.g. can be designed to carry genes that limit their ability to transmit diseases such as dengue, malaria etc.
 - **Reduction in use of chemicals** -> Maintenance and improvement of both human health and environmental health.
 - **Food Security:**
 - **Management of crop insect pests:** Insects can be genetically engineered to carry traits that reduce the population of agricultural pests.

- » For e.g. introducing sterile males can help control pest population.
 - **Increased food production:** Protein production for healthcare purposes; honey production etc.
 - » Engineering honeybees to make better-quality and/or quantities of honey can contribute to reduced imports and may facilitate exports.
 - **Improvement in beneficial insects** like pollinators, predators, parasitoids etc.

 - **Economic Application:**
 - Other than improved agri production, improvements in productive insects (e.g. silkworm, lac insect) etc can promote economic growth.
 - » E.g. GE silkworms can produce finer and/or cheaper silk, affecting prices and boosting sales.

 - **Fighting pollution and ensuring environmental sustainability:**
 - Reduction in use of chemical will contribute to reduced pollution and environmental sustainability. Similarly, improved pollinators can contribute to biodiversity production.
 - Some GE insects can be used as bio-indicators to monitor pollution or detect some specific substance in environment.
- **Some Concerns:**
- **Ecological Risk:** Once introduced in the environment, it's very difficult to contain these insects. And if some future problem emerges, it would be difficult to control.
 - **Unforeseen health implications** when these GM insects interact with humans.
 - **Bioweapons:** GE insects may be used to produce bioweapons.
 - **Regulatory challenges:** Government guidelines like Guidelines for Genetically Engineered insects; National Guidelines for Gene Therapy Product Development and Clinical Trials' have similar ambiguity.
 - **Ethical concerns:** GE insects raise a question – “If human being should act as God” and make changes in the living organisms around it.

A) GUIDELINES FOR GENETICALLY ENGINEERED (GE) INSECTS: RELEASED BY DBT IN APRIL 2023

- The guidelines provide procedural roadmaps for those interested in creating GE insects.
 - It intends to help Indian researchers navigate regulatory requirements.
 - The guidelines are harmonized to guidance from WHO on GE mosquitoes.

- But **experts have identified some issues with the guidelines:**
 - b) **Uncertainty of Purpose:** The guidelines don't specify the purpose for which GE insects may be approved in India. It only provides regulatory procedures for R&D on insects with some beneficial applications.

- c) **Uncertainty for Researchers:** The guidelines are applicable only to research and not to confined trials or deployment.
 - » Government authorities will also have to closely follow the deployment of these insects. Once deployed, the GE insects can't be recalled, and unlike GM foods, they are not amenable to individual consumer choice.
- d) **Uncertainty of Ambit:** The guidelines offer SOPs for GE mosquitoes, crop pests, and beneficial insects – but what 'beneficial' means, in the context is GE insect is not clear.

9. OTHER TOPICS (ONLY CLASS DISCUSSION)

1) GENE MAPPING / GENE SEQUENCING

2) EARTH BIO GENOME PROJECT

3) DARK DNA

4) STEM CELL RESEARCH

- Adult Stem Cells
 - Induced pluripotent stem cells
- Embryonic Stem Cells
 - 1) **Totipotent Stem Cells:** These can differentiate into all possible types of stem cells.
 - 2) **Pluripotent Stem Cells:** These are the cells from an early embryo and can differentiate into any cell type.
 - 3) **Multipotent Stem Cells:** These differentiate into a closely related cell type. E.g., the hematopoietic stem cells differentiate into red blood cells and white blood cells.
 - 4) **Oligopotent Stem Cells:** Adult lymphoid or myeloid cells are oligopotent. They can differentiate into a few different types of cells.
 - 5) **Unipotent Stem Cells:** They can produce cells only of their own type. Since they have the ability to renew themselves, they are known as unipotent stem cells. E.g., Muscle stem cells.

5) CHIM STUDIES IN INDIA

6) SYNTHETIC BIOLOGY

10. RELEVANT PYQS

1	<p>Which of the following professional(s) are more likely to run the risk of permanent change in their cell's DNA? [Prelims 1996]</p> <ol style="list-style-type: none"> 1. Researchers using Carbon 14 isotope 2. X-Ray Technician 3. Coal Miner 4. Dyer and Painter <p>Select the correct answer using the codes given below:</p> <ol style="list-style-type: none"> A. 2 alone B. 1, 2 and 3 C. 1, 2 and 4 D. 1, 3 and 4
2	<p>Which of the following techniques can be used to establish the paternity of a child? [Prelims 1997]</p> <ol style="list-style-type: none"> (a) Protein analysis (b) Chromosome counting (c) Quantitative analysis of DNA (d) DNA fingerprinting
3	<p>[Prelims 1999]</p> <p>Assertion(A): Insect resistant transgenic cotton has been produced by inserting BT gene Reason(R): The Bt gene is derived from a bacterium</p> <ol style="list-style-type: none"> (a) Both A and R are true and R is the correct explanation of A (b) Both A and R are true and R is not a correct explanation of A (c) A is true and R is false (d) A is false and R is true
4	<p>[Prelims 1999]</p> <p>Assertion(A): Dolly was the first cloned Mammal Reason(R): Dolly was produced by in vitro fertilization</p> <ol style="list-style-type: none"> (a) Both A and R are true and R is the correct explanation of A (b) Both A and R are true and R is not a correct explanation of A (c) A is true and R is false (d) A is false and R is true
5	<p>[2000]</p> <p>Assertion(A): DNA fingerprinting has become a powerful tool to establish paternity and identity of criminals in rape and assault cases Reason(R): Trace evidences such as hairs, saliva and dried semen are adequate for DNA analysis</p>

	<p>(a) Both A and R are true and R is the correct explanation of A (b) Both A and R are true and R is not a correct explanation of A (c) A is true and R is false (d) A is false and R is true</p>
6	<p>Insect Resistant Cotton plants have been genetically engineered by inserting a gene from a/an [2000] (a) virus (b) bacterium (c) Antibiotics (d) Alcohol</p>
7	<p>The American multinational company, Monsanto, has produced an insect resistant cotton variety that is undergoing field trials in India. A toxic gene from which one of the following bacteria has been transferred to this transgenic cotton? [2001]</p> <p>A. <i>Bacillus Subtilis</i> B. <i>Bacillus thuringiensis</i> C. <i>Bacillus amyloliquefaciens</i> D. <i>Bacillus globlii</i></p>
8	<p>With reference to latest developments in stem cell research, consider the following statements:</p> <ol style="list-style-type: none"> 1. The only source of human stem cells are the embryos at blastocyst stage 2. The stem cells can be derived without causing destruction to blastocyst 3. The stem cells can regenerate themselves in vitro virtually forever 4. Indian research centres also created a few cell lines which can be developed into many types of tissues <p>Which of the statements are correct?</p> <p>A. 1, 2 and 4 B. 1, 2 and 3 C. 3 and 4 only D. 1 and 3</p>
9	<p>Genetically modified 'golden rice' has been engineered to meet human nutritional requirements. Which of the following statements best qualifies golden rice? [2010]</p> <p>(a) the grain has been fortified with genes to provide three times higher grain yield per acre than other high yielding varieties (b) Its grains contain pro-vitamin A which upon ingestion is converted to vitamin A in the human body (c) Its modified genes cause the synthesis of all the nine essential amino acids (d) Its modified genes cause the fortification of its grains with vitamic D</p>

10	<p><i>At present, scientists can determine the arrangement or relative positions of genes or DNA sequences on a chromosome. How does this knowledge benefit us? (2011 Pre)</i></p> <ol style="list-style-type: none"> 1. It is possible to know pedigree of livestock. 2. It is possible to understand the causes of all human diseases. 3. It is possible to develop disease-resistant animal breeds. <p>Which of the statements given above are correct?</p> <ol style="list-style-type: none"> a. 1 and 2 only b. 2 only c. 1 and 3 only d. 1, 2 and 3 only
11	<p><i>A genetically engineered</i> from of Brinjal, known as the Bt-brinjal, has been developed. The objective of this is [prelims 2011]:</p> <ol style="list-style-type: none"> (a) to make it pest-resistant (b) to improve its taste and nutritive qualities (c) to make it drought resistant (d) to make its shelf-life longer
12	<p>With reference to 'stem cells', frequently in the news, which of the following statements is/are correct? [2012]</p> <ol style="list-style-type: none"> 1. Stem cells can be derived from mammals only 2. Stem cells can be used for screening new drugs 3. Stem cells can be used for medical therapies <p>Select the correct answer using the codes given below:</p> <ol style="list-style-type: none"> (a) 1 and 2 only (b) 2 and 3 only (c) 3 only (d) 1, 2 and 3
13	<p>What are the reasons for the people's resistance to the introduction of Bt brinjal in India (2012)</p> <ol style="list-style-type: none"> 1. Bt Brinjal has been created by inserting a gene from a soil fungus into its genome 2. The seeds of Bt brinjal are terminator seeds and therefore, the farmers have to buy the seeds before every season from the seed companies 3. There is an apprehension that the consumption of Bt Brinjal may have adverse impact on health 4. There is some concern that the introduction of Bt brinjal may have adverse effect on the biodiversity <p>Select the correct answer using the codes given below:</p>

	<ul style="list-style-type: none"> a. 1, 2 and 3 only b. 2 and 3 only c. 3 and 4 only d. 1, 2, 3 and 4
14	<p><i>Other than resistance to pests, what are the prospects for which genetically engineered plants have been created? (Prelims 2012)</i></p> <ul style="list-style-type: none"> 1. To enable them to withstand drought 2. To increase the nutritive value of the produce 3. To enable them to grow and do photosynthesis in spaceships and space and space stations 4. To increase their shelf life <p>Choose the correct answer from the codes provided below:</p> <ul style="list-style-type: none"> A. 1 and 2 only B. 3 and 4 only C. 1, 2 and 4 only D. 1, 2, 3 and 4
15	<p>Recombinant DNA technology (Genetic Engineering) allows genes to be transferred (Pre 2013)</p> <ul style="list-style-type: none"> 1. Across different species 2. From Animals to plants 3. From microorganisms to higher organisms <p>Select the correct answer using the codes given below:</p> <ul style="list-style-type: none"> a. 1 only b. 2 and 3 only c. 1 and 3 only d. 1, 2 and 3
16	<p>The Genetic Engineering Appraisal Committee is constituted under the: [Prelims 2015]</p> <ul style="list-style-type: none"> (a) Food Safety and Standards Act, 2006 (b) Geographical Indications of Goods (Registration and Protection) Act, 1999 (c) Environment (Protection) Act, 1972 (d) Wildlife (Protection) Act, 1972
17	<p>In the context of the development in Bio-informatics, the term 'Transcriptome', sometimes seen in the news, refer to: (Pre 2016)</p> <ul style="list-style-type: none"> a. A range of enzymes used in genome editing b. The full range of mRNA molecules expressed by an organism

	<p>c. The description of the mechanism of gene expression d. A mechanism of genetic mutations taking place in cells</p>								
18	<p>What is the application of Somatic Cell CJ Nuclear Transfer Technology? (Pre 2017)</p> <p>a. Production of bio larvicides b. Manufacture of biodegradable plastics c. Reproductive cloning of animals d. Production of organisms free of diseases</p>								
19	<p>Consider the following pairs: [Prelims 2018]</p> <table border="1"> <thead> <tr> <th>Terms sometimes seen in news</th><th>Context/Topic</th></tr> </thead> <tbody> <tr> <td>i. Belle II Experiment</td><td>Artificial intelligence</td></tr> <tr> <td>ii. Blockchain Technology</td><td>Digital/ Cryptocurrency</td></tr> <tr> <td>iii. CRISPR – Cas9</td><td>Particle Physics</td></tr> </tbody> </table> <p>Which of the pairs given above are correctly matched?</p> <p>A. 1 and 3 only B. 2 only C. 2 and 3 only D. 1, 2 and 3 only</p>	Terms sometimes seen in news	Context/Topic	i. Belle II Experiment	Artificial intelligence	ii. Blockchain Technology	Digital/ Cryptocurrency	iii. CRISPR – Cas9	Particle Physics
Terms sometimes seen in news	Context/Topic								
i. Belle II Experiment	Artificial intelligence								
ii. Blockchain Technology	Digital/ Cryptocurrency								
iii. CRISPR – Cas9	Particle Physics								
20	<p>With reference to the Genetically modified mustard (GM mustard) developed in India, consider the following statements (Prelims 2018)</p> <ol style="list-style-type: none"> 1. GM Mustard has the genes of a soil bacterium that give the plant the property of pest resistance to a wide variety of pests 2. GM Mustard has the genes that allow the plant cross-pollination and hybridization 3. GM Mustard has been developed jointly by IARI and Punjab Agricultural University <p>Which of the statements given above is/are correct?</p> <p>a. 1 and 3 only b. 2 only c. 2 and 3 only d. 1, 2 and 3 only</p>								
21	<p>What is cas9 protein that is often mentioned in news ? (Pre 2019)</p> <p>(a) A molecular scissors used in targeted gene editing (b) A biosensor used in the accurate detection of pathogens in patients.</p>								

	<p>(c) A gene that makes plants pest-resistant (d) A herbicidal substance synthesized in generally modified crops</p>
22	<p>With reference to the recent developments in science which one of the following statements is not correct? (Pre 2019)</p> <p>(a) Functional chromosomes can be created by joining segments of DNA taken from cells of different species (b) Pieces of artificial functional DNA can be created in laboratories. (c) A piece of DNA taken out from an animal cell can be made to replicate outside a living cell in a laboratory. (d) Cells taken out from plants and animals can be made to undergo cell division in laboratory petri dishes.</p>
23	<p>'RNA interference (RNAi)' technology has gained popularity in the last few years. why? (Pre 2019)</p> <p>1. It is used in developing gene silencing therapies. 2. It can be used in developing therapies for the treatment of cancer. 3. It can be used to develop hormone replacement therapies. 4. It can be used to produce crop plants that are resistant to virtual pathogens.</p> <p>Select the correct answer using the code given below.</p> <p>(a) 1, 2 and 4 (b) 2 and 3 (c) 1 and 3 (d) 1 and 4 only</p>
24	<p>Bollgard I and Bollgard II technologies are mentioned in the context of: [Prelims 2021]</p> <p>(a) Clonal Propagation of crop plants (b) Developing GM crop plants (c) Production of plant growth substance (d) Production of biofertilizers</p>
25	<p>Consider the following statements: [Prelims 2022]</p> <p>DNA Barcoding can be a tool to:</p> <ol style="list-style-type: none"> 1. Assess the age of a plant or animal. 2. Distinguish among species that look alike. 3. Identify undesirable animal or plant materials in processed foods. <p>Which of the statements given above is/are correct?</p>

	<p>A. 1 only</p> <p>B. 3 only</p> <p>C. 1 and 2 only</p> <p>D. 2 and 3 only</p>
26	<p>Microsatellite DNA is used in the case of which one of the following? [Prelims 2023]</p> <p>A. Studying the evolutionary relationship among various species of fauna</p> <p>B. Stimulating 'stem cells' to transform into diverse functional tissues</p> <p>C. Promoting Clonal Propagation of horticulture plants</p> <p>D. Assessing the efficacy of drugs by conducting a series of drug trials in a population</p>



TARGET PRELIMS 2024

BOOKLET-10; S&T-10

HEALTH

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2. NATIONAL FAMILY HEALTH SURVEY – 5 (NFHS)

- **Details: About NFHS**
 - The NFHS is a large-scale, multi-round survey, conducted in a representative sample of households throughout India. First survey was done in 1992-94 and since then 5 rounds have been conducted.
- **Who conducts this survey?**
 - International Institute for Population Sciences (IIPS), Mumbai, is the National Nodal Agency.
 - MoHFW has decided to conduct integrated NFHS with a periodicity of three years in lieu of different surveys from 2015-16 onwards to meet the evolving requirements for frequent, timely and appropriate **data** at the National, State and District level.
- **NFHS-5: Key Highlights**

Sl. No.	Indicator	NFHS-5 (2019-21)	NFHS-4 (2015-16)
Fertility and Family Planning			
1	Total Fertility Rate (TFR)	2.0	2.2
2	Women age 15-19 years who were already mothers or pregnant at the time of the survey (%)	6.8	7.9
3	Current Use of Family Planning Methods-Any method (%)	66.7	53.5
4	Current Use of Family Planning Methods-Any modern method (%)	56.4	47.8
5	Total unmet need for Family Planning (%)	9.4	12.9
Maternity and Delivery Care			
6	Mothers who had an antenatal check-up in the first trimester (%)	70.0	58.6
7	Mothers who had at least 4 antenatal care visits (%)	58.5	51.2
8	Mothers who received postnatal care from a doctor/nurse/LHV/ANM/midwife/other health personnel within 2 days of delivery (%)	78.0	62.4
9	Institutional births (%)	88.6	78.9
Child Vaccination and Child Feeding Practices			
10	Children age 12-23 months fully vaccinated based on information from either vaccination card or mother's recall (%)	76.6	62.0
11	Children under age 6 months exclusively breastfed (%)	63.7	54.9
Infant and Child Mortality Rates (per 1000 live births)			
12	Neonatal Mortality Rate (NNMR)	24.9	29.5
13	Infant Mortality Rate (IMR)	35.2	40.7
14	Under-five Mortality Rate (U5MR)	41.9	49.7

3. REPORTS

1) 'HEALTHY STATES, PROGRESSIVE INDIA' – A REPORT BY NITI AAYOG

- **Introduction**
 - » It is a comprehensive health index report which ranks states and UTs innovatively on their year on year incremental change in health outcomes, as well as their overall performance with each other.
 - » The report has been prepared by NITI Aayog with technical assistance from WB, and consultation with MoH&FW.
 - » States and UTs have been ranked in 3 categories namely Larger states, smaller states, and Union Territories (UTs) to ensure comparison among similar entities.
 - » The health index is a weighted composite index based on 24 indicators grouped under **three domains**, with each domain assigned weights based on its importance and higher scores for outcome indicators.
 - Health Outcomes (70%);
 - Governance and Information (12%);
 - Key inputs and processes (18%),
- **Significance** - An annual systematic tool; regular assessment of health sector; nudge badly performing states to do well; helps to move towards SDG goals.

4. SCHEMES/PROGRAMS/INITIATIVES

1) AYUSHMAN BHARAT – PRADHAN MANTRI JAN ARYOGYA YOJNA (AB-PMJAY)

- **About AB-PMJAY** (Pradhan Mantri Jan Arogya Yojana)
 - **Ministry:** MoH&FW
 - AB-PMJAY is an entitlement based scheme that aims to provide health insurance cover of upto **5 lakh rupees per family** to **over 10 crore poor families** (about 50 crore population) for **secondary and tertiary care hospitalization**. There is **no cap on the size of the family or age of the beneficiary**.
 - All pre-existing conditions are also covered from day 1 of implementation of PM-JAY in respective states/UT.
 - It is the world's largest government funded health care program.
 - The **eligible poor families** are decided on the basis of **SECC, 2011 data** and include poor, deprived rural families and occupational category of urban worker's families (Roughly 8.03 crore rural families and 2.33 crore urban families (11 occupational criteria))
 - In addition the beneficiary of RSBY are also included.
 - Further, there is no capping on number of family members or age of members -> this ensures that senior citizens and girl children also get good health services.
 - The scheme provides **cashless and paperless** access to services for the beneficiary at the point of service. Eligible people can avail the benefits at both government and listed (empanelled) private hospitals.
 - In case of **hospitalization**, members of the beneficiary families **don't need to pay anything** under the scheme, provided one goes to a government or an empanelled private hospital.
 - It is a **centrally sponsored scheme**, so, there is a state component too (**60:40**).

- It is a **portable** scheme, which means beneficiary can avail benefits in any of the states that is implementing the scheme.
- It subsumes Rashtriya Swastha Bima Yojana and the Senior Citizen Health Insurance Scheme (SCHIS).
- **Adhaar card is not mandatory** - identity to avail benefit can be established through ration card or election ID card.

2) AYUSHMAN BHARAT – DIGITAL HEALTH MISSION (AB-DHM)

- **Details**
 - » The missions aim to create a **complete Digital Health Ecosystem** which will connect the digital health solutions of hospitals across the country with each other.
 - This digital ecosystem will enable a host of other facilities like Digital Consultation; Consent of Patients in letting medical practitioners access their records, etc. This will ensure that all medical records are stored digitally and are thus not lost. They would be accessible through app or web-portal.
 - All this will help in improving the quality, access, and affordability of health services by making the service delivery "quicker, less expensive, and more robust".
 - » **Unique Health ID:**
 - Any person wanting to be part of ABDHM will get a health ID, which is a **randomly generated 14-digit number**. It will be used for three purposes - Unique Identification; Authentication; and Threading of the beneficiary's health records, only with their informed consent, across multiple systems and stakeholders.
 - **Facilities:**
 - You can access your digital records right from admission through treatment and discharge.
 - You can access and link your personal health records with your health ID to create a longitudinal health history.
 - » **NDHM Sandbox**
 - It is a digital architecture that allows private players to be part of the National Digital Health Ecosystem as health information providers or health information users.
 - » **Privacy:**
 - Citizen's consent is vital for all access.
 - Users can delete or exit the services anytime he wants.
 - » **Upcoming features:**
 - Future features will enable access to verified doctors across the country.
 - The beneficiary can also create health ID for her child, a digital health records right from birth.
 - She can add a nominee to access her health ID and view or help manage the personal health records.

- Also, there will be much inclusive access with the health ID available to people who don't have phones, using assisted methods.
- **Why can't Aadhaar be used as Digital ID:**
 - » The Aadhaar Act and Supreme Court verdict restrict the use of Aadhaar ID for welfare schemes promoting government subsidies.
- **Significance:** (ease of living; optimal treatment; reduce re-testing; increased accountability; easy identification of specialists, doctors, labs; Big Data, Data Mining and Artificial intelligence-based solution etc.

A) E-SANJEEVANI – NATIONAL TELEMEDICINE SERVICE

- **Ministry:** MoH&FW
- It is an innovative, indigenous, cost-effective, and integrated cloud based telemedicine system application to enable patient to doctor teleconsultation to ensure a continuum of care and facilitate health services to all citizens in the confines of their home.
- **Two verticals of eSanjeevani**
 - **eSanjeevaniAB-HWC:** It endeavors to bridge rural-urban digital health divide by providing assisted teleconsultation, and ensuring that e-beneficiaries of AB Scheme are able to avail the benefits that they are able to entitled to.
 - It operates on Hub and Spoke Model wherein the 'Ayushman Bharat - Health and Wellness Centre' are set up at the state level, act as spokes, which are mapped with the hub (comprising MBBS/ Specialty/ Super Specialty doctors) at zonal level.
 - **eSanjeevaniOPD** is the latter vertical which caters to citizens in both rural and urban alike. It leverages technology via smartphones, tablets, laptops etc. enabling doctor consultation to be accessible from the patient's residence regardless of location.
- **Progress So far:**
 - As of Jan 2023, 1,12,553 HWC in rural areas and 15465 Hubs at tertiary level hospitals, and medical colleges in the states have been enabled in the eSanjeevani.
 - **Patients Served:** It has served 9.3 crore patients so far and is serving around 4 lakh patients daily.
- **E-Sanjeevani** is evolved into the world's largest outpatient Services system.
- It is a cohesive part of Ayushman Bharat Digital Health Mission (ABDM) and more than 45,000 ABHA IDs have been generated using eSanjeevani Portal.

3) PM AYUSHMAN BHARAT HEALTH INFRASTRUCTURE MISSION (PMAB-HIM)

- PMABHIM, announced in the Budget 2021-22, is the largest pan-India Health Infrastructure Scheme which aims to strengthen the PAN-India health infrastructure.

- It is a centrally sponsored scheme with a budgetary outlay of Rs 64,180 crore for the FY 2021-22 to 2025-26 and will improve health care facilities from village to national level in this period.
- There are **three major aspects** of the ABHIM - Augmenting Healthcare facilities for treatment; Setting up of integrated public health labs for diagnosis of diseases; and Expansion of existing research institutions that study pandemics.

4) DECRIMINALIZATION OF MEDICAL NEGLIGENCE

- **Why in news?**
 - » Bhartiya Nyaya Samhita has kept the punishment for medical negligence lower than the punishment for causing death by other kinds of negligence (Dec 2023)
- **Introduction**
 - » As per the **Section 106(1)** of the Bhartiya Nyaya (Second) Sanhita (BNSS), doctors will continue to face a two year imprisonment and/or fine if convicted. This is lesser than the Sanhita's recommended punishment of five years for other cases of death by negligence (for e.g. by rash driving).
 - » **Note:** The maximum imprisonment of doctors with this amendment remain the same as it was under IPC section 304A - upto 2 years of imprisonment or fine or both.
 - Medical negligence has not been clubbed with other accidental deaths where punishment has been kept higher.
- **Need of lower punishment for medical negligence:**
 - » Doctor's shouldn't be punished for honest mistakes and negligence is a complex issue in medical field and therefore this shouldn't be clubbed with other kinds of negligence.
 - » It will also reduce harassment of doctors from frivolous lawsuits and harassment.
 - » It will ensure that doctors will be able to provide care without fear of persecution and patients can be assured of quality care.
- **Criticisms:**
 - » Critiques argue that doctors should be more careful and the scope of negligence should be lesser here.
 - » Owing to the "power imbalance" in the doctor-patient relationship, an act of negligence on the part of the doctor calls for a lower punishment but a higher one.

5) IMMUNIZATION PROGRAM IN INDIA/ VACCINATION

- **Various Initiatives**
 - » The government had launched **Expanded Program for Immunization** in 1978 which was further replaced by **Universal Immunization Program (UIP)** in 1985. It is the largest Immunization Program in the world, with the annual coverage of 2.6 crore infants and 2.9 crore pregnant women. Through this India has achieved groundbreaking success in eradicating/ eliminating life threatening vaccine preventable diseases like smallpox, Polio, Maternal Neonatal Tetanus etc.

- But despite a lot of efforts and improvements, the immunization coverage had been slow to increase with a coverage of **62%** according to NFHS-4 released in 2015-16.
- **Key Factors behind low Immunization Coverage**
 - » **Rapid and Unplanned urbanization**
 - » **Large migrating and isolated population** is difficult to cover
 - Difficult terrains, areas under LWE etc. are also difficult to cover.
 - » **Lack of awareness** among uninformed masses and unaware population leads to low demand of immunization.
- **Other problems with vaccination system in India**
 - » **Inequality in vaccine administration**
 - » **Vaccine Hesitancy: Rumor Mongering/ Misinformation among some population** also prevents full coverage.
- **Negative Impact of COVID-19 on routine vaccination**
- **Various Efforts to deal with above challenges:**
 - » **Mission Indradhanush** was launched by the MoH&FW in 2014. It is a strategic endeavor under UIP with an aim to target under-served, vulnerable and inaccessible populations.
 - It covers **8 vaccines** (Diphtheria, Whooping Cough, Tetanus, Polio, Measles, Childhood TB, Hepatitis B and Meningitis) across the country, **2 vaccines** (Pneumonia and Hemophilus influenza type B) in selected states and **2 vaccines** (Rotavirus Diarrhea and Japanese Encephalitis) in selected districts.
 - **MI** contributed to an increase of 6.7% in full immunization coverage after the first two phases of Mission Indradhanush.
 - » **Intensified Mission Indradhanush (IMI)** was launched in Oct 2017 - to achieve a coverage of 90% with focus towards districts and urban areas with persistently low levels.
 - » **In Dec 2019**, Government had launched **Intensified Mission Indradhanush 2.0 (IMI 2.0)** to be implemented between Dec 2019 - March 2020 that seeks to escalate efforts to achieve the goal of attaining a 90% national immunization coverage across the country.
 - » **Intensified Mission Indradhanush 3.0** aimed to reach those children and pregnant women who have been missed out of the routine immunization program. The first phase ran from 22nd Feb 2021 for 15 days.
 - » **Intensified Mission Indradhanush 4.0** launched in Feb 2022.
 - Three rounds of IMI 4.0 was planned to catchup on the gaps that might have emerged due to COVID-19 pandemic. The activity will be conducted in 416 districts across 33 states/Uts.
 - These districts were identified based on vaccination coverage as per the latest National Family Health Survey-5 report, Health Management Information System (HMIS) data and burden of vaccine preventable diseases.

- » **Intensified Mission Indradhanush 5.0 (IMI 5.0)** campaign was being conducted in three rounds:
 - 7-12 Aug 2023; 11-16 Sep 2023; and 9-14 Oct 2023 (**6 days every month**)
 - It aims to ensure immunization coverage of all vaccines provided under the UIP as per the National Immunization schedule.
 - **Special focus** is on improvement of Measles and Rubella vaccination coverage with the aim of Measles and Rubella elimination by 2023.
 - It ensures that routine immunization services reach the missed-out and dropped out children and pregnant women across country. This year, for the first time the campaign was conducted across all districts in the country and include children upto 5 years of age (previous campaigns included children upto 2 years of age)
 - It saw participation from ***Jan pratinidhis*** and **Social media** influencers have come in large numbers across all states/ Uts to appeal to people to visit nearest vaccination centres.
- » Since 2014, 11 phases of Mission Indradhanush have been completed.

6) BCG VACCINE – 100 YEARS AND COUNTING

- BCG was first used in humans in 1921.
- **Details about BCG vaccine (bacilli Calmette-Guerin)**
 - » BCG was developed by two Frenchmen, Albert Calmette and Camille Guerin.
 - It is a live attenuated strain derived from an isolate of Mycobacterium bovis and has been used widely across the world as a vaccine for tuberculosis. Currently, it is the only licensed vaccine available for the prevention of TB. It is the world's most widely used vaccine with about 120 million doses every year.
 - » **Interesting Fact:** Works well in some geographical locations and not so well in others. Generally, the farther a country is from equator, the higher is the efficacy. Therefore, it has high efficacy in UK, Norway, Sweden, and Denmark; and little or no efficacy in countries on or near the equator like India, Kenya, and Malawi, where the burden of TB is higher. These regions also have higher prevalence of environmental mycobacteria.
 - However, in children BCG provides strong protection against severe forms of TB. This protective effect appears to wane with age and is far more variable in adolescents and adults, ranging from 0-80%.
 - **A large clinical trial between 1968-1983 by ICMR's National Institute for Research** in TB in Chengalpattu district of TN, indicated that BCG offered no protection against pulmonary TB in adults, and a low level of protection (27%) in children.
- **Other uses of BCG**
 - BCG also protect against respiratory and bacterial infections of the newborns, and other mycobacterial diseases like leprosy and Buruli's ulcer.
 - It is also used as an immunotherapy agent in cancer of the urinary bladder and malignant melanoma.
- **BCG in India**
 - BCG vaccinations were first conducted in India in 1948 and it became part of the National TB control program in 1962.
 - It remains a part of basket of vaccines included under the **Universal Immunization Program**.

- **Other TB vaccines:**
 - Over the last ten years, 14 new Vaccines have been developed for TB and are in clinical trials.

5. MATERNAL HEALTH – SCHEMES

A) UNDERSTANDING MATERNAL MORTALITY RATE

- Maternal death is the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of duration of pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes.

Table VI.18: Trends in Mortality indicators

	2014	2016	2018	2020
Maternal Mortality Ratio (per lakh live births)	167 (2011-13)	130 (2014-16)	113 (2016-18)	97 (2018-20)
Infant Mortality Rate (per 1000 live births)	39	34	32	28
Neonatal Mortality Rate (per 1000 live births)	26	24	23	20
Under 5 Mortality Rate (per 1000 live births)	45	39	36	32
Early Neonatal Mortality Rate – 0- 7 days (per 1000 live births)	20	18	18	15

Source: Sample Registration System

- As per the Sample Registration Survey (SRS) data, India has successfully achieved the major milestones to bring Maternal Mortality Ratio (MMR) to below 100 per lakh live births by 2020 [laid down in the National Health Policy, 2017]
- **Eight states** have already achieved the 2030 SDG targets to reduce MMR to less than 70 per lakh live births by 2030. These include Kerala (19), Maharashtra (33), Telangana (43), Andhra Pradesh (45), Tamil Nadu (54), Jharkhand (56), Gujarat (57), and Karnataka (69).

B) NATIONAL HEALTH MISSION 2013

- With respect to mother's health, the NHM includes following initiatives:
 - Reproductive Maternal Neonatal Child and Adolescent Health (RMNCH+A) Program
 - **Janani Surakha Yojna (JSY)** to promote institutional delivery which is expected to reduce neonatal and maternal mortality.

C) JANANI SURAKHA YOJANA (2005 SCHEME)

- The JSY is a safe motherhood intervention launched in 2005 as part of the NRHM to improve maternal and neonatal health by promotion of institutional deliveries (childbirth in hospitals).
- It is a 100% centrally sponsored scheme which integrates cash assistance with delivery and post-delivery care
- **Key Features**
 - » Financial assistance under JSY is available to all pregnant women in states that have low institutional delivery rates namely, UP, UK, Bihar, Jharkhand, MP, Chhattisgarh, Orissa, Assam, Rajasthan & J&K (categorized as low performing states).
 - » In remaining states (where institutional delivery are satisfactory, pregnant women from BPL/SC/ST households only are entitled for JSY benefits.

- » It is implemented through ASHA, the accredited social health activists, acting as an effective link between the Government and poor pregnant women under the scheme.

D) JANANI SHISHU SURAKSHA KARYAKRAM

- The program launched in 2011 entitles all pregnant women delivering in public health institutions to absolutely free and no expense delivery including Caesarean section.
 - The program stipulates free drugs, diagnostics, blood and diet, besides free transport from home to institution, between facilities in case of a referral and drop back home.
 - Similar entitlement has been put in place for all sick infants accessing public health institutions for treatment.

E) MATERNITY BENEFIT SCHEME (MBS) / PRADHAN MANTRI MATRITVA VANDANA YOJANA (PMMVY)

- **Details of the Scheme:**
 - Under PMMVY a 'cash incentive of Rs 5,000 is provided directly to the bank account of the pregnant or lactating mothers for the first living child of the family.
 - It is aimed at improving health seeking behavior, arresting MMR, ensuring proper nutrition and offsetting wage loss.
 - The scheme is being implemented from 1st Jan 2017.
- **Target Women**
 - Eligible PW&LM, excluding women in regular employment who are in receipt of similar benefits under any law for the time being.
- **Other key provisions of the scheme:**
 - Center: State Share: 60: 40
 - The benefit of Rs 5000 to PW&LM in three installments for the birth of first live child by MWCD and remaining incentives as per the approved norms towards maternity benefit under existing programs after institutional deliveries so that on an average women would receive Rs 6,000.
 - Conditional cash transfer scheme would be in DBT mode.
- **Limitation of the Scheme**
 - Only for first child
 - Amount too small
 - Several conditions attached
 - **Subsuming of Janani Surakha Yojana:** JSY which is a cash based incentive of Rs 14,00 for institutional deliveries, has been subsumed under this scheme. JSY is an older scheme started for a different purpose and should not be confused with maternity benefits for wage compensation.

F) STATE GOVERNMENTS RUNNING THEIR EFFECTIVE SCHEMES (TN AND ODISHA)

- Dr. Muthulakshmi Reddy Maternity Benefit Scheme in TN provides for financial assistance of Rs 18,000 per child for the first two children.
- **MAMATA Scheme of Odisha** provides Rs 5,000 for first two children.
 - These two schemes are working reasonably well due to their wider coverage and simpler process.
 - In 2020-21, MAMATA showcased a 57% increase in women who received all installments, and PMMVY showcased a decrease.

6. NUTRITION

1) VARIOUS INITIATIVES TO FIGHT MALNUTRITION IN THE COUNTRY

- The government is implementing several schemes and programs under the Umbrella ICDS Scheme as direct target interventions to address the problems of malnutrition in the country.
- Initiatives like **PDS, Mid-Day Meal Scheme**.
 - In Sep 2021, the Mid day meal scheme has been renamed to PM POSHAN.
 - Under this not only Children of class 1 to 8 (around 11.8 crore) will be covered, but also around 24 lakh students receiving pre-primary education at government and government aided schools will also be brought under the ambit of the scheme from next year. This is in line with NEP which had recommended that the pre-school education should be formalized.
- **Poshan Abhiyan** (POSHAN -> PM's overarching scheme for holistic nutrition) (earlier known as **National Nutrition Mission**) is being implemented since 2017. It is aimed at reducing malnutrition in the country in a phased manner, through a lifecycle approach. It focuses on children, pregnant women, and lactating mothers.
 - » It has an aim to build a people's movement (Jan Andolan) around malnutrition.
 - » For implementation of **POSHAN Abhiyan** the four-point strategy/pillars of the mission are:
 - Inter-sectoral convergence for better service delivery
 - Use of Technology (ICT) for real time growth monitoring and tracking of children
 - Intensified health and nutrition for the first 1000 days
 - Jan Andolan
 - » Target was to bring down the stunting of the children in the age group of 0-6 years to 25% by the year 2022.
- **Mission Poshan 2.0**
 - » COVID-19 had worsened the situation and therefore, it was important to multiply our efforts towards **Poshan 2.0** with full vigour.
 - It is an umbrella program that encompasses ICDS (Anganwadi Services, Poshan Abhiyan, Scheme for Adolescent Girls, National Creche Scheme). It was announced in Union Budget 2021-22 and has merged supplemental nutrition programs and the **POSHAN Abhiyan** to tap the synergies.
 - Under this, malnutrition hotspots and aspirational districts will get extra attention.

- Steps to promote AYUSH systems for prevention of malnutrition and related diseases.
- A program to support development of Poshan Vatikas at Anganwadis centres to meet dietary diversity gap leveraging traditional knowledge in nutritional practices.
- **NFSA, 2013** which provides for coverage of upto 75% of the rural population and upto 50% of the urban population for receiving highly subsidized food grains under TPDS.
- **Pradhan Mantri Garib Kalyan Anna Yojna (PMGKAY)**

2) MICRONUTRIENTS VS MACRO NUTRIENTS

A) MICRONUTRIENTS

- These are the **vitamins and minerals** that our bodies need each day in order to properly function. Unlike macronutrients they are needed in small amounts.
 - **Vitamins** can be classified into **13 major types**: Vitamins A, B-Complex (Thiamine, riboflavin (Vitamin B2), niacin, pantothenic acid, biotin, vitamin-B-6, Vitamin B12, and folate), C, D, E and K.
 - They are organic compounds. They can be classified into two categories:
 - i. **Fat Soluble**
 - A,D, E and K
 - Important role in overall health by promoting healthy bones, skin, eyesight, lungs and digestive systems.
 - ii. **Water Soluble**
 - B-Complex and C
 - Not stored in fat (like fat soluble vitamins), so daily consumption is important.
 - They boost metabolism, act as powerful antioxidant and assist in the formation of collagen helping in healing wounds.
 - **Vitamin D**
 - » Vitamin D is an essential vitamin that helps regulate calcium and phosphorus in the body. It also plays a role in maintaining bone structure.
 - » There are different forms of Vitamin D, including **ergocalciferol (Vitamin D2)** and **Cholecalciferol (Vitamin D3)**.
 - It is found in fish, eggs and fortified milk. It's also made in the skin when exposed to sunlight. During periods of sunlight, Vitamin D is stored in fat and then released when sunlight is not available.
 - **Minerals** can be further classified as **major minerals** and **trace minerals**.
 - The six major minerals include sodium, potassium, chloride, calcium, phosphorus and magnesium. They are required in large amounts in body as compared to trace minerals. They are important for maintaining proper fluid balance and electrolytes (sodium and potassium) as well as help in supporting bones, hair, skin and nail health.

- Trace minerals are required in smaller quantities, but are as important as major minerals. The **nine trace** minerals include cooper, zinc, iron, iodine, manganese, molybdenum, cobalt, selenium and fluoride.

B) MACRO-NUTRIENTS

- These are the main nutrients that make up the foods we eat. There are three macro-nutrients - **Carbohydrate, Protein and Fat**.

FATS - SIGNIFICANCE - LIMITATIONS AND TYPES

- **Significance of fats as nutrients**
 - It is the most concentrated form of energy. Body uses fat as a fuel source and as major storage of energy.
 - It helps in absorbing vitamins like A, D, E and K.
 - They also provide cushioning for the organs.
 - They are an important constituent of cell membrane and provide taste, consistency, and stability.

A) TRANS FAT VS SATURATED FAT VS MONO-SATURATED FAT VS POLY-UNSATURATED FAT

- All fats have a similar structure - a chain of carbon atoms bonded to hydrogen atoms.
- The differentiating factor is the length and shape of the carbon chain and the number of hydrogen atoms connected to the carbon atoms.

1) Trans Fat (worst type of dietary fat)

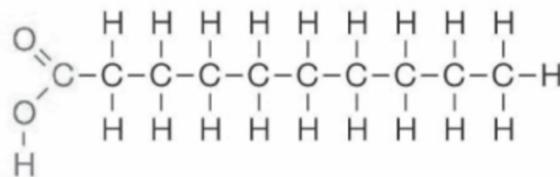
- According to the World Health Organization, approximately 5.4 lakh deaths take place each year globally because of the intake of industrially produced trans fatty acids. They come in both natural and artificial forms.
- Trans fats are the result of **partial hydrogenation of unsaturated fat**. This turns healthy oil into solids.
 - **Process:** Heating liquid vegetable oils in the presence of hydrogen gas and a catalyst, a process called hydrogenation.
 - **Advantages:**
 - Partial hydrogenation of vegetable oil makes them more stable and less likely to become rancid. The process also converts the oil into a solid, which makes it easy to handle.
 - Partial hydrogenation oils can withstand repeated heating without breaking down, making them ideal for frying fast foods.
 - **Note:** Partial hydrogenation is not the only source of trans-fat in our diet. Trans fats are also naturally found in beef fat and dairy fat in small amounts.
 - Trans fats have no known health benefits and no safe level of consumption.
- **Disadvantages:**
 - Trans-fats are worst type of fat for the heart, blood vessels, and rest of the body:

- Eating trans-fat increases harmful LDL (low density lipoprotein) cholesterol in the blood stream and reduces the amount of beneficial HDL (high density lipoprotein) cholesterol. It is linked to heart disease, stroke, diabetes, and other chronic conditions.
 - They contribute to insulin resistance.
- It is **banned** in many countries. India currently allows trans-fatty acids upto 3% (by weight).
 - In Jan 2020, 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.
 - **In May 2018**, WHO also gave a call to eliminate trans-fat in foods by 2023.
 - For this WHO has launched an initiative **REPLACE**, that will provide guidance for all countries on how to remove artificial trans fats from their foods, possibly leading to worldwide eradication.
 - It stands for **Review** dietary sources, **Promote** use of healthier fats, **legislate**, **assess** changes, **create** awareness, and **Enforce** regulation.
 - The initiative promotes countries to establish legislation to eliminate the trans-fats.

3) Saturated Fats

- A saturated fat is a type of fat in which the fatty acid chains have all or predominantly single bonds.

Saturated

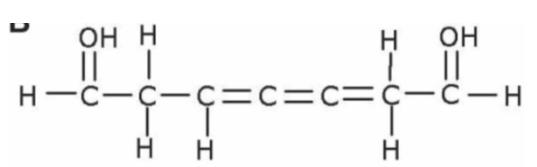
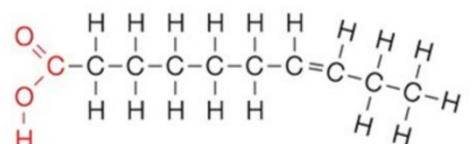


- Common **source** of saturated fats are red meat, whole milk and other whole milk dairy products, coconut oils etc.
- **Health Impacts**
 - Can drive harmful LDL cholesterol.
 - But recent research, have again raised the debate whether saturated fats are actually harmful and cause heart disease.

4) Monounsaturated Fat and Poly Unsaturated Fats

- **Monounsaturated Fats** are fatty acid chains that have one double bond in the fatty acid chain with all the remainder carbon atoms being single-bonded.
- **Poly Unsaturated Fats** are fatty acids with more than 1 double bond.
- Thus, these fats have fewer hydrogen atoms bonded to carbon atoms when compared to saturated fats.
- They are liquid at room temperature.
- **Sources of monounsaturated fats**

Monounsaturated Fat



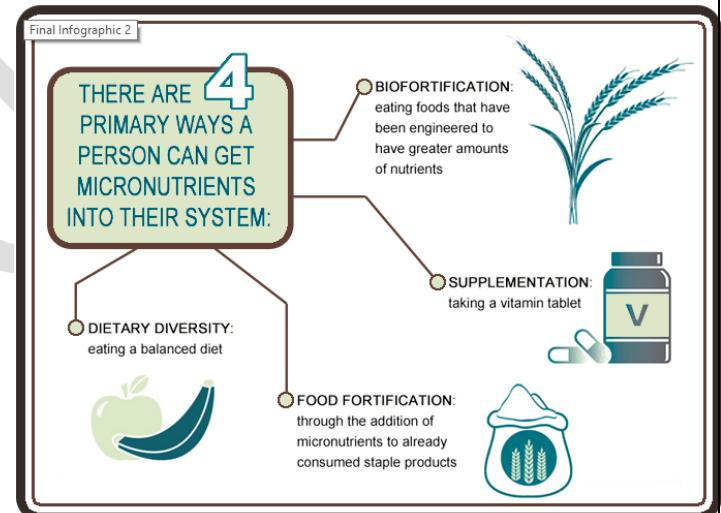
Polyunsaturated fatty acid

- Olive Oil, peanut oil, canola oil, avocados, nuts etc.
- **Sources of Polyunsaturated oils**
 - Corn oil, sunflower oil, and safflower oil, fish oil etc. are common examples.
 - These are **essential fats** and are required for normal body functioning, but our body can't make them. They are used in building of cell membrane and covering of nerves. They are also needed in blood clotting, muscle movement and inflammation.
- **Two Main types of Polyunsaturated Fatty Acids**
 - Omega-3 Fatty Acids
 - Omega-6 Fatty Acids

3) FORTIFICATION OF FOOD

A) FOOD FORTIFICATION

- Fortification means deliberately increasing the content of essential micronutrients in a food so as to improve the nutritional quality of food and to provide public health benefits with minimal risk to health.
- **Advantages of Food Fortification** over other nutrition fulfillment mechanisms:
 - **Cost Effective:**
 - **Well Proven Method:**
 - » It has been used around the world since 1920s.
 - » WHO, UNICEF, FSSAI all approve it.
 - **Eating Habits not needs to be changed**
 - **Socio-culturally more acceptable**
 - **Scalable and Sustainable:** Can be introduced quickly and can provide nutritional benefit to people in short period of time.
- **Different ways in which people get micro-nutrients** and why food fortification can be effective.
 - Since most population in resource-poor settings do not have access to adequate quantities of fruits, vegetables, and meats where micronutrients are abundant, and because providing vitamin tablets poses logistical and economic constraints, food fortification is a practical and inexpensive alternative.



B) BIOFORTIFICATION:

- » Biofortification is the process by which the nutritional quality of the food crops is improved through agronomic practices, conventional plant breeding, or modern biotechnology.
- » It aims to increase nutrient level in crops during plant growth rather than through manual means during processing of the crops.

- » Biofortification may therefore present a way to reach population where supplementation and conventional fortification activities may be difficult to implement and/or limited.
- » Scientists at ICAR have been developing biofortified crops in India with a view to eradicating malnutrition amongst the poor sections of society. As per ESI 2021-22, currently in India the number of biofortified varieties have increased to 87.
 - None of these are GM crops. They have been developed through conventional crop breeding techniques.
- » E.g.
 - Zinc biofortification of wheat, rice, beans, sweet potatoes and maize

C) RICE FORTIFICATION: EXTRUSION TECHNOLOGY:

- » In his Independence Day Speech (Aug 2021), PM Modi announced fortification of rice distributed under various government schemes, including the PDS and midday meals in schools, by 2024.
- » **Various technologies** are available for rice fortification - coating, dusting etc. But '**extrusion**' is considered the best technology. This involves the production of fortified rice kernels (FRKs) from a mixture using an extruder machine. The fortified rice kernels are then blended with regular rice to produce fortified rice.
- » **How does extrusion technology to produce FRK work?**
 - Dry rice flour is mixed with a premix of micronutrients, and water is added to this mixture. This mixture then goes into twin-screw extruder with heating zones, which produce kernels similar to shape and size to rice. These kernels are dried, cooled and packaged for use. FRK have shelf life of at least 12 months.
 - As per the guidelines issued by the Ministry of Consumer Affairs, Food and Public Distribution, the shape and size of the fortified rice kernel should "resemble the normal milled rice as closely as possible". According to the guidelines, the length and breadth of the grain should be 5 mm and 2.2 mm respectively.
- » **According to FSSAI norms, 1 kg of fortified rice will contain the following:**
 - Iron (28 mg-42.5 mg), folic acid (75-125 microgram), and vitamin B-12 (0.75-1.25 microgram).
 - Rice **may also be fortified** with zinc (10 mg-15 mg), vitamin A (500-750 microgram RE), vitamin B-1 (1 mg-1.5 mg), vitamin B-2 (1.25 mg-1.75 mg), vitamin B-3 (12.5 mg-20 mg) and vitamin B-6 (1.5 mg-2.5 mg) per kg
- » **Why is rice fortification needed?**
 - High levels of Anaemia and malnutrition in India. Rice is a stable crop of India.
- » **Cost of fortification:**
 - The Ministry estimates that the cost of producing FRK with three micronutrients - iron, folic acid, and vitamin B-12 - will come to around Rs 0.6 per kg. This cost is shared between centre and states and government will pay this cost to rice millers.
- » **Identification:**

- Fortified rice will be packed in jute bags with the logo ("+F") and the line "Fortified with Iron, Folic Acid, and Vitamin B12" will be mandatorily printed on them.

» **Has any other country done this?**

- Rice fortification is mandatory in 7 countries: The USA, Panama, Costa Rica, Nicargua, Papua New Guinea, Phillipines, and the Solomon Islands.

4) DISEASES DUE TO NUTRITIONAL DEFICIENCIES

Disease	Deficiency of	Other comments
Rickets	Vitamin D along with calcium and potassium	<ul style="list-style-type: none"> - Rickets is characterized by <u>weak and soft bones, bowed legs and bone deformities</u>. - <u>Fish, fortified dairy products, liver, oil and sunlight</u> are some rich sources of vitamin D.
Osteoporosis	Vitamin D with Calcium	<ul style="list-style-type: none"> - Deficiency of <u>Vitamin D</u> and calcium in the body can <u>negatively affect the health of the bones and spine</u>. It leads to <u>unhealthy, soft and brittle bones</u> that are prone to fractures and defects in the spine structure. - <u>Bananas, spinach, milk, okra, soy and sunlight</u> are natural sources of Vitamin D and calcium that act to eliminate this deficiency
Pellagra	Vitamin B3 or Niacin	<ul style="list-style-type: none"> - 4D's: Dementia, diarrhea, dermatitis and death are the four Ds that characterize Pellagra. - <u>Tuna, whole grains, peanuts, mushrooms, chicken etc.</u>
Scurvy	Vitamin C or ascorbic acid	<ul style="list-style-type: none"> - Scurvy basically <u>inhibits the production of collagen</u> in the body which is the <u>structural protein that connects the tissues</u>. - <u>Decaying of skin and gums, abnormal formation of teeth and bones, delay or inability to heal wounds and bleeding</u> are the effects of scurvy - Vitamin C can be derived from <u>Citrus fruits</u> like oranges, lemon, strawberry etc. and <u>Broccoli</u> regularly.
Beri-Beri	Vitamin B1 or Thiamin	<ul style="list-style-type: none"> - The most common symptoms of this illness are <u>altered muscle coordination, nerve degeneration and cardiovascular problems</u>. - <u>Meat, eggs, whole grains, dried beans</u> etc are rich in thiamine and thus, should be consumed in proper amounts every day to avoid this painful ailment

Xerophthalmia or Night Blindness	Vitamin A	<ul style="list-style-type: none"> - Xerophthalmia or night blindness is characterized by <u>blindness due to the poor growth, dryness and keratinisation of epithelial tissue or chronic eye infection.</u> - In worsened situations, night blindness can <u>aggravate to complete loss of vision</u> - The safest way to enhance the Vitamin A levels in the body is by <u>consuming natural food sources like carrots, green and leafy vegetables, cantaloupes etc</u>
Goitre	Iodine	<ul style="list-style-type: none"> - Goitre leads to <u>enlarged thyroid glands</u> causing <u>hypothyroidism, poor growth and development of infants in childhood, cretinism and even mental retardation</u> - This disease is commonly found to occur in places having <u>iodine deficit soil</u>. <u>Iodised salt and saltwater fish are rich sources of iodine</u>, and must be consumed regularly to avoid goitre.
Anaemia	Iron	<ul style="list-style-type: none"> - It is characterized by a <u>decrease in the red blood cell count or haemoglobin in the body</u>, resulting in <u>fatigue, weakness, dyspnoea and paleness of the body</u>. - It can be easily treated by changing to a <u>healthy diet and consuming iron supplements</u> on a regular basis. <u>Squashes, nuts, tofu, bran etc</u> are rich sources of iron for the body. -
Kwashiorkor	Protein and Energy	<ul style="list-style-type: none"> - It is characterized by anorexia, <u>an enlarged liver, irritability and ulcerating dermatoses</u>. - These are one of the <u>nutritional deficiencies in children, especially from famine-struck areas</u> and places with poor food supply, Kwashiorkor is caused by malnutrition. - A healthy and balanced diet enriched with protein and carbohydrate sources like eggs, lentils, rice etc helps combat this problem
Depression	deficiency of Vitamin B7 or biotin	<ul style="list-style-type: none"> - This deficiency can be <u>fatal if present in an aggravated form</u>. - <u>Consume poultry products, dairy items, peanuts, nuts etc</u> that are rich sources of biotin. These must be consumed along with supplements to recover and prevent these illnesses

7. SOME NUTRITION BASED UPDATES

1) ANAEMIA

- **What is Anaemia:**
 - » It is a condition in which number of red blood cells or the hemoglobin concentration within them is lower than normal or there are abnormal red blood cells.
 - » This negatively hampers the ability of blood to carry oxygen to tissues (Note: It is the hemoglobin which attaches to oxygen).
 - » It results into symptoms such as fatigue, weakness, dizziness, shortness of breath etc.
- **Causes:**
 - » **Nutritional Deficiency** - particularly iron deficiency, deficiency of folate (vitamin B-9 is important for RBC formation and for healthy growth and function), vitamin B12 and Vitamin A.
 - » **Haemoglobinopathies:** (hemoglobin C disease, hemoglobin S-C disease, Sickle Cell Anemia, and Thalassemia)
 - » **Infectious** diseases which impact blood such as malaria, TB, HIV and parasitic infections may also cause Anaemia.
- **Impact:**
 - » Anaemia compromises immunity and impedes cognitive development.
- **Global Situation:**
 - » As per WHO, around 42% of children under 5 and 40% of pregnant women worldwide are anaemic.
- **Anaemia Situation in India:**
 - » Between 2005 - 2015, the anaemia situation declined marginally in India.
 - » **But, as per the NFHS-5, the incidence of Anaemia in under-5 children (from 58.6 to **67%**), women (53.1% to 57%) and men (22.7% to 25%) has worsened in all states of India (20%-40% is considered moderate) (when compared to NFHS-4)**
- **Factors which cause high levels of Anaemia?**
 - » Cereal centric diet with less consumption of iron rich food groups like meat, fish, eggs, and Dark Green Leafy Vegetables (DGLF).
 - » Poor sanitation situation; lack of women empowerment etc.
- **India's great anaemia mystery – class discussion**

8. VIRAL DISEASES VS BACTERIAL DISEASES

i. Why can't we cure virus infection?

- **Bacteria** are living cells. They have outer antigens which can be targeted by human immune system and form the basis of vaccines. The cells of a bacteria contain unique (to bacteria) structures which can be disrupted by bactericidal antibiotics without affecting human cells too

much; these provide broad targets for therapy. The majority of bacteria find a place to grow inside a human/further invade tissues, but don't actually enter and live within a human cell. This gives them greater exposure to antibiotics and easier exposure to immune system.

- **Bacteria are virulent by two mechanisms.**
 - **Toxin production**
 - **Invasion/inflammation**
 - Exotoxins in particular are often treated with formaldehyde, acid, or heat in order to convert them into toxoids, which means they are still antigenic but have lost their toxicity. This provides another critical target for vaccines and treatments of bacteria that doesn't exist in (most) viruses. **Component of bacterial vaccines include these inactivated toxoids**, the outer capsular antigens of bacteria without the bacteria inside or other purified bacterial proteins, killed bacteria, or live (attenuated) bacteria.
 - Furthermore, antitoxins (pre-formed immune globulins which will target the bacterial antigens) are available to counteract the toxins of such bacteria as tetanus, diphtheria etc.
- **Bacteria** can also be targeted by several branches of immune system at its own.
- **Viruses** on the other hand are not cellular. We can't kill them simply by disrupting their cells. They are infective nucleic acid that cannot replicate outside living cells.
 - Some viruses replicate inside human cells and then bud off from the human cell inside an "envelope" made from the human cell's membrane, which helps them evade the immune system on their way to infecting another human cell.
 - Many viruses are protected by protein capsids, which are extremely protective -- unlike a bacterial cell wall or membrane, the virus doesn't have to be alive inside the capsid or exchange nutrients and waste with environment across the capsid; the capsid is merely there to protect the nucleic acid of the virus.
 - **Each virus uses a different receptor**
 - Viruses need to match some sort of receptor in order to gain entry into human cells, and in some viruses, this receptor is one of the few good targets for drug therapy; however, unlike antibacterial, the drug will only work for that particular virus/receptor, because each virus uses a different receptor

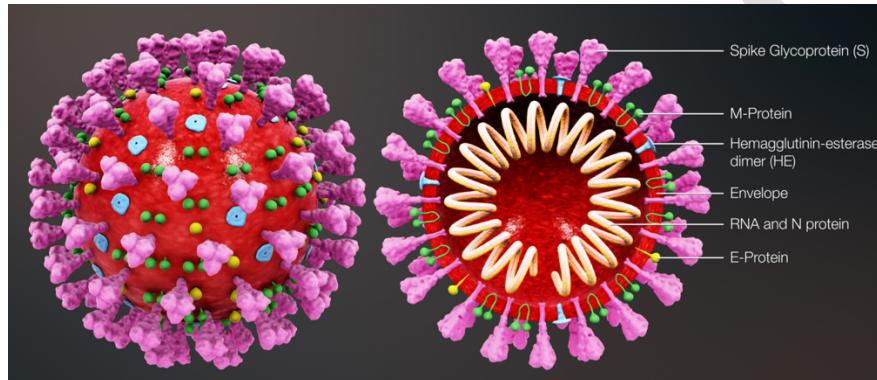
9. COVID-19

1) CORONA VIRUSES

- Coronaviruses are a group of viruses in the **subfamily Orthocoronavirinae**, in the **family Coronaviridae**. In humans they are known to cause infection in upper respiratory tract (sinuses, nose and throat) and/or lower respiratory tract (windpipe and lungs).
 - » **Most** of these viruses are harmless, but **some** can cause less severe common cold to more severe diseases such as severe acute respiratory syndrome (SARS), Middle East Respiratory Syndrome (MERS) and COVID-19.

- Coronaviruses were first identified in the 1960s. Almost everyone gets a coronavirus infection at least once in their life, most likely as a young child. The symptoms of most coronavirus are similar - a runny nose, coughing, sore throat and sometimes a fever.
- Many Coronaviruses are zoonotic i.e., they are transmitted from animals to humans.
 - » **SARS** coronavirus is believed to be an animal virus from an as-yet-uncertain animal reservoir, perhaps bats, that spread to other animals (civet cats) and first infected humans in the Guangdong province of Southern China in 2002.
 - » The **MERS** coronavirus was passed on from dromedary camels to humans in Saudi-Arabia in 2012.
 - » **SARS-COV-2** also seems to have transmitted from bats to humans (not confirmed yet). Pangolin may have acted as intermediary.
 - Note: SARS-COV-2 is a coronavirus very similar to the one that causes SARS.

- **Structure**



- » They are enveloped viruses with a **positive sense single stranded RNA genome** and a nucleocapsid of helical symmetry.
- » The genome size of the coronaviruses ranges from approximately 26 to 32 kilo bases, one of the largest among RNA viruses.

2) SARS-COV-2: NAMING, STRUCTURE AND PHYSIOLOGY

- SARS-COV-2 is one of the seven known types of known Corona virus, including SARS and MERS.
 - » **Naming of the Virus:** The Coronavirus Study Group of the International Committee on Taxonomy of Viruses, which had assessed the novelty of the human pathogen, has named the virus as "**Severe Acute Respiratory Syndrome Coronavirus 2**", or "**SARS-COV-2**".

3) STRUCTURE OF THE VIRUS

- Like other Coronaviruses, SARS-COV-2 virus particles are spherical in shape and have mushroom shaped protein called spikes protruding from their surface.
 - » The **spike binds and fuses with human cells**, allowing the virus to gain entry.
 - » The spike protein of the novel coronavirus **shares 98% sequence identity** with the spike protein of the bat coronavirus.
 - » The spike of the virus has something called a receptor binding domain (RBD) which facilitates the virus entry into the target cells by binding with the cellular receptor called Angiotensin

Converting Enzyme 2 (ACE2), which serves as the entry point into human cells. SARS corona virus also used the same mechanism for entry into the cells.

- But unlike SARS the case of SARS Corona, the **spike protein of the novel coronavirus binds to the cell receptor with much higher affinity - 10 to 20-fold higher**.
- This much higher binding affinity to the cell receptor explains high human to human transmission of the virus compared to SARS coronavirus.
- The virus (or virus particle) is **50-200 nm** in diameter.

4) NAMING OF THE DISEASE – CORONA VIRUS DISEASE-19 (COVID-19)

- On Feb 11, 2020, the **WHO officially announced COVID-19** as the name for the disease caused by the n-COV (novel Coronavirus)
 - » The name has a **standard format** to be used in any future corona virus disease.
- **Why was it important to name the disease?**
 - » To prevent the use of other names that can be "inaccurate or stigmatizing".
- Based on WHO's May 2015 guidelines.

5) COVID-19 DISEASE CAUSED BY INFECTION OF SARS-COV-2 (2019 N-COV)

- **Early symptoms** include - Fever, Dry Cough and Fatigue.
- The virus can lead to **pneumonia, respiratory failure, septic shock**, and **death**.
- **How does SARS-CoV-2 spread?**
 - It mainly spreads from person to person.
 - When a sick person coughs or sneezes, droplets containing virus are released in air, on various surfaces. If you inhale or swallow this virus, the virus gets into your body.
- **Vertical Transmission across Placenta**
 - » A study has found evidence that confirms vertical transmission of SARS-CoV-2 virus from the mother to foetus. The route of infection is **through the womb (in utero)** well before onset of labor and delivery of baby.
- **What is community transmission?** (Class discussion)
- **Reproduction Number (R₀)** (pronounced R naught) is used to describe the intensity of an infectious disease outbreak.
 - » Early studies of **COVID-19** in Wuhan estimated the average R₀ between 2.2 and 2.7.

6) DIAGNOSIS

- Antibody test
- RTPCR

7) CYTOKINE STORMS AND ITS IMPACT ON COVID-19 DEATHS

- What are Cytokines and what is their role in immune system?
 - » Cytokines are small proteins released by many different cells in the body, including those of the immune system where they coordinate the body's response against infection and trigger inflammation.
 - » Cytokines are signalling proteins that are released by cells at local high concentration.
- However, sometimes the body's response to infection can go to overdrive: Cytokine Storm Syndrome
-> Immune system over reacts

8) MUCORMYCOSIS OR BLACK FUNGUS

- Details
 - » The disease is caused by a group of molds known as mucormycetes present naturally in the environment.
 - It mainly effects people who are on medication for health problems that reduce their ability to fight environmental pathogens. It generally doesn't pose a serious threat to individuals with healthy immune system.
- Treatment: Antifungal medicines; Surgery may be required in worse cases.
- Management of COVID-19 patients with Mucormycosis is a team effort involving microbiologists, internal medicine specialists, intensivist neurologist, ENT specialists, ophthalmologists, dentists, surgeons and others.
- Life after Mucormycosis:
 - It can lead to loss of upper jaw and sometimes even the eye.
 - » Once the patient stabilizes, prosthetic replacement of the missing facial structures can commence.

9) VARIANTS OF CONCERN

- Variant of Concern: WHO classifies a variant as Variant of Concern when it is associated with an increase in transmissibility or detrimental change in COVID-19 epidemiology; increase in virulence; or decrease in effectiveness of the public health measure or available diagnostics, vaccines, therapeutics.
- So far, WHO has 5 variants of concerns (Omicron was the fifth one)



A) DETAILS OF DELTA VARIANT

- » The original Wuhan variant mutated into the **Alpha, Beta, Gamma and Delta Variants**.
 - » Note: All mutations don't mean that they are more harmful.
- The Delta variant, or the B.1.617.2 lineage was **first discovered in Maharashtra, India, in Oct 2020**.
 - » It has **mutation in its spike protein**, which helps it bind to the ACE2 receptors present on the surface of the cells more firmly, making it more transmissible and capable of evading the body's immunity.
 - Key characteristics of Delta Variants:
 - » Delta variant spreads faster and reduces protection gained from previous infections or vaccines
 - » Doesn't cause more severe illness
 - » Vaccines are effective (a bit less) on delta variants. It's just that delta variant is less sensitive to neutralizing antibodies.
 - Why Delta variant spreads faster?
 - » Evolution (Class discussion)

B) DETAILS OFOMICRON VARIANT (VARIANT B.1.1.529)

- » Omicron is WHO's fifth variant of concern.
- » It was first reported to WHO on 24th Nov 2021 and was classified as a variant of concern by WHO on 26th Nov 2021.
- » It spreads much easily than original virus and the Delta variant.
- » It generally causes less severe disease than infection with prior variants.
- » Symptoms: Similar to previous COVID-19 symptoms.

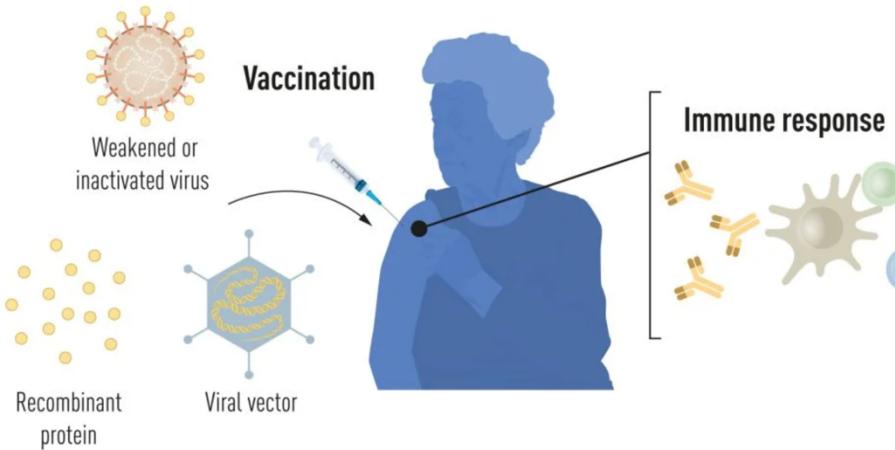
C) RECENT MUTATIONS IN NEWS:

FLip: The omicron subvariant JN.1. is likely to soon become the dominant lineage of the SARS-CoV-2 virus worldwide, according to researchers at the University of Tokyo. The subvariant has a mutation in its spike protein, L455S, also called a "FLip" mutation.

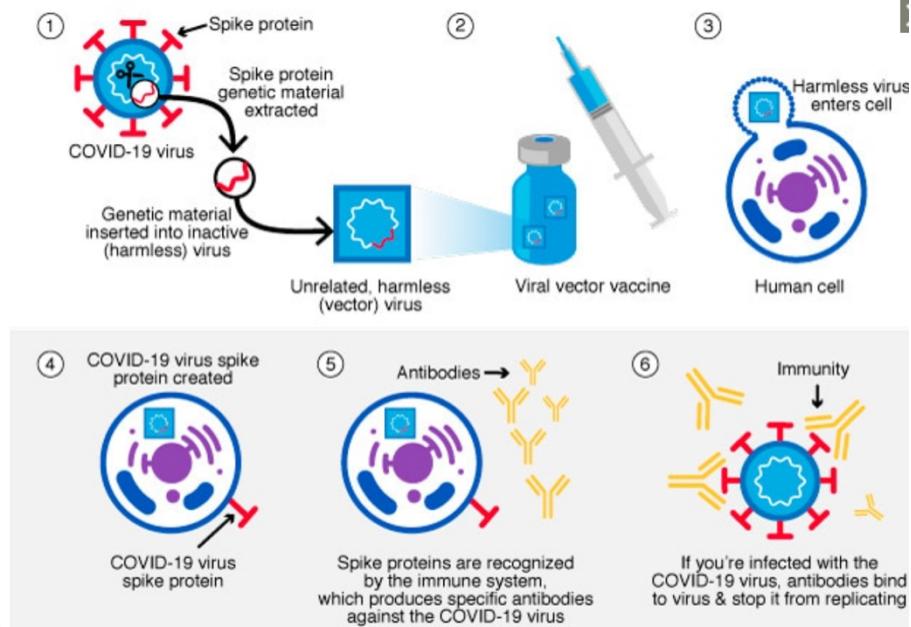
10. VARIOUS TYPES OF VACCINES:

- 1) **Live Attenuated virus vaccines** such as the combined rubella-mumps-measles vaccines and the yellow fever virus vaccine, induce robust and long-lived antibody and T-cell mediated immunity.
 - Note: For the development of yellow fever vaccine, Max Theiler was awarded the Nobel Prize in Physiology or Medicine in 1951.
 - These vaccines induce effective but transient immune responses, requiring repeated boosting.
 - COVID-19 vaccine developed using this mechanism - Covaxin developed by Bharat biotech.
- 2) **Viral Vector Vaccines:** It uses a safe virus (not harmful) which serves as a platform to produce target proteins to generate immune response.

- Such viral vector efficiently enter cells where the encoded antigen are produced by the bodies protein synthesis machinery.
 - The first example of a licensed viral vector vaccine was the Vesicular stomatitis virus - based vaccine against Ebola, approved in 2019, which was soon followed by an adenovirus based Ebola vaccine.



- During COVID-19 various vaccines
 - Oxford-AstraZeneca (ChAdOx1 nCoV-19) used adenovirus route.
 - Covishield used in India is a version of this.
 - Sputnik V Vaccine also has gone adenovirus route.



- Both the above methods (live attenuated virus or viral vector vaccine) used cell culture based manufacturing facilities which is resource intensive. Further they may also introduce diseases and is safer and stable than vaccine containing whole pathogens.
- Therefore, researchers have focused upon **sub-unit vaccines** that circumvent the need of large-scale cell cultures by delivering nucleic acid (DNA or mRNA) directly to vaccine recipients, exploiting the body's own capacity to produce proteins.

3) Sub-Unit Vaccines: (Protein subunit vaccines)

- Protein subunit vaccines include only the parts of virus that best stimulate immune system. These vaccines contain single protein components of the respective virus and are referred as subunit vaccine.
 - It includes Hepatitis B Vaccine (HBV) and Human papillomavirus (HPV) vaccine.
- **advantages:**
 - » No risk of introducing the disease and is safer and stable than vaccine containing whole pathogens.
 - » Suitable for immunocompromised individuals.
 - » Well established tech
- **Disadvantage**
 - Relatively complex to manufacture (compared to other vaccines like RNA vaccines)
 - May require multiple doses.
- **COVID-19 vaccine** developed using this method:
 - **Corbevax** is a protein subunit COVID-19 vaccine developed by Texas Children hospital. It delivers spike protein to the body directly.
 - **How was protein manufactured?**
 - Add gene of spike protein into yeast to produce large amount of proteins. After isolating the virus spike protein from the yeast and adding an adjuvant, which helps trigger an immune response, the vaccine was ready.

4) DNA and RNA subunit vaccines:

- » **Advantages** of sub-unit vaccines (DNA or mRNA vaccines)
 - **Less Resource intensive** and thus easy to manufacture.
 - **More flexibility** - Since the sequence can be easily changed to encode different antigens.
 - This also makes iterative testing of new candidate vaccines and generation of updated vaccines rapid and efficient.
- » **Initially DNA vaccine was thought to be more promising** but didn't translate into success. A likely reason for it was that injected DNA must cross two barriers, the plasma membrane and the nuclear membrane, to reach the cellular compartment where transcription takes place (DNA conversion to mRNA). In contrast, mRNA-based vaccines only need to gain access to the cell cytoplasm where translation takes place (mRNA conversion to protein)
- » **Another advantage of mRNA vaccine:** Delivered nucleic acid can't integrate into the host genome. This is an additional safety aspect of this method.
 - **E.g for mRNA vaccine** (developed for COVID-19): Moderna COVID-19 (mRNA-1273) vaccine.

1) 2023 NOBEL PRIZE IN PHYSIOLOGY OR MEDICINE

- The 2023 Nobel Prize in Physiology or Medicine has been awarded to **Katalin Kariko** (Hungary) and **Drew Weissman** (USA) for their discoveries concerning nucleoside base modifications that enabled the development of effective mRNA vaccine against COVID-19. Through their groundbreaking findings, which have fundamentally changed our understanding of how mRNA interacts with our immune system, the laureates contributed to the unprecedented rate of vaccine development during the COVID-19 crisis.

- **Background:**

- During the **1980s**, efficient methods of producing mRNA without cell culture were introduced, called in-vitro transcription. Ideas of using mRNA technologies for vaccine and therapeutic purposes also took off, but roadblocks lay ahead.

In vitro transcription	In vitro transcription is a laboratory technique used to synthesize RNA molecules outside of a living cell. This process involves using a DNA template and the enzyme RNA polymerase to generate a complementary RNA strand. In vitro transcription is a fundamental tool in molecular biology and biochemistry, and it has various applications, including the production of RNA molecules for research, such as RNA probes, RNA sequencing, and gene expression studies
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- In vitro transcribed mRNA was considered unstable and challenging to deliver. It required development of sophisticated carrier lipid systems to encapsulate the mRNA.
 - This mRNA also gave rise to inflammatory reactions.
 - These problems limited the enthusiasm for developing the mRNA technology for clinical purposes.

- **Contributions:**

- In **1990s**, Kariko was an assistant professor at the University of Pennsylvania and met immunologist Drew Weissman there.
 - They worked together to prevent the immune system from launching an inflammatory reaction against lab-made mRNA, previously seen as a major hurdle against therapeutic use of mRNA.
 - They found that inflammatory response was almost abolished when base modification was included in the mRNA. Therefore, in 2015 they published those adjustments (modifications) to nucleosides, can keep the mRNA under the immune system's radar.
 - Later, they also showed that the delivery of mRNA generated with base modification markedly increased protein production compared to unmodified mRNA. This effect was due to the reduced activation of an enzyme that regulates protein production.

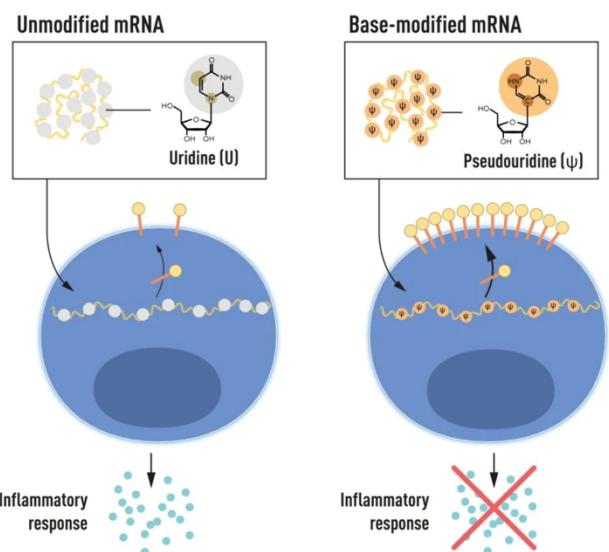


Figure 2. mRNA contains four different bases, abbreviated A, U, G, and C. The Nobel Laureates discovered that base-modified mRNA can be used to block activation of inflammatory reactions (secretion of signaling molecules) and increase protein production when mRNA is delivered to cells.
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- **Development of Vaccines:**
 - After the above discoveries, interest in mRNA technology picked up. Vaccines for Zika and MERS-CoV were pursued.
 - **After the outbreak of COVID-19 pandemic**, two base-modified mRNA vaccines encoding the SARS-CoV-2 surface protein were developed at record speed. Protective effects of around 95% were reported, and both vaccines were approved as early as Dec 2020.
 - The impressive flexibility and speed with which mRNA vaccines can be developed pave the way for using the new platform also for vaccine against other infectious diseases.
 - In the future, the technology may also be used to deliver therapeutic proteins and treat some cancer types.

- **How mRNA vaccine protects you against COVID-19:**

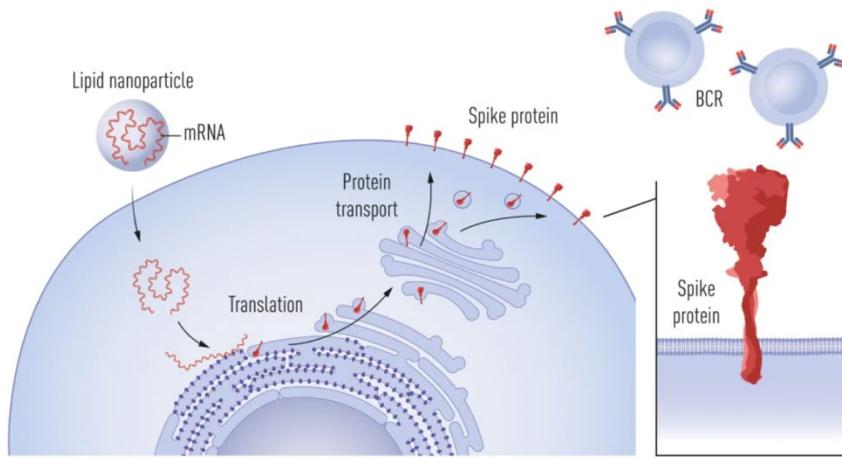


Figure 4. Spike production following mRNA vaccination and recognition of spike by B cells.
Following uptake of mRNA into cells, facilitated by lipid nanoparticles, the mRNA acts as a template for spike protein production. Spike is then transiently expressed on the cell surface, where it is recognized by B cells via their B cell receptors (BCRs), stimulating the secretion of spike-specific antibodies.

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- Through their fundamental discoveries of the importance of base modification in mRNA, this year's Nobel Laureates critically contributed to this transformative development during one of the biggest health crisis of our time.

11. OTHER VIRAL DISEASES

1) MEASLES

- **Measles** is a highly contagious infectious disease caused by measles virus. It spreads through air when an infected person coughs or sneezes. It is an acute respiratory illness. **Infection** is characterized by a prodrome of fever (as high as 105 degree F) and malaise, cough, coryza, and conjunctivitis - the three "C"s, followed by maculopapular rash. The rash spreads from the head to the trunk to the lower extremities.
 - It can severely sicken young children, but is normally kept under check due to large-scale vaccination.
- **About the Virus:**

- It is a single stranded, enveloped RNA virus with 1 serotype. It is classified as a member of the genus Morbillivirus in the Paramyxoviridae family.
 - Humans are the only natural host of the measles virus.
- **Detection:** RT-PCR; Anti-body test
- **Vaccinations:** Measles can be prevented with **Measles-containing vaccine**, which is primarily administered as the combination of measles-mumps-rubella (MMR) vaccine.
 - It can be used for children aged 12 months through 12 years. One dose of MMR vaccine is approximately 93% effective and two doses are approximately 97% effective.
- **Rise of Cases in 2022:** Covid-19 led to disruption in routine vaccination in 2020 and 2021.
- **WHO Report and India's Response (Nov 2023)**
 - A new report from the WHO and US Centre for Disease Control and Prevention (CDC) said measles cases in 2022 have increased by 18%, and deaths by 43% globally, compared to 2021.
 - **Cases:** 9 million & **Deaths** - 1,36,000
 - The report also said that globally 22 million children and in India 1.1 million infants didn't get the first dose of vaccine.
 - **India has differed from this report:**
 - MoH&FW says that just over 21,000 Indian children didn't get the shot.

2) RUBELLA

- Rubella is a contagious viral disease. Most people who get Rubella usually have a mild illness, with symptoms that can include a low-grade fever, sore-throat, and a rash that starts on the face and spreads to the rest of the body. It can cause a miscarriage or serious birth defects in a developing baby if a woman is infected while she is pregnant.
- **The best protection** against rubella is **MMR** (Measles, Mumps, Rubella) vaccine.

3) HUMAN IMMUNODEFICIENCY VIRUS (HIV) AND AIDS (ACQUIRED IMMUNODEFICIENCY SYNDROME)

- **Why in news?**
 - » Hopes dashed as last HIV vaccine trial in Africa for his decade ends in failure (Dec 2023: Source - DTE)
- **Introduction:**
 - » **About virus:**
 - HIV are two species of Lentivirus (genus) of Retroviridae family. The virus first emerged in 1920 in Kinshasa (then Leopoldville), Belgian Congo.
 - » The Human Immunodeficiency **Virus (HIV)** targets the immune system and weakens people's surveillance and defence systems against infections and some types of cancers.

- As the virus destroys and impairs the function of the immune cells, infected individuals gradually become immunodeficient. Immune function is typically measured by CD4 cell count (a type of white blood cells).
 - The most advanced form of HIV infection is **acquired immunodeficiency syndrome (AIDS)**, which can take from 2 to 15 years to develop depending on individual. It is defined by developments of certain cancers, infections, or other severe chemical manifestations.
- **Transmission**
- » Exchange of a variety of body fluids - blood, breast milk, semen and vaginal secretion
 - » **Note:** Individual can't be infected through ordinary day to day contact such as kissing, hugging, shaking hands, sharing food or water etc.
- **Behaviours or conditions which can put individual on risk:**
- » Unprotected sex (including anal); use of contaminated syringes; unsafe blood transfusion; from mother to unborn child etc.
- **Diagnosis**
- » **Three types of tests:**
 - **Antibody test**
 - **RNA (viral load) test (RT-PCR)**
 - **A Combination test.**
 - It detects both antibodies and viral protein called p24 (antibody-antigen test, or HIV Ab-Ag test).
 - P24 forms part of the core of the virus (an antigen of the virus).
- **Prevention**
- » **Avoid risk behaviours** (i.e. use condoms, test and counsel for HIV and STIs, Voluntary medical male circumcision, using only sterile injecting instruments)
 - » **Antiretroviral (ART) use for prevention.**
 - **ART as Prevention** - If an HIV positive person adheres to an effective ART regimen, the risk of transmitting the virus to their uninfected sexual partner can be reduced by 96%.
 - **Pre-exposure prophylaxis (PrEP) for HIV negative partner:** Oral PrEP of HIV is the daily use of ARV drugs by HIV uninfected people to block the acquisition of HIV.
 - **Post Exposure prophylaxis for HIV (PEP):** PEP is the use of ARV drugs within 72 hours of exposure to HIV in order to prevent infection. PEP includes counselling, first aid care, HIV testing, and administering of a 28-day course of ARV drugs with follow up care.
 - » **Drug releasing Vaginal Ring Cap:** To prevent HIV-AIDS in Women
 - The ring is made of flexible silicon matrix polymer. The woman inserts it into the vagina, where it, over the course of a month, releases the antiretroviral drug dapivirine. It has to be changed after 28 days.

A) STEM CELL THERAPY TO TREAT HIV HAVE SHOWN SUCCESS:

- » In 2022, a US patient was reported cured of HIV after stem cell transplant. By July 2023, six persons had been cured by this method.

- » In the first five cases, the treatment teams specifically looked for donors with CCR5 delta 32 mutation. It is associated with lower risk of HIV.
 - People who inherit CCR5 delta 32 mutation from both parents don't have the receptors which are used by HIV virus to enter the cells. Those who inherit the mutation from one of the parents have fewer receptors and are less likely to get infection.
 - Only 1% of the people on earth carry 2 copies of CCR5-delta 32 mutation.
- » **Why can't stem cell transplant become routine treatment for HIV?**
 - Finding matching donor for all 40 million patients would be impossible.
 - The CCR5 delta 32 mutation occurs mostly in Caucasians whereas most of the cases are in the African continent.
 - Further, stem cell transplant is a complex process and comes with its own risks.
- **SDG Goal 3.3:** To achieve the end of AIDS by 2030 i.e. zero new infection by 2030.

B) GLOBAL SITUATION OF HIV:

- **Successes Achieved in HIV Response:**
 - » As per UNAIDS, in 2022, 39 million people globally were living with HIV, of whom 29.8 million were accessing ART.
 - Coverage of ART has become 4 times of the number in 2010.
 - » **New Cases:** Around 1.3 million people got newly infected with HIV in 2022 - which is 59% lower from the peak in 1995.
 - » It is possible to end AIDS by 2030: UNAIDS.

C) VACCINATION EFFORTS:

- **Hopes Dashed as last HIV vaccine trial in Africa for this decade ends in failure (Dec 2023)**
 - » The study, known as **PrEPVacc**, was led by African researchers with support from European Scientists.
 - They were testing two different vaccine regimes on about 1500 volunteers in Uganda, Tanzania, and South Africa.
 - » After, multiple other high-profile trials failed in the past, PrEPVacc researchers were quite optimistic and had described the latest study as the final trial of the decade.

D) HIV SITUATION IN INDIA

- » More than 2 million people in India live with HIV.
 - HIV Epidemic has an overall decreasing trend in the country with estimated annual new HIV infections declining by 37% between 2010 and 2019.
- » **Success in controlling AIDS.**
 - 2015 HIV estimates results reaffirm the country's success story in responding to HIV/AIDS epidemic. India has successfully achieved 6th Millennium Development Goal (MDG6) of halting and reversing the HIV epidemic.

- » **Emergence of three north Eastern States as new HIV Hotspots: Mizoram (1.19%), Nagaland (0.82%), Meghalaya (0.73%), Tripura (0.56%) and Manipur (0.47%)**
 - Reasons: Injecting Drug Users and Unsafe Sexual Practices.

- **Steps taken by government of India in recent times to Reduce HIV transmission.**
 - **National Aids Control Program** was launched in 1992 and its four phases have been completed so far. It is a central sector scheme.
 - » It has been extended for five years (1st April 2021 to 31st March 2026)
 - » It is a comprehensive program for prevention and control of HIV/AIDS in India.
 - » Under this, ART Centres run by National AIDS Control Office (NACO) provide lifetime free medicines, diagnostic kits and other essentials for those in need.
 - **National Aids Control Organization (NACO)**, under MoH&FW, provides leadership to HIV/AIDS program.
 - **HIV & AIDS Prevention and Control Act 2017** provides a legal framework for protecting the rights of HIV positive people.
 - Implementation of **90:90:90** strategy adopted by UNAIDS
 - **Other steps** include - Multimedia campaigns; Red ribbon clubs in colleges; training and sensitization program for SHGs; etc;

4) POLIO

- **Basics:**
 - » Polio is a highly infectious disease caused by a virus. It invades the nervous system and can cause total paralysis in a matter of hours.
 - » **Transmission:** The virus is transmitted by person to person and spread mainly through faecal-oral routes, or less frequently by, a common vehicle (e.g., contaminated water or food) and multiplies in the intestine.
 - » **Affect:** 1 in 200 infections leads to irreversible paralysis (usually in legs). Among those paralyzed, 5% to 10% die when their breathing muscles become immobilized.
 - » **People most at risk**
 - Polio mainly affects children under five years of age
 - » **Prevention and Cure**
 - There is no cure
 - It can only be prevented. **Polio vaccine** given multiple times can protect a child for life.

- **Three Different strains of Polio Virus**
 - » 3 strains of poliovirus (type 1, type 2, and type 3).
 - » Wild polio virus **type 2 was eradicated in 1999**.
 - » Wild Polio virus **type 3 was eradicated in 2019**.
 - WPV3 is the **second strain of the polio virus to be wiped out**, following the certification of the eradication of WPV2 in 2015.
 - The **last case of WPV3** was detected in Northern Nigeria in 2012.

A) TWO TYPES OF VACCINES: OPV AND IPV

- **Oral Polio Vaccine (OPV)** is taken orally as drops. It has served as the main preventive measure against polio and is easily administered not requiring very trained health workers. Further, the cost per dose of OPV is much less than IPV. It also leads to passive immunization.
 - **Other Advantages**
 - **Passive immunization**
 - **Limitations**
 - Virus may mutate and turn virulent Or;
 - Virus may multiply in intestine and spread through excreta and over the period mutate to become virulent.
- **Inactivated Polio Vaccine (IPV)** is given through an injection by a trained health worker.
 - It is not a "live" vaccine (i.e. it is inactivated) and thus carries no risk of vaccine associated paralysis.
 - In countries still using OPV, IPV hasn't replaced OPV but is used to strengthen a child's immune system and protect them from polio.

B) ISSUE OF VACCINE DERIVED POLIO VIRUS

- **How vaccines may lead to infection**
 - Oral Polio Vaccine (OPV) contains an attenuated vaccine-virus. This weak form of the virus is used to activate an immune response in the body, which protects the child when challenged by WPV.
 - But when child is immunized with OPV, the virus replicates in the intestine and during this time the virus is excreted.
- **WHO recommendations**
 - » Use of OPV must eventually be stopped (starting with OPV containing Type-2 poliovirus) worldwide and at least one dose of IPV must be introduced, to protect against Type-2 Polio virus and to boost population immunity.
 - » **Why??**
 - Since, wild Polio virus of type 2 was eradicated in 1999, the risk of paralytic disease due to OPV type 2 now outweighs its benefits.
 - A single dose of IPV before OPV protects against VAPP (Vaccine Associated Paralytic Poliomyelitis).
- **IPV is very safe** vaccines in humans, whether used alone or in combination vaccines.
 - » No serious adverse events have been reported, only minor side effects.
- **Situation in India**
 - » India was declared Polio free in 2014, 3 years after the last case of Polio in 2011. But we still see cases of **vaccine derived Polio**.
 - » Further, there have been cases of Non-Polio Acute Flaccid Paralysis (NPAFP) which are associated with OPV.

5) EBOLA VIRUS DISEASE (EVD)

- **Introduction:**
 - » The Ebola virus causes an acute, serious illness which is often fatal if untreated.
 - » Ebola Virus Disease first appeared in 1976 in two simultaneous outbreaks, one in Nzara, Sudan, and the other in Yambuku, Democratic Republic of Congo. The later occurred in a village near the Ebola River, from which the disease takes its name.
 - » **2014-2016 outbreak:** This outbreak in Wet Africa was the largest and most complex Ebola outbreak since the discovery of virus. It had mostly impacted **Guinea, Sierra Leone and Liberia**.
- **Virus:** The virus family Filoviridae includes the Ebolavirus genus. This Ebolavirus Genus has 5 identified species so far: Zaire, Bundibugyo, Sudan, Reston and Tai Forest. The first three Zaire Ebola virus, Bundibugyo Ebolavirus, and Sudan Ebolavirus have been associated with large outbreaks in Africa. 2014 outbreak has been caused by Zaire Ebolavirus.
- **Transmission**
 - **Introduction in Human:** It is believed that fruit bats of the Pteropodidae family are natural Ebola virus hosts.
 - **Human to Human:** Via direct contact (through broken skin or mucous membranes) with the blood, secretions, organs or other fluids of infected people, and with surface and materials (e.g., bedding clothing) contaminated with these fluids.
- **Diagnosis**
 - **Difficult to distinguish EVD from other infectious diseases** such as malaria, Typhoid fever and meningitis.
 - **Confirmation tests:** Electron Microscopy, ELISA, RT-PCR etc.
- **Treatment and Vaccine**
 - Supportive care rehydration with oral or intravenous fluids - and treatment of specific symptoms, improves survival.
 - There is as yet no proven treatment available for EVD.
 - **Vaccines** has been developed and is being used in DRC.
 - Vaccine rVSV-ZEBOV (tradename "Ervebo") was approved by US FDA in Dec 2019.
 - **Monoclonal Anti-Bodies** have also been found effective in treatment: WHO

6) RABIES

- **About Rabies:**
 - » It is a vaccine preventable viral disease which occur in more than 150 countries in the world.
 - » **Dogs** are the main source of human rabies deaths, contributing to 99% of all rabies transmission to humans.
 - It is spread when infected animal bites or scratches a human or other animal. Saliva from an infected animal can also transmit rabies if the Saliva comes into contact with the eyes, mouth, or nose.

- » **Interrupting transmission** is feasible through vaccination of dogs and prevention of dog bites.
- » **Immediate, thorough wound washing with soap and water** after contact with a suspected rabid animal is crucial and can save lives.
- » **Rabies** is virtually 100% fatal once the clinical symptoms appear. And it is also **100% vaccine preventable**.
- » **WHO** is also leading a collective “**United Against Rabies**” to drive progress towards “Zero Human Deaths from dog mediated rabies by 2030”.
- » **World Rabies Day** is held on 28th September.

- » **About the Virus:**
 - » It is caused by lyssaviruses, including the rabies virus and Australian bat lyssavirus.
 - » The virus infects the central nervous system. If a person doesn't receive the appropriate medical care after potential rabies exposure, the virus can cause disease in the brain, ultimately resulting in death.

- **Situation of Rabies in India**

- As per WHO India is endemic to rabies and suffers approx. 36% of the world's human rabies deaths, transmitted by dogs.

- **Key Highlights about Efforts in India:**

- The ministers have urged all the States to make Rabies a notifiable Disease.
- They launched 'Joint Inter-Ministerial Declaration Support Statement' for elimination of Dog Mediated Rabies from India by 2030 through One Health Approach.
- On the occasion of the World Rabies Day (28th Sep), the MoH&FW and the Minister of Fisheries, Animal Husbandry and Dairying unveiled the National Action Plan for Dog mediated Rabies Elimination by 2030 (NAPRE).

7) HUMAN PAPILLOMA VIRUS (HPV)

- **What is HPV?**

- » HPV is a group of 150 related viruses.
- » **Cancer Causing:** Some HPV can lead to cancer, especially cervical cancer.
- » There are more than 40 HPV that can infect genital areas of males and females.

- **How do people get HPV?**

- » Transmitted through intimate skin to skin contact which can happen during vaginal, anal or oral sex with someone who has virus. **Most common sexually transmitted disease**. HPV is so common that nearly all sexually active men and women get it at some point in their lives. HPV can be passed even if the infected person has no signs or symptoms.

- **Does HPV Cause Health Problem?**

- » In most cases, HPV goes away on its own and doesn't cause any health problems. But when HPV doesn't go away, it can cause health problems like genital warts and cancer.
 - **Genital Warts** usually appear as a small bump or group of bumps in the genital area.

- » **Cancer:** HPV can cause cervical cancer and other cancers including cancer of vulva, vagina, penis and anus. The types of viruses that cause genital warts are not the same as types of HPV that cause cancers.
- **How can I avoid HPV and the health problems it can cause?**
 - » **Get Vaccinated:**
 - » **Get screened for cervical cancer:** Routine scanning for women aged between 21 to 65 years old can prevent cervical cancer.
 - » **For Sexually Active people:** Use condoms:
 - But HPV can infect areas that are not covered by condoms - so condoms may not give full protection against getting HPV
 - Be in mutually monogamous relationship
- **Can I be treated for HPV or health problems caused by HPV?**
 - » No treatment for virus itself, but there are treatments for health problems associated

8) CERVICAL CANCER

- Nine out of 10 women who die of cervical cancer live in low and middle-income countries, according to WHO.
- **Details:**
 - » The low- and middle-income countries have low rate of vaccination against the HPV, which causes the cancer.
 - Most HPV vaccination consignments go to wealthier nations, driving a gap in access similar to the inequitable distribution of vaccines against the COVID-19.
 - Vaccines haven't been introduced in 80 countries and these countries record 2/3rd the incidences of cervical cancer.
 - Globally, just 13% of girls between nine and fourteen years were vaccinated against HPV in 2020. This was a reduction from 15% girls in 2019.
- **4th HPV Vaccine:**
 - » In Oct 2021, WHO has given approval to Ceolin, manufactured by Xiamen Innovax Biotech Co Ltd to bridge the gap.

9) DENGUE

- **Dengue fever**, also known as break bone fever, is a mosquito borne tropical disease caused by the dengue virus.
 - » **Dengue Virus (DENV)** in one of the five serotypes is the cause of Dengue fever. It is a mosquito borne single positive stranded RNA virus of the family Flaviviridae; genus Flavivirus.
 - » **Dengue hemorrhagic Fever (DHF)** is a specific syndrome that tends to affect children under 10 years of age. It causes abdominal pain, hemorrhage (bleeding), and circulatory collapse (shock).
- **Possible to get dengue multiple times**
- **Symptoms:** Severe joint and muscle pain, swollen lymph nodes, headache, fever, exhaustion, and rash. The presence of fever, rash, and headache (**the dengue "triad"**) is characteristics of dengue fever.

- **Geographical Region:** Prevalent throughout the tropics and subtropics.
- **Transmission**
 - » The virus is contracted from the bite of a **striped Aedes aegypti** mosquito that has previously bitten an infected person. The virus is not contagious and cannot spread from person to person directly. There must be person to mosquito to another person pathway.
- **Treatment:** Symptomatic
- **Prevention:** Prevent mosquito bite
- **Vaccine:**
 - » Since there are around 5 serotypes of dengue virus known, vaccine making is difficult. It's because different vaccine is needed against each serotype.
 - » A vaccine against dengue, **DENGVAXIA**, from Sanofi Pasteur is approved in several countries and shows efficacies ranging from 42% to 78% against four serotypes of the virus.
 - » In India, Zydus Cadila has been developing a DNA vaccine against dengue

10) ZIKA FEVER / ZIKA DISEASE

- **About Zika Virus**
 - » Zika virus (ZIKV) is a member of the Flaviviridae virus family and the Flavivirus genus, transmitted by daytime active Aedes mosquitoes, such as A. aegypti, A. Africanus, A. furcifer etc. Virus can also get transferred during sexual contacts, across the placenta (affecting unborn child). A mother already infected with Zika virus near the time of delivery can pass on virus to the newborn around the time of birth, but this is rare.
 - » Zika virus is related to dengue, yellow fever, Japanese Encephalitis, and West Nile virus. The illness it causes is similar to mild form of dengue fever, is treated by rest, and cannot yet be prevented by drugs or vaccine.
- **Earliest discovery**
 - » Virus was first isolated in 1947 from a rhesus macaque monkey that had been placed in a cage in the Zika Forest of Uganda, near Lake Victoria, by the scientists of yellow fever research institute.
- **Spread among Humans:**
 - » For the first 60 years after detection, only 14 human cases have been reported from Tropical Africa and Asia (including India in 1952-53).
 - » The **first ever outbreak (185 cases)** of Zika virus was reported in 2007 in the island of Yap (a federated state in **Micronesia**) in the **Pacific**.
 - » In 2015 to Mexico, Central America, the Caribbean, and South Africa, where the Zika outbreak has reached pandemic levels.
 - The outbreak was associated with higher incidences of microcephaly as well as GB syndrome.
- **Symptoms and treatment**
 - » Common symptoms include mild headaches, maculopapular rash, fever, joint pains etc.
 - Thus far, Zika fever has been a relatively mild disease of limited scope, with only one in five persons developing symptoms, with no fatalities, but its true potential as a viral agent is unknown.

- » As of 2022, no WHO approved vaccine or preventing drug is available. Symptoms can be treated.
- Zika's link with Microcephaly and GB Syndrome
 - » **Microcephaly** is a condition where a baby has a head size much smaller than other babies of the same age and sex. According to WHO this condition may be caused in newborn by mother to child Zika virus transmission.
 - » **GBS (Guillain-Barre Syndrome)** is a rapid onset of muscle weakness as a result of damage to the peripheral nervous system. In a French Polynesian epidemic, 73 cases of GBS and other neurological conditions occurred in a population of 270,000, which may be complications of Zika virus.

11) JAPANESE ENCEPHALITIS

- It's a viral fever that affects the brain and is considered extremely dangerous for children, and it also has a high "mortality and morbidity rate".
- **About JE Virus**
 - » Japanese Encephalitis virus (JEV) is a flavivirus. It is the main cause of viral encephalitis in many countries of Asia with an estimated 68,000 clinical cases every year.
 - » **Symptoms** of JE includes sudden onset of fever, vomiting, headache, neck stiffness, and seizures.
- **Transmissions**
 - » The virus is maintained in a cycle between mosquitoes and vertebrate hosts, primary pigs, and wading birds. Humans are incidental or dead-end hosts because they don't develop high enough concentration of JE virus in their bloodstream to infect feeding mosquitoes.
 - **So It is not transmitted from human to human**
 - » JE virus transmission often occurs in primarily rural agricultural areas, often associated with rice production and flooding irrigation.
 - » **Transmitted by** the bite of **Culex tritaeniorhynchus, and Culex vishnui mosquitoes**.
- **Management Control and Prevention**
 - » **Vaccination:** In the **mission Indradhanush** - JE vaccination was included in May 2016.
 - » **Controlling mosquitoes**
 - » **Pigs act as a carrier** for the virus - so it is also important to control mosquito population around the pig domestication areas.
- **Treatment**
 - » No specific treatments: Symptomatic care

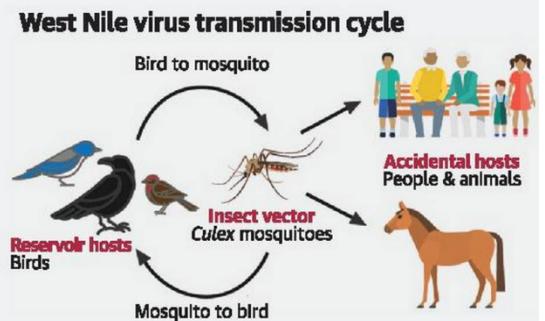
12) ACUTE ENCEPHALITIS SYNDROME (AES)

- **What is AES?**
 - » AES is a **complex syndrome that affects central nervous system**, mostly in children and young adults. It starts with fever, then hampers neurological functions causing mental disorientation, seizure, confusion, delirium, coma etc.

- » **Causes:** It may be caused by virus, bacteria, fungi, and a range of agents. Japanese Encephalitis (JE) is the most common cause of AES in India. But the syndrome is also caused by scrub typhus, dengue, mumps, measles, even Nipah or Zika virus.
- **Relation between Hypoglycemia, children, and AES**
 - » Some researchers have claimed that there is an increasing correlation between death due to AES and hypoglycaemia. So, **AES may affect undernourished children more**.
- **Any relation between Litchi and AES**
 - » **More research** needs to be done in this aspect.
 - Some toxin/virus/bacteria found in Litchi **may** be responsible for AES.
 - Unripe fruit contains **toxins** hypoglycin A and methylenecycloprophyglycine (MCPG) which cause vomiting if ingested in large quantities
 - » **Note:** AES is called "Chamki Bukhar" in Bihar
- **Prevention**
 - » **Preventing Mosquito bite**
 - » **Drink plenty of water** and **ensuring proper nutrition** flushes out toxins which may be causing AES from the body.
 - » **Properly washing fruits** before consuming them properly.

13) WEST NILE VIRUS

- **About the Virus**
 - » It is a member of flavivirus genus and Flaviviridae family.
 - » It was first isolated in a woman in the West Nile District of Uganda in 1937. It was also identified in birds (including crows) starting 1953 and have also been found to be pathogenic for them (birds).
 - » The WNV is commonly found in Africa, Europe, the Middle east, North America and West Asia.
- **Human Infection** is most often the result of bites from infected mosquitoes. Mosquitoes get infected by feeding on infected birds, which circulate the virus in their blood for a few days. It may also be transmitted through contact with other infected animals, their bloods or other tissues. There are also reports about few transmissions through organ transplant, blood transfusion, mother to child etc.



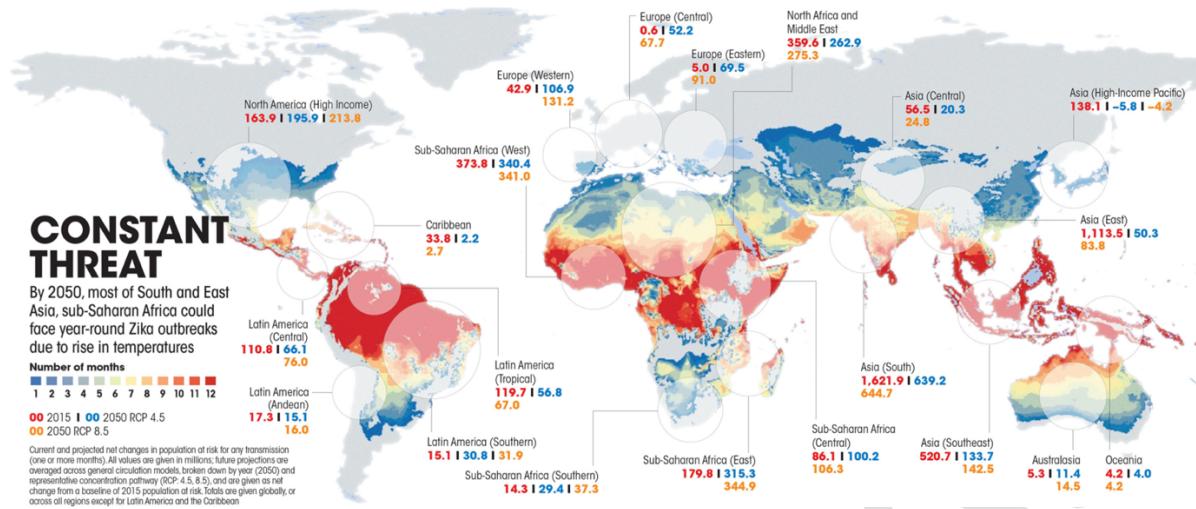
14) CHIKUNGUNYA

- **Basics about Chikungunya:**
 - » **Virus:** Chikungunya is a viral disease caused by an RNA virus that belongs to the aphavirus genus of the Togaviridae family.
 - » **Vector:** The bites of infected female mosquitoes, most commonly, Aedes Aegypti and Aedes Albopictus.
 - » **Symptoms:** Fever, severe joint pain, muscle pain, nausea, fatigue and rash.
 - » **Shares clinical signs with dengue** - They can be misdiagnosed with dengue.
 - » **Diagnosis:** RT-PCR (testing serum or plasma for detection of virus or viral nucleic acid)>

- » **Treatment:** No cure available, treatment is mostly symptomatic.
 - » **People at risk:** People living in the proximity of mosquito breeding sites.
 - » **Prevention and Control -> Prevent Mosquitoes and Mosquito bites**
 - » **Less dangerous than dengue** -> rarely leads to fatalities. However, it does affect patients severely, leaving them with pain in the joints and swelling.
- **India and Chikungunya:**
- » India has become an endemic reservoir for the virus with persistent global transmission from the country.
- **Vaccine Efforts:**
- » **BBV87:**
 - A multi-country Phase-II/III clinical trial of a vaccine led by the **International Vaccine Institute (IVI)** in partnership with Bharat Biotech International Ltd (BBIL) began in **Costa Rica** in Aug 2021.
 - The vaccine is called **BBV87**. It is an **inactivated whole virion vaccine** based on a strain derived from an East, Central and South African genotype.
- **Vaccine: No**
- **Treatment:** Symptomatic
- **Prevention:** Mosquito control.

15) MOSQUITOES ARE EMERGING AS BIG ISSUE

- **Details**
- » **Aedes Aegypti** is native to sub-Saharan Africa, and in its native environment it lives in tree holes and small pools of water and bites non-human primates. These mosquitoes may have first moved to nearby human settlements during droughts when the tree holes dried up. During trans-Atlantic slave trade, the mosquitoes moved out of Africa. The first case of Yellow fever reported outside Africa in Yucatan, Central America in 1648.
 - » **Aedes albopictus** is native to tropical SE Asia, where it was originally a forest species that fed on wild animals. During 1980s it spread to islands in the Indian and Pacific Oceans and then during the 1980s extended its range across temperate regions in Europe, Africa and the Americas.
 - » A modelling study published in Nature Communications on May 1, 2020, shows that the **world became about 1.5% more suitable per decade** for the development of **A aegypti** during 1950-2000.
 - » Another study showed that by 2050, 49% of the World's population will live in places where **A aegypti** and **A albopictus** are present if greenhouse gas emissions continue at the current rates.



- Climate change is increasing vector population:
 - » Mosquitoes are now able to breed throughout the year.
 - » Breeding behaviours of mosquitoes have also changed over the years. Now, they can lay eggs in dirty waters too. There is evidence that Aedes mosquitoes can breed in brackish water too.
 - » Artificial lights have increased the feeding period of Aedes mosquitoes.
- Other factors
 - » Aedes aegypti has also developed resistance to common insecticide permethrin.

16) WORLD MOSQUITOE PROGRAM (WMP)

- Intro
 - » WMP is a not-for profit initiative that works to protect the global community from mosquito-borne diseases such as Zika, Dengue, Chikungunya.
 - » Pioneered by Australian researchers, the WMP uses safe and natural bacteria called Wolbachia to reduce the ability of mosquitoes to transmit these viruses.
 - » WMP was first launched in Australia in 2011 and has expanded rapidly since then.
- About Wolbachia
 - » Wolbachia is a natural bacteria present in upto 60% of insect species, including some mosquitoes. It is one of the most common parasitic microbes and is possibly the most common reproductive parasite in the biosphere.
 - » However, they are naturally not found in Aedes aegypti mosquito.
- WMP research has shown that when introduced in Aedes aegypti mosquito, Wolbachia can help reduce the transmission of these virus in people. When introduced into this mosquito's cells, this parasite competes successfully against other parasites such as the viruses that cause dengue, chikungunya, yellow fever, Zika etc. Thus, it can be used to fight life-threatening diseases.
 - In a study in Djakarta, the number of cases saw a decline of 77% in the number of cases and a decline of 86% in hospitalizations due to dengue.
 - » Video link: [World Mosquito Program - Our Wolbachia method](#)

17) KYASANUR FOREST DISEASE (KFD) / MONKEY FEVER

- **Introduction**
 - » KFD is caused by KFDV, a member of virus family **Flaviviridae**. It was first identified in 1957 when it was isolated from a sick monkey in Kyasanur Forest in Karnataka state India.
 - » Since then, about 400-500 cases are reported every year from the state.
- **Reservoirs for Virus**
 - » **Hard Ticks** (*Hemaphysalis spinigera*) are the reservoir of the KFD virus and once infected, remain so for life.
 - » **Monkeys, shrews, and Rodents** are common hosts for KFDV after being bitten by an infected tick.
- **KFDV can cause epizootics** with high fatality in primates.
- **Transmission**
 - » Infected tick bite or contact with an infected animal (monkey, shrew etc.). No person-to-person transmission has been known so far.
 - » Transmission from other infected animals like goats, cows etc is extremely rare.
- **Symptoms**
 - » Chills, fever, headache, muscle pain, low platelet, low RBCs and WBCs.
- **Treatment:** No specific treatment -> hospitalization and support therapy like hydration and usual precautions is important.
- **Vaccine:** Yes; Used in endemic areas of India.
- **Distribution** Historically limited to western and central district of Kar, India. However, some samples have also been found from Tamil Nadu and Kerala.

18) INFLUENZA

A) INFLUENZA A VIRUS

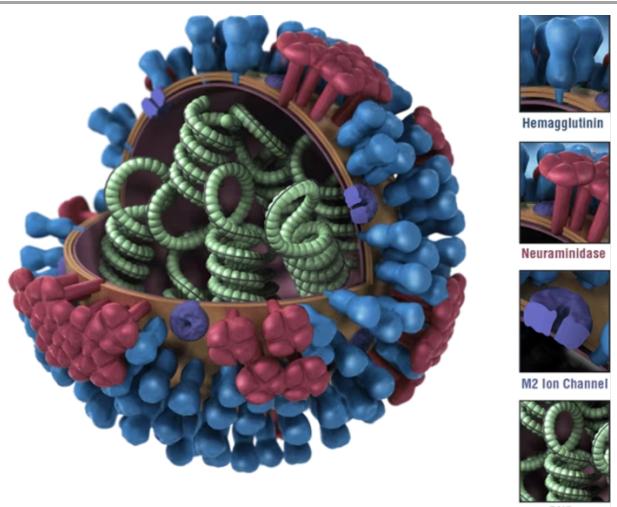
There are four types of Influenza viruses: A, B, C, and D. Influenza A and B viruses cause seasonal epidemics of diseases.

Influenza A viruses are the only influenza viruses known to cause flu pandemics (i.e. global epidemics of flu diseases)

Influenza A virus is the only species of the genus *Alphainfluenzavirus*. It is an RNA virus.

Influenza A viruses are divided into subtypes based on two proteins on the surface of the virus: hemagglutinin (H) and neuraminidase (N).

- There are 18 hemagglutinin subtypes (H1 - H18) and 11 different neuraminidase subtypes (N1 - N11)



More than **130 influenza A subtype combinations** have been identified in nature, primarily from birds, there are potentially many more influenza A subtypes combinations given the propensity of virus "**reassortment**".

Reassortment is a process by which influenza viruses swap gene segments. It can occur when two influenza viruses infect a host at the same time and swap genetic information.

- The influenza A virus subtypes that have been confirmed in humans, ordered by the number of known human pandemic deaths, are:
 - » **H1N1** caused Spanish Flu in 1918 and the 2009 swine flu pandemic.
 - A variant of H1N1 was responsible for the Spanish Flu pandemic that killed some 50 million to 100 million people worldwide in 1918 and 1919.
 - » **H2N2** caused "Asian Flu" in the late 1950s.
 - » **H3N2** caused "Hongkong Flu" in the late 1960s.

B) SWINE FLU

- **Swine Flu** is a respiratory disease caused by **influenza A viruses** that infects respiratory tract of pigs and result in barking cough, decreased appetite, nasal secretion, and restless behavior; the virus can be transmitted to human.
- **The first case of influenza A H1N1** was reported in Mexico in **April 2009**. Since then, this infection has affected almost all the countries of the world.
 - » **The Virus**
 - Most common virus causing swine flu is H1N1 but the flu virus can sometimes also come from other subtypes such as **H1N2, H3N1, and H3N2**. Since 2017, H3N2 is becoming a dominant strain.
 - » **Cross Species infections** (swine to humans, humans to swine) etc. have **mostly remained local and haven't caused national or worldwide infections** in either pig or humans.
 - » **Transmission to humans:**
 - Most common way for humans to catch swine flu is through contact with an infected pig (not through properly cooked pork)
 - Swine flu is transmitted from person to person by inhalation or ingestion of droplets containing virus from people sneezing or coughing.
 - » **Symptoms**
 - Similar to most influenza infections: - fever, cough, nasal secretion, fatigue and headache.
 - » **Prevention and cure**
 - **Vaccination** is the best way to prevent or reduce the chances of becoming infected with influenza virus.

- Two antiviral agents, **zanamivir (Relenza)** and **oseltamivir (Tamiflu)**, have been reported to help prevent or reduce the effects of swine flu if taken within 48 hours of the onset of symptoms.

C) AVIAN INFLUENZA: BIRD FLU

- **Intro**
 - Bird flu (Avian Influenza) is caused by influenza A viruses.
 - Only viruses of the H5 and H7 subtypes are known to cause the highly pathogenic form of the bird diseases.
 - Most avian influenza virus don't infect humans; however, some such as A(H5N1) and A(H7N9), have caused serious infections in people.
 - Recently, China reported that H10N3 has also infected humans.
- **There are several subtypes of Avian Influenza**
 - **AH5N1** is the most common virus causing bird flu, or avian influenza. It is largely restricted to birds, and often fatal (**high pathogenicity**) to them. It can sometimes cross over to other animals, as well as human.
 - According to WHO, the H5N1 was first discovered in humans in 1997 and has killed almost 60% of those infected. Though, it is not known to transmit easily among humans, the risk remains.
 - **A-H7N9**: It was reported in China in 2013. An outbreak of H7N9 strain killed around 300 people in 2016 and 2017.
- **Risk Factors for human infections**
 - The primary risk factor for human infection appears to be direct or indirect exposure to infected live or dead poultry or contaminated environments, such as live bird markets.
- **Impacts**
 - Outbreaks of AI in poultry may raise global public health concerns due to their effect on poultry population, their potential to cause serious disease in people and their pandemic potential.
 - Can impact local and global economies and international trade.
- **Note**
 - There is no evidence to suggest that the virus can be transmitted to humans through properly prepared poultry or eggs.

D) THE EUROPEAN UNION IS EXPERIENCING THE LARGEST BIRD FLU OUTBREAK IN EUROPE: REPORT BY EUROPEAN FOOD SAFETY AUTHORITY (EFSA) (2022 AND 2023)

More than 50 million birds culled between Oct 2021 to Sep 2022

E) FIRST CASE OF AVIAN FLU FOUND IN ANTARCTIC REGION (OCT 2023)

- Avian flu has been detected for the first time in Antarctic region and has raised concerns for birds and mammals which feed on these bids.
- **Which type?**
 - Highly Pathogenic Avian Influenza (HPAI) was detected in brown skua (a predatory seabird) populations on Bird Island, South Georgia, making it the first known case in the Antarctic region.
- **Risk Assessment:**
 - Sea-Gulls and Skuas are the most threatened avian group. They are followed by bird's prey such as hawks and carcasses, terns and shorebirds.
 - Among marine mammals, fur seals and sea lions are reportedly most vulnerable, followed by southern elephant seals and dolphins.

19) NIPAH

A) NIPAH

- **Why in news?**
 - » There has been an outbreak of the deadly Nipah virus in Kerala which have infected five people and killed two of them (Sep 2023)
- **Introduction**
 - » According to WHO Nipah Virus (NiV) infection is a newly emerging zoonosis (a disease that can be transmitted from animals to humans) that can infect both humans and animals.
 - It is classified as a "highly pathogenic paramyxovirus" and handling it requires the highest grade of facilities called BS-4.
 - » The natural host of the virus are fruit bats of the Pteropodidae family, Pteropus genus. Humans are generally infected by fruit bat or pigs. Human to human transmission is also known including in the hospital setting.
- **First identification**
 - » First identified during the outbreak of disease that took place in Kampung Sungai Nipah, Malaysia in 1998. In this case pigs were intermediate hosts. Since, then there have been several outbreaks even without intermediate hosts.
 - » In India it was first detected in Siliguri in 2001 and Nadia in 2007. This was a spillover of the outbreak in Bangladesh.
 - » Later in 2018, 19, 21 and again in 2023 it appeared in Kerala.
 - **Why?**
 - Kerala has several fruit plantations that host several species of bats.
 - Better health facilities in Kerala may be leading to better detection, surveillance etc., whereas in other states the cases may go undetected.
- **Symptoms** of NiV can be **neurological, respiratory and pulmonary**. They include:
 - i. **Encephalitis (brain swelling) due to Inflammation of the brain**
 - ii. Confusion, disorientation and even persistent drowsiness
 - iii. Headache, fever, nausea and dizziness (flu like symptoms)

- **Fatality:** Around 40-70% depending on the local capability for epidemiological surveillance and clinical management.
- **Prevention** (Avoid date palm sap; avoid close contact with NiV Patient; avoid direct contact with pigs/bats in endemic area)
- **Treatment / Vaccine**
 - » **Intensive Support care (no treatment or vaccine is available)**

According to NCDC (National Centre for Disease Control), Ribavirin, an antiviral, may have a role in reducing mortality among patients with encephalitis caused by NIPAH virus disease.

B) WHY ZOONOTIC DISEASES ARE INFECTING HUMANS MORE AND MORE

- » **Dramatic increase in population and mobility** -> Environmental changes, Deforestation etc. -> increase human contact with pathogens.
- » **Increased demand for animal protein**
 - Livestock production is moving closer to towns in the form of poultry farms etc.
- » **Rise in intense and unsustainable farming**
- » **Increased use and exploitation of wildlife**
- » **Unsustainable utilization of natural resources**
- » **Many Indian villages are located within or around forests**
 - Thus, significant number of people interact with forests in their day-to-day lives
- » **Global Warming**
 - Increases the population of insects like ticks that harbour and transfer the virus
- » **Poor Preparation in terms of infra and human resource**
 - Zoonotic diseases become more problematic in countries where health infrastructure is poor (e.g., Ebola in Africa, Zika in South America, Nipah in Asia etc.)
- » **Lack of awareness** especially in rural areas also

20) HEPATITIS

- **About Hepatitis**
 - Hepatitis refers to inflammatory condition of liver. It's commonly caused by viral infections, but there can be other causes too (e.g., auto-immune hepatitis that occurs as a secondary result of medication, drugs, toxins etc.)
- **5 Types of Viral Hepatitis**
 - Hepatitis A, B, C, D, and E.
 - A different virus is responsible for each of these types.
 - » **Hepatitis A** by Hepatitis A Virus (HAV)
 - Transmitted by consuming food or water contaminated by faeces from a person infected with hepatitis A.
 - » **Hepatitis B** (HBV) is transmitted through contact with infectious body fluids, such as blood, vaginal secretion, semen etc.
 - » **Hepatitis C** (HCV) is transmitted through direct contact with infected blood fluids typically through injection drug use and sexual contact.

- Injecting drug use is a major contributor to the number of people newly infected with Hepatitis C globally.
- » **Hepatitis D (HDV)**, also called Delta Hepatitis is transmitted through direct contact with infected blood.
- » **Hepatitis E (HEV)**, is mostly found in areas with poor sanitation and typically results from injecting fecal matter that contaminates the water supply.
- **Hepatitis B and C** are responsible for more than 96% of cases.
 - » Vaccine for Hepatitis B is available
 - » Vaccine for Hepatitis C is not available
- **National Viral Hepatitis Control Program** (launched in July 2018)
 - » By MoH&FW
 - » It is aimed at eliminating the deadly condition by 2030.
 - » It has been launched in collaboration with WHO.
 - » Under the program, government will be providing free drugs and diagnosis for **Hepatitis B and C**.
 - » **Key strategies under the program include** - Preventive and promotive intervention through awareness generation; safe injection practices; sanitation and hygiene; safe drinking water; infection control and immunization; collaboration and coordination among different ministries; access to testing and management; building capacities at district, state, and national levels.
- **World Hepatitis Day - 28th July**
 - » Aims at raising awareness of hepatitis (A,B,C,D,E) and encourage prevention, diagnosis and treatment.
 - » World Hepatitis Day is one of the 8 global public health campaigns marked by WHO, along with World Health Day (7th April), World Blood Donor Day (14th June), World Immunization Week (last week of April), World Tuberculosis Day (24th March), World No tobacco day (31st May), World Malaria Day (25th April), and World Aids Day (1st December)

21) NOROVIRUS

- **Norovirus:**
 - » Norovirus is thought to be the most common cause of acute gastroenteritis (diarrhea and vomiting illness) around the world. It spreads easily through food and drink and can have a big impact on people's health.
 - » Noroviruses also are sometimes called food poisoning because they can be transmitted through contaminated food. They aren't always the result of food contamination.
- » **Transmission of Norovirus:**
 - Having direct contact with an infected person.
 - Consuming contaminated food or water or touching contaminated surface.
- » **Symptoms:** Diarrhea, Vomiting, Nausea, and Stomach Pain.
- » **Prevention:**

- **General Hygiene:** Regular hand wash; rinse fruits and vegetables etc.
- » **Treatment:** Not available - generally goes away on its own within 1 to 3 days.

12. NON- VIRAL DISEASES

1) MALARIA

- **Cause of Malaria:** It is caused by plasmodium pathogens.
 - » There are five human malaria parasites: Plasmodium falciparum (deadliest of the five) and Plasmodium vivax are the most common causes. The list also includes P. ovale, P. malarie, and P. knowlesi.
 - » **Mosquitoes inject sporozoite (Spore-like) stage** of the parasite into the skin when they bite, and the sporozoites travel to the liver. The parasite multiply in liver, and then infect the red blood cells.
- **Mosquito Vector:** Female Anopheles Mosquito (e.g. A. gambiae, A. culicifacies, A. fluviatilis etc.)
- **Note:** Malaria is the largest parasitic killer in the world.
- **Key Interventions to control Malaria:**
 - » Prompt and effective treatment with artemisinin-based combination therapies.
 - » **Reducing Mosquitoes** and Mosquito bites (female Anopheles Mosquito (e.g. A. gambiae, A. culicifacies, A. fluviatilis etc.)

A) DEVELOPMENT OF DRUG RESISTANCE:

A study from Africa has found that P. falciparum has developed resistance to the primary drug used to treat the disease i.e. Artemisinin and Artemisinin based combination therapies.

- Resistance was earlier shown in Asia, but experts are more worried about the development of resistance in Africa as it has 90% of the world's Malaria cases

B) 2023 WORLD MALARIA REPORT – PUBLISHED BY WHO (DEC 2023)

- **India:**
 - » In 2022, India accounted for 66% of the cases in the WHO South-East Asia region. This region accounted for only 2% of the global cases.
 - Plasmodium vivax was responsible for almost 46% of all cases in the region.
- **WHO Africa region** accounts for around 95% of the cases.
- **Crucial milestone of the WHO Global Technical Strategy for Malaria 2016-2030** have been missed in 2020.
- **Key factors** impacting fight against Malaria:
 - » Covid-19 disruptions; Drug and Pesticide Resistance; Humanitarian Crisis; climate change response; delays in program implementation.

C) GLOBAL TECHNICAL STRATEGY FOR MALARIA 2016-2030: WHO

- Aimed at dramatically lowering the global malaria burden over the 15 year period

D) VACCINATIONS

As of Dec 2023, RTS/AS01 and R21/Matrix-M vaccines are recommended by WHO to prevent malaria in Children. Malaria vaccines should be provided to children in a schedule of 4 doses from around 5 months

of age. These malaria vaccines act against P. falciparum, the deadliest malaria parasite globally and the most prevalent in Africa.

RTS,S

- The WHO has recommended widespread use of the RTS,S/AS01 (RTS,S) malaria vaccine (Commercial name: Mosquirix) among Children in regions of moderate to high P. falciparum malaria transmission.
- RTS, S has been developed by PATH Malaria Vaccine Initiative (MVI) and GlaxoSmithKline (GSK) with support from Bill and Melinda Gates foundation.
 - » It is a **recombinant vaccine**. It consists of the P.falciparum circumsporozoite protein (CSP) from the pre-erythrocytic stage (i.e. the CSP is secreted at the sporozoite stage of this plasmodium). The CSP antigen causes the production of antibodies capable of preventing the invasion of hepatocytes and additionally elicits a cellular response enabling the destruction of infected hepatocytes.
 - » **Note:** Mosquito bites transfer the CSP and sporozoites into the human bloodstream, and the CSP nudges the parasite towards the liver, where it enters liver cells, matures and proliferates. The release of mature merozoites marks the onset of the symptoms of malaria

R21 MALARIA VACCINE

- **Why in news?**
 - » A malaria vaccine manufactured by the biotechnology company Serum Institute of Technology of India and University of Oxford have passed the next round of regulatory approval by the WHO (Dec 2023)
 - R21/Matrix-M meets the WHO standards for vaccine quality, safety, and efficacy.
- **Details about the vaccine:**
 - » R21 is a modified form of a vaccine called RTS,S or Mosquirix.
 - » Vaccine is highly effective and can reduce malaria cases by 75% over a year.
 - » It is the second malaria shot approved by WHO, following the RTS,S/AS01 one, which was approved in July 2022.
 - » R21 is designed to be both more potent and cheaper to produce than Mosquirix. .
 - **Note1:** R21 and Mosquirix both target the malaria parasite in the sporozoite phase of its life cycle - the phase in which it enters the human body from its mosquito host. The vaccines include a protein (Circumsporozoite Protein (CSP)) secreted by the parasite at that stage, in the hope of stimulating an antibody response against it. R21 includes a higher concentration of these proteins.
 - **Note2:** Each of the vaccine is administered with a chemical called an adjuvant, which boosts immune responses to the inoculation. But the Adjuvant used with R21 is easier to make than that used with Mosquirix, raising hopes that it could be cheaper as well.
- **WHO's Approval:**
 - WHO has added the vaccine to the WHO's list of prequalified vaccines.

- This was also recommended for use for the prevention of malaria in Children by the global health agency on 2nd Oct 2023.
- **How is a vaccine added in the WHO list of pre-qualified vaccine?**
 - If a vaccine has undergone through evaluation of relevant data, testing of samples and WHO inspection of relevant manufacturing sites - and the outcome is positive - it is included in the WHO list of Prequalified Vaccines.
 - Pre-qualification is also a pre-requisite for vaccine procurement by UNICEF and fuding support for development y Gavi, the Vaccine alliance.

E) MALARIA'S COMBACK IN USA

- **USA** has recorded its first homegrown malaria cases in decades. In the year 2023, 9 indigenous cases have been reported (7 in Florida, one in Texas, and one in Maryland)
- **How?**
 - » Anopheles mosquitoes capable of carrying malaria are still very much present in the USA they've just had very few opportunities to transmit the parasite because there are so few infected people to feed on.
 - **Experts believe that** a person infected with Malaria traveled to the USA from a malaria-endemic area and was bitten by a local Anopheles mosquito, which picked up the parasite and then bit someone else, passing on the parasite.
 - » **Climate change** is making environment more suitable for Malaria. Higher temperature also enhance the growth rate and transmissibility of the parasites responsible for malaria. Higher rainfall and sea level rise may also make the situation more suitable for malaria.

2) IMPORTANT INTERNATIONAL INITIATIVES RELATED TO MALARIA

A) E-2025 INITIATIVE

- Under this initiative WHO has identified 25 countries, including 3 from Africa, with the potential to eradicate malaria by 2025.
 - » The WHO will provide specialized support and technical guidance to these countries under the initiative.
- The initiative is built on the foundation of the E-2020 initiative. The countries were identified by WHO across four key criterias:
 1. The generation of government endorsed elimination plan
 2. Meeting a defined threshold of Malaria case reductions in recent years
 3. A designated government agency for Malaria elimination and the capacity to confirm 100% of suspected malaria cases in a laboratory
 4. Selected by the Malaria Elimination Oversight Committee

- Countries selected for the E-2025 initiative:

Automatically Nominated	Newly Added
1- Mexico 2- Costa Rica 3- Ecuador 4- Suriname 5- Belize 6- Cabo Verde 7- Saudi Arabia 8- Islamic Republic of Iran 9- Nepal 10- Bhutan 11- Republic of Korea 12- Malaysia 13- Comoros 14- Botswana 15- Eswatini 16- South Africa 17- Timor-Leste	1- Panama 2- Vanuatu 3- Honduras 4- Thailand 5- Guatemala 6- Dominican Republic 7- Sao Tome And Principe 8- Democratic People's Republic of Korea

B) CHINA CERTIFIED MALARIA FREE AFTER 70 YEARS OF FLIGHT: WHO (JUNE 2021)

- In 1940s, China used to report 30 million cases annually. Now, it has gone for four consecutive years without an indigenous case.
- **Requirement of WHO's Malaria Free status:** 3 Consecutive years of zero indigenous cases. The country must also present rigorous evidence and demonstrate the capacity to prevent transmission re-emergence.
- **China** has become the 40th territory to be certified malaria free. The other recent countries to get Malaria free status include - El Salvador (2021), Algeria and Argentina (2019), and Paraguay and Uzbekistan (2018).
 - China is also the first country in WHO's Western Pacific region to be awarded a malaria-free certification in more than three decades. The only others with certified status are Australia (1981), Singapore (1982) and Brunei (1987).
- **Key initiatives by China** which has made this possible?
 - Discovery of Artemisinin in 1970s -> most effective anti-malarial drug.
 - Among the first countries to test the use of insecticide treated net to prevent Malaria and China distributed millions of nets

C) MAJOR NATIONAL INITIATIVES

- **National Framework for Malaria Elimination (2016-2030)**
 - Released by MoH&FW and aims to make India Malaria free by 2030.

3) KALA AZAR (VISCERAL LEISHMANIASIS, BLACK FEVER, AND DUMDUM FEVER)

- As per WHO, there are three main forms of Leishmaniases of which Kala-azar is the most serious form.
- **Basics of Kala Azar (Black Fever)**
 - **Parasite:** Protozoan parasite called '**leishmania donovani**'. (Genus: Leishmania)
 - **Vector:** female Sand fly.
 - » The parasite is spread to humans by bites from infected female sand flies.
 - **Second largest parasite killer** in the world (after malaria)
 - It is one of the most neglected Tropical Diseases (NTD).
 - The parasite migrates to the internal organs such as liver, spleen (hence visceral), and bone marrow, and, if left untreated, will almost always result in the death of the host.
 - **Other factors:**
 - » The disease affects some of the poorest people in the world and is linked to malnutrition, population displacement, poor housing, a weak immune system and a lack of financial resources.
 - » It is also linked to environmental changes such as deforestation etc.
 - **Symptoms:** Irregular fever, weight loss, anaemia, and swelling of the spleen and liver.
 - **Only infects humans** (no other animal known to harbour the infection in Asia), and **humans are considered the only reservoir of the parasite**.
 - **Treatment:** Anti-leishmanial medicines are available for treatment. Vector control is another aspect.
- **Cases of Visceral Leishmaniasis or Kala Azar in India (Jan 2023)**
 - **Kala Azar cases in India fell to 834 in 2022 from 44,533 in 2007 - a 98.7% decline**: Union health Ministry.
 - After missing deadlines thrice, India is poised to achieve the elimination target for visceral leishmaniasis or Kala Azar this year with no block in the country reporting more than 1 case per 10,000 people. (Dec 2023)
 - India needs to sustain the momentum over the next 3 years in order to receive the WHO certification.
 - India contributes to 11.5% of total cases reported globally.
 - 89% of the cases were reported from eight countries - Brazil, Eritrea, Ethiopia, India, Kenya, Somalia, South Sudan and Sudan.
- In October 2023, Bangladesh became the first country in the world to be officially validated by the WHO for elimination of Kala Azar as a public health problem
- **National Kala Azar Elimination Program (NKEP)**
 - Though the initial 2015 deadline has been missed, the numbers have been brought down significantly.
 - **Key steps taken:**

- India has also expanded vector control interventions:
 - Indoor residual spraying to control the population of sandflies.
 - Since sandflies have developed resistance to DDT, the NVBDCP introduced a synthetic pyrethroid for indoor residual spraying in 2015.
 - Reducing Crevices in 'Kuccha' walls to reduce breeding areas.
 - ASHA (Accredited Social Health Activist) network was tasked with ensuring that people with PKDL complete treatment.
- Note:
- Since 2003, National Vector Borne Disease Control Programme (NVBDCP) is in charge of coordinating with endemic states to eliminate disease.
 - NVBDCP now funds consultants at state and district level and Kala-Azar Technical Supervisors (KTS) at the State's blocks (or clusters of village panchayats) to conduct surveillance.
- International efforts to control Kala Azar
- An initiative was launched by WHO to eliminate VL as a public health problem from SE Asia region by 2020. The deadline has now been extended to 2023.

POST KALA-AZAR DERMAL LEISHMANIASIS (PKDL)

- » It is a complication of Kala-Azar, in which the disease-causing protozoan invades the patient's skin cells. These cases act as reservoirs of the pathogens.
- » **PKDL treatment is a bigger problem**
 - **Diagnostic is difficult**
 - PKDL cannot be diagnosed by the trademark rapid diagnostic kits. So, a skin snip examination is required. But not all PHCs are equipped with such tools.
- » **Longer dose and greater quantity of drugs**
 - PKDL requires a longer dose and greater quantity of drugs than primary Kala Azar.
- » **Why treating PKDL is important?**
 - It is not life threatening but can act as a source for Kala Azar infection to others.

A) OTHER TWO FORM OF LEISHMANIASIS

CUTANEOUS LEISHMANIASIS (CL)

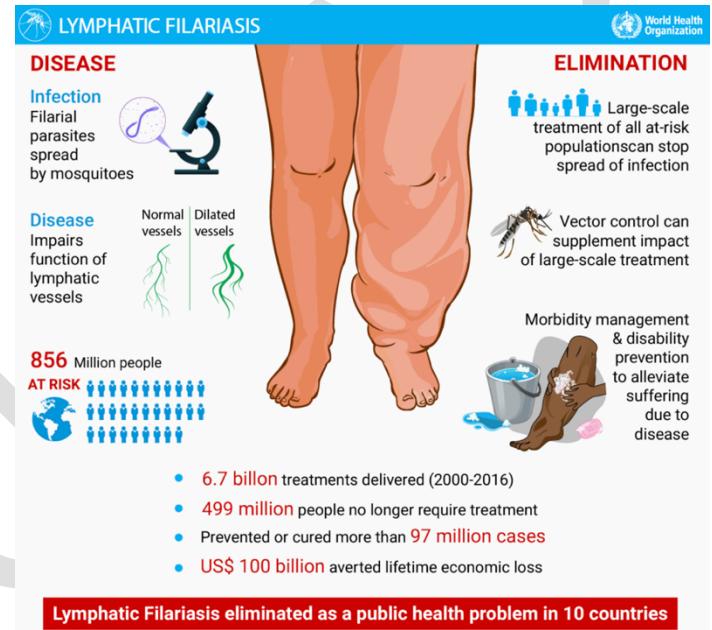
- It is the most common form of leishmaniasis.
- It is caused by 15 different species of the protozoan parasite Leishmania, transmitted by infected female sandflies.
- They are not life threatening, but can cause skin lesions, mainly ulcers, on exposed parts of the body, leaving life-long scars and serious disability or stigma.
 - » About 95% of CL cases occur in the Americas, the Mediterranean basin, the Middle East and Central Asia.

MUCOCUTANEOUS LEISHMANIASIS

It leads to partial or destruction of mucous membranes of the nose, mouth, and throat. More than 90% of the cases come from Bolivia, Brazil, Peru, and Ethiopia.

4) FILARIASIS

- **Basics:**
 - » It is a parasitic disease caused by infection with roundworms of the **Filarioidea** type.
 - » **Lymphatic Filariasis** impairs the lymphatic system and can lead to the abnormal enlargement of the body parts, causing pain, severe disability, and social stigma. It is also known as elephantiasis and is a Neglected Tropical Disease.
- **Vectors: Mosquitoes** are infected with microfilariae (immature larvae) when biting an infected host. This larva matures in the mosquito and when the mosquitoes bite people, people are infected with mature parasite larvae. The larvae then migrate into lymphatic vessels where they develop into adult worms.
 - » It may be transmitted by different types of mosquitoes including the Culex Mosquito.
- The disease is prevalent in more than 50 countries.



5) NEUROCYSTICERCOSIS

- **Details**
 - » Neurocysticercosis (NCC) is caused when a human consumes meat from (or is indirectly in contact with) - a pig infected with tapeworm.
 - The eggs of tapeworms invade muscles of the human body to make cysts. Sometimes these cysts get into human brains, triggering epileptic seizures, headaches, difficulty with balance and excess fluid around the brain.
 - » A study published in the ***Nature journal*** in 2021 reported higher prevalence (42.2%) of NCC among patients with active epilepsy in the tea gardens of Assam. These findings were in sync with the older findings that NCC was one of the leading causes of seizures in developing countries, particularly in areas without proper sanitation and where pig rearing was widespread.

6) TUBERCULOSIS

- **Introduction**
 - » TB is an infectious **bacterial disease** caused by bacillus Mycobacterium tuberculosis, which most commonly affects the lungs (pulmonary TB) but can affect other sites as well (extra pulmonary TB)
- **Symptoms:**
 - » Healthy people -> often no symptoms (immune system wall off the bacteria)
 - » **Symptoms of active TB of the lung** include coughing (sometimes with sputum or blood), chest pains, weakness, weight loss, fever, night sweats etc.
- **Diagnosis**
 - » **Sputum Smear Microscopy** - used since more than 100 years.
 - » **Rapid Molecular Test** - developed recently - uses polymerase chain reaction (**PCR**)
 - » **Culture Methods** - needs developed laboratory capacity.
- **Treatment**
 - » The effective drug treatments were **first developed in the 1940s**.
 - The most effective first-line anti-TB drug, rifampicin, became available in the 1960s.
 - The currently recommended treatment for new cases of drug-susceptible TB is a six month regimen of four first line drugs: rifampicin, isoniazid, ethambutol and pyrazinamide. Treatment success rates of 85% or more for new cases are regularly reported to WHO by its member states.
 - » Additionally, social determinants of TB such as under-nutrition, overcrowding and poor ventilation in slums and clinical risk factors such as diabetes mellitus, smoking etc. should be addressed simultaneously.
 - Treatment for **Multi drug resistant TB (MDR-TB)**, defined as resistance to isoniazid, rifampicin (the two most powerful anti TB drugs) is longer, and requires more expensive and more toxic drugs. For most patients with MDR-TB, the current regimens recommended by WHO last 20 months, and treatment success rates are much lower.
- **Vaccine**
 - » Not yet (BCG is not effective in tropical countries)
- **Steps Taken**
 - i. **For Detection**
 - **National Policy of Mandatory Reporting** of detected cases since 2012
 - Launch of **Nikshay Platform** - a nation wide web-based and case-based reporting system that facilitates reporting of detected cases by care providers in public and private hospitals.
 - ii. **National Strategic Plan for Tuberculosis Elimination (2017-2025)**



- **Goal**
 - » Achieving rapid decline in the burden of TB, morbidity and mortality while working towards elimination of TB by 2025
- **100% case finding by 2020**
- **Elimination of TB 2025 (< 1 per 1,00,000 population)**

- **Updated MDR-TB Recommendations from WHO (Aug 2018)**
 - Replace all injectable with oral regime for MDR-TB patients.
 - Injectables have been found to be less effective
 - Prioritize newer drugs like **Bedaquiline** in the fully oral regime.
 - Data has shown that newer drugs show greater success in treatment and lower mortality rate.

- **24 March: World Tuberculosis Day**

- **New Vaccines and Medicines**
 - i. New BCG based TB vaccine, VPM1002 has shown promise in animal and small-scale human trials. It is to be supplied by Pune based Serum Institute of India.
 - ii. **Bedaquiline** - a new drug for drug resistant TB - launched by Union Health Ministry on 24th March 2016 (Worth TB Day)

A) WHO'S GLOBAL TB REPORT

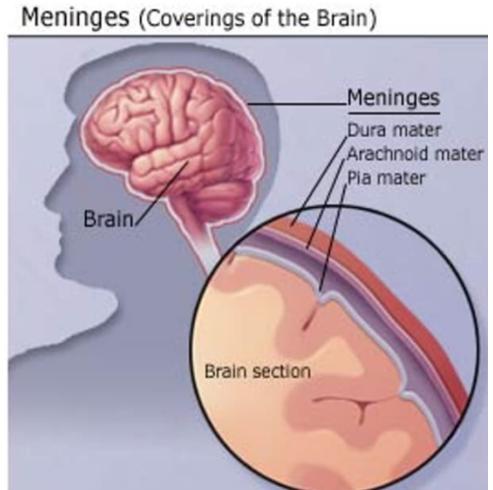
7) LEPROSY

- **Introduction**
 - » Leprosy, also known as Hansen's disease, is a chronic infectious disease caused by *Mycobacterium leprae*. It is one of the oldest diseases known to humans and despite advances in all spheres of medical science, continues to be a public health challenge in India.
 - » The disease mainly affects the skin, the peripheral nerves, mucosal surfaces of the upper respiratory tract and the eyes. The deadening of hands and feet leaves patients prone to kinds of disabling injuries that have become stigmatizing symbol of leprosy.
 - » Leprosy is known to occur at all ages. Leprosy is a leading cause of permanent physical disability.
 - » It is included under the list of Neglected Tropical Diseases of WHO.
 - » India, Indonesia and Brazil constitute around 81% of the cases with India contributing to more than 50% of the cases.
- **Transmission**
 - » The exact mechanism of transmission of leprosy is not known.
 - » Till recently, most widely held belief was that the disease was transmitted by **contact** between cases of leprosy and healthy persons.
 - » More recently, possibility of transmission by **respiratory route** is gaining ground. There are other possibilities like transmission through insects which can't be ruled out.
- **Treatment**
 - » Leprosy is curable with combination of drugs known as **multidrug therapy (MDT)** (to prevent drug resistance)

- » Treatment, before nerve damage occurs, is the most effective way of preventing disability due to leprosy.
- **Leprosy Situation in India**
- India currently accounts for 60% of the total new leprosy cases in the world. Though, technically, WHO declared India leprosy free in 2005(<1 case per 10,000 population), the disease is still widespread in the region where poverty and stigma have kept patients hidden and untreated.
 - Bihar, Jharkhand, Odisha, West Bengal, Madhya Pradesh, Chhattisgarh, Odisha and Maharashtra account for 76% of the new leprosy cases.
 - Further, another worrying trend is that Leprosy is impacting the marginalized population more. For e.g. an analysis by ORF indicates that Adivasis account for 18.8% of India's new cases and this percentage has been increasing over the last decade.
- **Steps taken by India towards eradicating Leprosy:**
- a. **National Leprosy Eradication Program (NLEP)**, running since 1983 - a centrally sponsored health scheme of MoH&FW, GoI.
 - NLEP is aimed at eradicating the disease from the country. India was able to eliminate leprosy (bring the number of cases to less than 1 per 10,000 population) by 2005, but complete eradication has not taken place yet.
 - b. **Sparsh Leprosy Awareness Campaign (SLAC)** under NLEP was launched in 2017.
 - c. **Personal Laws (Amendment) Act, 2019** is aimed at removing leprosy as a ground for divorce in India family laws.
 - The act amends five acts - The Divorce Act, 1869, the Dissolution of Muslim Marriage Act, 1939, the Special Marriage Act, 1954, the Hindu Marriage Act, 1955, and the Hindu Adoption and Maintenance Act, 1956 - on provisions related to marriage, divorce, and separation of Hindu and Muslim couples.

8) MENINGITIS (BOTH VIRAL AND BACTERIAL REASONS)

- **What is Meningitis?**
 - » It is inflammation of the meninges (three membranes that cover the brain and spinal cord). It occurs when fluid surrounding the meninges becomes infected.
- **Causes:** Viral and bacterial infections; Cancer; chemical irritation; fungi; and drug allergies.
 - » **Bacterial Meningitis:** It is an extremely serious illness. It can be caused by several bacteria including Streptococcus pneumoniae (pneumococcus), Neisseria meningitidis (meningococcus) etc.
 - **Meningococcal meningitis** (caused by the Neisseria meningitidis bacteria), is associated with high fatality rate. It primarily affects small children (though can infect everyone) and can cause severe brain damage if left untreated. It holds the potential to cause large epidemics as it has the potential to transfer from person to person through respiratory droplets.
 - This is vaccine preventable.



- *Haemophilus influenzae type b* (Hib) was a common cause of meningitis in babies and young children until the Hib vaccine became available for infants.
- » **Viral Meningitis** is more common but generally less serious than bacterial meningitis.
- » **Fungal Meningitis** is very rare. Generally, people with weak immune system are vulnerable to it.
- » **Parasitic and Amoebic meningitis** are also rare.
- » **Noninfectious meningitis** is caused by diseases like cancer or in case of injury due to accident, surgery or reactions to medications.
- **Contagious?**
 - » Some viral and bacterial meningitis are contagious. They can be transmitted by coughing, sneezing, or close contact.
- **Symptoms:** In the beginning the viral and bacterial meningitis have similar symptoms. However, bacterial meningitis symptoms are usually more severe. These symptoms also vary depending on your age.
- **Regions most affected:** Meningitis epidemics have occurred in the last decade in all regions of the world. But it is most common in the 'Meningitis Belt', which spans 26 countries across sub-Saharan Africa.
- **Vaccines:**
 - » Several vaccines protect against meningitis, including meningococcal, Haemophilus Influenza type b and Pneumococcal vaccines.
- **"The Global Roadmap to Defeat Meningitis by 2030" by WHO (Sep 2021)**
 - » It aims to eliminate the epidemic of bacterial meningitis - the deadliest form of the disease - and to reduce deaths by 70 percent and halve the number of cases.
 - » Focus on urgently expanding access to existing tools like vaccines, spearheading new research to prevent, detect, and treat the various causes of the disease and improving the rehabilitation for the affected.

13. NEGLECTED TROPICAL DISEASES (NTDS)

- **WHO Definition:**
 - NTDs are a diverse group of 20 conditions that are mainly prevalent in tropical areas, where they mostly affect impoverished communities and disproportionately affect women and Children.
 - The epidemiology of NTDs is complex and often related to environmental conditions.
 - They are caused by variety of pathogens - viruses, bacteria, protozoa, and parasitic worms (helminths).
- **Which are the diseases included in NTDs:**

- Buruli Ulcer, Chagas Disease, Dengue & Chikungunya, dracunculiasis (Guinea-worm disease), echinococcosis, foodborne trematodiases, human African trypanosomiasis (sleeping sickness), leishmaniasis, leprosy (Hansen's disease), lymphatic filariasis, mycetoma, chromoblastomycosis and other deep mycoses, onchocerciasis (river blindness), podoconiosis, rabies, scabies, and other ectoparasitoses, schistosomiasis, soil-transmitted helminthiases, snakebite envenoming, taeniasis/cysticercosis, trachoma, and yaws and other endemic treponematoses.

- **Note:**
 - 'Noma' is the latest addition to WHO's list of neglected tropical diseases (Dec 2023)
- These diseases are **contrasted with the "big three" infectious diseases** (HIV/AIDS, tuberculosis, and malaria), which generally receive greater treatment and research funding.
- **Jan 30: World NTD Day**
 - In May 2021, the delegates at the 74th World Health Assembly unanimously adopted a proposal to declare Jan 30 as 'World NTD Day.'
- **WHO's new roadmap for 2021-2030 calls for three strategic shifts to end NTDs:**
 - From measuring process to measuring impact.
 - From disease-specific planning and programming to collaborative work across sectors.
 - From externally driven agendas reliant to programmes that are country-owned and country-financed

A) INCLUSION OF NOMA ON THE WHO'S LIST OF NTD

It is a severe gangrenous disease of the mouth and face. It primarily affects young children (between the ages of 2 years to 6 years) in regions of extreme poverty.

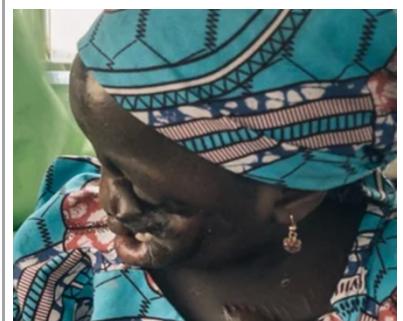
It starts as an inflammation of gums, which, if not treated early, spreads quickly to destroy facial tissues and bones.

Cause: Evidence indicate that NOMA is caused by bacteria found in the mouth. There are multiple risk factors associated with the disease. It includes malnutrition, weakened immune system, infections, and extreme poverty. If the child is malnourished and has recently been sick with an infectious disease, such as measles or chickenpox, they are at more risk for developing noma.

It is not contagious but tends to strike when the body's immune system is weak.

Impact: It can be fatal and may also cause severe disfigurement for survivors.

Treatment: It involves antibiotics, advice and support on practices to improve oral hygiene with disinfectant mouth wash and nutritional supplements. In case of early diagnosis, proper wound healing without long-term consequences may take place. In severe cases, surgery may be necessary.



NOMA is sometimes called the 'Face of Poverty' as it is a social marker of extreme poverty and malnutrition.

Significance of Including NOMA in the NTD's list:

- Amplify global awareness.
- Catalyze research, stimulate funding and boost efforts to control

Cases are mostly found in sub-Saharan Africa. Some cases are also reported from Americas and Asia.

the disease through multisectoral and multi-pronged approaches.

Accurate estimation of the number of noma cases is challenging due to rapid progression of the disease and the associated stigma.

14. NON-COMMUNICABLE DISEASES

1) HYPERTENSION (HIGH BLOOD PRESSURE)

- **Why in news?**
 - » Who releases its first-ever report on global impact of high BP, states approximately four in every five not treated adequately (Sep 2023)
- **What is Blood Pressure?**
 - » **Blood pressure** is a measure of how much the blood moving through your arteries pushes against the vessel walls. According to medical standards, the reading on a doctor's BP monitor going above 140/90 accounts for hypertension. **High Blood Pressure (Hypertension)** is a serious medical condition that significantly increase the risks of heart, brain, kidney and other diseases.
 - » A large number of people who suffer from hypertension are unaware of this, therefore it is also sometimes referred as a silent killer.
 - » It is a condition that knows no boundaries affecting people of every age and different socio-economic conditions. It can't be cured but can be managed through lifestyle changes, medication, and regular monitoring.
- **WHO Report on Global Impact of High BP (Sep 2023)**
 - » Hypertension affects 1 in 3 adults worldwide and around 1/3rd of the adults with hypertension are unaware of their conditions. Nearly 4/5 people with hypertension are inadequately treated. Scaling up coverage can avert 76 million deaths between 2023-2050.
- The number of people living with hypertension (blood pressure of 140/90 mmHg or higher or taking medication for hypertension) doubled between 1990 and 2019, from 650 million to 1.3 billion.
- **Hypertension Situation in India:**
 - » **As per a paper published in *The Lancet*:**
 - Hyper Tension is the most important risk factor for death and disability in India.
 - Less than 1/4th of hypertensive patients in India had their blood pressure under control during 2016-2020.
 - There is a growing prevalence of hypertension amongst younger adults and those from lower socioeconomic backgrounds.
 - » **NFHS-5** reported a hypertension prevalence of 24% in men and 21% among women, an increase from 19% and 17% respectively from the previous round (NFHS-4)

- **Key Issues with Hypertension situation in India:**
 - Lack of Awareness:** As per WHO, 1/3rd of the hypertension patients don't even know that they are suffering from hypertension.
 - Limited Access to healthcare services**
 - Inadequate adherence** to medication and lifestyle modifications

A) BENEFITS OF REDUCING SALT INTAKE (DEC 2022)

- Adding less salt to food -> Fewer heart attacks and strokes.
 - This was found to be true even in participants who were following DASH diet (Dietary Approaches to Stop Hypertension).
 - **DASH** is the best recommended diet to prevent cardiovascular events. It involves eating fruits, vegetables, lean meat, poultry, nuts, whole grains, and reducing intake of saturated fats, cholesterol, and sugar.
 - WHO recommends only 5 gm of salt per day.
- **Other key things to know:**
 - **Sodium** intake from processed and restaurant food contributes to high rates of high blood pressure, heart attack, and stroke. Reducing sodium intake could prevent thousands of deaths annually.
 - **How does salt raise blood pressure** -> Class discussion?

2) DIABETES AND INSULIN

A) WHAT IS DIABETES?

- A medical condition when person's blood sugar level is too high.
- It is classified in **two types**:
 - » **Type 1 diabetes:** This type of diabetes appears in childhood where body can't make insulin or make insufficient Insulin, a hormone that regulates blood sugar level. It helps glucose get into cell. This condition occurs because body's immune system attacks the cells in the pancreas that make insulin.
 - » **Type 2 diabetes:** The body doesn't make enough insulin or when cells are not responding to insulin. This type of diabetes is associated with **obesity** and can lead to blindness, strokes, heart disease and even death.

B) TYPE 1 DIABETES LEADING CAUSE OF DIABETES DEATHS IN THOSE BELOW 25, EASILY PREVENTABLE: STUDY PUBLISHED IN LANCET

- » **Type 1** diabetes in those below 25 years accounted for at least 73.7% of the overall 16,300 diabetes deaths in this age group in 2019. This is despite fatalities from this condition being largely curable.
- » The **death rate** varied based on the Socio-demographic index (SDI) of a country.
 - Countries on the higher end of the SDI spectrum recorded 0.13 deaths per 100,000 people.

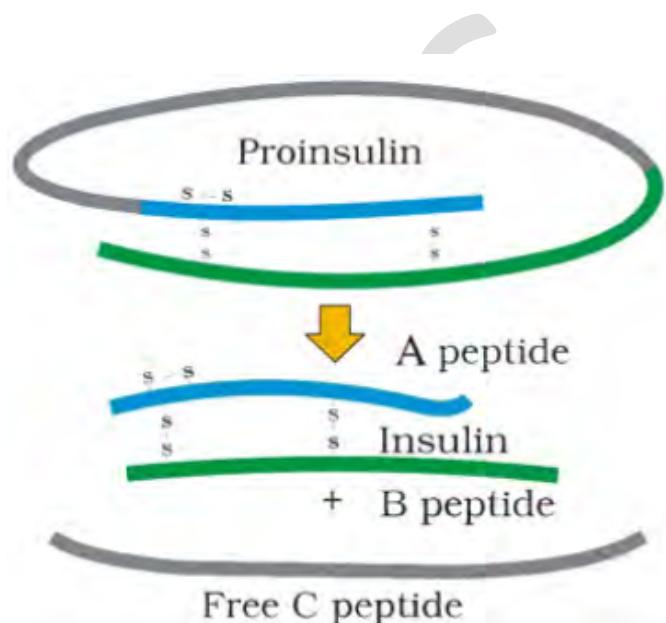
- Countries on the low middle SDI spectrum recorded 0.6 deaths per 100,000 people.
- Countries on low SDI spectrum recorded a 0.71 per 100,000 population death rate.
 - Myanmar (1.93/1,00,000 population), Papua New Guinea (1.78 per 100,000 population) and Haiti (1.57 per 100,000 population) had the highest age-standardized death rates for diabetes.

C) INSULIN

- **Details**
 - » Insulin is a peptide hormone produced by pancreas. Inside the pancreas, the hormone insulin is made in the beta cells, which are part of islets of Langerhans. With each meal, beta cells release insulin to help the body use or store the blood sugar it gets from the food.
 - » In the beta cells, insulin is first created as a big molecule called "proinsulin". Proinsulin is broken into two pieces: Insulin and C-Peptides.
 - » **Note:** Insulin cannot be taken as pill as it would be broken down during digestion just like the protein in food. It must be injected into the fat under your skin for it to get into your blood.
- **Discovery of Insulin:**
 - » Insulin was discovered in 1921 by **Sir Frederick G Banting**, Charles H Best, and JJR Macleod at the University of Toronto in 1921 - after which it was purified by James B Collip for safer testing on humans. It was the **greatest medical breakthrough of the 20th century** and remains the go-to treatment for type-1 diabetes globally today.
 - **Note:** Back in the 19th century, those suffering from type-1 diabetes were rarely expected to live longer than a year or two after detection. This happens because type-1 diabetes is an autoimmune disease where the body destroys the cluster of cells in the pancreas
 - » In **Jan 1922**, Leonard Thompson was administered first dose. **Banting and Macleod** went on to win the **Nobel prize in Physiology** or Medicine on Oct 25, 1923.
 - » **Important Video:** 100 years of insulin use: How it was discovered and where we stand today
- **Situation today:**
 - » Globally, 15/1 lakh people suffer from type-1 diabetes. The international diabetes federation have estimated that 451 million adult suffered from diabetes worldwide in 2017. This would increase to 693 million by 2026 if not effective prevention methods are adopted.

D) NON SUGAR SWEETNERS

- **What are non-Sugar Sweeteners?**



- » Non-Sugar Sweeteners (NSS) or Non-Nutritive Sweeteners (NNS) are substances used in place of sweeteners that have sugar (sucrose) or sugar alcohols. They have negligible or zero calories because, unlike sugar, they don't get broken down by the body into products that provide energy or calories.
- » They are used as tabletop sweeteners as well as in food items marked as 'Sugar Free', 'Diet' etc.
- » They are of primary **two types - i) Artificial, ii) Natural**
 - **Artificial:** These NSS are prepared in laboratories. Examples include Aspartame, Saccharine, Acesulfame-potassium, Sucratose, Neotame (derived from aspartame), Advantame (derived from aspartame) etc.
 - **Natural:** These are extracted from plants (e.g. Stavia, Thaumatin, Monk Fruit etc.)
- » All the six artificial NSS and 3 natural NSS are approved by the US Food and Drug Administration. India's FSSAI has also approved all of them (except Advantame, and Monk Fruit).

- **Why are they used?**
 - » TO reduce consumption of sugar (which has led to global rise in diabetes and obesity).
- **Market:**
 - » As per a report by global market consultancy The Business Research Company the market for these NSS was worth \$20 billion in 2022 and it is expected to reach about \$30 billion by 2027.
- **Criticisms:**
 - Little Evidence to substantiate the benefits of NSS in controlling diabetes and obesity.
 - Growing body of research says that these NSS may lead to cardiovascular diseases, cancers, and type-2 diabetes.
 - For e.g. WHO in its July 2023 guidelines have classified Aspartame as "possibly carcinogenic to humans".

D) PRELIMS FACTS: ASPARTAME:

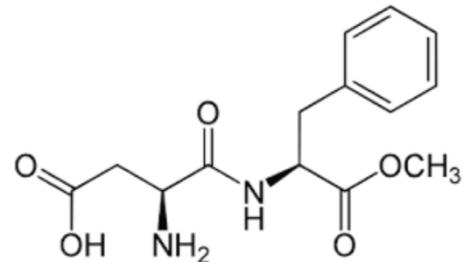
Aspartame is an artificial sweetener which was invented in 1965 and has been in use in USA since early 1980s.

It is a compound of carbon, hydrogen, nitrogen, and oxygen with chemical formula $C_{14}H_{18}N_2O_5$.

It is among the most popular sugar substitute used in the world.

Several Studies have highlighted problems associated with Aspartame:

- The **WHO** analyzed some 1,300 studies, and cited the following three, to declare aspartame "possibly carcinogenic to humans" -> European Journal of Nutrition, 2016; Cancer Epidemiology, 2022; Cancer Epidemiology, Biomarkers & Prevention, 2022;



- **WHO has placed aspartame in Group 2B.** This group consist of those substances which are possibly carcinogenic.
- **Details about various Groups:**

- » **Group-1: Carcinogenic:** These substances have shown sufficient evidence in humans and animals to be treated as carcinogenic. It includes tobacco smoking, alcohol consumption, Solar Radiation, ionizing radiation.
- » **Group-2A: Probably Carcinogenic:** Limited evidence in humans but sufficient evidence in animals. It includes insecticide DDT, Red Meat, Night Shift Work, Emission from high temperature frying etc.
- » **Group-2B: Possibly Carcinogenic:** Limited evidence in humans or sufficient evidence in animals. It includes aspartame, gasoline engine exhaust, heavy metal lead;
- » **Group-3: Not classified as carcinogen:** Inadequate evidence in humans and in animals. It includes coffee, Mercury, Paracetamol, crude oil etc.

15. RARE GENETIC DISEASES

- **Introduction**
 - » A rare disease is a health condition of low prevalence that affects a small number of people compared with other prevalent diseases in general population.
 - They generally include genetic diseases, rare cancers, infectious tropical diseases, degenerative diseases etc.
 - » The most common rare diseases recorded in India are Haemophilia, Thalassemia, sickle cell anaemia, primary immuno-deficiency in children, auto-immune diseases, Lysosomal storage disorders such as Pompe disease, Hirschsprung disease, Gacher's disease, Cystic fibrosis etc. These diseases may be impacting around 70 million people from India, 50% of which are children.
- **Why special focus is needed for rare diseases / Need of a separate policy on Rare Diseases**
 - » **High cost of treatment** or no treatment -> not affordable for most of the citizens -> health insurance generally excludes rare diseases.
 - Available are primarily expensive because pharma companies are not interested in R&D as the number of patients for each disease is very less (Orphan Drugs)
 - As per WHO, only 5% of the identified rare diseases have treatment.
 - » **Difficult to diagnose.**
 - » **Early screening generally doesn't happen** because of lack of awareness among primary care physicians, lack of adequate screening and diagnostic facilities etc. There are very few medical professionals who can deal with these diseases
 - » Currently there is inadequate insurance cover and treating practitioners are lacking management practices.

1) NATIONAL POLICY FOR RARE DISEASES, 2021

- MoH&FW came up with the policy in March 2021.
- It aims to lower the high cost of treatment for rare diseases with increased focus on indigenous research with the help of a National Consortium to be set up by Department of Health Research, MoH&FW as convenor.

- It envisages creation of a national hospital based registry of rare diseases so that adequate data is available for definition of rare diseases and for R&D.
- It focuses on **early screening and prevention** through primary and secondary healthcare infrastructure such as H&W Centres and District Early Intervention Centres (DEICs) and through counselling of high risk parents.
 - Screening will also be supported by NIDAN Kendras set up by the DBT.
- The policy aims to strengthen tertiary health care facilities for prevention and treatment of rare diseases through designating 8 health facilities as Centre of Excellence and these CoEs will also be provided one-time financial support of upto Rs 5 crores for upgradation of diagnostic facilities.
- **Provision for financial support:** The policy was amended in May 2022. It now provides a financial assistance of upto Rs 50 lakh for treatment of rare diseases of all categories.
- The policy also envisages a **crowd funding mechanism** in which corporates and individuals will be encouraged to extend financial support through a robust IT platform for treatment of rare diseases.
 - Funds so collected will be utilized by CoEs for treatment of all three categories of rare diseases as first charge and then the balance financial research could also be used for research.
- **Performance of the policy (Critical Analysis)** (Jan 2023)
 - LS MP Varun Gandhi have written to Union Health Minister and have said that more than 4,000 identified patients of rare diseases - mostly children - are yet to receive the Rs 50 lakh financial assistance for treatment guaranteed by the Union Government under the National Policy for Rare diseases, 2021.
 - More than 10 children who were awaiting treatment have already lost their lives.
 - The 10 CoEs constituted under the policy are yet to seek financial assistance (crowdfunding) for patients with rare diseases.

2) SOME RARE GENETIC DISEASES IN MORE DETAILS

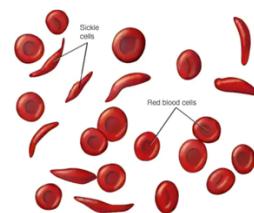
A) SICKLE CELL ANAEMIA

- **Why in news?**
 - » The first therapy based on gene editing technology Crispr-Cas9 for Sickle cell disease and thalassemia has been approved in UK (Nov 2023)

About Sickle Cell Anaemia:

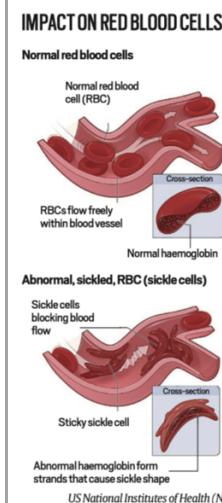
It is one of a group of inherited disorders known as Sickle Cell Diseases. It affects shape of the red blood cells which carry oxygen to all parts of the body.

RBCs are usually round and flexible so that they move easily through the blood vessels. But, in sickle cell Anaemia, some of the RBCs are shaped like sickle and also become rigid and sticky. This slows or blocks blood flow.



Note: Both Sickle Cell Anaemia and thalassemia are caused by errors in the gene for haemoglobin, a protein in the red blood cells that carry oxygen to organs and tissues.

Symptoms: Anaemia -> fatigue; Episodes of extreme pain called pain crises; Swelling of hands and feet; delayed growth and puberty; Vision problems etc.



THE UK DRUG REGULATOR, IN A LANDMARK BREAKTHROUGH, IN NOV 2023 APPROVED A GENE THERAPY FOR THE CURE OF SICKLE CELL DISEASE AND THALASSEMIA.

- This therapy is called **Casgevy**. It is the first licensed therapy in the world based on gene editing technology CRISPR-CAS9. This therapy edits the faulty gene that leads to these blood disorder, potentially curing person for life.
- **How does the therapy work?**
 - » The therapy uses the patient's own blood stem cells, which are precisely edited using Crispr-Cas9. A gene called BCL11A, which is crucial for switching from foetal to adult is targeted in the therapy.
 - » Foetal haemoglobin, which is naturally present in everyone at birth, doesn't carry the same abnormalities as adult haemoglobin. The therapy uses the body's own mechanisms to start producing more of this foetal haemoglobin, alleviating the symptoms of the two conditions.
- **How is the therapy prepared and given:**
 - » **Casgevy** is one time treatment for which the doctor has to first collect blood stem cells from the bone marrow using a process called apheresis - used to filter out the blood for different components. The cells are then sent to the manufacturing site where it takes about six months for them to be edited and tested.
 - » **Then the edited cells are then transplanted**. Before this doctor gives a conditioning medicine for a few days to clear the bone marrow of other cells that will be replaced by modified cells.
 - » **The patient has to stay in hospital for at least one month** so that the edited cells take up the residence in bone marrow and start making RBCs with normal haemoglobin.
- **Side effects** from the treatment are similar to those associated with autologous stem cell transplants, including nausea, fatigue, fever and increased risk of infection.
- **Key challenges of the treatment:**
 - » **Very Costly**: it is estimated that the therapy will cause around \$2 million per patient, which is in line with other gene therapies.

- » **Absence of local manufacturing technology:** This means that the harvested blood stem cells have to be sent across countries.
- » **Preventing the misuse of CRISPR-CAS9:**

- **Situation in India:**

- An estimated 30,000 - 40,000 children in India are born with this disorder every year. Thus, India has one of the highest burdens of sickle cell anaemia in the world.

- **Steps taken by India:**

- In Budget 2023-24, a Mission to Eliminate Sickle Cell Anaemia by 2047 was announced. It entails awareness creation, universal screening of 7 crore people in the age group of 0-40 years in affected tribal areas, and counselling through collaborative efforts.

B) THALASSEMIA:

- Thalassemia is an inherited blood disorder in which the body makes an abnormal form of hemoglobin.

- If both of your parents are carriers of thalassemia, you have a greater chance of inheriting a more serious form of disease.

- The disorder results in excessive destruction of RBCs, which leads to anemia.

- **Treatment Option**

- Blood Transfusion
- Bone Marrow transplantation
- Medication and supplements
- Possible surgery to remove spleen or gallbladder.

- **Situation in India**

- India is the thalassemia capital of the world with 40 million carriers (highest in the world) and over 1,00,000 patients (Majors) under blood transfusion every month. It is the most common genetic blood disorder that is prevalent in India.
- People suffering from the disease are unknowingly transferring on this genetic disorder to their children.

- Around 10,000 births of Thalassemia major are taking place every year.

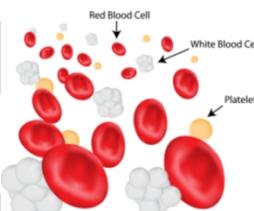
- Most of the thalassemia treatment takes place in private sector with out-of-pocket expenses.
- The 2021 policy and associated benefits haven't been operationalized yet.

- **World Thalassemia Day**

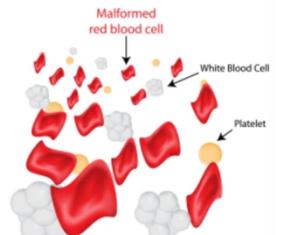
- It is observed on May 8 every year to commemorate Thalassemia victims and to encourage those who struggle to live with the disease.
- The day was created by Thalassemia International Federation (TIF) in 1994.
- **Theme for 2023:** "Strengthening Education to Bridge the Thalassemia Care gap"

Thalassemia

Normal



Thalassemia



C) HUNTER SYNDROME OR MPS-II

1. It is a very rare inherited, genetic disorder caused by a missing or malfunctioning enzyme iduronate 2-sulfatase. This enzyme's job is to break down certain molecules (large sugar molecules called glycosaminoglycans), and without enough of this enzyme, the molecule build up in harmful amounts.
2. The buildup of massive amounts of these harmful substances eventually causes permanent, progressive damage affecting appearance, mental development, organ function and physical disabilities.
3. The condition is one type of a group of inherited metabolic disorders called mucopolysaccharidoses (MPSs). Hunter syndrome is also known as MPS II.
4. **Cure:** There is no cure for hunter syndrome. Treatment involves managing symptoms and complications.
5. **It mainly affects males.**
 - It is caused by a defective X chromosome. For females, even if one X chromosome is defective, the other may provide the correct gene. But males have only one X chromosome and hence the defective X chromosome would lead to Hunter Syndrome.

D) HAEMOPHILIA A AND HAEMOPHILIA B (ALREADY DISCUSSED WITH BIOTECHNOLOGY)

16. OTHER DISEASES

1) DEMENTIA

- **Details**
 - **What is dementia?**
 - It is the loss of cognitive functioning - thinking, remembering, and reasoning - to such an extent that it interferes with a person's daily life and activities.
 - Dementia is more common as people grow older (about 1/3rd of all the people aged 85 or older may have some form of dementia) but it is not a normal part of aging. Many people live in 90s and beyond without any sign of dementia.
 - There are different forms of dementia including Alzheimer's disease which is responsible for 70% of the cases.
 - **Situation in India:**
 - According to a 2020 report published by the Alzheimer's and Related Disorder Society of India, there are 5 million people in India living with dementia.
 - **Cause:** When healthy neurons, or nerve cells, in the brain stop working; sometimes genetic mutation may also be responsible.
 - The exact causes of Alzheimer's are still unknown, but a classical feature of the disease is the build up of two proteins in the brain: beta amyloid and tau.

- In people with Alzheimer's, **beta-amyloid** is usually found in large quantities outside of neurons (brain cells), and tau "tangles" are found inside axons, the long, slender projection of neurons.
- Three genes have been linked to Alzheimer's disease in the young: **amyloid precursor protein (APP)**, **presenilin 1 (PSEN1)** and **presenilin 2 (PSEN2)**.
 - These genes are involved in producing a protein fragment called **beta-amyloid peptide**, a precursor to the previously mentioned beta-amyloid. If the gene is faulty, it can lead to an abnormal build-up (plaques) of beta-amyloid in the brain – a hallmark of Alzheimer's disease and a target for treatments such as the recently approved drug **lecanemab**.
 - People only need **one of APP, PSEN1 or PSEN2** to be faulty to develop **Alzheimer's disease**.
- Prevention of Dementia:
 - No proven prevention
 - In general, **leading a healthy lifestyle** may help reduce the risk factors that have been associated with these diseases.
- A 19-year-old from China is the youngest person to be diagnosed with Alzheimer's disease - the cause is a mystery (Feb 2023)
 - Nearly, all cases of Alzheimer's disease in people younger than 30 are due to **inherited faulty genes**. In fact, the previous youngest case - a 21-year-old - had a genetic cause.
 - But, in this case, **genetic cause was ruled out**.
- Lecanemab gains FDA approval for early Alzheimer Disease (Jan 2023)
 - This is a treatment that may **moderately slow mild cognitive decline and reduce amyloid-B plaques in the patients with early Alzheimer disease**. It gained **accelerated approval from the US FDA**.

17. MITOCHONDRIAL DISEASE

- Introduction
 - » Mitochondrial disease is a group of disorders **caused by dysfunctional mitochondria**, the organelles that generate energy for the cell.
 - » It is an **inherited chronic illness** that can be **present at birth or develop later in life**. It causes debilitating physical, developmental, and cognitive disabilities with symptoms including poor growth; loss of muscle coordination; muscle weakness and pain; seizures; vision and/or hearing loss; gastrointestinal issues; learning disabilities; and organ failures. About 1 in 2000 people have this disease in USA. It's **progressive and there is no cure**.
 - » There are many forms of mitochondrial disease, and it is inherited in a number of ways.
- What causes Mitochondrial diseases?
 - » For many patients, mitochondrial disease is an **inherited genetic condition**. Some percentage of patients **acquire symptoms** due to **other factors, including mitochondrial toxins**.
 - » The types of inherited mitochondrial diseases inherited include:
 - **DNA inheritance** (DNA contained in the nucleus of the cell). Also called autosomal inheritance

- **MtDNA Inheritance (DNA contained in mitochondria)**
 - There is **100% chance of trait occurring in other siblings, since all mitochondria are inherited from mother**, although symptoms might be more or less severe.
 - Note: Mitochondrial DNA is separate from DNA found in the cell nucleus and does not affect human characteristics such as hair or eye color, appearance or personality traits.
- » **Other causes**
 - Diseases specifically from deletions of large parts of mitochondrial DNA molecule are usually sporadic without affecting other family members.
 - Medicine or other toxic substances can trigger mitochondrial disease.
- **Treatment**
 - » The goal is to improve symptoms and slow the progression of diseases.
 - Use vitamin therapy.
 - Conserve energy
 - Pace activities
 - Maintain an ambient environmental temperature.
 - Avoid exposure to illness.
 - Ensure adequate nutrition and hydration.
- **Three Parent Babies**
 - » In 2015, Britain became the first country in the world to allow a three-parent baby to prevent some inherited incurable diseases.
 - » It is considered only hope for women who carry defective mitochondria to have healthy children. It is designed to help couples with mitochondrial disease, incurable condition passed down the maternal line that affect around one in 6500 children worldwide.
 - » The treatment is known as "three-parent" in vitro fertilization (IVF) because the babies, born from genetically modified embryos, would have DNA from mother, a father and from a female donor.
- In 2018, UK doctors selected first women to have 'three person babies'.
 - They carried genetic mutations which caused rare genetic disease.

How to make a three-person embryo



18. ANTI-MICROBIAL RESISTANCE

- **Why in news?**
 - » **Genes fuel antibiotic resistance in Yemen Cholera Epidemic (Sep 2023)**
 - The Cholera outbreak in Yemen, which began in 2016, is the largest in modern history and anti-biotic resistance has become widespread among V. cholerae bacteria since 2018.

- A study has found the **presence of a new plasmid** - a small, circular DNA molecule - in *V. cholerae* from late 2018 to the bacterial strain behind the epidemic. This plasmid introduced **genes encoding resistance to multiple clinically used antibiotics**, including macrolides (such as azithromycin).
- **Introduction:**
 - » Antibiotic resistance occurs **when an antibiotic has lost its ability to effectively control or kill bacterial growth**; in other words, the **bacteria become "resistant" and continue to multiply in the presence of therapeutic levels of antibiotic**.
- Why do bacteria become resistant to antibiotic?
 - » **Natural Phenomena: Evolution** - Selective pressure for the survival of resistant strains of bacteria.
 - » **Human Action:** **Current higher levels of antibiotic resistant bacteria are attributed to the overuse and abuse of antibiotics**.
- **How do bacteria become resistant?**
 - » Some bacteria are naturally resistant to certain type of antibiotics.
 - » However, bacteria may also become resistant **in two ways**
 - **By Genetic Mutation**
 - **By acquiring resistance from another bacterium**.
- **Why Anti-biotic resistance is more prevalent in India: Key Factors**
 - » **India is the largest consumer of anti-microbials globally** and the use of **last resort anti-microbials like cephalosporins is soaring**.
 - **Easy availability and overuse** of anti-biotics is the most important factor: Over the Counter Availability; Irrational Use; over-prescription by doctors
 - » **Poor Health Sector** -> improper treatment -> Development of anti-biotic resistance
 - Further, **exposure to subtherapeutic levels of anti-microbials or non-adherence to prescribed medications** has also been cited as a driver of AMR
 - E.g.: in case of TB
 - » Increasing and completely **unregulated use of antibiotic in Agriculture, live stocks and Poultry sector**.
 - **Amount of antibiotics used in the farm animal and food industry is three to four times more than those used by humans**.
 - For instance, **Colistin is extensively used in veterinary practices as a growth promoter**. This leads to generation of colistin-resistant bacteria in poultry and fresh water fish.
 - » **Poor Sanitation conditions** -> More diseases -> More use of medicines -> More AMR development
 - » **Unchecked discharge of effluents by the pharmaceutical industries** -> high concentration of pharmaceutical substances are found in **surface and ground water systems near production facilities** -> anti-biotics cause development of anti-microbial resistance in environment.
- **Impact of increasing anti-microbial resistance**
 - » **Damage to Public Health:**

- In 2019, drug-resistant superbugs killed about 1.27 million people globally - a toll more than HIV/AIDs or malaria - and according to the UN estimates, the number could reach 10 million by 2050.
 - Demands complicated treatment pattern, with longer stay in hospitals -> increase in cost of treatment.
 - Stronger antibiotics which are used after the first line of drugs fail generally have toxic side effects
 - Resistance also emerging for second line of drugs (e.g. XDR-TB emerging)
 - Without functional anti-microbials to treat bacterial and fungal infections, even the most common surgical procedures, as well as cancer chemotherapy, will become fraught with the risk of untreatable infections.
 - All this is compounded by the fact that no new class of anti-biotics have made it to the market in the last three decades, largely on account of inadequate incentives for their development and production.
- » **Economic damages** due to AMR can be equivalent to what 2008-09 economic shocks resulted into: UN Report
- » **Environmental Damages**
 - Extensive amount of anti-biotics lead to development of AMR in some micro-organisms. It impacts the microbial biodiversity and thus the environmental balance needed.
- **Steps that government has taken:**
 - **National Policy** for Containment of Antimicrobial Resistance, 2011
 - Guidelines for appropriate antibiotic usage which have revised Schedule H drugs to make over-the-counter availability of certain antibiotics nearly impossible
 - Programs such as Red Line Campaign
 - Sanitation campaigns such as Swatch Bharat Mission etc.
 - National Surveillance system for AMR (April 2017)
 - **National Action Plan on Antimicrobial Resistance (April 2017):** Focused on enhancing awareness, strengthening surveillance, improving rational use, promoting research and supporting neighboring countries.

19. SMOKING/DRINKING ETC.

1) SPURIOUS LIQUOR/ HOOCH TRAGEDIES/ METHYL ALCOHOL

- **Why do spurious drinks become poisonous sometime?**
 - » **Excess Methanol:** Illicit brewing is unscientific, hooch brewers inadvertently mix excessive amounts of methanol in their liquor every once in a while, leading to mass death.
 - » **Why is Methyl Alcohol (Methanol) used?**
 - It is similar in appearance and test to Ethyl Alcohol
 - It is easily available.
 - In Industry it is used as antifreeze, solvent, fuel, and ethanol denaturant.
 - » The potential lethal dose of methanol is variable, adverse effects has reportedly occurred at 30 ml. The toxicity of methyl alcohol manifests as permanent blindness or ultimately death due to respiratory failure.
 - » **Why is Methanol poisonous?**

- Due to accumulation of formic acid, a metabolite of methanol metabolism.
- Why do people go for this kind of drink?
 - » Cheap Price:
 - » Availability
 - » Strong effect
- Other reasons Spurious liquor prosper-> Corruption

20. INTERNATIONAL INITIATIVES

2) THE LANCET

- Details about the Lancet:
 - » The Lancet is a weekly peer-reviewed general medical journal and one of the oldest of its kind. It is also world's highest-impact academic journal. It was founded in 1823.
 - » It publishes original research articles, review articles, editorials, book reviews etc.
 - » The journal has editorial offices in London, New York City, and Beijing.
- The Lancet announced a new commission on Dec 15, 2022, to address public health threats.
 - » The scope of work by The Lancet Commission on 21st-Century Global Health Threats includes demographic changes and inverted population pyramids, high body mass index, anti-microbial resistance, eroding sexual and reproductive rights for women, food security, and fraying multilateralism.
 - » In 2024, the body will release its report after detailed study of 2 years.

21. FOOD SAFETY

1) LAWS AND INSTITUTIONS

A) FOOD SAFETY AND STANDARDS ACT, 2006

- Came into force in 2011.
- Key Provisions
 - i. **Consolidation of existing mechanisms**
 - The FSS Act consolidated a number of food legislations, rules, orders etc and established a single law for all matters relating to food safety and standards.
 - It subsumes acts like Prevention of Food Adulteration Act, 1954, The Fruit Product Order, 1955 etc.
 - ii. **Classification into standardized and non-standardized**
 - **Standardized Food products** - Standards are prescribed and do not require product approval prior to manufacture, sale distribution, or import. The first time manufacturer or importer only requires an FSSAI license to begin a food business.
 - **Non-standardized food products** - don't have standards as their safety parameters are either not known or either not yet ascertained.

- iii. **Statutory Authority: Food Safety and Standards Authority of India (FSSAI) and State Food Safety Authorities**
 - FSSAI is the apex body for food quality regulation in the country. It is responsible for setting standards and regulate, manufacture, storage, distribution, sale and import of food items to ensure food safety.
- iv. **Commissioner of Food Safety of state**
 - Appointed by respective state governments.
 - For efficient implementation of the Food Safety Act and various rules and regulations regarding food safety
 - Commissioner also responsible for appointing Food Safety Officers for various local areas
- v. **Graded Punishment and penalties** for contravention of the Act
- vi. **Adjudicating and Appellate Tribunal**

B) FOOD SAFETY AND IPC

- **Section 272 of IPC** prescribed punishment for adulteration of food or drink intended for sale.
- **Section 273 of IPC** punishes sale of noxious food or drink.
 - These two sections provides for imprisonment (upto six months) and/or fine (upto 1,000 rupees)

C) STATE FOOD SAFETY INDEX (FSI)

- **Details**
 - SFSI is an index developed by FSSAI. It aims to measure the performance of states and UTs on selected parameters of food safety.
 - It is aimed at encouraging states and Uts to improve their performance and work towards establishing a proper od safety ecosystem in their jurisdiction.
 - It is an annual report which has been released since 2018-19.
 - **Key Parameters used:**
 - » **Human Resources and Institutional Data (20%):**
 - » **Compliance (30%)**
 - » **Food Testing - Infrastructure and Surveillance (20%):**
 - » **Training and Capacity Building (10%)**
 - » **Consumer Empowerment (20%)**

22. MAKING MEDICINES AFFORDABLE

1) GENERIC MEDICINES:

- **Why in news recently?**
 - » On Aug 2023, the National Medical Council (NMC) directed all doctors to prescribe only generic names and not brand names which led to protest. Following the Indian Medical Association's protest, the NMC has withdrawn the order on 'generic prescribing' since Aug 23, 2023.
 - **Why the protest?**

- Doctors trust certain brands
- The control over which brands to take will go to chemist shops.
- **What is a generic drug?**
 - Generic drug is a low cost version of pharmaceutical drug that is equivalent to a brand-name product in dosage, strength, route of administration, quality, performance and intended use.
 - They usually enter market after patent protection of the original drug expires.
- **Note:** Broadly Medicines can be of three types:
 - **Branded:** These are still on patent
 - **Branded Generic:** Off-Patent and Generic, but nonetheless produced by a reputed company, with a brand.
 - **Generic:** Off Patent, and unbranded.
- **Advantages**
 1. Affordable healthcare
 2. Breaks the doctor-pharma nexus
 - Reduce unnecessary prescription
 3. Promotes domestic pharma companies.
 4. Difficult for quacks to function
- **Limitations**
 1. Quality concerns
 2. Erode doctor-patient relationship
 3. Low profit margins for retailers
 4. Shortage
 5. Difficult for common person to understand, especially the multiple salt names in a FDC.
 6. May discourage big pharma companies to launch their new medicines in India

2) JAN AUSHADHI KENDRAS

- **Intro:**
 - » Pradhan Mantri Bhartiya Janaushadhi Pariyojna (PMBJP) was launched by Department of Pharmaceuticals, Ministry of Chemical and Fertilizers, Government of India as a direct market intervention scheme in 2008.
- It aims to make quality generic medicines available to all at affordable prices through Jan Aushadhi Stores (JAS) opened in each district of the states.
 - » First Jan Aushadhi Store (JAS) was opened at Amritsar Civil Hospital in 2008.
- Other key focus of the scheme is to create awareness and demand for generic medicine.
- **Incentives given:**
 - » The scheme provides an excellent opportunity of self-employment with suitable and regular earnings.

- » An incentive of **Rs 5,00,000** is provided to the Jan Aushadhi Kendras as financial assistance and one-time additional incentive of Rs 1 lakh (as reimbursement for IT and infra expenditure) is provided to Jan Aushadhi Kendra opened in **North-Eastern India, Himalayan state, island territories, and backward areas identified by NITI Aayog as aspirational districts or if opened by women entrepreneurship, Ex-Serviceman, Divyangs, SCs and STs.**
- As of Jan 2023, **9,000 Jan Aushadhi Kendras** are functional across the country.
 - » The government has set up a target to increase the number of Jan Aushadhi Kendras to **10,000 by March 2024.**
 - It offers **1759 medicines, and 280 surgical devices** covering all major therapeutic groups.

PYQs:	
1	<p>Living organisms require at least 27 elements, of which 15 are metals. Among these, those required in major quantities include: [Prelims 1995]</p> <p>(a) Potassium, manganese, molybdenum and calcium (b) Potassium, molybdenum, copper and calcium (c) Potassium, Sodium, Magnesium, and Calcium (d) Sodium, Magnesium, Copper and manganese</p>
2	<p>Which of the following hormones contains iodine? [1995]</p> <p>(a) Thyroxine (b) Testosterone (c) Insulin (d) Adrenaline</p>
3	<p>Which of the following are associated with <i>Diabetes mellitus</i>, a common disease in adults? [1996]</p> <ol style="list-style-type: none"> 1. Higher sugar level in blood 2. Low sugar level in blood 3. Lower insulin level in blood 4. Higher insulin level in blood <p>Select the correct answer by using the codes given below:</p> <p>A. 2 and 4 B. 1 and 2 C. 2 and 3 D. 1 and 3</p>
4	<p>Consider the following statements: [1996]</p> <p>AIDS is transmitted</p> <ol style="list-style-type: none"> 1. By sexual intercourse 2. By Blood Transfusion 3. By Mosquito and other blood sucking insects 4. Across the placenta <p>Select the correct answer using codes provided below:</p> <p>A. 1, 2 and 3 B. 1, 2 and 4</p>

	C. 1, 3 and 4 D. 1 and 3										
5	Which of the following leads to malnourishment? [1996] 1. Overnutrition 2. Undernutrition 3. Imbalance nutrition Select the correct answer using the codes given below: A. 2 only B. 2 and 3 only C. 1 and 3 only D. 1, 2 and 3										
6	Antigen is a substance which: [1997] (a) lowers body temperature (b) destroys harmful bacteria (c) triggers the immune response (d) is used as an antidot to poison										
7	Consumption of fish is considered to be healthy when compared to flesh of other animals because fish contains: [1997] (a) polyunsaturated fatty acids (b) saturated fatty acids (c) essential vitamins (d) more carbohydrates and proteins										
8	Match List-I with List-II and select the answer using the codes given below: [1998] <table border="1" style="display: inline-table; vertical-align: middle;"> <thead> <tr> <th>List-1</th> <th>List-2</th> </tr> </thead> <tbody> <tr> <td>A - Malaria</td> <td>1 Fungi</td> </tr> <tr> <td>B - Polio</td> <td>2 Bacteria</td> </tr> <tr> <td>C - TB</td> <td>3 Virus</td> </tr> <tr> <td>D - Ringworm</td> <td>4 Protozoan</td> </tr> </tbody> </table> (a) A-4, B-3, C-2, D-1 (b) A-4, B-3, C-1, D-2 (c) A-3, B-4, C-1, D-2 (d) D-3, B-4, C-2, D-1	List-1	List-2	A - Malaria	1 Fungi	B - Polio	2 Bacteria	C - TB	3 Virus	D - Ringworm	4 Protozoan
List-1	List-2										
A - Malaria	1 Fungi										
B - Polio	2 Bacteria										
C - TB	3 Virus										
D - Ringworm	4 Protozoan										
9	Haemophilia is a genetic disorder which leads to: [1998] A. Decrease in haemoglobin level B. Rheumatic Heart Disease C. Decrease in WBC D. Non-clotting of blood										

10	<p>Assertion (A): Unsaturated fats are more reactive compared to saturated fats Reason (R): Unsaturated fats have only single bonds in their structure</p> <p>(A) Both A and R are true and R is the correct explanation of A (B) Both A and R are individually true but R is not the correct explanation of A (C) A is true but R is false (D) A is false but R is true</p>
11	<p>Consider the following statements about probiotic food: [2008]</p> <ol style="list-style-type: none"> 1. Probiotic food contains live bacteria which are considered beneficial to health 2. Probiotic food help in maintaining gut flora <p>Which of the statements given above is/are correct?</p> <ol style="list-style-type: none"> A. 1 only B. 2 only C. Both 1 and 2 D. Neither 1 nor 2
12	<p>Regular intake of fresh fruits and vegetables is recommended in the diet since they are good source of anti-oxidants. How do antioxidants help a person maintain health and promote longevity? [Prelims 2011]</p> <ol style="list-style-type: none"> A. They activate the enzymes necessary for vitamin synthesis in the body and help prevent vitamin deficiency B. They prevent excessive oxidation of Carbohydrates, fats and proteins in the body and avoid unnecessary wastage of energy C. They neutralize the free radicals produced in the body during metabolism D. They activate certain genes in the cells of the body and help delay the ageing process
13	<p>Which of the following is/are correct? [2013]</p> <ol style="list-style-type: none"> 1. Viruses lack enzymes necessary for the generation of energy 2. Viruses can be cultured in the synthetic medium 3. Viruses are transmitted from one organism to another by biological vectors only <p>Select the correct answer using the codes given below:</p> <ol style="list-style-type: none"> A. 1 only B. 2 and 3 only C. 1 and 3 only D. 1, 2 and 3
14	<p>Consider the following minerals [Prelims 2013]</p> <ol style="list-style-type: none"> 1. Calcium 2. Iron 3. Sodium

	<p>Which of the minerals given above is/are required by human body for the contraction of muscles?</p> <ol style="list-style-type: none"> 1 only 2 and 3 only 1 and 3 only 1, 2 and 3
15	<p>Which of the following diseases can be transmitted from one person to another through tattooing? [Prelims 2013]</p> <ol style="list-style-type: none"> Chikungunya Hepatitis B HIV-AIDS <p>Select the correct answer using the codes given below:</p> <ol style="list-style-type: none"> 1 only 2 and 3 only 1 and 3 only 1, 2 and 3
16	<p>Consider the following diseases: [Prelims 2014]</p> <ol style="list-style-type: none"> Diphtheria Chickenpox Smallpox <p>Which of the above diseases has/have been eradicated in India?</p> <ol style="list-style-type: none"> 1 and 2 only 3 only 1, 2 and 3 None
17	<p>H1N1 virus is sometimes mentioned in news with reference to which one of the following diseases? [Prelims 2015]</p> <ol style="list-style-type: none"> AIDS Bird Flu Dengue Swine Flu
18	<p>Which of the following statements is/are correct? (2016 Pre)</p> <p>Viruses can infect</p> <ol style="list-style-type: none"> bacteria fungi plants <p>Select the correct answer using the code given below.</p> <ol style="list-style-type: none"> 1 and 2 only 3 only 1 and 3 only 1, 2 and 3

19	<p>'Mission Indradhanush' launched by the Government of India pertains to (Pre 2016)</p> <ul style="list-style-type: none"> (a) immunization of children and pregnant women (b) construction of smart cities across the country (c) India's own search for the Earth-like planets in outer space (d) New Educational Policy
20	<p>Consider the following statements: (Pre 2017)</p> <ol style="list-style-type: none"> 1. In tropical regions, Zika virus disease is transmitted by the same mosquito that transmits dengue. 2. Sexual transmission of Zika virus disease is possible. <p>Which of the statements given above is/are correct?</p> <ul style="list-style-type: none"> (a) 1 only (b) 2 only (c) Both 1 and 2 (d) Neither 1 nor 2
21	<p>Which of the following statements is not correct? (Pre 2019)</p> <ul style="list-style-type: none"> (a) Hepatitis B virus is transmitted much like HIV. (b) Hepatitis B, unlike Hepatitis C, does not have a vaccine. (c) Globally, the number of people infected with Hepatitis B and C viruses are several times more than those infected with HIV. (d) Some of those infected with Hepatitis B and C viruses do not show the symptoms for many years.
22	<p>Which of the followings are the reasons for the occurrence of multi-drug resistance in microbial pathogens in India? [Prelims 2019]</p> <ol style="list-style-type: none"> 1. Genetic predisposition of some people. 2. Taking incorrect doses of antibiotics to cure diseases. 3. Using antibiotics in livestock farming. 4. Multiple chronic diseases in some people. <p>Select the correct answer using the code given below.</p> <ul style="list-style-type: none"> (a) 1 and 2 (b) 2 and 3 only (c) 1,3 and 4 (d) 2,3 and 4
23	<p>A company market food products advertises that its items don't contain trans-fats. What does this campaign signify to customers? [Prelims 2021]</p> <ol style="list-style-type: none"> 1. The food products are not made out of hydrogenated oils 2. The food products are not made out of animal fats 3. The oil used are not likely to damage the cardiovascular health of consumers <p>Which of the statements given above is/are correct?</p> <ul style="list-style-type: none"> A. 1 only B. 2 and 3 only C. 1 and 3 only D. 1, 2 and 3
24	<p>The term ACE2 is talked about in the context of (Prelims 2021):</p> <ul style="list-style-type: none"> A. genes introduced in the genetically modified plants B. development of India's own satellite navigation system

	<p>C. radio collars for wildlife tracking D. spread of viral diseases</p>
25	<p>In the context of hereditary diseases, consider the following statements: [Prelims 2021]</p> <ol style="list-style-type: none"> 1. Passing on mitochondrial diseases, from parent to child can be prevented by mitochondrial replacement therapy either before or after in vitro fertilization of egg 2. A child inherits mitochondrial diseases entirely from mother and not from father <p>Which of the statements given above is/are correct?</p> <ol style="list-style-type: none"> A. 1 only B. 2 only C. Both 1 and 2 D. Neither 1 nor 2
26	<p>Consider the following statements in respect of probiotics: [Prelims 2022]</p> <ol style="list-style-type: none"> 1. Probiotics are made of both bacteria and yeast. 2. The organisms in probiotics are found in foods we ingest but they do not naturally occur in our gut. 3. Probiotics help in the digestion of milk sugars. <p>Which of the statements given above is/are correct?</p> <ol style="list-style-type: none"> A. 1 only B. 2 only C. 1 and 3 D. 2 and 3
27	<p>'Wolbachia method' is sometimes talked about with reference to which one of the following?</p> <ol style="list-style-type: none"> (a) Controlling the viral disease spread by mosquitoes (b) Converting crop residues into packing material (c) Producing biodegradable plastics (d) Producing biochar from thermochemical conversion of biomass

TARGET PRELIMS 2024

BOOKLET-11; EB&CC-1

ENVIRONMENTAL ECOLOGY - BASICS

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2. SOME BASIC FACTS

1) RAMDEO MISRA

- He is considered the **father of ecology in India**. He was born in 1908 and obtained **Ph.D. in Ecology (1937)**, from LEEDS University in UK.
- He **established teaching and research in ecology at the Department of Botany of the Banaras Hindu University (BHU)**.
- His research laid the **foundations for understanding of tropical communities and their succession**, environmental responses of plant populations and productivity and nutrient cycling in tropical forest and grassland ecosystems.
- He **formulated first post graduate course in ecology in India**.
- Due to his efforts, the GoI established the **National Committee for Environmental Planning and Coordination (1972)** which, in later years, paved the way for the **establishment of the Ministry of Environment and Forest (1984)**.

3. ORGANISMS, POPULATION, ECOSYSTEM AND ECOLOGY

- **Ecology** is the study of the **relationships of living organisms with the abiotic (physical-chemical factors) and biotic components (other species) of their environment**. It is concerned with **four levels of biological organization – Organisms, Populations, Communities and Biomes**.

1) ORGANISM AND ITS ENVIRONMENT; ECOLOGY AND ECOSYSTEM

- **Environment:** Everything that surrounds an organism is its environment.
 - » In simple terms, **environment of an organism refers to the physical, chemical, and biological conditions and factors** that surround and influence the life of an organism. It includes **all the living (biotic components)** and non-living things (**abiotic components**) that an organism interacts with, such as the air, water, soil, light, temperature, **other organisms**, and the physical structure in its surroundings.
 - » The environment of an organism is critical for its survival and protection as it affects many aspects of its life including metabolism, behaviour, growth and development.
 - » **Understanding Environment of organism** is very important because:
 - Environment is **critical for the survival and protection**.
 - Different organisms have **different environmental requirements** and adaptations. Some may be **more tolerant or adaptable to change in their environment than others**.

- By studying environment of an organism, scientists can gain insights into how it has evolved and adapted to its surroundings and how it may respond to future changes in environment.
- **Ecology** is the study of relationship between living organisms, including humans and their environment. It seeks to understand the vital connections between plants and animals and the world around them. It seeks to understand how organisms interact with each other and with their physical environment, and how these interactions affect the sustainability of the entire system.

2) LEVEL OF ORGANISATIONS IN ECOSYSTEM

Ecosystems are complex and dynamic systems that can be studied at different levels of organization each provide a different perspective on the ecosystem. The level of organizations in ecosystem include:

- 1) **Individual Organisms:** The smallest unit of an ecosystem is the individual organism, such as a single plant, animal or microbe.
- 2) **Population:** A population is a group of individuals usually of the same species living in the same area and interacting with each other.
- 3) **Community:** It is a group of populations of different species living in the same area and interacting with each other. It consists of all the biotic factors of an area.
 - Communities in most cases are named after the dominant plant from (species). E.g. Grassland community is dominated by grasses. Though it may contain herbs, shrubs, some trees, and other animals. It is named after grasses.
 - **Communities can be classified into – Major Community vs Minor Communities**

Features:	Major Community	Minor Community
Definition:	These are <u>large sized, well organized, and relatively independent</u> (<u>self-sustaining</u>) and depend on only sun's energy and is independent of inputs and outputs from adjacent community. E.g. <u>Grasslands; Deserts; Evergreen rain forests etc.</u>	These are <u>smaller</u> and are <u>dependent on neighbouring communities</u> . These are secondary congregation within a major community and are <u>not therefore completely independent units</u> as far as energy and nutrient dynamics are concerned. E.g. (<u>stream within a forest; mat of lichen on a cow dung pad</u>)
Size	Large	Small; localized area
Self-sustainability	Yes	No; depends on resources from other neighbouring communities
Impact of disturbance	More resilient due to larger size and diversity	More vulnerable to disturbance due to smaller size and dependence on other community.

- 4) **Ecosystem:** It includes all the biotic and abiotic components in the given area and the interactions between them.

- 5) **Biome:** A biome is a large geographical area characterized by a specific set of climatic conditions and plant and animal communities.
- 6) **Biosphere:** The biosphere is the portion of the Earth that supports life, including all of the ecosystems on the planet

Each level of organization in an ecosystem is interconnected and interdependent, and changes at one level can have cascading effects on the other levels. Understanding the different levels of organization in an ecosystem can help us better understand how ecosystem function, how they respond to disturbance, and how we can manage them for sustainability.

3) ECOSYSTEM AND VARIOUS COMPONENTS OF AN ECOSYSTEM

- An ecosystem is a community of living organisms (plants, animals, and microorganisms) that interact with each other and with the non-living components (such as air, water, and soil).
- Ecosystem can vary in size, from a small pond to a vast forest. Each ecosystem is a functioning unit of nature.
 - Every organism in an ecosystem is dependent on the other component of the ecosystem. Therefore, if some part of the ecosystem is damaged, it has an impact on other organisms living in that ecosystem.
- **Components of Ecosystem:**

A) ABIOTIC COMPONENTS

- Energy
- Water/Rainfall
- Temperature
- Atmosphere
- Substratum (soil and minerals)
- Latitude and Longitude

B) BIOTIC COMPONENT

- It consists of living organisms and are classified as per their functional attributes into **producers** and **consumers**:
 - a) **Primary Producers (Autotrophs):** These are organisms which are capable of making their own food using sunlight (photosynthesis) or inorganic compounds (chemosynthesis).
 - Examples include plants, algae, and some bacteria.
 - b) **Consumers (Heterotrophs or phagotrophs)**
 - They don't produce their own food and depend on food derived from other plants, animals and other species.
 - They can be divided into macro-consumers and micro-consumers.
 - **Macroconsumers:** They feed on both plants and animals and can be classified into **herbivores/primary consumers** (e.g. Deer) (feed mainly on plants);

- carnivores/secondary consumers** (e.g. wolves) (feed on primary consumers); **carnivores/tertiary consumers** (e.g. lion) (feed on secondary consumers) and **Omnivores** (e.g. humans, monkeys etc.) (feed on both plants and animals).
- **Micro consumers – Saprotrophs** (decomposers or osmotrophs): These are bacterias and fungi which derive their energy and nutrients by decomposing dead organic substances (detritus) of plant and animal origin. They release inorganic nutrients into environment which are used by primary producers and thus are recycled. Earthworms, and some soil organisms (such as nematodes and arthropods) are detritus feeders and help in decomposition of organic matter and are called detrivores.

4) ECOTONE

Ecotone refers to the transitional zone or boundary where two different ecosystems or biomes meet and integrate with each other. It is characterized by a mix of vegetation, soil and animal species from both ecosystems, creating a unique habitat with its own set of ecological dynamics.

It can be found in various terrestrial and aquatic environments, such as where a forest meets a grassland, or where a river meets a lake.

Important Characteristics of ecotones:

- 1) **Transitional zone**
- 2) **High Species Diversity** compared to either of the adjacent ecosystem, as they contain species from both ecosystems and may offer greater range of resources for organisms.
 - a. **Edge Effect**: Sometimes number of species, and the population density of some of the species is much greater in this zone than either ecosystem. This is called edge effect.
 - b. **Edge Species**: Edge dwelling or ecotone dependent species are those that are particularly adapted to living in the transitional zone or boundary between two different ecosystems or biomes. These organisms occur primarily or most abundantly in the ecotone zone. In terrestrial ecosystem the edge effect is most applicable on birds. Density of birds is greater in the mixed habitat of ecotone between the forest and desert.
 - E.g., of edge species: Indian Spotted eagle; Indian rock python; Golden jackal etc.
- 3) **Unique Species Composition**: Ecotones may contain unique species that are specialized to the transitional habitat and not found in either adjacent ecosystem.
- 4) **Abiotic Gradient**: Ecotones may be characterized by abiotic gradient, such as changes in soil, water, temperature, or light conditions, which create different microhabitats and ecological niches for species.
 - a. This brings a linearity -> progressive increase in composition of one in coming community and a simultaneous decrease in species of the other outgoing adjoining community.

Significance of ecotone:

- **Support high level of biodiversity** due to greater range of resources (higher species richness and ecological resilience)

- Act as **important corridors for movement of species** between different ecosystems, allowing for a genetic exchange and maintaining population viability.
- **Important indicator of ecosystem health:** They can also be particularly sensitive to environmental changes and disturbances. Thus, they can inform conservationists about the required management efforts.

Overall, ecotones play a crucial role in maintaining the health and functioning of ecosystems, as well as providing important ecosystem services and biodiversity.

2) ECOLOGICAL NICHE

Ecological Niche refers to the role or position of a species within an ecosystem. It includes its interaction with biotic and abiotic factors of the ecosystem. It encompasses the species habitat requirements, food and water requirements, reproductive strategy and its relationship with other species in the ecosystem.

Niche Differentiation: Each species in an ecosystem occupies a unique ecological niche to minimize competition for resources. This allows different species to co-exist and allows for a greater biodiversity within an ecosystem.

- For example, some species may occupy a niche as primary producers, converting sunlight and inorganic nutrients into organic matter, while others may occupy a niche as **herbivores or carnivores**, feeding on the primary producers or other consumers in the ecosystem

Competitive Exclusion Principle: The two species competing for same limited resources cannot coexist in the same niche at a constant population level. If the needs are identical and resources limited than one will outcompete other leading to extinction or niche differentiation.

- **E.g.-1: Darwin Finches** (Galapagos Finches): On Galapagos island, different finch species have evolved different beak types so that they can depend on different kind of food sources. This allowed them to co-exist even within limited resources.
- **E.g.-1: Competitive Dominance:** An invasive species which has some competitive advantage can lead to extinction of native species.

Fundamental vs Realized Niche:

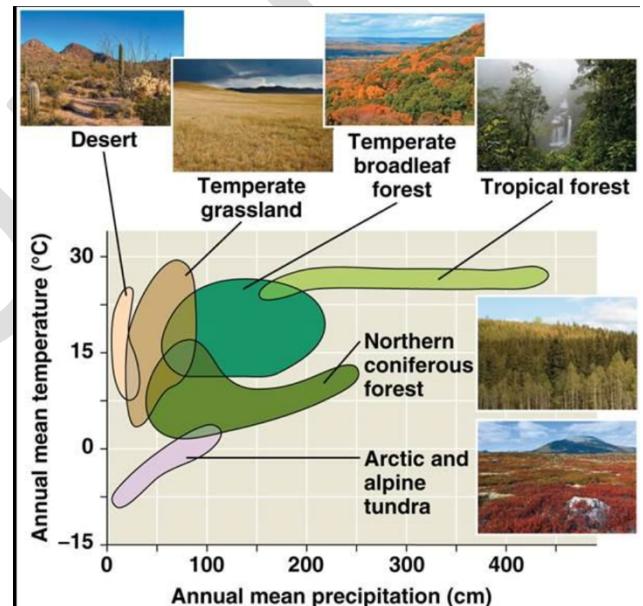
- **Fundamental niche** refers to range of environmental conditions which will allow a species to reproduce and survive successfully, if there was no competition or predators. It reflects species full ecological capabilities and adaptations, assuming ideal conditions.
- **Realized Niche:** It refers to actual set of conditions and resources a species utilizes in the presence of competition from other species. Competition, Predation, and limited resources restrict the species' access to some parts of its fundamental niche. The realized niche is always smaller than or equal to fundamental niche. The same species can have different realized niche in different locations, depending on the local community and environment.

The ecological niche of a species is not fixed, but rather can change over time due to changes in the environment, competition with other species, and other factors. In some cases, two or more species may occupy similar ecological niches, leading to competition for resources and potential changes in the niche of one or both species.

Understanding the ecological niche of a species is important for conservation and management efforts, as it can help to identify the key resources and environmental conditions that are necessary for the survival of the species. By protecting the ecological niche of a species, conservationists can help to maintain the biodiversity and functioning of the ecosystem as a whole.

3) BIOMES

- A biome is a large geographical area characterized by a specific set of climatic conditions and plant and animal communities. Variation in temperature, precipitation (both rain and snow) account for the formation of biomes.
- It can also be defined as a major life zone, that includes communities of plants and animals that have a common adaptation to that particular environment.
- **Biomes of the World:** For general understanding purpose we have divided the terrestrial biome into following types (based on NCERT). Please note that some other sources may make this division in many different ways, some going to the extent of 20 different biomes.



C) VARIOUS TYPES OF TERRESTRIAL BIOMES AND KEY FEATURES:

1) Arctic and Alpine Tundra:

- It is characterized by cold, dry and windy conditions.
- Most of the region is under permafrost (a thick layer of ice lying just below the shallow soil). Because of this tree cant penetrate to anchor their roots.
- **Flora:** Lichens, Mosses, grasses, shrubs etc.
- **Fauna:** Polar bears, arctic foxes, migratory birds, reindeer etc. Here reptiles and amphibians are almost absent.



2) Taiga/ Northern Coniferous Forests/ Boreal Forests:

- Boreal forests are full of life that are adapted to withstand frigid temperatures year around (or very long cold winters). They are made up of conical evergreen trees with needle like trees. These trees are called conifers because their seeds are clumped into cones. They include spruce, fir, pine etc.
- **Fauna** includes birds, hawks, fur bearing carnivores, little mink, elks, puma etc.
 - During cold winters mammals hibernate and birds migrate. Some animals have evolved to grow dense feathers or fur to survive the winters.
- **Taiga** is the largest land (terrestrial) biome in the world.



3) Temperature Deciduous Forest:

- Characterized by moderate temperatures and rainfall
- Deciduous trees, shrubs, grasses
- Fauna: Deer, bears, squirrels, birds etc.

4) Tropical Rain Forests:

- High temperatures and rainfall, little seasonal change,
- **Fauna:** Broad leaf evergreen trees, lianas, epiphytes, orchids. Multiple storey of broad-leaved evergreen trees are in abundance.
- **Floras:** Most animals and epiphytes are concentrated in the canopy or tree top zones. They include monkeys, sloths, jaguars, snakes etc.

Why tropical rain forests are not suitable for agriculture-> very less fertility:

- Surface soil is heavier leached (nutrients washed away) by running water. Here, the inferior surface soil is the limiting factor that limits the germination of seeds.
- Germinated saplings may not survive due to lack of light because of the dense canopy. Here, the absence of light (shade of the forest) is the limiting factor.

5) Savannah Grasslands/ Tropical Grasslands:

- Most extensive in Africa
- Warm and hot conditions with distinct wet and dry seasons
- **Flora:** Grasses are the dominant vegetation in Savannah grasslands, with trees and shrubs scattered throughout the landscape.
 - **Acacia tree** is commonly found in African Savannahs and eucalyptus trees are found in Australian Savannahs.
 - **Enough seasonal rainfall** so that trees can grow in open groups or singly throughout.
- **Fauna:** Large herbivores like zebra, giraffes, antelopes, as well as predators like Lions, Cheetahs, and hyenas.
- **Fire:** It is a common characteristic of Savannah which help to maintain grassy landscapes by clearing away excess vegetation and promoting new growth.
- **Soil:** Soil is typically nutrient poor and shallow and thus it finds difficulty in supporting trees.



6) Temperate Grasslands:

- They are popularly known as prairies, steppes or pampas.
- **Climate:** Continent climate with hot summers cold winters. They receive moderate rainfalls.
- **Fauna:** Large herbivores such as bison, pronghorn, and deer as well as predators such as foxes, coyotes, wolves etc.
- **Fire:** they are also characterized by frequent forest fires.
(The region is dry enough to cause fires and trees can't survive).
- **Soil:** Nutrient rich due to accumulation of organic matter from the grasses. The soil is often deep, and fertilize making it suitable for agriculture.



7) Desert:

- **Climate:** Low precipitation; extreme temperature fluctuations
- **Flora:** Cacti, Succulents scrubby bushes
- **Fauna:** Lizards, snakes, scorpions, coyotes, kangaroo rats etc.

D) VARIOUS TYPES OF AQUATIC BIOMES AND THEIR KEY FEATURES:

The aquatic biomes are divided into fresh water and marine regions.

1) Fresh Water Biomes:

- a. **Rivers and Lakes:** Fast moving, flowing water that originates from mountains and has high oxygen levels.
- b. **Lakes and Ponds:** Standing bodies of water with varying depths, temperatures, and oxygen level
- c. **Wetlands:** Low lying area with standing water, such as marshes, swamps.

2) Marine Biomes:

- a. **Oceans:** The largest biome on earth, oceans are divided into zones based on depth and receive varying amount of sunlight, affecting the types of organisms that can survive in each zone
- b. **Coral Reefs:** Warm, shallow waters where diverse species of corals thrive
- c. **Estuaries:** Areas where freshwater meets saltwater, creating unique habitats for species adapted to changing salinity levels.

Please note: This is not an exhaustive list of terrestrial and aquatic biomes.

4) BIOSPHERE

- The biosphere is the part of the earth where life exists, which includes all living organisms and their interactions with the environment. It extends from the deepest ocean depths to the highest altitudes in the atmosphere and includes all terrestrial and aquatic ecosystems.
- The biosphere is composed of various biomes.
- The biosphere is a complex system, with numerous ecological interactions and feedback loops. It consists of various food chains and food webs.

5) HABITAT AND HOW ORGANISMS HAVE EVOLVED TO ADAPT TO OPTIMIZE ITS SURVIVAL AND REPRODUCTION IN ITS HABITAT

- **Regional and local variations** with each biome leads to formation of habitat.
 - » Over a period of time, the organism had evolved to adapt to optimize its survival and reproduction in its habitat.

A) MAJOR ABIOTIC FACTORS/ ABIOTIC COMPONENTS

- **Temperature:** It is the most important ecologically relevant environmental factor. It affects the kinetics of enzymes and through it the metabolic activity and other physiological functions of the organism. The levels of thermal tolerance of different species determine to a large extent their geographical distribution.
 - » A few organisms can tolerate and thrive in wide range of temperatures (they are called euthermal). (e.g., Humans, Cows, Monkeys, Sheep, Goats etc.)
 - » A vast majority of organism are restricted to a narrow range of temperatures (they are called stenothealthal). (e.g. penguins, crustaceans etc.)

- **Water:** Life on earth originated in water and can't sustain without water. In limited water conditions like deserts, special adaptations techniques are needed for organisms to live there. The productivity and distribution of plants are also dependent on water. Even aquatic organisms face water related issues as sometimes the quality, pH etc. becomes problematic. The salt concentration of water is also an important factor. Many freshwater species can't survive in ocean water for long because of the osmotic pressure that they face.
 - » Some organisms may tolerate a wide range of salinities (euryhaline), but others are restricted to narrow range (stenohaline).
- **Light:** Autotrophs who form the first level of any food chain depend on light for generating food. Thus, light is important for all living organisms.
 - » **Some organisms** survive in less light conditions (e.g., herbs and shrubs growing in tropical rain forests have adapted to do photosynthesis optimally under very low light conditions because they are constantly overshadowed by tall, canopied trees).
 - » **Many plants** are dependent on sunlight to meet their photoperiodic requirement for flowering.
 - Most angiosperms (flowering plants) use photoperiodism to determine when to flower. To do that they use one of the photoreceptor protein present in their body such as cryptochrome or photochrome.
 - » **For many animals too, light is important** in that they use diurnal and seasonal variation in light intensity as cues for timing their foraging, reproductive and migratory activities.
 - » **Note:** How do deep sea organisms get their energy (since light doesn't reach there)?
 - **Three major methods** – Marine Snow; Whale Falls; Chemosynthesis.
 - **Marine Snow:** It refers to biological debris that originate from the top layers of the ocean and drift to the seafloor, providing primary source of energy for animals in the deep ocean. It primarily consists of phytoplankton produced through photosynthesis and as they sink, it collects other floating debris, including fecal material, dead or decaying animals, suspended sediments etc.
 - **Whale Fall:** When whales die and sink, the whale carcasses, or whale falls provide a sudden concentrated food source and a bonanza for organisms in the deep sea. Useful video: https://youtu.be/LUFKzP8ql_A?si=aSWIQtOw2u1xeAsi
 - » **Among the red, green and brown algae** that inhabits the sea, which is likely to be found deepest in water?
 - **How sunlight penetration varies with depth of ocean? Short wavelength/high frequency** light can penetrate sea water more easily. Thus, as depth increases, blue light reaches, green reaches less, Yellow further lesser and Red reaches the least.

- Red algae at the depth of the ocean thus absorbs blue green wavelength and survive at deeper layer. They have more quantity of the pigment **phycoerythrin**. It absorbs the blue-green spectrum of the visible light.
- **Soil:** Characteristics of soil such as soil composition, grain size, and aggregation determine the percolation and water holding capacity of the soils. These characteristics along with other parameters like pH, mineral composition, and topography determine to a large extent the vegetation in any area. This in turn dictates the type of animals that can be supported. Similarly, the aquatic environment, the sediment-characteristics often determine the type of benthic animals that can thrive in the soil.

B) RESPONSES TO ABIOTIC FACTOR

- **Abiotic components** of a habitat may vary drastically with time.
 - » But most species have evolved to have a relatively constant internal (within the body) environment. This constant environment provides maximal efficiency for all biochemical and physiological functions and thus enhances the overall fitness of the organisms. This may be in terms of optimal temperature and osmotic concentration of the body fluid.
 - » **Ideally then**, the organism should try to maintain the constancy of its internal environment (a state called homeostasis) despite varying external conditions that tends to upset its homeostasis.
 - **Note:** Homeostasis is the state of steady internal, physical, and chemical conditions maintained by living environment.
- How do organisms living in such habitats cope or manage with such stressful conditions?
 - » **Regulate:** Some organisms are able to maintain homeostasis by physiological means (sometimes behavioral means also).
 - **All birds and mammals**, and a very few lower vertebrates and invertebrates are capable of such regulation (thermoregulation and osmoregulation).
 - Evolutionary biologists believe that success of Mammals is largely due to their ability to maintain a constant body temperature and thrive weather they live in Antarctica or Sahara Desert
 - **For e.g.: Human** maintain the body temperature at 37-degree C. In summers, we sweat to produce evaporating cooling and in winters, we shiver to produce heat and raise the body temperature.
 - **Regulation is energetically expensive.** This is particularly true for small animals like shrews and hummingbirds. Small animals have large surface area relative to their volume, they tend to lose their body heat very fast when it's cold outside; and they would need a lot of energy to maintain the body temperature. This is the reason why very small animals are rarely found in Polar region.
 - » **Conform:** Conformers are organisms that lack the ability to regulate their internal body temperature (endothermy) and instead rely on their environment to dictate their internal

temperature (ectothermy). This means that they experience significant changes in their body temperature along with the fluctuations in their surrounding environment.

- In aquatic animals, the osmotic concentration of body fluids changes with that of the ambient air, water osmotic concentration. These animals and plants are conformers.
- **E.g. of conformers:**
 - » **Fish:** Many fish are conformers, meaning that their body temperature matches to their surrounding water. They adjust metabolic rates and activity levels based on the outside temperature. Some fish species like trots which prefer colder waters will migrate to deeper or cooler oceans during warmer seasons.
 - » **Reptiles** are classic examples of conformers. They rely on external source of heat such as sunlight to regulate their body temperature. Basking in the sun helps them warm up, while seeking shade or burrowing underground helps them cool down.
 - » **Amphibians** – most are conformers. Basking in sun, shelter in cooler areas to avoid overheating etc.
 - » **Ectothermic Plants** – The metabolic activities and growth of plants are influenced by ambient temperature. For e.g., the rate of photosynthesis in plants increase at higher temperature and decreases with low temperature.
- **Why didn't these animals and plants become regulators?**
 - » Thermoregulation is energetically expensive for many organisms.
 - » During evolution, the cost and benefit of maintaining a constant internal environment are taken into consideration. Some species have evolved the ability to regulate, but only over a limited range of environment, beyond which they simply conform.
- » **Migrate:** If the stressful external condition is localized or remain only for short duration, the organisms have two other alternatives for survival Migration or Suspension.
 - **Migration:** In migration, organism move temporarily from the stressful habitat to a more hospital area and return when stressful period is over. (E.g., Siberian crane coming to Rajasthan in winters)
 - **Suspension:**
 - In bacteria, fungi and lower plants, various kinds of thick-walled spores are formed which help them to survive unfavorable conditions – these germinate on availability of suitable environment.
 - In higher plants, seeds and some other vegetative reproductive structures serve as means to tide over periods of stress besides dispersal – they germinate to form new plants under favorable moisture and temperature condition. They do so by reducing their metabolic activity and going into a state of 'dormancy'.

- **Animals** which are unable to migrate, may escape in time (i.e., **hibernate** during winters). Some animals go into **deep sleep** for extended period of time, while **others will just slow down** but **remain active**. Some will go into a combination of both, known as **Torpor**.
 - » Animals like bats, Squirrels, Marmot, Lemurs, Hedgehog, Earthworms, Toads, Bees, bears etc. **hibernate in a warm place during winters**.
 - » **Bears** living in cold climate hibernate during winters – when the food is scarce, but the bear in warmer climate can find plenty of food all year long so they don't have any reason to hibernate. **Bears** are **true hibernators** and sleep heavily never to wake up again till the spring arrives. Only the Mama Bear wakes up in Jan/Feb to give birth to the new cubs, and the babies will be happy nestling with Mamma until she can take them out on their first adventure.
 - » **Bats also hibernate** (again the once in warmer areas don't).
 - » **Some snakes** also hibernate.
- **Some snails and fish** go into **aestivation** to avoid summer-related problems-heat and desiccation.
 - » **Note:** Aestivation or estivation is a state of dormancy that some animals enter during hot and dry periods. It is similar to hibernation, which is a state of dormancy during cold and harsh conditions.
- Under unfavorable conditions, many zooplankton's species in lakes and ponds are known to enter diapause, a stage of suspended development.
- **Dieback:** It refers to the progressive dying, usually backwards from the tip of any portion of the plant. This is one of the adaptive mechanisms to avoid adverse conditions like droughts. In this mechanism, the root remains alive for years together, but the shoots die. E.g., Sal, Red Sanders, Silk-Cotton etc.

C) ADAPTATION

- Adaptation is any attribute of the organism (morphological, physiological, behavioral) that enable the organism to survive and reproduce in its habitat.

Many adaptations have evolved over long evolutionary time and are genetically fixed. In the absence of external source of water, the **Kangaroo rat**, in North American deserts is capable of meeting all its water requirements through its internal fat oxidation (in which water is a byproduct). It also has the ability to concentrate its urine so that less water is lost



- **Desert plants** have adapted to following features to survive in water scarce conditions:

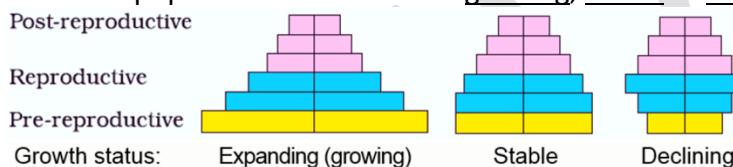
- » **Reduced Leaf Size:** Smaller leaves minimize water loss through transpiration.
 - » **Thick Cuticles:** Desert plants have a thick waxy layer on the surface of their leaves and steps to reduce water loss.
 - » **CAM Photosynthesis:** Some desert plants, such as cacti and succulents, use a special type of photosynthesis called Crassulacean Acid Metabolism (CAM), which allows them to conserve water during photosynthesis.
 - In this system, CO₂ is fixed at night when temperature is cooler, and stomata (pores in leaves) can remain open without excessive water loss. Here CO₂ is converted into malate (a four carbon acid) which will be used during day time for photosynthesis.
 - E.g. of CAM mechanisms: Succulents like aloe-vera and Jade plant; some orchids; Crassula, a genus of flowering plants giving CAM its name.
 - » **Deep Roots:** To access water from deep underground.
 - » **Efficient Water Use:** Desert plants have adapted to use water efficiently by closing their stomata during the day and opening them at night to reduce water loss.
 - » **Succulent Tissues:** Some desert plants have fleshy, water storing tissues that allow them to survive for long periods without water.
 - » **Spines or Thorns:** To deter herbivores and to reduce water loss from leaf surface.
- **Allen's Rule:** Mammals from colder climate, generally have shorter ears and limbs to minimize heat loss (This is called Allen's Rule).
- In the **polar seas**, aquatic mammals like **seals**, have a thick layer of fat (blubber) below their skin that acts as insulator and reduces loss of body heat.
- **Tribes living in high altitude region**, normally have higher RBC count (or total hemoglobin) than people living in plains. Why?
- **Some microbes** (archaeabacteria) flourish in hot springs and deep-sea hydrothermal vents where temperature far exceeds 100-degree C.
 - » Microbes which can live at such high temperature are called **thermophiles**. They are able to survive in such high temperatures because their bodies have adapted to such environmental conditions. They contain specialized thermo resistant enzymes, which carry out metabolic functions that don't get destroyed at such high temperatures.
- **How do fish in Antarctic water prevent their body fluids from freezing?**
 - They have developed proteins that act as **anti-freeze**. These anti-freeze proteins are a group of unique macromolecules that help some polar and subpolar marine bony fishes avoid freezing in their icy habitat. These **proteins bind to and inhibit growth of ice crystals** within body fluids through an absorption-inhibition process. These proteins attach to small ice crystals stemming their growth.
- **How do deep sea organisms live under high pressure?**
 - Most living things in the deep sea are largely water and water is incompressible. **Without gas filled spaces** like lungs or bladders, organisms in the great deep are less affected by pressure than we imagine. Further, they have "**piezolytes**" – small, organic molecules which have only recently been discovered. These piezolytes stop the other molecules in the creatures' bodies, such as membranes and proteins, from being crushed by the pressure.

5) POPULATIONS

- Majority of organisms live in groups in a well-defined geographical area, share or compete for similar resource, **potentially interbreed (same species)**, and thus constitute a **population**.
- Although the term interbreeding may imply **sexual production**, a group of individuals resulting from **even asexual reproduction** is also generally considered a population.
 - » E.g.: Rats in an abandoned dwelling; bacteria in a culture plate, lotus plants in a pond etc.
- So far, we had studied that Individual organism is the one that has to cope with a changed environment, it is at population level that **natural selection operates to evolve the desired traits**. Population ecology is, therefore, an important area because it links ecology to population genetics and evolution.

Individual	Population
Individuals don't show attributes	Population has certain attributes
Individual may have <u>births and deaths</u>	Population has <u>birth rates and death rates</u>
Individual may be male/female etc.	Population can have <u>sex ratio</u> .

- **Age distribution of a population** forms what is called **Age Pyramid**. The shape of the pyramid reflects the growth status of population. Whether it is growing, stable or declining.



- The size of the population tells us a lot about the habitat.

A) POPULATION GROWTH

- The density of a population in a given habitat during a given period, fluctuates due to changes in four basic processes: **Natality and Immigration** contribute to an increase in population. **And Mortality and Emigration** contribute to decrease in population.

B) LIFE HISTORY VARIATION

- Populations evolves to maximize their reproductive fitness, also called **Darwinian fitness** (high r value), in the habitat in which they live. Life history traits of organisms have evolved in relation to the constraints imposed by the abiotic and biotic components of the habitat in which they live. They develop the most efficient reproductive strategy.

For e.g. – Some organisms breed only once (for e.g., Pacific Salmon fish, Bamboo); while others breed many times during their lifetime (most birds and mammals)

C) POPULATION INTERACTION:

- In nature, animals, plants and microbes don't and cannot live in isolation but interact in various ways to form a biological community. Even in minimal communities, many interactive linkages exist, although all may not be readily apparent.
- Interspecific interactions arise from the interaction of population of two different species. This interaction could be **beneficial (+)**, **neutral (0)** or **detrimental (-)** to one of the species or both. All possibilities are given below:

Species A	Species B	Name of Interaction
+	+	Mutualism
-	-	Competition
+	-	Predation
+	-	Parasitism
+	0	Commensalism
-	0	Amensalism

- In **parasitism and predation** only one species benefits (parasite and predator, respectively) and the interaction are detrimental to other species (host and prey, respectively).
- **Mutualism, Predation, Parasitism, and Commensalism** share a common characteristic, the interacting species live closely together.

MUTUALISM

- The interaction confers benefits to both the interacting species.
- E.g.
 - » **Lichens** (intimate mutualistic relationship between fungus and photosynthesizing algae or cyanobacteria)
 - » **Mycorrhizae** are associations between fungi and the roots of higher plants. The fungi help the plant in the absorption of essential nutrients from the soil, while the plant in turn provides the fungi with energy yielding carbohydrates.
 - » **Plant Animal Relationship:** Plants need animals for pollinating their flowers and dispersing the seeds, whereas plants given them in return, honey fruits etc.
 - » Now you can see **why plant-animal interactions often involve co-evolution of the mutualists**, that is, the evolutions of the flower and its pollinator species are tightly linked with one another.
 - » In **many species of fig trees, there is a tight one-to-one relationship with the pollinator species of wasp**. It means that a **given fig species can be pollinated only by its 'partner' wasp species** and no other species. The female wasp uses the fruit not only as an oviposition (egg-laying) site but uses the developing seeds within the fruit for nourishing its larvae. The wasp pollinates the fig inflorescence while searching for suitable egg-laying sites. In return for the favour of pollination the fig offers the wasp some of its developing seeds, as food for the developing wasp larvae

COMPETITION

- Competition occurs when closely related species compete for the same resources that are limiting.
 - » But totally unrelated species may also compete (for e.g., visiting flamingoes and resident fishes compete for their common food, the zooplanktons in a lake).
 - » Even in case of abundant resources, competition may occur, in **interference competition**, the feeding efficiency of one species might be reduced due to interfering and inhibitory presence of the other species.
- Therefore, competition is best defined as “a process in which **fitness of one species**, is significantly lower in the presence of another species”.
- E.g., **Abingdon tortoise in Galapagos Islands** became extinct within decade after goats were introduced on the island, apparently due to the greater browsing efficiency of the goats.
- Species facing competition might also evolve mechanisms that promote co-existence rather than exclusion. One such mechanism is “**resource partitioning**”. Here species avoid competition by choosing for instance, different time for feeding on different foraging patterns.

PREDATION:

- » **Significance:** Transferring the energy to higher trophic levels; Keeping prey population under control and contribute to ecosystem stability; they also help in promoting species biodiversity in a community, by reducing the intensity of competition among competing prey species.
 - In the absence of predator, a prey may become invasive and damage the ecosystem. E.g., when prickly pear cactus was introduced in Australia in the early 1920s, they caused havoc by spreading rapidly to millions of hectares. It was only when a cactus feeding predator (a moth) was introduced, the population could be controlled and damaged could be reduced.
 - **Predators by nature are prudent.** Because if the overexploit and prey population reduces drastically, predators would also suffer.
 - **Prey species** have also evolved various mechanisms to protect themselves from predators – e.g., insects and frogs are cryptically colored (camouflaged) to avoid being detected easily by predator. Some are poisonous and thus are avoided by Prey. **Monarch Butterfly** is highly distasteful to its predators (birds) because of a special chemical present in its body.
 - **For Plants**, herbivores and predators, so plants also develop various mechanisms to protect themselves.
 - » **Thorns** (Acacia, Cactus) are the most common morphological means of defence.
 - » Many plants produce **chemicals that make herbivore sick** when they are eaten, inhibit feeding or digestion, disrupt its reproduction or even kill it.
 - i. **E.g., Calotropis** (they grow in abandoned fields, and they produce highly poisonous cardiac glycosides and that is why you never see any cattle or goats browsing on this plant.



- ii. **A wide variety of chemical substances** that we extract from plants on a commercial scale (nicotine, caffeine, quinine, strychnine, opium, etc.) are produced by them actually as defences against grazers and browsers.

PARASITISM

- **Majority of the parasites harm the host.** They may reduce the survival, growth and reproduction of the host and reduce its population density. They may also render the host more vulnerable to predation by making it physically weak.
- **Ectoparasites:** Parasites feeding on the external surface of the host organisms.
 - » E.g., lice on humans, ticks on dogs.
 - » Many fish species are infested by ectoparasitic copepods.
 - » Cuscuta, a parasitic plant, has lost its chlorophyll and leaves in the course of evolution. It derives its nutrition from the host plant that it parasites.
 - » **Note:** The female mosquito is not considered a parasite, although it needs our blood for reproduction. Why?
 - Because it needs blood for reproduction not for nutrition. Human blood is required for nourishment of the offspring. A parasite depends for its entire lifespan or at least for a considerable period within a host body and completely depends on the host for nutrition and habitat.
- **Endoparasites:** Parasites that live inside the host body at different sites (liver, kidney, lungs, red blood cells, etc.)
 - » The lifecycle of endoparasites is more complex because of their extreme specialization. Their morphological and anatomical features are greatly simplified while emphasizing their reproductive potential.
- **Brood Parasitism:** Here parasitic bird lays its eggs in the nest of its host and lets the host incubate them. During the course of evolution, the eggs of the parasite bird has evolved to resemble the host's eggs in size and color to reduce the chances of the host bird detecting the foreign egg and ejecting them from the nest.
 - » Asian Koel, like many of its related cuckoo kin is a brood parasite that lays its eggs in the nests of crows and other hosts, who raise it young.

COMMENSALISM

- Interaction in which one species benefit, the other is neither harmed nor benefited.
- E.g.
 - » Orchid growing as an epiphyte on mango branch.
 - » Barnacles growing on the back of a whale. They don't harm whales or feed on them. They don't serve any obvious advantage to whale, but they give helpful lice a place to hang onto the whale without getting washed away in water.

- » The **cattle egret** and the grazing cattle is a classic example of commensalism. The egrets always forage close to where the cattle is grazing because the cattle, as they move, stir up and flush out insects from the vegetation that otherwise may be difficult for egrets to find.

4. FUNCTIONS OF AN ECOSYSTEM

Ecosystems perform some basic functions which are essential for supporting life on earth and maintaining ecological balance. These functions can be categorized under the following heads:

- 1) **Primary Production:** This refers to the production of food by autotrophs through the process of photosynthesis (plants, algae, bacteria etc.) and chemosynthesis (in some bacteria). Primary production provides energy and nutrients for all other organisms within the ecosystem.
- 2) **Energy Flow:** This refers to one-way transfer of energy from producers to consumers and eventually to decomposers through food chain. At each level some energy is lost as heat.
- 3) **Nutrient Cycling:** Essential nutrients, like nitrogen, phosphorus, carbon etc. are constantly recycled in the ecosystem. This continuous cycle ensures the availability of these vital elements for all organisms.
- 4) **Water Cycle/Water Regulation :** Ecosystems regulate the water cycle, which is essential for the survival of living organisms.
- 5) **Habitat Provisions:** Ecosystem provides diverse habitats for various species. Each habitat, with its particular set of features support unique set of species.
- 6) **Environmental Provisions:** Regulation of climate, air quality and water quality.
 - Absorbing Carbon, reducing global warming and mitigating effects of climate change
 - Plants also filter air pollutants and release oxygen through photosynthesis.
 - Wetlands and forests act as natural filters and help in removing sediments and pollutants from water as it flows through them. This helps in maintaining of clean water for humans and other organisms.
- 6) **Ecological Succession:** Ecological succession is the process by which natural communities replace (or succeed) one another over time.
- 7) **Soil Formation**
- 8) **Cultural and Recreational Services**

In this chapter, we will primarily focus on three important functions of ecosystem – **Energy Flow; Nutrient Cycling and Biogeochemical Cycles:**

1) ENERGY FLOW THROUGH AN ECOSYSTEM

Energy flow through an ecosystem refers to transfer of energy from one organism to another within a food chain or food web. The sun is the primary source of energy in most ecosystems, and it's captured by plants through photosynthesis. This energy flows through the ecosystem as one organism consume other organism for food.

A) TROPHIC LEVEL:

- Trophic level refers to different levels of food chain where organisms obtain energy and nutrients. There are primarily four main trophic levels – Producers; Primary Consumers; Secondary Consumers; Tertiary Consumers. The energy flow through the trophic levels from producers to subsequent trophic levels is unidirectional.
- Each trophic level represents a transfer of energy and nutrients from one group of organisms to another. As organisms consume other organisms, they extract energy and nutrients from their food, and some of this energy is lost as heat. This means that there is typically less energy available at higher trophic levels, which is why food chain tend to be relatively short.
- The trophic level interaction involves three concepts viz. Food Chain, Food Web and Ecological Pyramids.

B) FOOD CHAIN:

- Transfer of food energy from green plants (producers) through a series of organisms with repeated eating and being eaten link is called a food chain. A food chain starts with producers and ends with top carnivores. The trophic level of an organism is the position it occupies in a food chain.
 - E.g., Grassland Ecosystem:
 - Grasses-Grasshopper-Frog-Snake-Hawk/Eagle.
 - E.g., Aquatic Ecosystem:
 - Algae -> Zooplankton (smaller animals and immature stages of large animals) -> Small fish -> large fish -> Shark

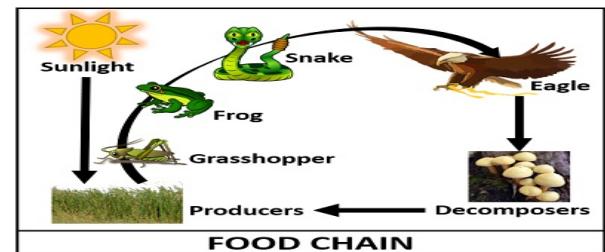
- **Diatom** (microscopic algae) -> **Crustaceans** -> **Herring** -> **Shark**
 - **Note:** Crustaceans such as copepods are typically herbivores that feed on phytoplankton, including diatoms. Herring are small fish that feed on zooplanktons, including Crustaceans.
- **E.g., Forest Ecosystem**
 - **Trees** – Caterpillar – Blue Jay (small bird) – Hawk
- **E.g., Desert Ecosystem**
 - **Cactus** -> Grasshopper -> Lizard -> Snake -> Eagle
- **E.g., Arctic Ecosystem**
 - Phytoplankton's -> Krill (crustacean)-> Arctic Cod (fish) -> Seal (mammal) -> Polar Bear (Mammal)

Types of Food Chains:

1. Grazing Food Chain
2. Detritus Food Chain

Grazing Food Chain:

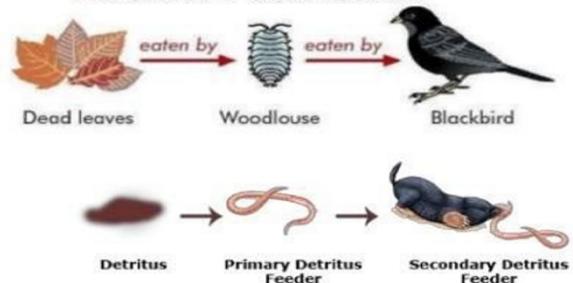
- The consumers which start the food chain, utilizing the plant or plant part as their food, constitute grazing food chain.



Detritus Food Chain:

- Starts from **organic matter of dead and decaying animals and plant bodies** from the grazing food chain.

Detritus Food Chain



E.g.: Forest Floor Deteritus food chain: Leaf litter
→ Fungi → Mites → Beetles → Salamanders

E.g.: Aquatic Detritus Food chain: Dead algae and other organic matter → Bacteria → Zooplankton
→ Small fish → Larger fish

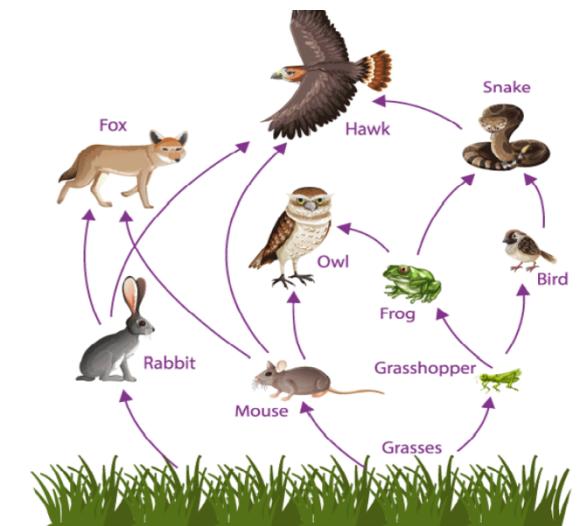
- In aquatic ecosystems, the grazing food chain is the major conduit for energy flow.
- In terrestrial ecosystem, a much larger fraction of energy flows through the detritus food chain than through the grazing food chain.

NOTE:

- 1) **Detritus Food Chain is important** because it increases the soil process/fertility by the process of 'Humification'.
 - a. **Humus:** It is a dark, organic rich substance that forms as a result of decomposition of plant and animals and animal material in soil. It is a complex mixture of organic compounds, including carbon, nitrogen, phosphorus, and sulfur, as well as minerals such as calcium, magnesium and potassium. It is key to healthy soil and can help to improve soil structure, retain moisture, and provide a source of nutrients for plants. In addition, it can help restore carbon in soil.
- 2) **Catabolism:** It is a set of metabolic processes that involve the breakdown of complex molecules into simpler ones, releasing energy in the process. The term catabolism is often used in contrast to **anabolism**, which refers to the set of metabolic activities that involve the synthesis of complex molecules from simpler ones, using energy.
- 3) **Humification and mineralization** occur during decomposition in the soil. Humification leads to accumulation of a dark-colored amorphous (formless) substance called humus viz. highly resistant to microbial action and undergoes decomposition at an extremely slow rate. The humus is further degraded by some microbes and release of inorganic nutrients occur by the process known as **mineralization**.

C) FOOD WEB:

- Multiple interlinked food chains make a food web. Food web represents all the possible paths of energy flow in an ecosystem.
- If any of the intermediate food chains is removed, the succeeding links of the chain will be affected largely.
- The food web provides more than one alternative for food to most of the organisms in an ecosystem and therefore increases their chance of survival.



D) ECOLOGICAL PYRAMIDS

The pyramidal representation of trophic levels of different organisms based on their ecological position (producer to final consumer) is called as Ecological Pyramid.

The ecological pyramids are of three categories:

1. Pyramid of Numbers
2. Pyramid of Biomass, and
3. Pyramid of Energy or Productivity

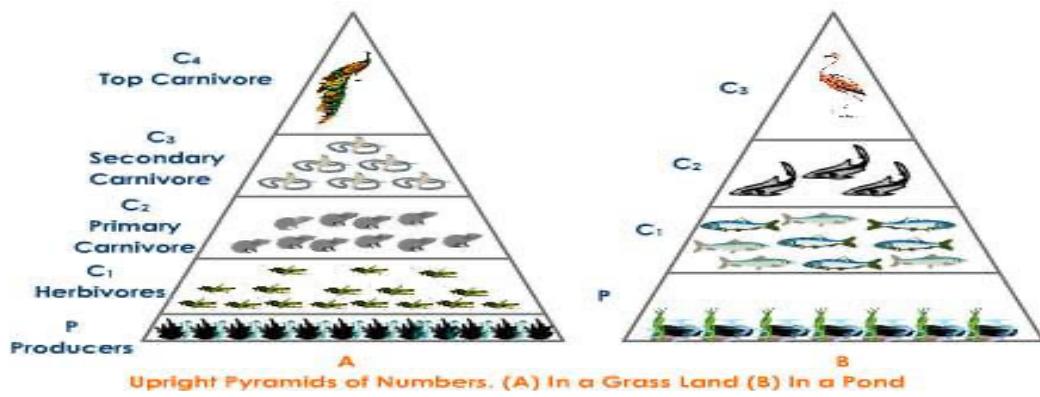
PYRAMID OF NUMBERS:

- It represents the total number of individuals of different species (population) at each trophic level.
- Depending upon the size, the pyramid of numbers may not always be upright, and may even be completely inverted.

(a) Upright:

In this pyramid, the number of individuals is decreased from lower level to higher trophic level.

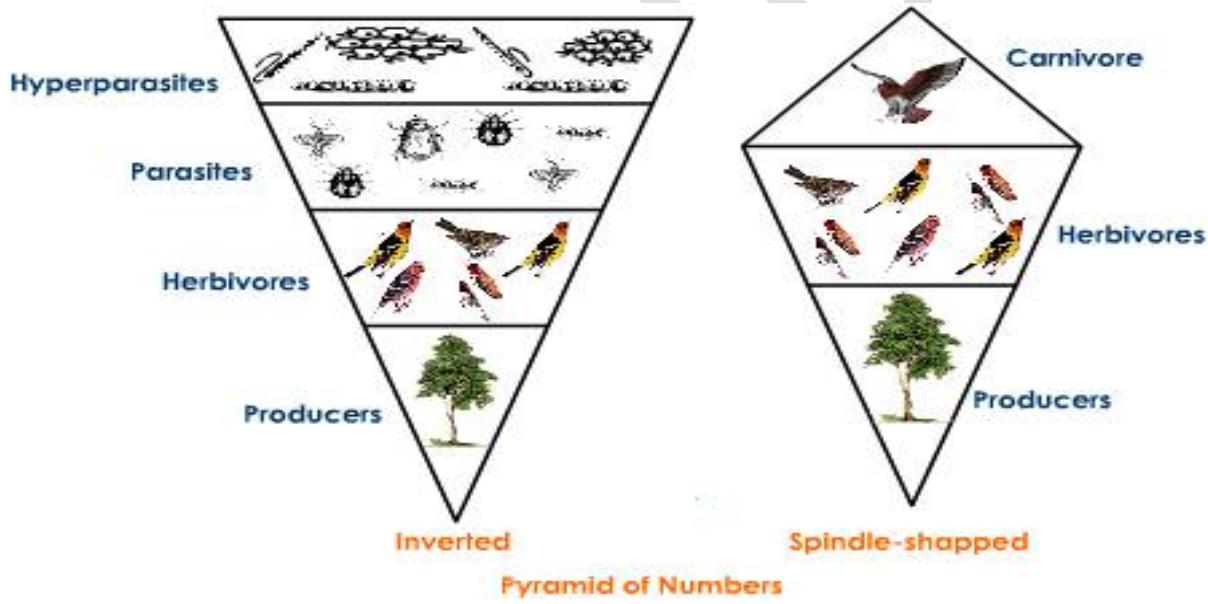
This type of pyramid can be seen in the Grassland Ecosystem and Pond Ecosystem.



(b) Inverted:

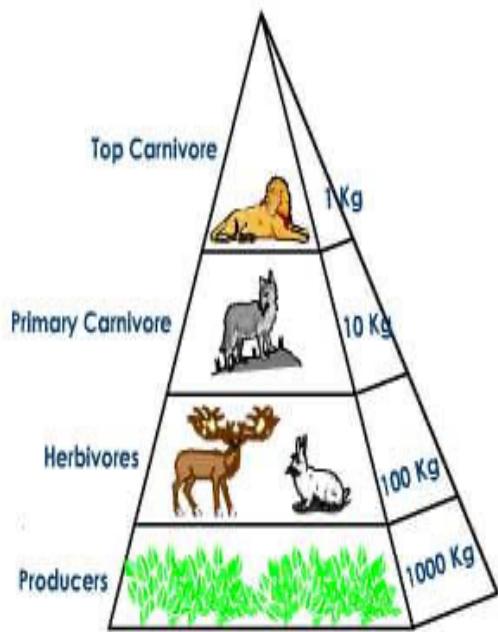
In this pyramid, the number of individuals is increased from lower level to higher trophic level. E.g., Tree Ecosystem

NOTE: Pyramid of Number is ALWAYS Upright in Aquatic Ecosystem, but it may be Upright as well as Inverted in Terrestrial Ecosystem.

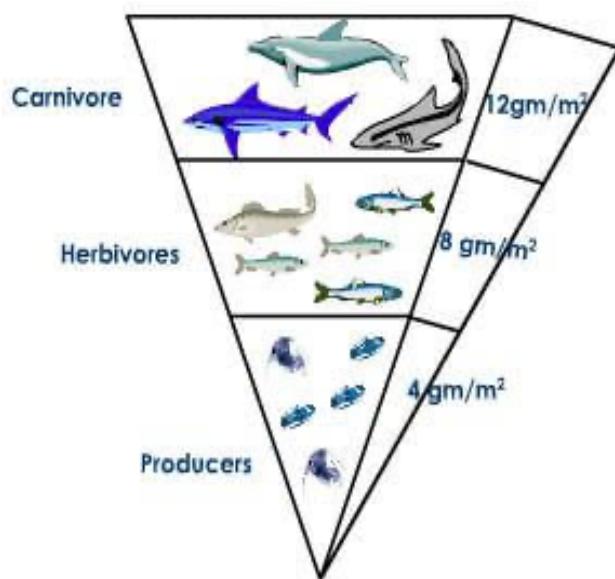


PYRAMID OF BIOMASS:

- Biomass means the weight of an organism in a given area and volume. To calculate the biomass of pyramid, we consider the 'dry weight'.
- NOTE:** Pyramid of Biomass is ALWAYS Upright in Terrestrial Ecosystem, but in Aquatic Ecosystem, as Producers are microscopic, small phytoplankton's, they do not have much weight. Hence, pyramid of biomass is Inverted.



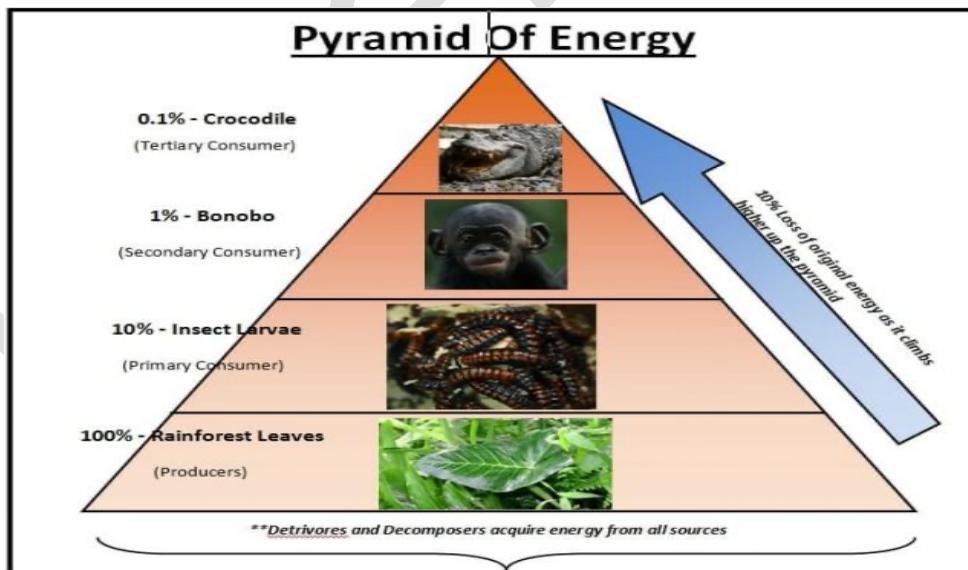
Upright Pyramid of biomass in a Terrestrial Ecosystem



Inverted Pyramid in an Aquatic Ecosystem

PYRAMID OF ENERGY:

- It is **most important pyramid** because it represents the amount of energy at each trophic level.
- As per Lindeman's law, **only 10 % of Energy** is transferred from lower to higher trophic level.
- At each trophic level, energy lost in respiration or in metabolism or in locomotion. **Therefore, pyramid of energy is ALWAYS uni-directional & Upright.**



NOTE: As ecological efficiency is LOW, therefore, organisms higher in food chains are LESSER in Number than they require more food.

As they require more food, Higher Organism in food chains, then there is GREATER chance of Biomagnification & Bioaccumulation.

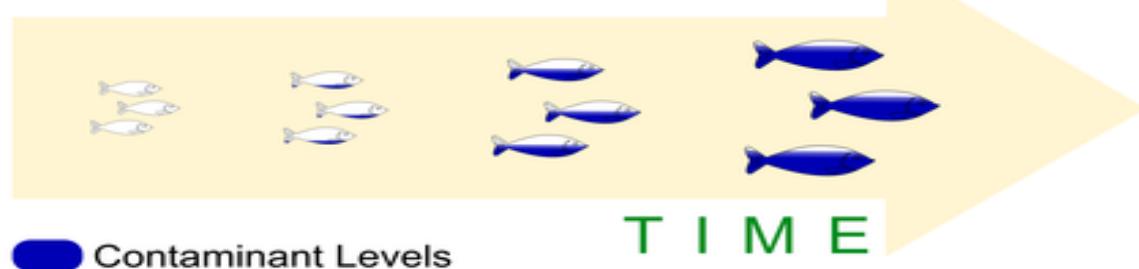
E) POLLUTANTS AND TROPHIC LEVELS

- Pollutants, especially the non-degradable ones move through various trophic levels in an ecosystem.
- Because of the mechanisms of bioaccumulation and biomagnification even small concentrations of chemicals in the environment find their way into organisms in high enough dosages to cause problems.

BIO-ACCUMULATION

- It refers to entry of a pollutant or toxic substance in the food chain. It actually is gradual accumulation of substances like pesticides or other chemicals, in an organism's body over time.
- It will take place when rate of absorption of pollutant is more than the rate of elimination (metabolism or excretion).
- Bioaccumulation typically occurs within individual organism, particularly those at lower trophic levels of a food chain. The concentration of pollutants in the organism may increase with repeated exposures or with prolonged exposures to contaminated environments.
- **Note:** Bioaccumulation doesn't necessary mean higher concentration of pollutant at higher trophic levels.
- **Source of pollutant** may be food, soil, water, air etc.
- **Substances which are likely to bioaccumulate:** Long lives (doesn't easily break/destroy); Mobile; fat soluble and biologically active (thus causes damage)
- **E.g.: Mercury in Fish** (Mercury is absorbed by algae and plankton, which are then consumed by small fish. Here mercury accumulate in the tissue of the fish.

Bioaccumulation

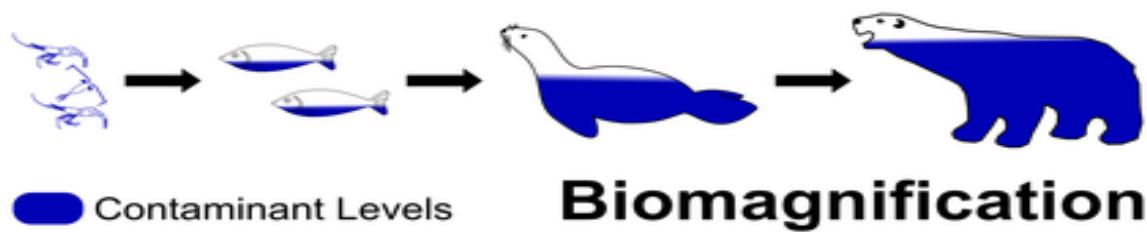


BIO-MAGNIFICATION

Bio-Magnification: The tendency of pollutant to increase in concentration as it moves from lower to higher trophic level, is known as Bio-magnification. This usually occurs across the entire food chain and affects all the organisms in the food chain. The animals at the higher trophic levels are affected more.

E.g.: **DDT**: it is a pesticide which is non-biodegradable. It gets incorporated in the food chain and gets deposited in the tissues of the organisms. When DDT enters water bodies, it gets accumulated in the body of fish (bioaccumulation) and when these fish are eaten by bigger fish, the concentration of DDT increase at each successive step (biomagnification).

Note: Biological magnification specifically refers increasing concentration of material in each higher connecting link in the food chain. However, bioaccumulation examines the increased presence of particular substance in a single organism.



Causes of Bio-accumulation & Bio-magnification:

1. **Agricultural Products:** Highly toxic substances such as herbicides, pesticides, fungicides etc. and these substances can also penetrate into the soil.
2. **Organic Contaminants:** Bio-solids used in agriculture farms are treated using toxic chemicals that may contain heavy metals.
3. **Plastic Pollution:** Disposal of plastic waste near or in water bodies. It is caused by 'Ghost Nets' for fishing nets. For instance, Bisphenol A is one of the major contaminants released into the water bodies.
4. **Mining:** Zinc, Copper, Lead and other chemicals may be released into the aquatic and farm environment.
5. **Toxic Gases and Air Pollution:** Exhaust gases from vehicles, refineries industries can be dissolved by the rainwater and fall as acidic rain. These chemicals are absorbed by soil and water bodies.

Effects of Bio-accumulation and Bio-magnification:

- On Human Health:** Accumulation of mercury and Polycyclic Aromatic Hydrocarbons affect the tissues of marine organisms. Therefore, in recent years, the consumption of seafood has been linked to certain types of cancer, kidney failure, brain damage etc.
- On aquatic animals-** Toxic chemicals such as selenium and mercury include effects on reproductive process of fish.

Some Important Bio-accumulators:

- DDT:** It is pesticide and insecticide, generally used for control the malaria population (i.e., mosquito population).
 - (a) DDT has been banned under Stockholm Convention, but it is used in tropical countries like India to control the spread of growth of malaria, dengue etc.
 - (b) Effects: Headache, Noroviral disorder, thinning of egg-shells & loss of fertility which ultimately result to Cancer.
- Endosulfan:** It is an insecticide which is used in Cashew, Rubber & Plantation agriculture (tea plantation).
 - (a) It is cheap but dangerous bioaccumulate because it is associated with birth defects including cryptorchidism (absence of testis in male), neurological disorder including autism (mental retardness), cancer etc.
 - (b) Endosulphane was added to the list of POPs in the year 2011. Government of India has banned the use of endosulphane, but the matter is in sub-judice.

2) BIO-GEO-CHEMICAL CYCLING OR NUTRIENT CYCLING

- “Nutrient Cycle” or “Biogeochemical cycle” refers to the movement or exchange of nutrients among the living and non-living constituent of an ecosystem. Nutrient Cycling is the process through which components change into different forms and then return to their original state.
- Based on the nature of reservoir, a nutrient cycle is divided into two types of cycles viz. Gaseous cycle; and Sedimentary Cycle.
 - o **Gaseous Cycle:** In Gaseous cycle, atmosphere or hydrosphere acts as the primary reservoir and elements primarily cycle through the atmosphere and living organisms, with minimal

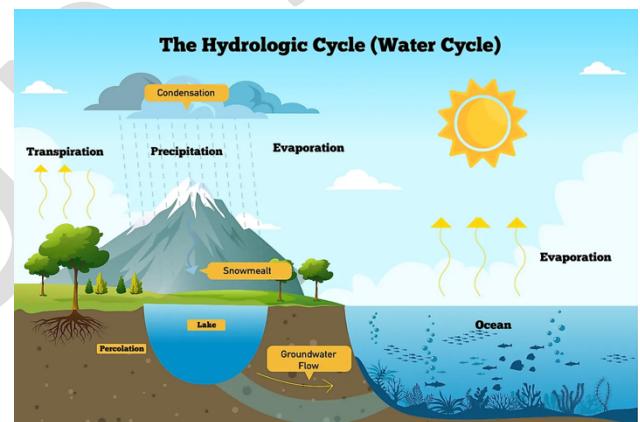
involvement of soil or sediments. It includes, water cycle (hydrologic); carbon cycle; nitrogen cycle etc.

- **Sedimentary Cycle:** In this cycle, earth's crust act as the primary reservoir. It includes phosphorus cycle; sulphur cycle etc.

- **Biogeochemical Cycle (Nutrient Cycle)** can also be divided into perfect nutrient cycle and imperfect nutrient cycle.
 - **Perfect Nutrient Cycle** is one in which nutrients are replaced as fast as they are utilized. Most of the gaseous cycles are generally perfect cycles.
 - **Imperfect Nutrient Cycle** sees loss of some nutrients from cycle and the nutrients get locked into sediments and so become unavailable for immediate cycling.

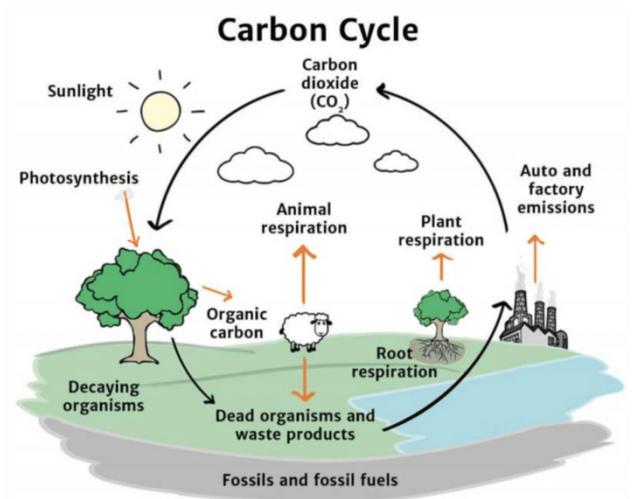
A) WATER CYCLE (HYDROLOGIC CYCLE)

- Water Cycle is the continuous circulation of water in the Earth-Atmosphere system which is driven by solar energy. There are various reservoirs of water on earth including ocean, atmosphere, lakes, rivers, soils, glaciers, snowfields, and groundwater. Water moves from one reservoir to another through the process of evaporation, transpiration, condensation, precipitation, percolation, ground water flow, deposition etc.



B) CARBON CYCLE

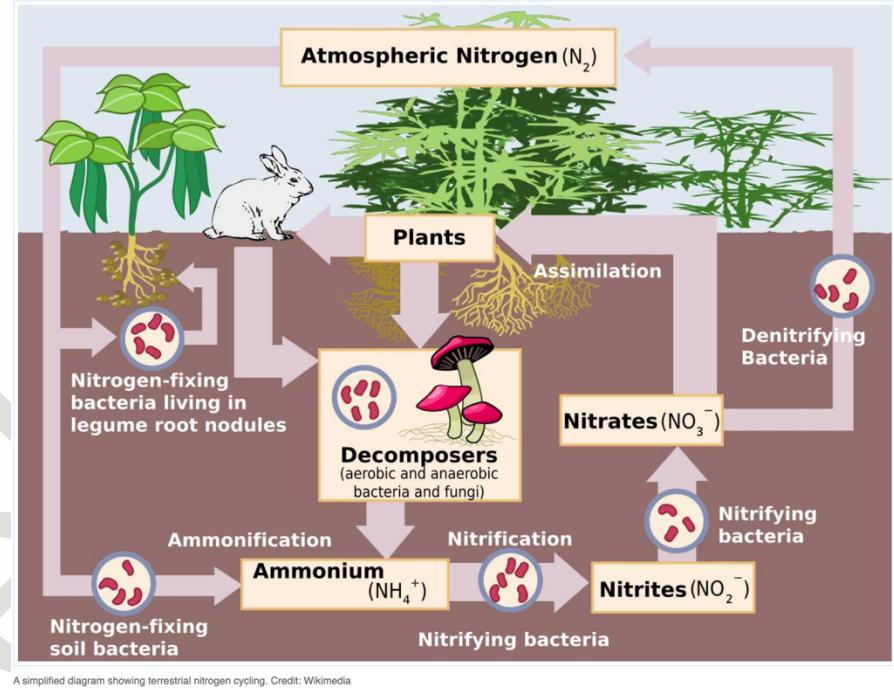
- The carbon cycle is the process that circulates the carbon between plants, animals, and microbes; minerals on earth; and the atmosphere.
- **Photosynthesis** leads to carbon from atmosphere moving to green plants and then to animals. **Respiration and decomposition** of dead organic matter leads to return of carbon back to atmosphere. This is usually a short-term cycle.
- Some carbon also enters a long-term cycle. It accumulates an undecomposed carbon in the peaty layers and as insoluble carbonates in the bottom sediments of aquatic systems. In the deep ocean, carbon can remain buried for millions of years.



years until geological movement uplifts the rocks and erosion releases carbonates and bicarbonates. Fossils also trap carbon for millions of years.

C) NITROGEN CYCLE

- Nitrogen is the key component of the bodies of living organisms. Nitrogen atoms are found in all proteins and DNA.
- Though, Nitrogen is the most abundant element in the atmosphere (N₂ is 78% of atmosphere), it is still a limiting nutrient in nature and agriculture. It is because it is not available in atmosphere in usable form.
 - Note: A limiting nutrient is the nutrient that's in the shortest supply and limits growth.
- **Nitrogen Fixation:** It is the process by which bacterial and other single celled prokaryotes convert atmospheric nitrogen (N₂) into biologically usable form i.e. ammonium ion (NH₄⁺).
 - Some species of nitrogen fixing bacteria are free living in soil or water (aerobic Azotobacter and anaerobic Clostridium), while others are symbiotic nitrifying bacteria (living in association with leguminous plants) and symbiotic bacteria living in non-leguminous root nodule plants (e.g. Rhizobium) as well as blue green algae (e.g. Anabaena, Spirulina).
 - Ammonium ion can directly be taken up as a source of nitrogen by some plants, or are oxidized to nitrites or nitrates by two groups of specialized bacterial:
 - Nitrosomonas bacteria promote transformation of ammonia into nitrite.
 - Nitrobacter bacteria convert nitrite into nitrate.



- Nitrates synthesized by bacteria in the soil are taken up by plants and converted into amino acids, which are the building blocks of proteins. This can further go to higher trophic levels.
- **Organic Nitrogen** will again be converted into N₂ gas by bacterial. Nitrogenous compounds from dead organisms or wastes are converted into ammonia-NH₃ – by bacteria, and the ammonia is converted into nitrite and nitrates. In the end, the nitrates are made into N₂ gas by denitrifying prokaryotes (e.g. Pseudomonas). This nitrogen escape into atmosphere, thus completing the cycle.

Note: Nitrogen fixation also happens by other mechanisms:

- 1) Industrial Process (fertilizer factories)

- 2) **Atmospheric phenomenon** (thunder and lightning): The periodic thunderstorms convert the gaseous nitrogen into the atmosphere to ammonia and nitrates which eventually reach the earth's surface through precipitation and then into the soil to be utilized by plants.

Note1: Water Cycle, Carbon Cycle and Nitrogen Cycle were Gaseous Cycle.

Note2: Phosphorus, Calcium, Magnesium and sulphur circulate using sedimentary cycle. The elements involved in sedimentary cycle generally follow a pattern of Erosion -> Sedimentation -> Mountain Building -> Volcanic Activity and biological transport through the excreta of marine birds.

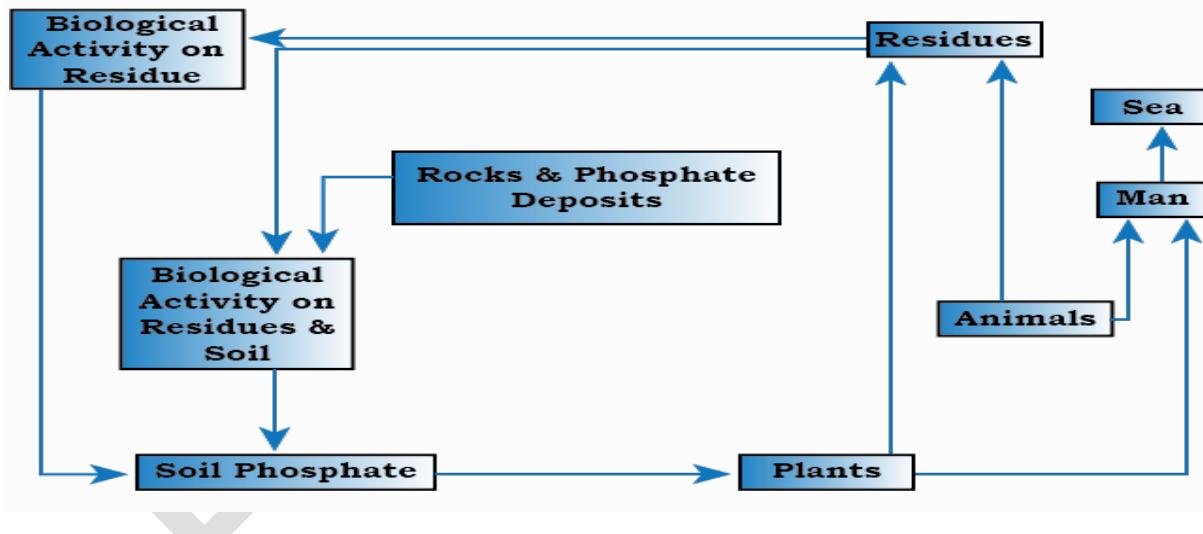
D) PHOSPHOROUS CYCLE

Unlike carbon and nitrogen, phosphorus occurs in large amounts as a mineral in phosphate rocks and enters the cycle from erosion and mining activities.

By the process of weathering and erosion, phosphate enter rivers and streams that transport them to ocean.

In Ocean, phosphorus will accumulate on continental shelves in the form of insoluble deposits. After millions of years, the crustal plates rise from the sea floor and expose the phosphates on land. After more time, weathering will release them from rock and the cycle's geochemical phase begins again.

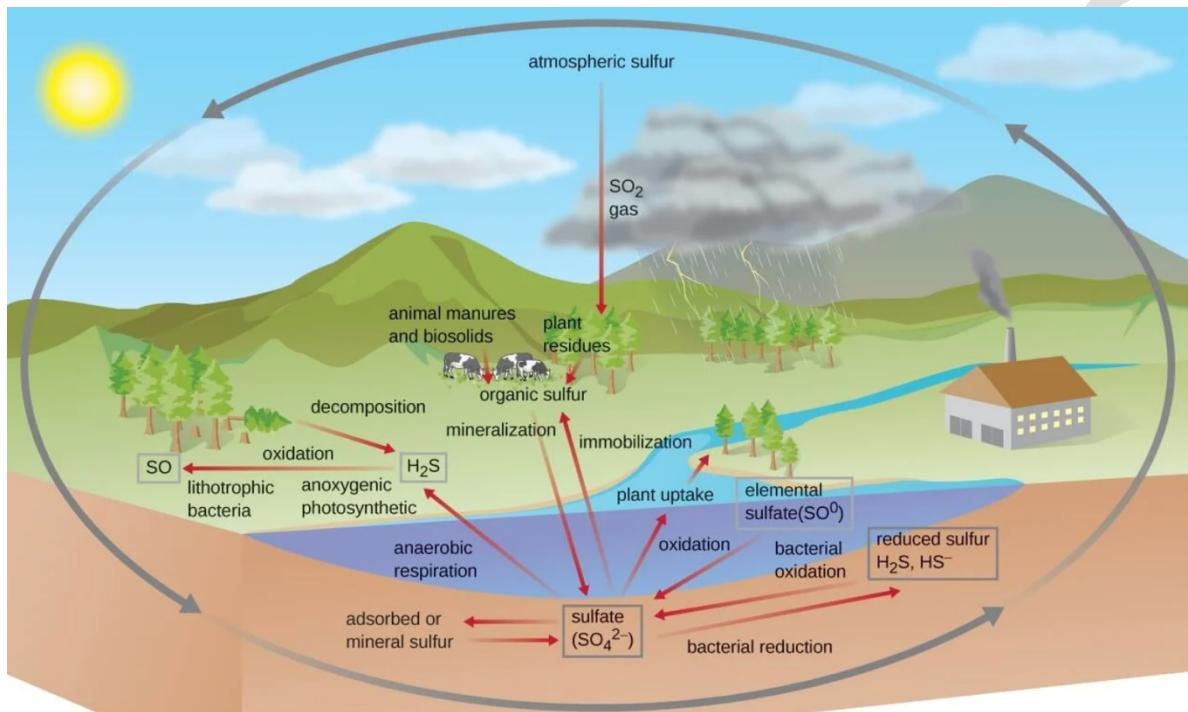
Note: Phosphorus is a primary nutrient that causes eutrophication in lakes causing algal blooms.



F) SULPHUR CYCLE:

- **Sulphur Reservoir** is in the soil and sediments where it is locked in organic (coal, oil and peat) and inorganic deposits (pyrite rock and sulphur rock) in the form of sulphates, sulphides and organic sulphur.
- **Release:** Weathering of rocks; Erosional runoff and decomposition of organic matter. It is carried to terrestrial and aquatic ecosystem in salt solutions.

- **Note:** The sulphur cycle is mostly sedimentary except two of its compounds Sulphur dioxide (SO_2) and Hydrogen Sulphide (H_2S) which add gaseous component to its sedimentary cycle.
- **Various ways in which Sulphur enters atmosphere:** Volcanic eruption, burning of fossil fuels, from surface of ocean and from gases released by decomposition. Atmospheric hydrogen Sulphide (H_2S) also gets oxidized to sulphur dioxide and is carried back to earth as Acid Rain.



3) ECOLOGICAL SUCCESSION:

- The process by which communities of plant and animal species in an area are replaced or changed into another over a period of time is known as ecological succession. Succession is a universal process of directional change in vegetation, on an ecological time scale. The process involves a progressive series of changes with one community replacing another until a stable, mature, climax community develops.

(A). Stages in Ecological Succession:

- 1. Pioneer Species:** The first plant to colonize an area. Pioneer Species will occupy the bare rocks. E.g., Bacteria, Fungus, Weeds, Moss, Lichens and in Tundra region, Rhododendrons.
- 2. Climax Community:** The final stage of succession is called climax community. A climax community is stable, mature, more complex and long-lasting.
 - E.g.: Temperature Deciduous forests; Tropical Rain forests etc.

3. Seral Community: A seral community is temporary and transitional stage in ecological succession, leading to the development of a stable and self-sustaining climax community. During ecological succession, a seral community represents a stage where a specific set of plant and animal species are dominant, but **they are not the final or permanent community.**

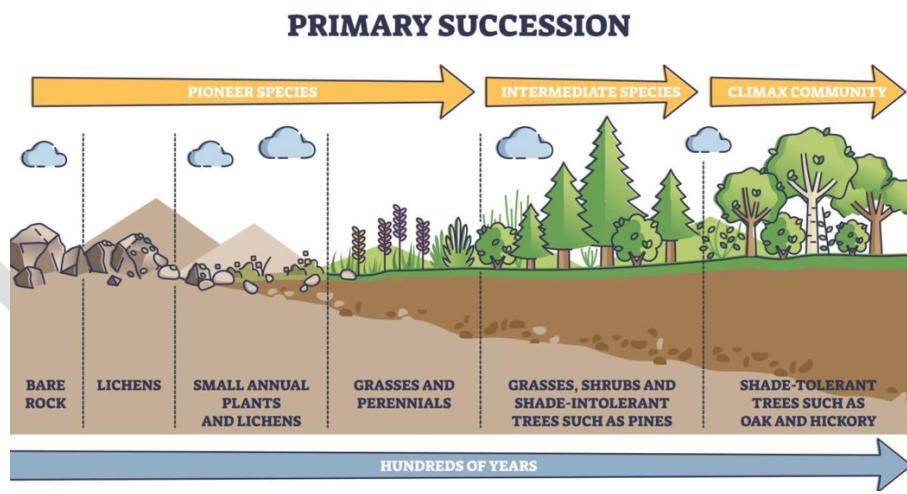
NOTE: Each ecological succession is characterized by **the increased productivity**, the shift of nutrients from the reservoirs, increased diversity of organisms, and a gradual increase in the complexity of food webs.

A) TYPES OF ECOLOGICAL SUCCESSION:

1. Primary Succession
2. Secondary Succession

PRIMARY SUCCESSION:

- Primary succession takes place an over where no community has existed previously. Such areas include rock outcrop, newly formed deltas and sand dunes, emerging volcano islands and lava flows, glacial moraines etc.
- In primary succession on a terrestrial site, the new site is first colonized by a few hardy pioneer species that are often microbes, lichens and mosses.



SECONDARY SUCCESSION:

- Secondary succession is the sequential development of biotic communities after the complete or partial destruction of the existing community.

- A mature or intermediate community may be destroyed by natural events such as floods, droughts, forest fires etc. or anthropogenic activities such as deforestation, agriculture, overgrazing etc.
- This abandoned land is first invaded by hardy species of grasses that can survive in bare, sunbaked soil.
- These grasses may be soon joined by tall grasses and herbaceous plants. These dominate the ecosystem for some years along with mice, rabbits, insects etc. Eventually some trees come up in this area, seeds of which may be brought by wind or animals.
- And over the years, a forest community develops. Thus, an abandoned land over a period becomes dominated by trees and is transformed into a forest.

ECOLOGICAL SUCCESSION IN WATER/AQUATIC:

- In primary succession in water, the pioneers are the small phytoplankton, and they are replaced with time by free-floating angiosperms, then by rooted hydrophytes (aquatic plants), grasses and the finally, trees.
- The climax again would be a forest. As the time passes, the water body is converted into land.

NOTE:

1. All the succession whether taking place in water or on land, proceeds to a similar climax community-the mesic.
2. Secondary Succession is faster process than the primary succession because the secondary succession starts on a well-developed soil already formed at the site.
3. Succession would happen faster in the area existing in the middle of the large continent. Here seeds related to various species would reach much faster, establishing and ultimately resulting in climax community.
4. In Savanna or Grasslands, Succession do not take place due to water and fire limits.
5. In Tropical Evergreen forests, original dense forest/vegetation does not re-grow once it is cleared because the soil is deficient in nutrients due to intense leaching.
6. In Tundra region, natural vegetation consists of Moss, Lichens & Rhododendrons, because in such tough conditions, only pioneer species can survive.

7. **Human beings affect 'secondary succession'** by causing 'soil erosion, global warming, loss of biodiversity, introduction of invasive alien species etc.' E.g., Due to introduction of invasive alien species such as pine, wattle, eucalyptus in Shola Forests of Western Ghats, forest fires (canopy fires occurs in Western Ghats) are increasing.
8. **Autogenic and Allogenic Succession:**
 - a. **Autogenic:** Succession brought about by living inhabitants of the community itself, the process is called autogenic succession.
 - b. **Allogenic:** Succession brought by outside forces.
9. **Autotrophic and Heterotrophic Succession:** Succession in which, initially the green plants are much greater in quantity is known as autotrophic succession; and the ones in which the heterotrophs are greater in quantity is known as heterotrophic succession.



TARGET PRELIMS 2024

BOOKLET-12; EB&CC-2

AIR POLLUTION

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2. POLLUTION AND POLLUTANTS

- Pollution refers to introduction of harmful materials (pollutants) into environment.
- Many things which are useful to people produce pollution.
 - » **Vehicles, Electricity production, Fertilizers, Pesticides, Plastic etc.**
- **There** are various types of pollution - Air Pollution, Water Pollution, Soil/Land pollution, plastic pollution, noise pollution, light pollution etc.
- There are various ways of classifying pollutants:
 - i. **Primary vs Secondary**
 - **Primary Pollutants:** It is an air pollutant emitted directly from the source.
 - Examples of primary pollutants: (Particulates, CO, NO₂, SO₂ etc.)
 - **Secondary Pollutant:** It is not directly emitted from the source as such, but forms when other pollutants (primary pollutants) react in the atmosphere.
 - Examples of secondary Pollutants: (Ozone, NO₂, Acid Rain, Haze (Organic Aerosol))
 - ii. **Quantitative Pollutants vs Qualitative Pollutants**
 - **Quantitative Pollutant:** These substances are naturally present in environment. They become problematic only when their quantity increase.
 - **Qualitative Pollutant:** These are not naturally present in environment and are introduced in environment by human activities. E.g., Fungicide, herbicide etc.
 - iii. **Persistent Pollutant vs Non-Persistent Pollutant**
 - **Persistent Pollutants** are those pollutants which remain consistent in the environment for a long period of time without any change in its original form. (For e.g., nuclear wastes, pesticides, plastics etc.)
 - **Non-Persistent Pollutants** are the opposite of persistent pollutants and breakdown in the simple form.
 - iv. **Biodegradable vs non-Biodegradable**
 - Biodegradable pollutants are the pollutants which can be decomposed by micro-organisms.
 - **Non-biodegradable pollutants** are those which are not decomposed by microbial action (e.g., plastics, glass, DDT, salts of heavy metals etc.)
 - v. **Natural vs Anthropogenic**

3. AIR POLLUTION

- Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere: WHO.

- **Sources** of Air pollution:
 - Vehicular emissions, industrial fuel burning, energy production, forest fires, household combustion etc. are important sources of air pollution.
- **Pollutants** of major public health concern include PM, CO, Ozone, NO₂, SO₂, Smog, Hydrocarbon, CFCs etc.

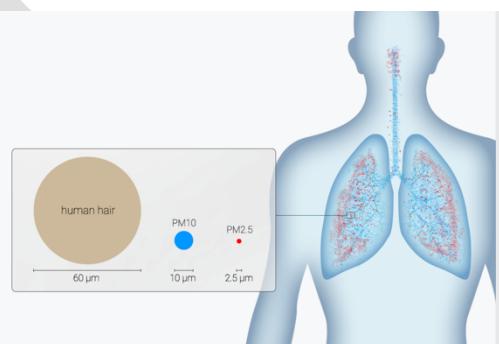
1) CO₂

It is a greenhouse gas which results into global warming.

2) SUSPENDED PARTICULATE MATTER (SPM)

A) PM2.5

- PM2.5 is defined as ambient airborne particulates (including dust, soot, dirt, smoke, and liquid droplets) that measure upto 2.5 microns in size. These particles include a range of chemical makeups and come from a range of source.
- **Main sources** include fossil fuel powered vehicles, power generation, Industries, Agriculture and biomass burning etc.
 - **Chemical reaction between gases** can also be a source of PM2.5 This include reactions between: SO₂, NO₂, Ammonia, Black carbon, Mineral dust, water, volatile organic carbon.
- Among criteria pollutants commonly measured in real time, fine particulate matter (PM2.5) is currently understood to be the most harmful to human health. Due to very small size, they can remain suspended in air for long periods and the microscopic size allows these particles to be absorbed deep into the bloodstream upon inhalation.
- **Exposure to PM2.5** have been linked to negative health effects like cardiovascular diseases, respiratory illness, premature mortality, low birth weight, and stroke.
- **PM2.5 can also cause negative environmental impact:** Damage to materials and buildings; Acid Deposition; increase ozone levels.



B) PM10

- **PM10** are suspended coarse particles, either solid or liquid, with a diameter of 10 micrometers or less. For comparison, a human hair is, on average, 50 to 70 micrometers in diameter. They are also sometimes referred to as floating dust or aerosols.
- **Difference between PM2.5 and PM10**
 - **Size:** PM2.5 is very fine, and PM 10 is larger and coarser.
 - **Less Harmful:** PM10 is less likely to cross from lungs to the bloodstream. Though they can penetrate deep into lungs.
- **Various sources:**
 - Smoke, Dust, and dirt from unsealed road, construction, landfill and agriculture

- Pollen
- Mold
- Smoke
- Industrial sources
- Fossil fuel burning
- Sea Salt

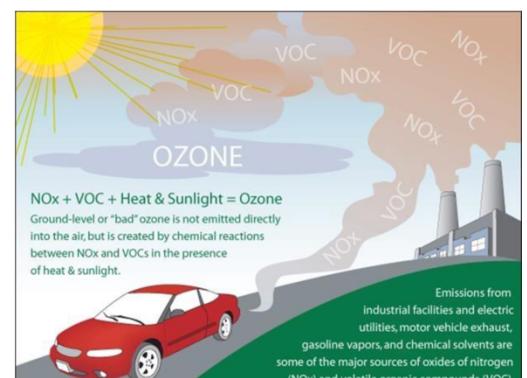
- **Health Impact:**
 - **Short term** - Difficulty breathing; coughing; eye, nose and throat irritation; Chest tightness and pain; Fatigue; General respiratory discomfort.
 - **Long term impact:** Heart failure, asthma, heart failure, cancer, adverse birth outcomes etc.
- **Environmental Impact:** Can corrode organic and inorganic material from vegetation to buildings. Painted surfaces, stone, fabrics, metal, and wood can become damaged and discolored.

3) CARBON MONOOXIDE

- CO is an odorless, colorless, and tasteless gas produced by the incomplete combustion of carbon in fossil fuels such as wood, propane, charcoal, oil, coal or other fuel.
- **Carbon monoxide Poisoning:** It occurs when carbon monoxide builds up in your bloodstream. When too much CO is in the air you're breathing, your body replaces the oxygen in your RBCs with carbon monoxide. This prevents oxygen from reaching your tissues and organs.
 - **Science behind this:**
 - Hemoglobin binds carbon monoxide (CO) 200 to 300 times more with oxygen, resulting in the formation of carboxyhemoglobin and preventing the binding of oxygen to hemoglobin due to competition of the same binding sites.
 - **Signs and symptoms** of CO Poisoning: Dull headache, weakness, dizziness, nausea or vomiting, shortness of breath, confusion, blurred vision, loss of consciousness etc.
 - It can particularly be dangerous for people who are sleeping or intoxicated. People may have a irreversible brain damage or even die before they realize the problem.

4) OZONE

- **Ozone (O_3)**
 - Ozone is a gas composed of three atoms of oxygen (O_3).
 - » **Key Properties:** It is a bluish gas. It is also a major oxidant.
 - It occurs in both earth's upper atmosphere and at ground level.
 - Ozone can be "good" or "bad" for health and the environment depending on where it's found in atmosphere.
- **What is Ground Level Ozone Pollution?**
 - Ozone pollution is a **secondary pollution** and is not emitted by source directly. It is created by chemical reactions between oxides of Nitrogen (NOx) and Volatile Organic Compounds that are



emitted from combustion sources like vehicles, industry, power plants etc. in **the presence of sunlight and heat.**

- It is most likely to reach unhealthy levels on hot sunny days in urban environment. It may also reach high level during colder winter months because of high pollution and sunlight.
- Since it can also be transported for long distances by wind, it may also impact rural areas.

- **Unprecedented Ozone Levels have made Delhi Air More Toxic: CSE analysis (June 2022)**
- **Why increasing in Delhi**
 - High level of pollution, with high sunshine and high ambient temperatures.
- **Negative Impact of Ozone Pollution**
 - **Health Impacts** -> Breathing problems, chest pain, cough, throat irritation; Further people with certain genetic conditions, and people who have lower intake of Vitamin C and Vitamin E are at greater risk of Ozone exposure.
 - **Environmental Impact** -> impact sensitive vegetation during growing season
- **Monitoring of Ozone**
 - **NAAQS (National Ambient Air Quality Standards)** by CPCB measures Ozone
 - AQI and SAFAR measurements also has listed ozone as a pollutant which is regularly measured.
- **Increase in Ozone levels even during lockdown: CSE Study (June 2020): Class Discussion**

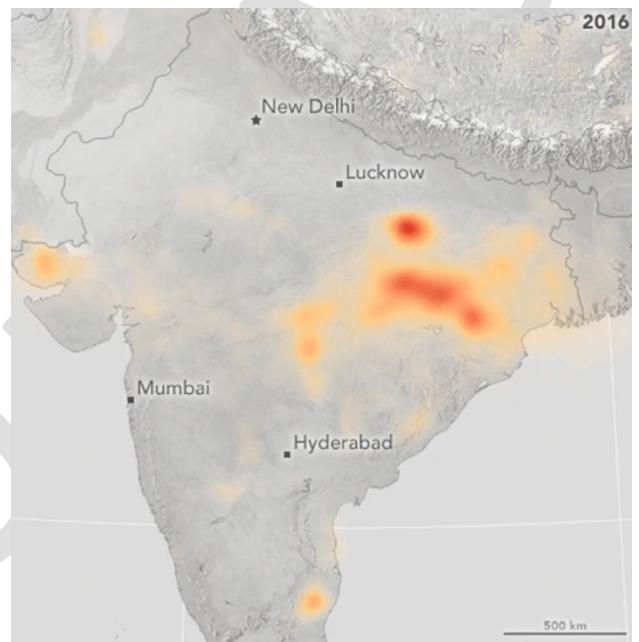
5) NITROGEN DIOXIDE

- **Details**
 - **Physical features:** It is a deep red-orange gas and when released into the air, it is seen as a reddish-brown haze. It has a pungent and acrid odour.
 - NO₂ is a major contributor in the formation of Smog and a precursor to many harmful secondary pollutants, including ozone and particulate matter. It is highly reactive with other chemicals and is strong oxidizing agent.
 - **Sources of NO₂**
 - **Natural Sources:**
 - Lightning Strikes
 - Volcanoes
 - Oceans
 - Biological decay
 - **Manmade sources:**
 - **Combustion** creates oxides of nitrogen, a major portion of which is nitrogen dioxide. When vehicles emit oxides of nitrogen, 90-95% of the emissions are nitric oxide (NO). However, nitric oxide quickly oxidizes in outdoor air when reacting to oxygen, ozone, and volatile organic carbons (VOCs) to form nitrogen dioxide.
 - **It is both a primary and secondary pollutant.**
 - As primary pollutant, NO₂ is emitted in limited amounts through vehicles.

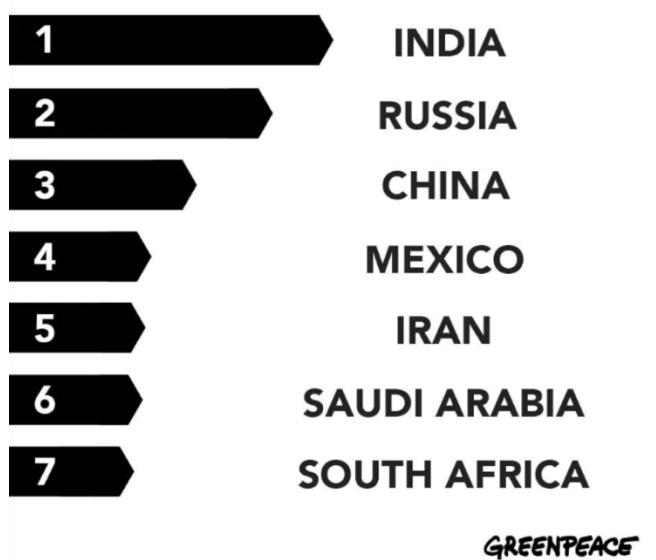
- It is also a secondary pollutant as it can be formed through oxidation. Nitrogen dioxide further oxidizes into **Nitric Acid (HNO₃)**, which can enter the environment through the ground as droplets or nitrate containing particles.

6) SO₂

- **Basics**
 - SO₂ is a colorless gas which has a nasty, sharp smell. It reacts with other substances to form harmful compounds, such as sulfuric acid, sulfurous acid, and sulfate particles.
- **Main Sources** - Burning of Fossil fuels and ships, locomotives using furnace oil/ heavy oil; Other small sources are - **industrial processes** like extracting metal from ore; nature sources such as volcanoes.
- **Why Sulphur dioxide pollution is problematic?**
 - **Health Issues:** Respiratory diseases; contribute to PM pollution.
 - **Environmental Issues ->**
 - **Harm trees and plants** -> Damaging foliage and decrease growth of trees and plants.
 - **ACID Rain** -> harms sensitive ecosystem
 - **Damage Cultural Heritage**
 - Deposition of sulfur particles may cause discoloration and damage of monuments, statues etc.
 - The fine particles may reduce visibility (Haze)
- **India has emerged as the largest SO₂ emitter in the world: NASA data.**
 - India has **highest number (more than 15%) of all anthropogenic SO₂ hotspots** in the world detected by the **Ozone Monitoring Instrument (OMI)** satellite. These include Singaruli, Nevyeli & Chennai, Talcher & Jharsuguda, Korba, Kutch etc.
- **Key reasons for High Sulphur pollution in India**
 - Nearly all the SO₂ emission in India comes from coal burning power plants which are the major source of energy for India.
 - The vast majority of power plants in India lack flue-gas desulfurization technology to reduce their air pollution.



Worst emitters of SO₂ pollution in the world



- **Note: Flue Gas Desulfurization (FGD)** is a set of technologies used to remove SO₂ from exhaust gas of fossil fuel based power plants.

7) BENZENE

- **Details**
 - Benzene (C₆H₆) is an aromatic, organic compound with a single six-member unsaturated carbon ring. It is clear, colorless, volatile, highly inflammable liquid with a characteristic order and a density of 874/m³.
 - Benzene in air mostly occurs in vapor phase, with residence times varying between 1 day to two weeks, depending on the environment, the climate and the concentration of other pollutants.
 - It is an **air pollutant** emitted from gasoline stations, motor vehicle exhausts and fuel evaporation, the burning of coal and oil, and various other sources. Urban areas generally have higher ambient air concentration of benzene than other areas.
 - **Indoor sources** of benzene pollution are material used in construction, remodeling, and decorating. Benzene is also present in particle board, furniture, plywood, fiberglass, flooring adhesives, paints, wood paneling, paint removers etc. Therefore, new buildings or recently decorated indoor environments have been associated with high concentration of benzene from materials and furnitures. Use of **fuel for space heating** like coal, wood, gas, Kerosene, LPG etc. also produce benzene.
 - **Negative Health Impacts of Benzene**
 - » Cancer, damage to immune system, neurological, reproductive or developmental issues.
 - In addition of being an air pollutant, it may also pollute water.
- **Joint Committee by NGT**
 - The joint committee consisted of officials from MoEF&CC, CPCB, SPCBs, NEERI etc. The committee was directed to assess the ambient air quality levels in the state, especially in major cities of Kerala.
 - **Key findings**
 - » Petrol refueling stations were a major source of benzene emissions, volatile organic compounds, and particulate matter 2.5 concentration.
 - **Key recommendations**
 - » Installation of vapor recovery systems at the fueling stations
 - » Retrofitting of diesel vehicles with particulate filters to improve air quality.
 - » Stringent action against industrial units that don't comply with emission norms.
 - » Retrofitting of emission control devices of generators and replacing diesel generators with gas-based ones.
 - » Promoting battery operated vehicles and banning old diesel vehicles in a phased manner, greening of open areas, and creation of green buffers along traffic corridors.

8) AMMONIA

- **About Ammonia**
 - Ammonia is a colorless gas with characteristics pungent odor.
 - **Natural sources** include decaying organic matter and animal waste.

- **Manmade sources** include fertilizer manufacturing, waste disposal sites, industrial processes etc.
- It doesn't last long in environment and thus doesn't bio-accumulate.

- Applications

- 80-90% of ammonia all over the world is used for **making fertilizer** (ammonium nitrate is an important nitrogen fertilizer)
- It is a precursor of various nitrogenous compounds. Virtually, all synthetic nitrogen compounds are derived from ammonia.
- It is also used in making household cleaners, plastics, dyes, pharmaceuticals etc.
- It is an anti-septic and is used in food preservation industry.
- Scientists are also experimenting with using ammonia as a storage of renewable energy. (Nitrogen gas and water use energy to convert into Ammonia). Later Ammonia can be used a fuel in the fuel cell.

- Ammonia Pollution

- Majority of airborne ammonia comes from fertilizers.
- Ammonia can also contribute to formation of PM_{2.5} (ammonia combines with VOC, NO_x, SO₂ etc. to form PM_{2.5})



- Health Impacts:

- At higher concentration ammonia is toxic, caustic, and hazardous. Exposures at high levels of ammonia can be irritating to a person's skin, eyes, throat, lungs, and cause coughing and burns.
- **Long term health concerns** associated with Ammonia exposure include – severe cardiovascular and respiratory effects, decreased lung function, asthma aggravation, premature death etc.

- Environmental Impacts -> Eutrophication, Soil Acidification; biodiversity loss -> promote species which prefer nutrient fueled growth to outcompete other species.

- Indo-Gangetic Plain Global Hotspot of atmospheric Ammonia: Study by IIT KGP (Dec 2020)

- The study titled “**Record high levels of atmospheric ammonia over India: Spatial and temporal analysis**” has been published in the international Elsevier journal “*Science of the Total Environment*”. In this study, the seasonal and inter-annual variability of atmospheric ammonia emitted by the agricultural sector was analyzed and the key highlights have raised certain concerns:
 - » The general trend in atmospheric ammonia over India is negative in most seasons. But, in USA, China and Europe, this trend is positive.
 - » For the period 2008-2016, the atmospheric ammonia during the month of June to Aug have grown rapidly at a rate of 0.08% annually.
 - » The Indo-Gangetic Plain is a global hotspot of atmospheric ammonia.
 - **Reason:** Intense agri activity and a lot of fertilizer use and production
 - » Atmospheric Ammonia has a positive correlation with Fertilizer use, hot weather (high temperature supports volatilization) and fires.

- » It has a negative correlation with total precipitation as wet deposits helps in the removal of ammonia.

- Water Pollution

- An ammonia concentration of upto 0.5 ppm (BIS) is maximum limit for drinking water. But, if the ammonia concentration is more than 1 ppm, it would negatively impact our health in long run. Similarly, ammonia concentration of more than 1 ppm in water bodies is dangerous for fish population.
- **High Ammonia Concentration in Yamuna River** is regularly disrupting water supply in Delhi.
 - For e.g., in July 2020, the ammonia concentration in Yamuna River reached 3 ppm. This led to reduction of water supply from Yamuna for Delhi, as Delhi Jal Board doesn't have technology to treat this high concentration of water.
- **Why ammonia pollution is so high?**
 - Industrial units of Sonipat and other drains joining the river along the way may be contributing to this.
- **Way Forward – Precision agriculture; Regulation of discharge; Reducing Nitrogen feed to animals; Improving water treatment technology; maintaining ecological flow of water.**

9) SMOG

- Smog

- Smog is a kind of air pollution, originally named for the mixture of smoke and fog in the air.
 - » **Classical smog** results from the large amount of coal burning in the area and is caused by mixture of Sulphur dioxide and smoke.
 - » Today, **most of the smog** that we see is **Photochemical Smog** (or ground level Ozone). It is produced when Nitrogen oxides in presence of **sunlight** react with **Volatile Organic Compounds (VOCs)** in the atmosphere.
 - **Nitrogen oxides** come from car exhaust, coal power plants, and factory emissions.
 - **VOCs** are released from petrol, paints, and many cleaning solvents.
 - When sunlight hits these chemicals, they form airborne particles and ground-level Ozone or Smog.

- Harmful impacts of SMOG

- **Health Impacts:** Ground level ozone, SO₂, NO₂, CO are especially harmful for senior citizens, children, and people with heart and lung conditions such as bronchitis and Asthma.
 - It may inflame breathing passage, impacting the functioning of lungs thus causing breathlessness, wheezing and coughing. It can also cause irritation to eyes and nose. It also dries out the protective membrane of the nose and throat and interfere with the body's



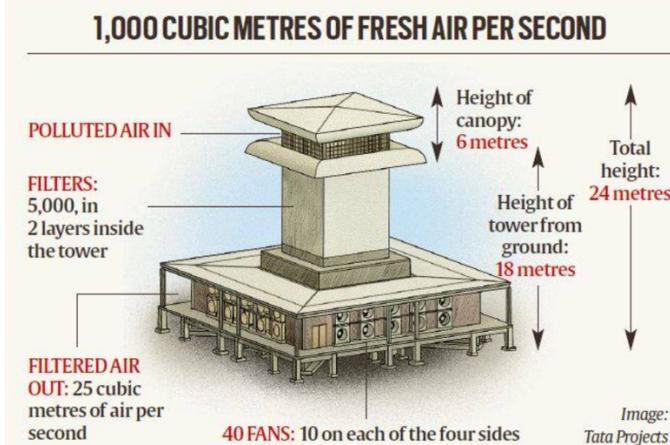
ability to fight infection, increasing susceptibility to illness.

- **By decreasing visibility**, it slows down traffic and increases the chance of accidents.
- Smog also negatively affects the **aesthetics** of the city by making sky brown and gray.

- **Supreme Court verdict:**

- **The Supreme Court** in Nov 2019 asked the CPCB and the Delhi government to come up with a road map on installing smog towers in the NCR to combat air pollution. In Jan 2020, the SC directed that the two towers should be installed by April as a pilot project.

- **Components of Delhi's first Smog tower by Government of Delhi:**



- The tower uses a '**down draft air cleaning system**' developed by University of Minnesota.
 - Polluted air is sucked in at a height of 24 meters, and filtered air is released at the bottom of the tower, at a height of about 10 meters from the ground.
 - When the fan at the bottom layer operates, the negative pressure created sucks in the air from the top. The 'macro layer' in the filter traps particles of 10 microns and larger, while the 'micro layer' filters smaller particles of around 0.3 microns.
 - This method is **different from the 'Updraft system'** - in which air is sucked in from the ground and is propelled upwards by heating and convection. Filter air is released at the top of the tower.
- **Expected Impacts**
 - Computational fluid dynamics modelling by IIT Bombay suggest that towers could have an impact on air quality of upto 1 KM.
- **Criticism**
 - Experts say that there isn't enough evidence to show that Smog towers work.

10) AEROSOL POLLUTION

- **What is aerosol?**

- » An aerosol is a **mixture of tiny particles suspended in a gas**, typically air. This particle can be solid, liquid, or a combination of both. These particles can range in size from a few nanometers to several tens of micrometers and can be produced naturally or by human activities.
 - » **Examples of natural aerosols** include dust, pollen, sea salt, and volcanic ash.

- » Examples of Human made aerosols include smoke, soot, exhaust fumes from vehicles, and particles generated by industrial processes like mining and manufacturing. They include PM2.5 and PM10.
- Impacts that aerosols can have:
 - » On Human Health: they may cause respiratory problems and exacerbating heart disease.
 - A study published in Science Advances showed that excess infant deaths in India were estimated to be three million - the highest among the eight regions evaluated in the study.
 - » On Environment: They can contribute to climate change by altering the balance of radiation in the atmosphere and affecting cloud formation.
- Aerosol Optical Depth (AOD):
 - » It is a measure of how much atmospheric aerosols, such as smoke, dust, and pollution, are scattering and absorbing sunlight.
 - It is typically measured using specialized instruments that detect the amount of light that is scattered or absorbed by aerosols in the atmosphere.
 - It is the quantitative estimate of the aerosol present in the atmosphere and it can be proxy measurement of PM2.5.
 - » The value of AOD range from 0 and 1. 0 indicating crystal-clear sky with maximum visibility whereas a value of 1 indicates very hazy conditions.
 - » AOD value less than 0.3 falls under green zone (safe), 0.3-0.4 is the blue zone (less vulnerable), 0.4-0.5 is orange zone (vulnerable) while over 0.5 is the red zone (highly vulnerable)
- Aerosol Pollution in West Bengal and Bihar (Nov 2022)
 - A study by Bose Institute in Kolkata as revealed that aerosol pollution in WB is anticipated to rise by 8% and continue to remain in the "highly vulnerable" red zone for aerosol pollution. This is the second highest forecasted aerosol pollution level in the country after Bihar.
 - India's regional weather patterns and topography makes the country highly vulnerable to aerosol pollution.
- Why?
 - West Bengal receives Indo-Gangetic Plain air pollution outflows and its local emissions have put WB in the highly vulnerable zone.

11) FLY ASH

- Introduction
 - Fly ash is a coal combustion byproduct produced in coal based thermal power plants. It refers to ash that is driven out of coal fired boilers together with the flue gases.
 - In modern coal fired power plants, fly ash is captured by electrostatic precipitators or other particle filtration equipment before the flue gas reaches the chimney.
 - The composition of fly ash varies considerably, but all fly ash includes substantial amount of Silicon di oxide (SiO₂), Aluminium oxide (Al₂O₃) and Calcium oxide(CaO), the main mineral compounds in coal-bearing rock strata.
 - **Note:** The ash that falls to the bottom of the boiler is called bottom ash.

- **Key characteristics of fly ash**
 - **Harmful for human health:** Fly ash contains toxic constituents like lead, cadmium, chromium, arsenic which can be very dangerous for human health. They contribute heavily to particulate matters in air and cause lung problems.
 - **Bad for environment**
 - Toxic content results in both soil pollution and water pollution (toxic leaching)
 - **Affects large land area.**
 - If fly ash is not captured at the power plant itself, it spreads easily through air and affects large land area.
 - **It is a pozzolan, a substance containing aluminous and siliceous material that forms cement in the presence of water.** Hence it can be used in construction process.

- **Reducing Fly Ash pollution**
 - Washing the coal at its place of origin is an important step which ultimately reduces the amount of ash being produced.
 - Increasing R&D, for enhancing the efficiency of power plants, would also help in reducing the ash content.
 - Capturing fly ash before it is released in air by Chimney using various types of precipitators.

- **Where can the captured fly Ash be used?**
 - Cement industry uses Fly Ash in the manufacturing of Portland Pozzolana Cement.
 - Recently, scientists at IIT-Hyderabad have found ways to turn fly ash into products like paints, textile coatings etc.
 - It can also be used fly ash bricks/blocks/ and tiles manufacturing, road embankments construction etc.
 - Fly ash may also be utilized in agriculture as soil conditioners.
 - It is also used as a substitute of soil/sand for reclamation of low lying areas.
 - In mining it can be used for backfilling of mines.

- **Steps taken to promote the use of Fly Ash?**
 - i. **Various notification for fly ash utilization** since 1999
 - The **2016 notification** calls for every agency engaged in construction activity within a radius of 300 km of coal-based thermal power plant to use ash based products for construction.
 - It also mandates the use of ash-based bricks or products in all government schemes and programs.
 - ii. **Maharashtra** is the first state to have a Fly Ash Utilization Policy. It is also looking to export fly ash to countries like Singapore and Dubai where it is in demand.
 - iii. **GST rates** on fly ash and its products have been reduced to **5%**.
 - iv. Launching of **ASHTtrack Mobile App** for better management of fly ash produced by thermal power plant in Feb 2018.
 - It will act as an interface between fly ash producers (thermal power plants) and potential ash users such as road contractors, cement plants etc and thus will help in increasing the utilization of fly ash being produced at coal based thermal power plants.
 - v. **Various awareness campaigns**

- Through workshops and other programs.
- **Draft Fly Ash Notification (2021)** - it is the proposed 5th amendment to the 1999 fly ash notification.
 - It introduces a concept of 3-5 years compliance cycle to achieve a target of 100 percent fly ash utilization by the end of cycle.
 - It also gives an extension of 10 years to power plants to progressively utilize their legacy ash.

12) INDOOR AIR POLLUTION

- Indoor Air Pollution or Household Pollution is the air pollution whose source lies within the household. Various recent studies have found that indoor PM2.5 level in most Indian households is much higher than the outdoor PM2.5 concentration of the respective geographic area.
 
- **Causes:**
 - Use of **the traditional biomass** (Cow dung cake, firewood, coal etc.) for cooking is the leading cause of air pollution.
 - Burning fuels such as dung, wood, coal in inefficient open hearth produce a variety of health-damaging pollutants, including particulate matter, methane, CO, polycyclic aromatic hydrocarbon and VOCs.
 - These pollutants may **further accumulate** in the indoor environment if the indoor air is not well ventilated.
 - **Tobacco** consumption
 - **Building Materials** (Deteriorating asbestos containing insulation, paints, varnishes, wood flooring, etc.)
 - Products for household cleaning and maintenance, personal care, or hobbies.
 - Broken CFLs, Tubelights etc.
 - **Increased penetration of closed ventilation** due to Air-conditioners etc. makes situation worst.
 - **Outdoor sources** such as Radon, Pesticides, outdoor air pollution.
- **Health Impacts**
 - Household air pollution is responsible for 3.2 million deaths per year in 2020.
 - Household air pollution leads to non-communicable diseases including stroke, ischaemic heart disease, chronic obstructive pulmonary disease (COPD) and lung cancer.
 - The most common effect of IAP is called **sick building syndrome**, in which people experience uncomfortable or acute health effects such as irritation of nose, eyes and throats, skin ailments, allergies and so on.
- **Key steps being taken by government.**
 - **RAISE initiative**.
 - **Unnat Chulha Abhiyan** – By Ministry of New and Renewable Energy for providing a clean cooking energy solution with a view to reduce consumption of fuel wood with higher efficiency and low emissions.
 - **PM Ujjwala Yojna**

A) RADON (Rn^{222})

- It is an odorless, invisible, radioactive gas, naturally released from rocks, soil, and water.
 - It is a noble gas and thus doesn't react chemically with other substances.
- It is formed by decay of uranium and thorium in the earth's crust.
- It can seep into buildings and accumulate to dangerous levels, especially in areas with poor ventilation.
- **Harmful Impacts:**
 - Carcinogen: It can cause lung cancer.
 - In USA, radon is the leading cause of lung cancer after smoking.
- **The risk of developing lung cancer** from radon exposure depends on the level of radon in air, the duration of exposure, and whether or not the person is smoker.
 - **Note:** For smokers the risk is higher as smoking can damage the lungs and make them more susceptible to the harmful effects of radon.
- **Detection of Radon:**
 - Since, radon is colorless, odorless gas, the only way to know if the building has higher levels of radon is to test for it.
 - The test is relatively easy and inexpensive, and it can be done by homeowners and professionals.
- **Some Steps that can be taken are:**
 - Sealing cracks in the foundation
 - Installing a ventilation system
 - Relocating to different house

13) PET COKE (PETROLEUM COKE) AND ASSOCIATED ISSUES

- **Introduction: What is Pet Coke**
 - » It is a type of coke derived from oil refining process. It is the final carbon-rich solid material from the bottom of the barrel after refining of heavy oils.
 - **Coking Process:** In petroleum coker units, residual oils from other distillation processes used in petroleum refining are treated at high temperature and pressure leaving petcock after driving off gases and volatiles, and separating off remaining light and heavy oils.
 - » **Properties**
 - Petcoke is 90% carbon and emits 5-10% more carbon dioxide (CO₂) than coal on a per-unit-energy basis when it is burned.
 - As they have higher energy content, they emit between 30-80% more CO₂ than coal per unit weight.
 - It also contains higher sulfur content which makes it burning more polluting.
 - It is cheaper and burns hotter than coal.
 - » **Used less in western countries.**
 - Its higher sulfur content makes it a less attractive fuel in US and thus power hungry India becomes an easy export destination.
 - » **Impact of use of petcock in India**
 - **India is the largest user** of the Pet coke.
 - It is making a bad situation worse in India due to its higher CO₂ and Sulfur emissions.

- **Ban on Pet Coke Import as fuel (Aug 2018)**
 - DGFT has banned import of Pet-Coke as fuel.
 - Import is allowed for only Cement, Lime Kiln, Calcium carbide and gasification industries, when used as feedstock or in the manufacturing process of actual condition.

14) FUEL OIL/ HEAVY OIL/ FURNACE OIL -> ISSUES CONCERNING THEM

- **Introduction**
 - » Fuel oil/ Heavy Oil/ Furnace Oil is the heavier fraction obtained from petroleum distillation.
 - **Note: Fractional Distillation**
 - Crude oil is separated into fractions by fractional distillation. The fractions at the top have lower boiling points than the fractions at the bottom.
 - » All the fractions are processed further in refining units.
 - » **Bunker Fuel** is the fuel used aboard vessels (heavy ships). Generally the heaviest variety of oil i.e. fuel oil is used there. It is also known as marine fuel oil.
- **Some features of heavy fuel oil:**
 - » Heavy fuel combustion products remain high in NO_x, So_x, Particulate matter and CO₂.
 - » It has high viscosity when compared to Diesel, Kerosene and Petrol. To be used as fuel it's viscosity should be less and therefore it needs to be kept at higher temperature. It is also mixed with lighter fuel (e.g. diesel) to reduce its viscosity.
- **In case of oil spills heavy oil is more aggravating in nature because:**
 - i. Marine fuel is hazardous and very toxic to marine life.
 - The incombustible material that remains after the combustion mainly consists of the metals vanadium, silicon, aluminium, nickel, sodium, and iron that are present in the original heavy fuel oil supply
 - Marine organisms are very susceptible to these heavy metals.
 - ii. It evaporates at a slower pace when compared to other fuel (petrol, Kerosene, diesel etc) and thus remain in water for longer period impacting marine diversity more.
- Despite the above limitations the use continues because of the cheap price and large availability (as it keeps getting produced in oil refineries)

15) AGRI-SUBSIDY AND AIR POLLUTION

- High MSP for Rice -> Rice grown in Haryana, Punjab etc. -> Stubble burning.

- Power subsidy -> more use of water -> paddy cultivation -> stubble burning
- Fertilizer subsidy -> Overuse -> Indo-Gangetic plains emerging as atmospheric ammonia hotspots

16) WHO'S AIR QUALITY GUIDELINES

- In Sep 2021, WHO revised the air quality guidelines. This was the first major update to the standards in 15 years.
- **Why was there a need of update?**
 - New studies have found that even smaller quantity of pollutants were harmful for human beings.
- Therefore, WHO has strengthened nearly all pollutant standards in comparison to the quality guidelines established in 2005 (published in 2006)
 - **Expected Impact:** If the target levels are implemented and achieved by governments, it would lead to saving of lakhs of lives.
- **The new guidelines recommend air quality levels for 6 pollutants**, where evidence has advanced the most on health effects from exposure.

Recommended 2021 AQG levels compared to 2005 air quality guidelines

Pollutant	Averaging Time	2005 AQGs	2021 AQGs
PM _{2.5} , µg/m ³	Annual	10	5
	24-hour ^a	25	15
PM ₁₀ , µg/m ³	Annual	20	15
	24-hour ^a	50	45
O ₃ , µg/m ³	Peak season ^b	-	60
	8-hour ^a	100	100
NO ₂ , µg/m ³	Annual	40	10
	24-hour ^a	-	25
SO ₂ , µg/m ³	24-hour ^a	20	40
CO, mg/m ³	24-hour ^a	-	4

- **Expected impact of the new guidelines:**
 - » Spur greater global reactions in pollution emissions.
 - » Contribute to fight against climate.
- **Note:** These guidelines are not legally binding on any country. But, countries and legislative bodies regularly refer to WHO guidelines when setting airborne pollutant control legal policy.
- **Implications for India**
 - » As per the new WHO guidelines, almost the entire India, specially the Urban areas would now be considered polluted for entire year.

4. INSTITUTIONS, INITIATIVES, SCHEMES, PROGRAMS ETC.

1) CENTRAL POLLUTION CONTROL BOARD (CPCB)

India's Central Pollution Control Board sets national ambient air quality standards and is responsible for both testing air quality and assisting governments in planning to meet such standards.

1974

2) AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981

Provides for the prevention, control and abatement of air pollution through boards established under this Act like Central Pollution Control Board.

1981

3) ENVIRONMENT POLLUTION (PREVENTION AND CONTROL) AUTHORITY (EPCA) [1998 - 2020]

- **About EPCA**
 - » EPCA was a **Supreme Court mandated body** tasked with taking various measures to tackle air pollution in National Capital Region (NCR).
 - » MoEF&CC notified this body in 1998 under the EPA, 1986.
 - » **Mandate**
 - Protect and improve the **quality of environment** and prevent and control **environmental pollution** in the **NCR**.
 - It is also mandated to implement the **Graded Response Action Plan (GRAP)** in NCR as per the pollution level.
 - » The Authority can take complaints **suo motu** or on the basis of a **filed complaint**.
- **Key contributions of EPCA** in 22 years of its existence
 - » Notification of Graded Response Action Plan
 - » Early adoption of BS-VI fuels standards
 - » Suggestions for Construction of the regional rapid transport system
- **Note:** The 22-year-old Environment Pollution (Prevention and Control) has been dissolved. (Oct 2020)

4) THE COMMISSION FOR AIR QUALITY MANAGEMENT IN NATIONAL CAPITAL REGION AND ADJOINING AREAS

- **Need**
 - A major reason behind high pollution levels in NCR has been the inability of CPCB, EPCA etc. to impose rules on the ground.
- The new permanent Commission envisages a multi-sectoral, participatory, multi-state dynamic body with a statutory status.
- **Details**

- The commission has been set up to monitor and check air pollution levels in the NCR and adjoining region.
 - » It **supersedes all existing bodies**. The commission shall have exclusive jurisdiction in respect of matters covered by the law.
 - » **Powers of CPCB/SPCB continue:** The CPCB and its state branches have the power to implement provisions of the Environment Protection Act for air, water and land pollution.
 - However, in case of **dispute** or clash of jurisdictions, the Commission's writ will prevail specific to matters concerning air pollution.
 - **The commission** will look at:
 - » Coordination between states
 - » Planning and execution of policy and interventions
 - » Operations of industry
 - » Inspections
 - » Research into the cause of pollution etc.
 - The powers to **levy fines - ranging up to Rs 1 crore or five years of prison** also lies with the commission.
 - The commission will be empowered to constitute special investigative groups for stricter implementation of air pollution norms on the ground.
 - **Structure**
 - » There will be at least six permanent members and it will be headed by a former or incumbent secretary to the GoI, or chief secretary to a state government.
 - » Overall, there would be **18 members** which would include five ex-officio members representing the five states; technical members from CPCB and ISRO; three representatives from NGOs with experience in combating air pollution; one representative from NITI Aayog.
 - **NGT:** Only the NGT, and not civil courts, is authorized to hear cases where the commission is involved.
 - **Area covered:** Delhi, Punjab, Rajasthan, Haryana and Uttar Pradesh
- **How is it different from EPCA?**
- **EPCA** was a Supreme Court mandated body, whereas the commission will be a **statutory body**.
 - **Area coverage:** EPCA - NCR, Commission -> NCR and adjoining areas.
 - » The pollution in Delhi is also caused by adjoining areas and therefore it has been given powers accordingly.
 - **State representation** was absent in EPCA but is present in the commission.
 - » The new 18-member commission brings together the Centre, states, and other stakeholders on one collaborative platform.
 - **Improved coordination:** the body has the mandate/powers to coordinate among states, which was absent in case of EPCA.

5) GRADED RESPONSE ACTION PLAN (GRAP)

- **GRAP** is the Delhi's **five-step escalating plan** to counter air pollution.
 - It was formulated in 2016 by Environmental Pollution Control Authority (EPCA) and approved by SC in the same year.
- **MoEF&CC had notified GRAP** for Delhi and NCR in 2017 and it draws its authority from this notification.
 - It institutionalized measures to be taken when air quality deteriorates.
 - The plan is **incremental in nature**. The **nature scope and rigor of measures** to be taken is linked to levels of pollution viz. Severe+ or Emergency, Severe, Very Poor, Moderate to Poor and Moderate.
 - **Note:** GRAP works only as an emergency measure and doesn't include actions by various state governments to be taken throughout the year to tackle industrial, vehicular and combustion emission.
 - Various directives of GRAP kick in based on the recommendations of a committee of experts;
- **Note:**
 - Since the formation of "the Commission for Air Quality Management in National Capital Region and Adjoining Areas", it is the designated agency for the implementation of the plan.
- **Significance**
 - GRAP has been successful in doing two things that had not been done before:
 - Creating a step-by-step for the entire Delhi-NCR region.
 - Getting on board several agencies: All pollution control boards, industrial area authorities, municipal corporations etc.
 - Fixed accountability and deadlines. For each action to be taken under a particular air quality category, executing agencies are clearly marked. In a city like Delhi which has multiplicity of authority, this has had a crucial difference.
 - EPCA along with GRAP has contributed in **three major policy decisions**:
 - Closure of thermal power plant at Badarpur, bringing BS-VI fuel to Delhi before the deadline set initially, and the ban on Pet Coke as a fuel in Delhi-NCR.
- **Limitations of GRAP**
 - **Focus on Delhi** - other states have managed to delay several measures, citing lack of resources;
- **How was GRAP implementation different in 2022:**
 - On 5th Aug 2022, the CAQM issued statutory direction, for the implementation of revised schedule of the GRAP.
 - **Key Changes in the revised action plan:**
 - a. Restriction on polluting activities will be dependent on Air Quality Index (AQI) rather than PM2.5 and PM10 concentration.
 - b. Measures could be taken up to three days in advance based on forecasts, the revised plan states.
 - **Earlier**, measures were implemented only after the PM2.5 and PM10 concentrations (micrograms per cubic meter) reached a certain threshold.
 - The **GRAP** for Delhi-NCR is divided into four stages. As per the plan, actions under stages 2-4 are invoked at least three days in advance of the AQI reaching the projected levels.

Stage	Key steps in each stage:
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Stage-1: "Poor" AQI: 201-300	<p><u>Ban on construction and demolition activities at specific sites.</u></p> <p>Agencies must ensure that all solid waste is lifted from dedicated dump sites, and none is dumped on the open land.</p> <p>Heavy fines are to be imposed for <u>openly burning municipal solid waste and biomass</u>.</p> <p>Roads will be <u>mechanically cleaned</u> and water will be <u>sprinkled from time to time</u>.</p> <p>Authorities will ensure that <u>thermal power plants comply with emission norms</u> and that <u>industries use approved fuel</u>.</p> <p>The <u>ban on firecrackers</u> should be followed as per the directions of respective courts</p> <p>Social Media is to be used to <u>update people about pollution levels and control room contact details so that violations can be reported to the authorities</u>.</p>
Stage-2: Very Poor AQI: 301-400	<p>Daily Mechanized sweeping of roads; Water sprinkling with dust suppressants at least on alternate days;</p> <p><u>Use of Coal and firewood in eateries would be banned.</u></p> <p><u>Use of Diesel Generators</u> might be allowed only in <u>certain cases</u>. Parking fees may be raised to discourage private transport.</p> <p><u>Resident Welfare Associations</u> would be required to provide <u>electric heaters</u> to security staff during winter to prevent the burning of solid waste or biomass.</p>
Stage-3: Severe AQI: 401-450	<p>The frequency of cleaning roads intensifies in this stage. Water would be <u>sprinkled daily before traffic hours</u>.</p> <p>Strict ban on <u>all construction activities except ongoing work on roadways, railways, metro, hospital etc.</u> Authorities will levy <u>different rates on public transport services to encourage off-peak travels</u>.</p> <p>The <u>state government</u> will be empowered to impose restrictions on BS-III petrol and BS-IV diesel light motor vehicles (4-wheelers)</p>
Stage-4: Severe Plus AQI > 450	<p>Entry of <u>all trucks</u> except those carrying essential commodities, or providing essential services is to be stopped into Delhi. This will be <u>followed by a ban on plying of diesel-operated medium goods and heavy goods vehicles in Delhi</u>, except those carrying essential items.</p> <p>All construction and demolition activities would have to be <u>stopped</u>.</p>

The respective government could meanwhile, take a call on allowing public, municipal and private offices to work at 50% strength.

If required, the Centre can allow work from home for central government employees.

Additional emergency measures like closing schools and other educational institutes, non-emergency commercial activities and plying of vehicles on an odd-even basis may also be enforced.

- **Revised GRAP to deal with adverse air quality scenario (Nov 2022)**

- In a move to mitigate dust arising out of C&D activities sites and intensify actions to further ameliorate the overall air quality of the NCR, the CAQM has mandated all C&D projects in NCR to deploy adequate number of anti-smog guns, in proportion of the total area of construction for the project.
 - Different number of guns have been recommended based on different size of the project. (1-> 5,000 - 10000 sqm; 2 for 10001-15,000 sqm; 3 for 15,001 - 20,000 sqm; 4 for 20,000 sqm)

- **Role of Citizens:**

- GRAP also includes a graded advisory for public:
 - **Under Stage-1**, the measures include properly tuning the engines of their vehicles, ensuring accurate air pressure in tyres, and updating PUC (pollution under control certificates). Turn off engines at red lights; don't dispose of waste or garbage in open space. Report air pollution activities through apps 311, Green Delhi, SAMEER"
 - **For Stages-2, 3 and 4**, the commission advises the public to opt for public transport, or work from home if required.
 - **Under stage-4**: the elderly and those with respiratory, cardiovascular, cerebrovascular or other chronic diseases are advised to avoid outdoor activities and stay indoors once stage-4 is implemented.

6) NATIONAL CLEAN AIR PROGRAM

- It is a pollution control initiative that was launched by the **Ministry of Environment** in Jan 2019 with the intention to cut the concentration of coarse particulate matter(**PM10**) and fine particles or **PM2.5** by at least **20%** (20-30%)in the **next five years** (i.e. by 2024), with **2017 as the base year** for comparison.
- It is a long term time bound national level strategy to tackle air pollution across Indian in a comprehensive manner.
- **Which are the cities covered?**
 - **132 Non-attainment Cities** identified on the basis of Ambient Air Quality Data for the period 2011-2015 and WHO report 2014/18.
- **Objectives**
 - Ensure implementation of **prevention, control and abatement** measures for air pollution
 - Improve the **monitoring network**.

- Enhance public awareness regarding air pollution and capacity building measures.
- Who all are participating?
- Apart from experts from industry and academia, various ministries like Ministry of Road Transport and Highways, Ministry of Petroleum and Natural Gas, Ministry of New and Renewable Energy, Ministry of Heavy Industries, Ministry of Housing and Urban Affairs, Ministry of Agriculture, Ministry of Health, NITI Aayog, and CBCB are participating.
- Key Steps being Taken
- i. Pollution Reduction measures
 - Plantation drives, promotion of better technology, sectoral interventions like electric vehicle promotion, promoting renewable energy, waste management etc.
 - City specific Plan - A separate emergency action plan will be created for each of the 132 cities. It will include measures for strengthening the monitoring network, reducing vehicular/industrial emissions, increasing public awareness etc.
 - ii. Enhancing R&D and Data collection
 - Studies related to air pollution and its impact will be taken on
 - Monitoring infrastructure will be expanded and will start covering rural areas as well.
 - A National Emission inventory will be established to provide proper inputs for future policy making.
 - iii. Strengthening various pollution related institutions
 - A National Apex Committee under MoEF&CC, a steering committee under Secretary (environment) and a monitoring committee (under joint secretary) will be established.
 - There will be project monitoring committees at the state-level with scientists and trained personnel.
 - In Addition sectoral working groups, National level project monitoring units, State level project monitoring units, city level review committee under Municipal Commissioner and DM level committee in the districts are to be constituted under NCAP for effective implementation and success of the program.
 - iv. Increased focus on awareness generation and people's participation.

7) BHARAT STAGE EMISSION STANDARDS (BS NORMS)

- Intro:
 - » Bharat stage emission standards (first introduced in 2000) have been instituted by the GoI to regulate the output of certain air pollutant (NO_x, CO, HC, PM, SO_x) by vehicles and other equipment using internal combustion engine. As stage goes up, the control on emissions become stricter.
 - » The standards and timeline for implementation are set up by the Central Pollution Control Board under the Ministry of Environment, Forest and Climate Change.
- Dates of Application
 - » BS-4: BS-IV norms are applicable throughout the country from 1st April 2017.
 - » BS-V: GoI has decided to skip the standards and directly move to BS-VI standards by 2020.

- » **BS-VI:** Introduced in Delhi from 1st of April 2018, it is applicable **throughout the country from April 2020** for all vehicles.

- **Differences in BS-IV and BS-VI standards**

- » The main difference between BS-IV and BS-VI norms is the **amount of Sulphur** in the fuel.
 - Reduction in Sulphur will make it possible to equip vehicles with better catalytic converters that capture pollutants.
- » Similarly, **NO_x emission** from diesel is expected to come down by 70% and by 25% in petrol vehicles. Further, the **restrictions on PM** has been increased in both diesel and petrol vehicles.
- » There are also lower limit for **HC and NO_x** in diesel engine.

	g/km	g/km	g/km	g/km	g/km	Sulphur
Petrol Emission Norms	CO	HC	NO_x	HC + NO_x	PM	
BS-III	2.3	0.2	0.15	---	--	
BS-IV	1.00	0.1	0.08	---	--	50 ppm
BS-VI	1.00	0.1	0.06	---	0.005	10 ppm (10 mg/kg)
Diesel Emission Norms	CO	HC	NO_x	HC + NO_x	PM	
BS-III	0.64	--	0.50	0.56	0.05	
BS-IV	0.50		0.25	0.30	0.025	50 ppm
BS-VI	0.50	--	0.06	0.17	0.005	10 ppm

- **Other Key Changes being brought:**

- **Diesel Particulate Filter (DPF) and Selective Catalytic Reduction (SCR)** are being introduced with the roll-out of Bharat Stage VI norms, which were not a part of Bharat Stage IV.
- **Real Driving Emissions (RDE)** will be introduced in India for the first time with the implementation of Bharat Stage VI emission norms. It will measure a vehicle's emission in real-time conditions against laboratory conditions.
- **Onboard diagnostics** has been made mandatory for all vehicles.
- BS VI would require usage of **Fuel Injection Technology** for two wheelers. This will the first such norm in India. This will filter out some PMs, some NO_x etc.

8) PETROL VS DIESEL COMPARISON

- **Conversion to CNG**

- » Converting petrol car to CNG only costs around 30,000 rupees, whereas in case of diesel car it costs around 1,50,000 rupees, as it requires fundamental changes in the engine of the car and is an expensive time-consuming process.

- **Is Diesel worse than petrol?**

- » **More SPMs:** A diesel car emits 22 times more Suspended Particulate Matters (SPM) - the tiny particles which easily penetrate your lungs, hearts and even brains.

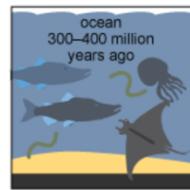
- » **More Nitrogen di oxide:** Diesel emits four times more nitrogen di oxide.
- » **Less CO₂ and better fuel economy:** However, a diesel car emits 15% less CO₂ than petrol and since it is more efficient fuel (it burns more than petrol), it also gives a higher fuel economy.

9) NATURAL GAS

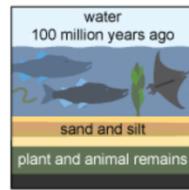
- Natural gas is a fossil fuel containing different organic compounds. It primarily consists of **methane**. Some other compounds in it includes ethane, propane etc. It is a colorless, tasteless and odorless gas.
- **How is natural gas formed?**
 - It is a fossil fuel which is formed due to extreme pressure and heat for millions of years on remains of plants and animals buried under the surface of the earth.

Petroleum and natural gas formation

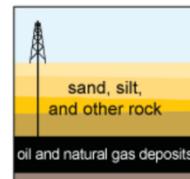
Tiny marine plants and animals died and were buried on the ocean floor. Over time, the marine plants and animals were covered by layers of silt and sand.



Over millions of years, the remains were buried deeper and deeper. The enormous heat and pressure turned the remains into oil and natural gas.



Today, we drill down through layers of sand, silt, and rock to reach the rock formations that contain oil and natural gas deposits.



- **Advantages of Natural Gas**
 - **Environmentally more clean than other fossil fuels:** It releases very less byproducts into the atmosphere as pollutants.
 - **Economical** - it is cheaper than other fossil fuels.
 - **Safer to use:** Unlike LPG cylinders which has the risk of leakage and accident, natural gas is lighter than air. In case of leakage, it dissipates quickly into air avoiding fire.
 - **Abundance**
 - **Easy to deliver - Piped transportation** make it easy to transport.
- **Limitations**
 - **Non-Renewable Fossil Fuel** - Emits CO₂ - Global Warming, Climate change.
 - **Easily inflammable**
- **Natural Gas comes in four basic forms:**
 - **Liquified Natural Gas** (liquified at -160 degree celsius). This facilitate transportation in large volumes in cryogenic tankers across seas/ land.
 - **Regasified LNG (RLNG)**: LNG re-gasified at import terminals before transporting it to consumers through pipelines.
 - **Compressed Natural Gas (CNG)**: Compressed to a pressure of 200-250 kg/ cm³ - used for fuel transportation.
 - **Piped Natural Gas**: Natural gas distributed through a pipeline network that has safety valves to maintain the pressure, assure safe, uninterrupted supply to the domestic sector for cooking and heating/ cooling applications.

5. RECENT AIR POLLUTION ISSUES

1) DELHI'S AIR POLLUTION PROBLEM

- Introduction

- » Delhi's air quality dips drastically every year with the arrival of harvest season during October-November. Though, government generally blames the stubble burning in the neighboring states as the key cause, but the air pollution in Delhi is a complex phenomenon that is dependent on a variety of factors.

- Key Factors include:

i. Input Pollutants

- Dust is the biggest cause of pollution during winters. Dry cold weather leads to dust being easily available in the entire region.
- Vehicular Pollution is the second biggest cause of pollution in winters.
 - According to a study by IIT Kanpur, around 20% of PM2.5 in winters comes from vehicular pollution.
- Stubble burning
 - At the time of Rabi harvesting around 25% of PM content in Delhi is due to stubble burning.
- Industries, thermal power plants, burning of waste during winters
- Diwali Pollution

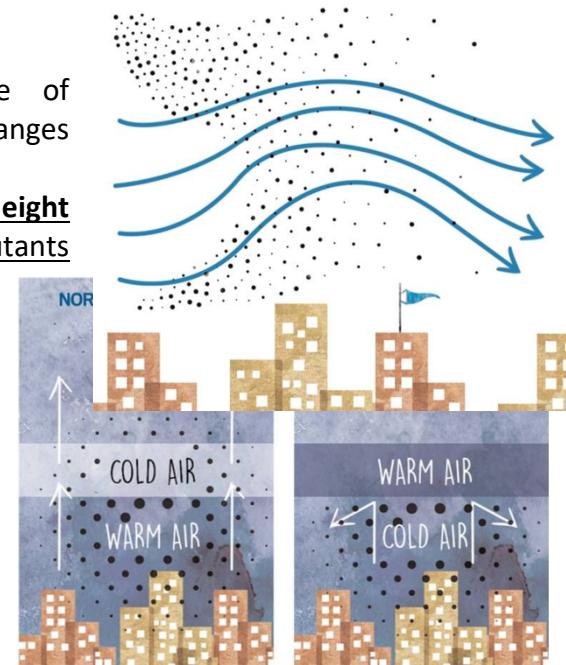
ii. Meteorological Factors

- **Wind Direction:** With the departure of Monsoon, the wind direction in Delhi changes from easterlies to westerlies.
- **Dip In Temperature brings the inversion height to lower levels.** The concentration of pollutants in the air increases when this happens.
 - Note: Inversion Height is the layer beyond which pollutants cannot disperse into the upper layer of the atmosphere.

- iii. **Low Wind speed in winters:** High wind speeds are effective in dispersing pollutants, but with arrival of winters, the average wind speed decreases.

iii. Other factors

- When compared to other metropolitan (i.e. Kolkata, Mumbai and Chennai) - Delhi is surrounded by high density region on all the sides. The other three cities are located near the coast, thus leaving the breathing space for the cities.



- **Steps taken in Delhi in the past to fight Air Pollution:**
 - In 1996, the Supreme Court took a note of the extremely poor air quality of Delhi and ordered the closure and relocation of over 1,300 highly polluting industries from Delhi's residential areas beyond the NCR in a phased manner. Multiple brick kilns were also directed to be relocated outside the city limit.
 - In 1998, the Supreme Court ordered the MoEF&CC to establish an authority for Delhi, which led to the creation of **Environment Pollution Control Authority (EPCA)** in 1998.
 - Supreme Court subsequently ordered conversion of the whole fleet of DTC buses, taxis and autos to CNG.
 - During this time centre also took several steps:
 - It revamped its Air Quality Monitoring Program and established a network of monitoring stations, under the National Air Quality Program.
 - In 2009, National Ambient Air Quality Standards were revised to include the 12 categories of pollutants including PM 2.5 - a noxious pollutant which can penetrate deep into the lungs and even enter the blood stream.
- **Steps taken in recent years to deal with pollution in Delhi**
 - **The Commission for Air Quality Management in National Capital Region and Adjoining Areas**
 - Formed in Oct 2020 through an ordinance to strengthen the air pollution control system in NCR and adjoining region
 - Replaces the EPCA
 - **Ban on Coal and other unapproved fuels from 1st Jan 2023**
 - Introduction of **BS-VI norms for Vehicles**
 - **Graded Response Action Plan (GRAP)**
 - **Push for Electric Vehicles - Delhi's Electric Vehicle Policy, 2019** subsidizes buying of electric vehicle and encourage people to move to electrical
 - **Various steps for controlling stubble burning**
 - **Prohibition on polluting crackers and promotion of green crackers**
 - **Odd-Even rule for vehicles** as emergency measures
 - **Construction of Eastern and Western Peripheral Expressways**
 - To provided fast alternative routes to vehicles not destined for Delhi.

2) BAN ON COAL AND OTHER UNAPPROVED FUEL IN DELHI (JAN 2023)

- CAQM has imposed a ban on coal and other unapproved fuels from 1st of Jan 2023. Industries using them would be closed and heavy fines would be imposed on them.
 - **Exceptions:**
 - Use of low sulphur coal in thermal power plants in Delhi NCR is allowed. It can be used wherever the primary purpose is power generation.
 - Firewood and biomass briquettes can be used for religious purposes and cremation.
 - Wood or bamboo charcoal can be used for tandoors and grills of hotels, restaurants, banquet halls (with emission control systems), and open eateries and Dhaba.
 - Use of wood charcoal for cloth ironing is allowed.
- The ban was notified by CAQM in June 2022

3) STUBBLE BURNING – CLASS DISCUSSION

A) PUSA DECOMPOSER

- a technology developed by IARI to manage paddy stubble in fields. It can rapidly degrade paddy straws in the field and convert them into compost, which then doesn't pose any issues for sowing of wheat crops, as per IARI scientists.
 - » It contains seven strains of fungi, which is to be mixed with water, 150 gms of jaggery and 50 gms of besan, to prepare a 25-litre solution that can be sprayed on 1 hectare of field.
 - » **Results:** Farmers of north Delhi found in 2020 that PUSA decomposer took about 20-22 days for stubble to decompose. This has helped in increasing soil fertility (less fertilizer use) and reduced the need of extensive ploughing to mix stubble with soil.

4) FIRE CRACKERS

- **Introduction**
 - » Firecrackers are among the most poisonous air pollutants. The **chemical footprint left by them have a devastating impact on human health and especially affects children**.
 - » CPCB in a study in Delhi in 2016 found that the levels of Aluminium, Barium, Potassium, Sulphur, Iron and Strontium rose sharply in Diwali night, from low to extremely high.
- **Science behind Firecrackers**
 - » Firecrackers use fuel and oxidizers to produce a combustion reaction, and the resulting explosion spreads the material in a superheated form. The metal salts in the explosive mix get 'excited' and emit light. Metals in the mix, which have varying arrangement of electrons in shells outside their nucleus, produce different wavelength of light in this reaction, generating spectacular colors.
 - For e.g. **Barium compounds** produce green light, Strontium and lithium salts produce red colors.
- **But firecrackers are big health hazards.**
 - » Chemicals such as barium nitrate and cadmium compounds cause respiratory irritation and gastrointestinal problems.
 - » Aluminium sulphide is known to cause Alzheimer's.
 - » Lithium and copper compounds cause hormonal imbalance and so on.
- In order to tackle the air and noise pollution during the festival season, the Supreme Court in a judgment (**Arjun Gopal & others Vs Union of India & others**), in Oct 2018 have mandated a series of steps to reduce the pollution from firecrackers. The key highlights of the Supreme Court Judgment includes:
 - i. **Improving the quality of crackers to reduce Air pollution**
 - a. Use of reduced emission firecrackers (**improved crackers**) only.
 - Avoiding use of ash as filler material -> Reduce particulate matter by 15-20%.
 - Use of charcoal meeting the PESO specifications.
 - b. Use of Reduced emission firecrackers (**green crackers**)
 - To reduce emission of PM, NO_x, and SO₂ due to in-situ water generation as dust suppressant.

- c. **Firecrackers only with permitted chemicals** to be allowed -> PESO shall test and check for the presence of banned chemicals like lithium/arsenic/antimony/lead & mercury.
 - d. **Banning of Barium salts in Firecrackers**
 - Barium emits poisonous gas causing respiratory problems and may have health complications due to long-term exposure.
 - **Why Barium so common in firecrackers:** emits green light, low cost, readily available.
 - e. **Enough facilities should be created to ensure use of quality raw material** in gun/flash powder as per the Petroleum and Explosives Safety Organization (PESO) specifications. This will address the issue of high content of unburnt/partially combusted material.
 - f. **PESO to ensure firecrackers satisfy decibel levels**
- ii. **Time Limit**
 - a. Firecrackers are only allowed from **8-10 pm** in Diwali and **11.55 pm - 12.30 pm** in Christmas and New year.
 - iii. **Blanket ban on online sale**
 - iv. **Ban on series cracker ('laris').**
 - v. **Stations house officer** will be held liable for contempt of court in case of violation of any judgment.

5) NGT BANS FIRE CRAKERS (NOV 2020)

- In Nov 2020, NGT has prohibited the sale and use of firecrackers during Deepavali in the NCR and in urban centres that recorded poor or worse air quality in Nov 2019.
- Sale of green crackers are allowed in cities and towns where air quality is moderate or below. But bursting of firecrackers are restricted to two hours during Diwali, Chatth, Christmas, and New Year.
- **Significance:**
 - A response to deteriorating air quality in various parts of the country. Primacy to precautionary principle in sustainable development over employment and revenue losses.
- **In July 2021, the SC upheld the NGT judgement.**

6) PETROLEUM AND EXPLOSIVE SAFETY ORGANIZATION (PESO)

- PESO is an statutory authority entrusted with the responsibility under the Explosives Act, 1884; Petroleum Act, 1934; Inflammable Substances Act, 1952, Environment (Protection Act), 1986 and rules made under those acts.
- It is a subordinate office under Department of Industrial Policy & Promotion.
- It is the nodal organization to look after the safety requirements in manufacture, storage, transport and use of explosives and petroleum.
- The organization is headed by Chief Controller of Explosives with its headquarter at Nagpur (MHA).
- **Other Recent Developments**
 - » In May 2018, Union Cabinet approved formation of Group 'A' service of the technical cadre of PESO in the name of Indian Petroleum & Explosives Safety Services (IPESS).
 - » The measure will enhance the capacity and efficiency of the organization and it will also enhance the career progression of its Group 'A' Officer.

- **Barium Nitrate** is used to produce green light and can produce more colors in combination with other chemicals.
 - » It is used in all light emitting fireworks.
 - » **Health Hazards:** Barium salts, as per the SC, can lead to health complications.
 - » **A replacement** of the salt is yet to be explored

7) GREEN CRACKERS

- **What are Green Crackers?**
 - » **Green Crackers** are firecrackers produced using less harmful raw materials and additives to reduce emissions.
 - CSIR-NEERI has defined Green crackers as those which will reduce emission by 30% and can limit sound to 125 decibels (at a distance of 5 meters).
 - Since the Supreme Court had banned barium nitrate, the green chemicals contain Potassium nitrate and zeolite in green crackers instead.
 - They newly developed crackers also include Safe Water Releaser, Safe Minimal Aluminum Cracker and Safe Thermite Crackers.
 - The additives in Safe Water Releaser give out water, air and dust suppressants.
 - The Safe Minimal Aluminium minimizes the use of aluminium, potassium nitrate and sulfur.
 - The Safe Thermite Cracker is based on a combination of metals, including aluminium, and metal oxides like iron oxides to produce heat.
 - » The **packaging** of these crackers contains a **QR code** and a **green logo** that states that they have been certified by CSIR and NEERI.
- **Supreme Court** in Nov 2019 has said that it wants every consignment of the material used in manufacturing green fire crackers to be tested for quality control.
 - » Quality control mechanism should be set up in each manufacturing unit of green fire crackers within 15 days and such units be monitored by officials from the Petroleum and Explosive Safety Organization (PESO).
- **Are Green Crackers completely Green?**
 - » **No**
 - » They produce 30% less PM2.5 and 50% less SO₂ emissions. But they still produce PM2.5 and SO₂.

8) SMELTING INDUSTRY AND POLLUTION

- Smelting is a metallurgical process that involves heating raw ore or metal in order to extract or refine a desired metal.
 - » The process involves use of high temperatures and chemicals to break down the ore, allowing the desired metal to be separated from the other materials in the ore or metal.
 - » Generally, the raw material is usually heated to a high temperature in a furnace, along with a reducing agent such as coke or charcoal, which helps to reduce the metal oxide in the ore or metal to a pure metal.

- Smelting is used in the extraction of metals like iron, copper, lead and zinc as well as in the production of alloys such as steel.
- **Smelting is also a major source of Pollution:**
 - » It releases large amounts of pollutants such as sulfur dioxide and heavy metals into the air, water, and soil. The industry also causes noise pollution.

9) ODOUR POLLUTION

- **Introduction**
 - World Health Organization recognizes Odour (unpleasant smell) as a pollution and says it affects the quality of life and social well-being of individuals. The unpleasantness is created by presence of compounds such as Ammonia, Hydrogen Sulphide, butyric acid, ethyl and methyl mercaptan and dimethyl sulphide.
 - **Impact**
 - Effect of odour varies from person to person but at sufficiently high concentrations, odour compounds may have direct effect on human health.
 - It may lead to vomiting, headaches, nausea, stress, anxiety, frustration, restriction in outdoor activities, children unable to sleep and discomfort for elderly and others.
- **Main Sources of Odour Pollution**
 - MSW dumpyards, oil refineries, fish markets, slaughter houses, distilleries, pharmaceuticals, biomedical and hazardous waste disposal sites and pesticide plants.
- **Steps Taken**
 - i. **Central Pollution Control Board (CPCB) issues detailed guidelines for proper Monitoring and Management of Odour at Urban Municipal Solid Waste Landfills (Sep 2017)**
 - The guidelines were based on the 'scientific pilot study' of East Delhi's Ghazipur landfill site.
 - **Buffer zones: Green Belt around land fill** sites and suggested selection of appropriate plant species for vegetation cover to assist in reducing odour.
 - **Trapping LFG gases:** MSW landfill sites should be designed to tap landfill gases (LFG) efficiently to mitigate fugitive odorous emissions.
 - **Legislative norms on baseline data:** The guidelines also suggested for initiating legislative norms for creating baseline data on odour.
 - Need for **gradual shift for installation of Continuous Odour Measurement Systems** (Sensor based) similar to Continuous Air Quality Monitoring Stations (CAAQMS).
 - This is needed as manual measurement is time consuming
 - **Various Considerations before choosing landfill sites**
 - Present population and projected growth for the next 20 years
 - Whether the selected site is free from the impact of other odorous sources and the topography of the site (slope, proximity to water sources like river and natural springs)
 - Selection should be integrated with the urban development plan of the city so that even expansions of the city in next two or three decades are not encompassing the selected MSW site

6. VARIOUS AIR QUALITY MEASURING INITIATIVES IN INDIA

1) NATIONAL AIR QUALITY MONITORING PROGRAMMES (NAMP)

- CPCB is executing a nation-wide program of ambient air quality monitoring known as National Air Quality Monitoring Program (NAMP).
- Objective of NAMP is:
 - i. To Determine status and trends of ambient air quality
 - ii. To Ascertain whether the prescribed air quality standards are violated
 - iii. To obtain the knowledge and understanding necessary for developing preventive and corrective measures
 - iv. To understand the natural cleansing process undergoing in the environment through pollution, dilution, dispersion, wind-based movement, dry deposition, etc.
- Pollutants covered:
 - i. Under NAMP, four air pollutants viz., Sulphur dioxide (SO₂), Oxides of Nitrogen (NO₂), Respirable Suspended Particulate Matter (RSPM/ PM10), and Fine Particulate Matter (PM 2.5) have been identified for regular monitoring at all the locations.
 - ii. The monitoring of meteorological parameters such as wind and wind direction, relative humidity (RH) and temperature were also integrated with the monitoring of air quality.

2) NAAQS (NATIONAL AMBIENT AIR QUALITY STANDARDS) BY CPCB

- Ambient Air Quality refers to the condition or quality of air surrounding us in the outdoors.
- NAAQS are the standards for ambient air quality set up by CPCB and are applicable nationwide.
 - The CPCB has been conferred this power by the Air (Prevention and Control of Pollution) Act, 1981.
- The current standards were set up in 2009 and were an improvement over previous standard. It covers **12 pollutants**:
 - CO, SO₂, NO_x, PM10, PM2.5, Ozone, NH₃, lead, Arsenic, Benzene, Benzopyrene, Nickel.

3) AIR QUALITY INDEX (AQI)

- Air Quality Index is a number used by government agencies to communicate to the public how polluted the air quality is or how polluted it is forecasted to become.
- In India, National Air Quality Index, was launched in Sep 2014 as part of Swachh Bharat Abhiyan by MoEF&CC.
- The CPCB, the nodal agency for air pollution data in India, has developed a color coded air-quality index to mark hazardous levels for the public benefit.
- There are six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and severe.
- It considers 8 pollutants (PM₁₀, PM_{2.5}, NO₂, SO₂, CO, O₃, NH₃, and Pb.)
- Initially it was launched in 10 cities and today it covers 24 cities in 10 states.

Color	AQI	Remark
Green	Good 0-50	Minimal Impact
Yellow	Satisfactory 51-100	May cause minor breathing discomfort in sensitive people.
Orange	Moderate 101-200	May make breathing difficult for people with lung diseases and cause discomfort in children, older adults and heart patients.
Red	Poor 201-300	May make breathing difficult after prolonged exposure, and cause discomfort to people with heart diseases.
Dark Red	Very Poor 301-400	May cause respiratory illnesses in people on prolonged exposure. Effect may be more pronounced in those with lung and heart diseases.
Black	Severe 400	May cause respiratory problems even in healthy people, and seriously impact those with lung/heart diseases. Even increased breathing during light physical activity can impact health.

- **Need of AQI**

- Traditionally air pollution data has been reported in very voluminous way. It was important that information of air quality is put up in public domain in simple linguistic term that is easily understood by common person.



TARGET PRELIMS 2024

BOOKLET-13; EB&CC-3

WATER – RIVER, GROUND WATER AND OCEANS

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2. INTERNATIONAL EFFORTS – CONVENTIONS, REPORTS, MEETS ETC.

1) WATER CONVENTION

- Negotiated under: United Nation Economic Commission for Europe.
- Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) was adopted in Helsinki in 1992 and entered into force in 1996.
 - » It is a legally binding instrument and aims to protect and ensure the quantity, quality and sustainable use of transboundary water resources by facilitating cooperation.
 - » It provides inter-governmental platform for day-to-day development and advancement of transboundary cooperation.
 - » It was initially negotiated as a regional (Pan-European) instrument. Later, it turned into a universally available legal framework for transboundary water cooperation, following the entry into force of amendments in Feb 2013, opening it to all UN Member States.
- It has emerged as a powerful tool to achieve the objective of SDG 6 (clean water and sanitation)
- **Is India a member?**
 - » No
- **Report:** "The Water Convention: 30 Years of Impact and Achievements on the Ground"

2) WORLD WATER DAY: 22ND MARCH

- **About World Water Day**
 - » WWD is an annual UN Observance Day which highlights the importance of fresh water. The day is used to promote awareness related to water conservation and advocate sustainable management of the freshwater resources.
 - » **UN-Water** is the convener for World Water Day and selects the theme for each year in consultation with UN organizations that share an interest in that year's focus.
 - » The day was first formally proposed in the 1992 UN Conference on Environment and Development in Rio de Janeiro. UNGA adopted the resolution regarding this in Dec 1992.
 - » The **first WWD** was observed on 22nd March 1993.
- **World Water Day, 2023**
 - » The theme for the year 2023 is "Accelerating Change."
 - It focuses on accelerating change to solve water and sanitation issues.

3) THE UN WORLD WATER DEVELOPMENT REPORT, 2023

- **Who Publishes the report.**
 - The UN World Water Development Report (WWDR) is an **UN-Water's flagship report** on water and sanitation issues, focusing on a different theme each year.
 - The report is published by UNESCO, on behalf of UN-Water and its production is coordinated by the UNESCO World Water Assessment Program.

- **Key Highlights of the 2023 Report:**
 - It assesses the role of partnerships and cooperation among the stakeholders in water resources management and development and their role in accelerating progress towards water goals and targets.

3. INITIATIVES IN INDIA

1) REPORT: COMPOSITE WATER MANAGEMENT INDEX (CWMI)

- **Introduction**
 - The CWMI is a first of its kind, comprehensive scorecard for identifying, targeting and solving problems in water sector across the country. It was first published in 2018.
 - **It is expected to:**
 - » Promote data-based decision making and thus scientific management of water.
 - » Encourage competitive and cooperative federalism.
 - » Establish a clear baseline and benchmark for state-level performance on key water indicators.
 - » Uncover and explain how states have progressed on water issues over time, including identifying high-performers and under-performers, thereby inculcating a culture of constructive competition among states.
 - » Identify areas of deeper engagement and investment on the part of the states.
 - » Eventually, the NITI Aayog plans to develop the index into a composite national-level data management platform for all water resources in India.
- **The indicators in the Water Index have been grouped into nine major broad themes.**
 - i. Source Augmentation and Restoration of water bodies
 - ii. Source Augmentation (ground water)
 - iii. Major and medium irrigation (supply side management)
 - iv. Watershed development - supply side management
 - v. Participatory Irrigation Practices - Demand side management
 - vi. Sustainable on-farm water use practices - Demand side management
 - vii. Rural Drinking water
 - viii. Urban water supply and sanitation
 - ix. Policy and Governance
- **Note:** CWMI 3.0 is worked in progress; CWMI 2.0 was published in Aug 2019
- **Note:** NITI Aayog now plans to combine CWMI 3.0, 4.0, 5.0 and 6.0 to cover the years 2021-22, and 2022-23. It is also contemplating data coverage to district level.

2) GOVERNMENT INITIATIVES

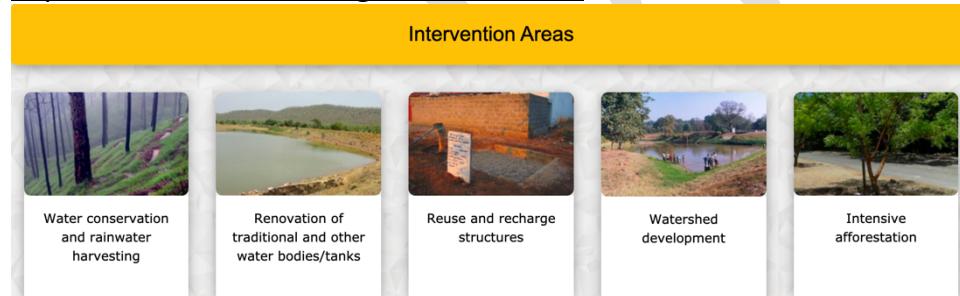
A) MINISTRY OF JAL SHAKTI

- A Unified Ministry of Jal Shakti was launched in May 2019 as an immediate response to the escalating water crisis in the country.

- The ministry was formed by **merging of two ministries**: Ministry of Water Resources, River Development & Ganga Rejuvenation and Ministry of Drinking Water and Sanitation.
- **Functions** of the new ministry ranges from providing clean drinking water, international and inter-state water disputes, cleaning Ganga river, its tributaries and sub tributaries.
- **Why?**
 - All water related initiatives are complementary to each other and therefore it's better to have one ministry for better coordination and integrated data management system.

B) JAL SHAKTI ABHIYAN

- **What is Jal Shakti Abhiyan?**
 - » It is Jal Shakti Ministry's flagship **water-conservation campaign**.
- **Need of the program:**
 - » In 1951, per-capita water availability in India: 5,000 cu m per year
 - » In 2011 -> 1,545 cu m per year
- **Jal Shakti Abhiyan-1**
 - » **Campaign was first launched in 2019** which was focused on water-stressed districts and blocks (256 districts and 1592 blocks). It was run through citizen participation during Monsoon season. (July - Sep and Oct - Nov (for states receiving north-east retreating Monsoon))
 - Under this, Gol worked with state and district officials in this water stressed districts to promote water conservation and water resource management by focusing on accelerated implementation of five target interventions:



- **Special Intervention Areas**

Special Intervention Areas				
Block and District Water Conservation Plan Development of Block and District Water Conservation Plans (To be integrated with the District Irrigation Plans)	Krishi Vigyan Kendra Mela Krishi Vigyan Kendra Melas to promote efficient water use for irrigation (Per Drop More Crop), and better choice of crops for water conservation	Urban Waste Water Reuse In urban areas, plans/approvals with timebound targets to be developed for waste water reuse for industrial and agriculture purposes. Municipalities to pass by-laws for the separation of grey water and blackwater	Scientists and IITs Scientists and IITs to be mobilised at the national level to support the teams	3D Village Contour Mapping 3D Village Contour Maps may be created and made accessible for efficient planning of interventions

- It was aimed at **making water conservation a Jan Andolan** through asset creation and extensive communication.
- **No separate funds** were allocated for JSA-1 and funds from convergence of different central and state government schemes were utilized.
- **Jal Shakti Abhiyan 2.0** couldn't be undertaken due to **COVID-19 restrictions**.
- However, Ministry of Jal Shakti has taken up the "***Jal Shakti Abhiyan: Catch the Rain***" (**JSA: CTR**) with the theme "Catch the rain, where it falls when it falls" covering both rural as well as urban areas of **all districts in the country**, during the pre-monsoon and monsoon period - i.e., upto 30th Nov 2021.
- "Jal Shakti Abhiyan: Catch the Rain" (JSA: CTR) -2022, **the third in the series of JSAs**, has been launched on 29.3.2022.
 - » It covers all blocks of all districts (rural as well as urban areas) across the country during 29th March 2022 to 30th Nov 2022 - the pre-monsoon period.
 - » The targeted interventions of the campaign in the current year are (1) water conservation and rainwater harvesting (2) enumerating, geo-tagging & making inventory of all water bodies; preparation of scientific plans for water conservation based on it (3) Setting up of Jal Shakti Kendras in all districts (4) intensive afforestation and (5) awareness generation.
 - » In this campaign, additional activities/ sub-interventions have been incorporated under the intervention 'water conservation & rainwater harvesting' which include spring shed management, protection of water catchment areas and creation/ renovation of 'amrit sarovars'

C) JAL JEEVAN MISSION (JJM) (WATER FOR LIFE) (HAR GHAR NAL SE JAL)

- JJM was launched in 2019 to provide **functional household tap connection (FHTC)** to every household by the end of 2024
- **Need:**
 - » Water inequality is a major concern in India. 81% of households in India were without tap connection (14.6 cr /17.87 cr)
 - » Safe drinking water together with a comprehensive sanitation program is important for reducing the disease burden of the poor.
- **Details**
 - » JJM restructures and subsumes the National Rural Drinking Water Program (running since 2009). The scheme is also known as **Har Ghar Nal Se Jal (HGNSJ)**.
- **The Broader Objectives of JJM are:**
 - » To provide Functional Household Tap Connections (FHTC) to every rural household by 2024 with a service level of 55 litres per capita per day (lpcd).
 - » To prioritize provision of FHTCs in quality affected areas, desert areas, drought prone areas and Sansad Adarsh Gram Yojna villages.
 - » To provide functional tap connection to Schools, Anganwadi centres, GP buildings, Health centres, wellness centres and community buildings



- » To monitor functionality of tap connections.
 - » To promote and ensure voluntary ownership among local community by way of contribution in cash, kind and/ or labour and voluntary labour (shramdaan)
 - » To assist in ensuring sustainability of water supply system, i.e. water source, water supply infrastructure, and funds for regular O&M
 - » To empower and develop human resource in the sector such that the demands of construction, plumbing, electrical, water quality management, water treatment, catchment protection, O&M, etc. are taken care of in short and long term.
 - » To bring awareness on various aspects and significance of safe drinking water and involvement of stakeholders in manner that make water everyone's business.
 - » A dedicated fund called '*Rashtriya Jal Jeevan Kosh*' has been set up by Ministry of Jal Shakti to mobilise and accept contributions received from other sources such as Corporate Social Responsibility to fund JJM.
- **Cost:** The total project is estimated to cost Rs 3.60 lakh crore.
- » **Center: State:** 50: 50 (90:10 for NE and Himalayan States and 100% for UTs)
- **Implementations**
- » JJM is implemented by the Department of Drinking Water and Sanitation (DDWS) under the recently formed MJS.
- **Steps which are planned:**
- » augment local water sources.
 - » recharge existing sources and.
 - » promote water harvesting and de-salination wherever required.
 - » Reuse grey water or discharged water.

D) MISSION AMRIT SAROVAR

- **Ministry:** Ministry of Rural Development (MoRD)
 - Mission Amrit Sarovar was launched on National Panchayati Raj Day on 24 April 2022 with the objective to conserve water for the future.
 - The Mission is aimed at developing and rejuvenating 75 water bodies in each district of the country during this Amrit Varsh, 75th Years of Independence.
- **The impact of this initiative has been.**
- » About 32 crore cubic meters of water holding capacity has been enhanced.
 - » Water Users' groups have been associated with each Amrit Sarovar inter-alia improving the livelihoods base of the local community.
 - » Participation of freedom fighters, Martyr's families, Padma Awardees, and other eldest citizens of the local areas helped in community participation at a large scale, promoting social harmony and patriotism, and making this mission a mass movement.
 - » People's participation has been seen in this mission in a form of "Shram -Daan".
 - » This will result in the creation of a total carbon sequestration potential of 1,04,818 tonnes of carbon per year.

3) JALDOOT APP

- **Ministry: MoRD**
- MoRD has developed 'JALDOOT App' which will be used across the country to capture water levels of selected well.
 - » It will enable Gram Rojgar Sahayak (GRS) to measure the water level of selected wells twice a year (pre-Monsoon post-Monsoon).
 - » In every village adequate number of measurement locations (2-3) have to be taken

A) NATIONAL WATER AWARDS

- **Why in news?**
 - 5th National Water Awards Launched on Rashtriya Puraskar Portal (www.awards.gov.in) (Oct 2023)
 - Application for awards could be filed here. Last date for submitting applications is 15th Dec 2023.
- **Department and Ministry:** The Department of Water Resources, River Development and Ganga Rejuvenation (DoWR, RD, & GR), Ministry of Jal Shakti .
- **Details**
 - NWA were instituted to recognize and encourage exemplary work and efforts made by states, districts, individuals, organizations, Panchayats, ULB, School, Industry, Society, Water User Association, Individual etc. across the country in attaining the government's vision of a 'Jal Samridh Bharat'.
 - It also strives to create awareness among the people about the importance of water and motivate them to adopt the best water usage practices.
 - SO far, it has provided a good opportunity to start-ups as well as leading organizations to engage and deliberate with senior policymakers on how to adopt the best water resources management practices in India.
 - The first National Water Award was launched by the Jal Shakti Ministry in 2018.

4. WATER POLLUTION RELATED ISSUES

1) RIVER POLLUTION

- **Why in news?**
 - » The number of polluted stretches in India's rivers has fallen from 351 in 2018 to 311 in 2022, though the number of most polluted stretches is practically unchanged: Report by CPCB (made public in Dec 2022)
- **Current River Pollution Situation in India (Dec 2022)**
 - » CPCB in association with pollution control boards/committees in different states/Uts monitors water quality of rivers and water bodies across the country through a network of monitoring

stations under the **National Water Quality Monitoring Program**. Total 4,484 locations in 28 states and 7 UTs including rivers, lakes, creeks, drains and canals are observed.

» **Standards of measurement by CPCB:**

- CPCB measures pollution level on the basis of **Biological Oxygen Demand**. If BOD is less than 3mg/L, it means the river stretch is fit for 'outdoor bathing'. If BOD of a point is > **3.0 mg/L**, it is identified as polluted locations.
 - Two or more polluted locations on a river in a continuous stretch are considered as a "polluted river stretch".
- **Polluted stretches** are classified between **Priority1** (BOD of 20-30 mg/L) to **Priority-5** (BOD of 3-6 mg/L).
- The success of river cleaning program is measured on the basis of how the river stretches are moving from Priority-1 to Priority 5 and if the priority-5 stretches are getting reduced.

» **Situation in 2018 report:** Number of stretches under various priorities:

- P1 (45); P2 (16); P3 (43); P4 (72); P5 (175);

» **Situation in 2022 report**

- P1 (46); P2(16); P3 (39); P4 (65); P5 (145);

» **Thus, there are no changes or slight changes in Priority 1 and 2.** This indicates that number of worst polluted regions remain the same.

- **Gujarat and Uttar Pradesh** have the maximum number (6) of Priority 1 river stretches.
- **Maharashtra** has the maximum number of polluted river stretches.

- **Factors:**

- **Discharge of untreated or partially treated sewage and Industrial effluents** from cities/towns in their respective catchments is the main cause of river pollution in states.
- **Illegal dumping of solid waste** on the banks of the rivers
- **Shortage of STP/ETP Capacity**
 - As per CPCB report (March 2021), the sewage generation in urban areas is at **72,368 million liters**/ day whereas total operational treatment capacity was only 26,869 MLD.
- **Poor operations and maintenance of Sewage and Effluent Treatment plants**
- **Non-points sources of pollution**
- **Rapid Industrialization and Urbanization** is further compounding the issue.
- **Min-Ecological flow** is not being ensured in many rivers.

- **Key steps being taken.**

- » It is the responsibility of states/UTs/local bodies to ensure treatment of sewage and industrial effluents before it being discharged into water bodies.
- » **MoEF&CC** is contributing in conservation of rivers by **providing financial and technical assistance** for abatement of pollution in identified stretches of rivers in the country through the Central Sector Scheme of Namami Gange for rivers in Ganga Basin and the Centrally Sponsored Scheme of National River Conservation Plan (NRCP) for other rivers.
- » Further, under MGNREGA, rejuvenation of small rivers is being prioritized.

- » In Addition, sewerage infrastructure is created under the AMRUT and Smart Cities Mission of MoHUA.
- » **Law and Regulations:**
 - As per the Environmental (Protection) Act, 1986 and the Water (Prevention and Control of Pollution), Act 1974, the industrial units are required to install effluent treatment plants (ETPs) and treat their effluents to comply with stipulated environmental standards before discharging into river and water bodies.
 - CPCBs, SPCBs and Pollution Control Committees (PCCs) monitor the industries with respect to treatment of effluent discharge standards and act for non-compliance under the provision of various acts.

2) NAMAMI GANGE

- **Introduction**
 - There have been several initiatives to clean Ganga so far. **National Ganga Action Plan 1** was started in 1986, **NGA-2** in 1993 and later extended to other states. Till 2014, more than 4,000 crores had been spent. But the river had remained dirty.
 - So, when government launched the Namami Gange in mid-May 2015, there was a new hope.
- **Namami Gange Program** was launched from June 2014 to 31st March 2021 to rejuvenate River Ganga and its tributaries with a budget of Rs 20,000 crores.
 - A total of Rs 14,084 crores has been released by GoI to NMCG, from FY15 to 31st Jan 2023, out of which Rs, 13,607 crores have been released by NMCG to state governments, state mission for clean ganga, and other agencies for the implementation of projects related to Ganga Rejuvenation.
 - In 2023, Government approved **Namami Gange Mission-II** with a budgetary outlay of Rs 22,500 crores till 2026. It includes projects of existing liabilities (Rs 11,225 crores) and new projects/interventions (Rs 11,275 crores)
 - **Eight Mains Pillars of Namami Gange Scheme**
 - Sewage Treatment Infrastructure
 - River Surface Cleaning
 - Industrial Effluent Monitoring
 - Ganga Gram
 - Afforestation
 - River Front Development
 - Biodiversity Protection
 - Public Awareness
- **Improved Governance Structure under Namami Gange:**
 - **Implementation** by NMCG and its state counterparts - State Program Management Groups (SPMGs).
 - **National Ganga Council** (replaced NGRBA) which is headed by PM and has chief ministers of five ganga basin states - UK, UP, Bihar, Jharkhand and West Bengal.

- It has the overall responsibility for the superintendence of pollution prevention and rejuvenation of River Ganga Basin, including Ganga and its tributaries.
 - **For Monitoring**
 - High level task force chaired by Cabinet secretary and assisted by NMCG.
 - State level committee chaired by Chief Secretary and assisted by SPMG.
 - District level committee chaired by the District Magistrate.
 - An **empowered task force**, headed by Union Water Resource Minister, was created and it has on board the chief secretaries of the five Ganga basin states. It is supposed to meet every three months.
 - **State Ganga Committee** have been formed. These committees would be the **nodal agency to implement the Program in states**. Further, they would also conduct safety audits of the river and river remedial measures.
 - **Synergy between different ministries** - Ministry of Jal Shakti have signed MoUs with 10 other ministries to synergize the activities under Namami Ganga.
 - **Focus on involvement of more stakeholders** including states, ULBs and PRIs, People and private sector (through PPP projects)
 - **4 Battalion of Ganga Eco-Task force** has also been envisaged to spread awareness and for protecting the river.
- **Mains Focus** on Namami Gange is on **pollution abatement interventions** which include
- Interception, diversion and treatment of waste water through bio-remediation, in-situ treatment, innovation technologies, STPs, Effluent Treatment Plants etc.
 - **Rehabilitation** of existing STPs
 - Immediate short-term measures for arresting pollution at exit points on river front to prevent inflow of sewage etc.
- **Other Steps under the Namami Gange Program**
- i. Hariyali is a plantation project along the stretch of Ganga in all five states through which it flows.
 - ii. **Ganga Gram Yojana**
 - To develop STP, toilets etc. in all villages along the river ganga. Based on Sichewal model (a Punjab village) which is based on cooperation of villagers for water management and waste disposal.
 - Government will spend Rs 1 crore per village in this plan.
 - iii. **Smart Ganga Cities**
 - Program for infra development along cities on Ganga river.
 - iv. **Promotion of organic farming** in villages along the Ganga.

A) NATIONAL GANGA COUNCIL (NGC)

- About National Ganga Council

- » National Ganga Council (NGC) chaired by the Prime Minister is an authority created in Oct 2016 under the River Ganga (Rejuvenation, Protection and Management) Authorities Order, 2016, dissolving the National Ganga River Basin Authority.
- » It has been given the overall responsibility for the superintendence of pollution prevention and rejuvenation of River Ganga Basin, including Ganga and its tributaries.

- Composition

- » PM is the ex-officio chairperson.
- » Union Minister of Jal Shakti is the ex-officio Vice Chairperson.
- » The other ex-officio members of the council are from various ministries and CMs of the corresponding states among other stakeholders.

- Jurisdiction

- » The Jurisdiction of NCG extends to states through which Ganga, its tributaries and sub-tributaries flow - Himachal, Uttarakhand, Uttar Pradesh, Haryana, NCR of Delhi, Rajasthan, Madhya Pradesh, Bihar, Chhattisgarh, Jharkhand, West Bengal etc.

3) ECOLOGICAL FLOW OF RIVERS

- What is ecological flow (e-flow) of a river?

- Ecological flow (or environmental flow) is the acceptable flow regimes that are required to maintain a river in the desired state. It is the quantity and timing of water essential for the river to fulfil its ecological, social and economic functions.

- In Oct 2018, the central government **notified the minimum e-flow for River Ganga** with an aim to maintain the natural pattern of the river flow (*Aviral Dhara*)

- NMCG has laid down these norms. It's applicable to the upper Ganga River Basin - starting from the Originating Glacier to **Haridwar** - and the main stem of Ganga upto Unnao district in Uttar Pradesh.
 - The e-flow notification specifies that the upper stretches of the Ganga — from its **origins in the glaciers and until Haridwar** — would have to maintain:
 - **20% of the monthly average flow of the preceding 10-days between November and March**, which is the dry season.
 - **25% of the average during the 'lean season' of October, April and May; and**
 - **30% of monthly average** during the monsoon months of June-September.

4) GROUND WATER ISSUES

Introduction: Global Situation

- As per World Water Development Report, 2022, Ground water accounts for 99% of the liquid freshwater on earth. It has continued to serve humankind for many millennia and currently around 50% of water used in domestic purpose and 25% of water used for irrigation globally comes from groundwater.

India's Situation:

Annual extractable groundwater availability in India (2017) is **393 BCM**.

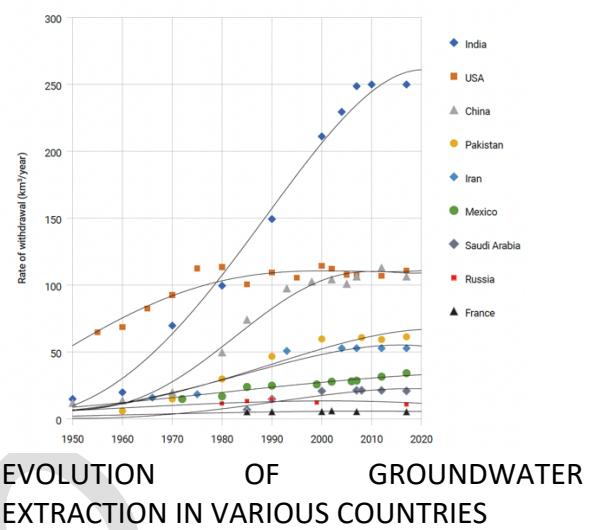
- India is the largest user of ground water in the world, extracting **253 BCM** per year, which is 25% of the global ground water extraction. It extracts more groundwater than USA and China combined together.

Most of the ground water extracted in India is for **Irrigation** (228 billion Cubic Meter (BCM)) which accounts for 90% of the total extraction.

- In India, 60% of irrigation requirement is fulfilled by groundwater.

The remaining **10%** (225 BCM) is for drinking, domestic as well as industrial uses.

- **Industrial use** accounts for only 5% of the total extraction



EVOLUTION OF GROUNDWATER EXTRACTION IN VARIOUS COUNTRIES

- **Satellite Gravimetry** has provided convincing evidence in support of the alarming rates of groundwater depletion.
- The data is supported by local level water table measurements in wells, where in 61% decline has been seen by CGWB.
- As per the 2022 assessment by the CGWB, 14% of assessments units in the country (1006/7089) have been categorized as 'Over-exploited' where the annual groundwater extraction is more than annual available Ground Water Resource. 4 States/Uts viz. Haryana, Punjab, Rajasthan, Dadra & Nagar Haveli and Daman & Diu have stage of Ground Water Extraction greater than 100%.
- **Key Challenges:**
 - **Depletion due to Over-extraction:**
 - » Over the years, groundwater has become the dominant source of irrigation as well as for domestic purpose. This is primarily due to unavailability of surface irrigation in regions such as Rajasthan.
 - » Installation of tube-wells have increased in north-western plains. Since the 1980s, 77% of the total addition to irrigation has come from tubewells. This has allowed farmers in the region to grow water intensive crops like Wheat and Rice. It has also allowed increase in cropping intensity by allowing for sowing of crops during dry winters.
 - » **Electricity Subsidy for agriculture and increased rural electrification** has also been a factor behind over-exploitation of ground water.

- » Expansion of solar powered irrigation systems which have led to very affordable cost of ground water extraction.
- » Weak law and regulations to prevent or limit diffuse groundwater pollution.
- » Industry that withdraws groundwater include manufacturing, mining, oil, and gas, power generation, engineering, and construction.
 - Bottled water industry is emerging as a major extractor.
- Destruction of wetlands, aquifers etc. which used to act as water sinks and contributed to ground water recharge.
- Pollution: (Both from Agriculture and Industry)
- Irreversibility: Once polluted, the aquifers tend to remain with polluted water.
- Climate Change: CC impacts groundwater through impacting precipitation, leakage from surface water, sea water intrusion into coastal aquifers

- Key Efforts for Groundwater:

- Recent Schemes:
 - » Jal Shakti Abhiyan: First launched in the year 2019, it focuses primarily upon effectively harvesting the monsoon rainfall through creation of artificial recharge structures, watershed management, intensive afforestation, awareness generation etc. JSA for the year 2023 was launched on 4th March 2023 with the theme "Source Sustainability for Drinking Water".
 - » Amrit Sarovar Mission - launched in April 2022 - focuses on developing and rejuvenating 75 water bodies in each district of the country as part of celebration of Azadi ka Amrit Mahotsava.
 - » Atal Bhujal Yojana is being implemented by central government in collaboration with states. It has an outlay of Rs 6,000 crores and is being implemented in certain water stressed areas of Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh. The Primary aim of the scheme is demand side management through scientific means based on water budgeting of the area involving local communities at village levels leading to sustainable groundwater management in targeted areas.
- Institutions:
 - » Central Ground Water Authority (CGWA) has been constituted under Section 3(3) of the "Environment (Protection) Act, 1986" for the purpose of regulating and control of ground water by industries, mining projects, infrastructure, projects etc. in the country.
 - The latest guidelines in this regard with Pan- India applicability was notified by Ministry in 2020. CGWA and State issues No Objection Certificate (NOC) for extraction of groundwater to various industries/project proponents as per their jurisdiction and as per the extant guidelines.
 - » CGWA is also implementing National Aquifer Mapping Program (NAQUIM) in the country. These reports along with management plans are shared with States/Uts for suitable intervention.

- MoHUA has formulated Model Building by Laws (MBBL), 2016 for the states/ Uts, wherein adequate focus has been given on requirement of rainwater harvesting and water conservation measures. 35 states/Uts have adopted the features of the Model Bye Laws.
- Major and Medium projects under Accelerated Irrigation Benefit Program are also reducing dependency on ground water extraction.

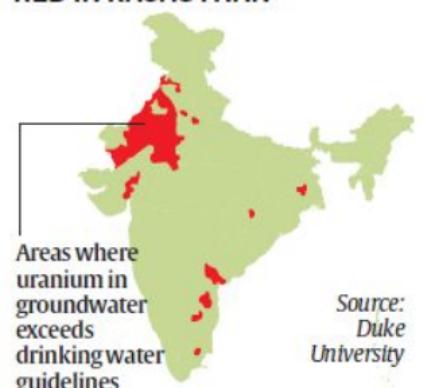
A) INSTITUTIONS FOR GROUND WATER

- Central Ground Water Authority, Ministry of Jal Shakti has the mandate of regulating ground water development and management in the country.
 - It has been doing it through measures such as issue of advisories, public notice, grant on NOC for ground water withdrawal etc.
 - It has been constituted under section 3(3) of the Environment (Protection) Act, 1986 to regulate and control development and management of ground water resources in the country.
- Central Ground Water Board (under ministry of Jalshakti) monitors water levels and quality through a network of 23,916 "National Hydrograph Monitoring Stations" - 6,503 dug wells and 16,693 piezometers.
 - Note: **Piezometer** is a device placed in a bare hole to monitor the pressure of groundwater.

5) URANIUM CONTAMINATION OF GROUND WATER

- How much of Uranium in Water is acceptable?
 - » WHO has set a provisional safe drinking water standard of 30 micrograms of Uranium per liter for India. This standard is also consistent with the US Environment Protection Agency Standards.
 - » In India, the Indian Standard IS 10500: 2012 for Drinking Water specification has specified the maximum acceptable limits for radioactive residues as alpha and beta emitters, values in excess of which render the water not suitable.
 - But Individual radioactive elements have not been specifically identified.
 - As per Information provided by Bureau of Indian Standards (BIS), they are **working to incorporate** maximum permissible limit of Uranium as 30 micrograms/liter.
- Situation in India:
 - » According to a study published in *Environmental Science and Technology* - there is **high Uranium Contamination in Ground Water of 16 Indian States**.
 - » A report by Duke University, USA in association with Central Ground Water Board and State Ground Water Departments states that Andhra Pradesh, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jharkhand, Karnataka, MHA, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, UP, WB and J&K have localized occurrence of Uranium concentration.

RED IN RAJASTHAN



- » WHO has also said that there is prevalence of concentration above 30 mg/l of Uranium in some localized pockets of few states/UTs in the country.
- » Why the contamination?
 - Ground Water Depletion and Nitrate Pollution may be aggravating the already present natural uranium contamination to dangerous levels.
 - Process:
 - Many of India's aquifers are composed of clay, silt and gravel carried down from Himalayan weathering by streams or uranium-rich granitic rocks. When over-pumping of these aquifers' groundwater occurs and their water levels decline, it induces oxidation conditions that, in turn, enhance uranium enrichment in the shallow groundwater that remains.
 - Though the primary source is geogenic, anthropogenic factors such as ground water table decline and nitrate pollution may further enhance uranium mobilization.
- » Impact
 - Uranium contamination of drinking water may be responsible for chronic kidney diseases. Radioactivity is not an issue here, but the toxicity is.

6) DETERGENT AND WATER POLLUTION

- Water pollution caused by detergents is emerging as a big concern all over the world.
- How much of detergent is consumed in different countries?

Country	Per capita detergent consumption per year
India	2.7 kg
Phillipines and Malaysia	3.7 kg
USA	10 kg
- Pollution due to detergents
 - Nonylphenol, a hazardous chemical present in detergents, is known to enter water bodies and food chain. It also bio-accumulates and can cause severe environmental and health risks.
 - » It has been detected from human breast milk, urine and blood.
 - » The Bureau of Indian Standards (BIS) has set the standard of phenolic compounds in drinking water at 0.5 mg/L and surface water at 5.0 mg/L.
 - The detergents are also suspected to contain carcinogenic compounds.
 - Many laundry detergents contain 35 - 75% of phosphate salt. This can cause many water pollution problems.
 - » It can inhibit biodegradation of organic substances.
 - » Eutrophication can also be caused by phosphate salts.
 - This may choke water bodies with algae and other plants. It can also deprive water of available oxygen, causing the death of other organisms.
 - » In Belgium, phosphate has been restricted since 2003 in detergents.
 - Detergents can also harm biodiversity

- » They are capable of destroying the external mucus layers that protect the fish from bacteria and parasites, causing severe damage to the gills.
 - Fish can die at detergent concentration near 15 ppm. Even at a concentration of 5 ppm, fish eggs would be killed.
- Detergents may also cause the water to grow murky. This blocks out light and disrupts the growth of plant. Turbidity also clogs the respiratory system of some fish species.
- **Way forward**
 - Finding **sustainable substitutes for harmful components** (for e.g. for Nonylphenol)
 - Efficient Use - Reduce
 - **Nanotech** - to develop newer varieties of fiber -> don't need harmful chemical detergent to wash.
 - **Improved Regulation** for chemical sector -> identify harmful chemicals; phase out these chemicals.

7) FRESH WATER SALINATION SYNDROME (FSS)

- **Introduction**
 - » Approx. 70% of the earth is covered by water; only 2.5% of that is fresh water.
- **How is FSS caused?**
 - » Road salts
 - » Human accelerated weathering of infrastructure, rocks and soils
 - » Sea-level rise and saltwater intrusion
 - » Evaporative concentration of salt ions from hydrologic modifications and climate
 - » Disturbance in vegetation and local groundwater hydrology.
- **Impacts**
 - » Increased water toxicity
 - » Reduction in freshwater resources
 - » FSS also increases chances of heavy metal pollution of water.
 - For e.g. saltwater can mobilize elevated levels of arsenic in water.
 - » Salination may degrade fertile land and make agriculture unviable.

8) HEAVY METAL POLLUTION

- **Heavy Metals and their Health Impacts**
 - » Heavy Metals are metals with relatively high densities, atomic weights, and atomic numbers.
 - Some heavy metals are either essential nutrients (Iron, Cobalt, Zinc etc.) or relatively harmless (such as ruthenium, silver, indium etc.), but can be toxic in large amounts.
 - Other heavy metals like (**Lead, Cadmium, Mercury, Chromium, Arsenic etc.**) are highly poisonous.
 - **Lead** was the most common cause of heavy metal poisoning. But with phasing out of leaded petrol all across the world, this would go down.

- Lead poisoning may lead to damage to brain, nervous system, Kidney etc. It may also interfere with the development of RBCs
 - **Mercury** - covered separately in details.
 - **Cadmium** - Industrial waste, batteries etc. are the most important source of cadmium poisoning. It negatively hampers the heart condition. It may also cause cancer and organ system toxicity such as skeletal, urinary, reproductive, cardiovascular etc.

- » Long term exposure to heavy metals may result in slowly progressing physical, muscular, and neurological degenerative process.

- » Once dispersed in the biosphere, these metals **cannot be recovered or degraded**. Hence, environmental effects of metal pollution tend to be permanent.

- **Sources of Heavy Metal Poisoning:**
 - **Mining**
 - For e.g. mining releases chromium, cadmium, lead and mercury - all toxic heavy metals.
 - Raniganj in West Bengal, Jharia in Bihar and Singrauli in Madhya Pradesh are considered some of the "hot spots" of metal pollution.
 - **Tailings**
 - **Industrial Waste**
 - **Agricultural runoffs**
 - **Occupational exposures**
 - **Paints**
 - **Treated Timber**

A) LEAD POISONING

- **Lead:**
 - » It is a naturally occurring toxic metal found in the Earth's crust. Its widespread use has resulted in extensive environmental contamination, human exposure and significant public health problems in many parts of the world.

 - » There is no safe level of lead in the body.
 - Mental impairment can occur due to the presence of five micrograms of lead per deciliter (mcg/dL) of blood. Levels in excess of 100 mcg/dL can be fatal.

 - » **Where is lead used?**
 - More than 3/4th of the global lead consumption happens in manufacture of lead acid batteries for motor vehicles.
 - It is also used in products like pigments, paints, solder, stained glass, lead crystal glassware, ammunition, ceramic glazes, jewellery, toys and some cosmetics and traditional medicines.

 - » **Important sources of environmental contamination:**
 - **Mining**
 - **Smelting**

- Manufacturing
 - Recycling activities
 - Use of leaded paint and leaded aviation fuel
 - Drinking water - delivered through lead pipes or pipes joined with lead solder may contain lead.
- » Much of the global use of lead is now obtained through recycling.
- Health Issues:
 - » Young children are particularly vulnerable to the toxic effects of lead. It also causes long-term harm in adult, including increased risk of high blood pressure and kidney damage.
 - » Pregnant women, if exposed to high level of lead, may suffer from miscarriage, stillbirth, premature birth or low birth weight.
 - Sources and routes of exposure:
 - » Inhalation of lead particles generated by burning materials containing lead for e.g. during smelting, recycling, stripping etc.
 - » Ingestion of lead contaminated dust, water (from leaded pipes) and food (from lead-glazed or lead soldered containers).
 - » Some traditional medicines (in India, Mexico and Vietnam), also had presence of lead.
 - World Freed from toxic leaded Petrol: UNEP (Aug 2021)
 - » Details
 - A global campaign led by the UNEP and its Partnership for Clean Fuels and Vehicles (PCFV) have successfully led to freeing world from the toxic leaded petrol.
 - » India and leaded Petrol
 - India was among the early countries to take steps against lead. The process of phase down started in 1994 and got completed in 2000.

B) MERCURY POLLUTION

- Introduction
 - » Mercury occurs naturally in the earth's crust, but human activities, such as mining and fossil fuel combustion, have led to widespread global mercury pollution.
 - » Mercury emitted into the air eventually settles into water or onto land where it can be washed into water. Once deposited, certain microorganisms can change it into methylmercury, a highly toxic form that builds up in fish, shellfish and animals that eat fish.
- Prescribed standards by Indian government and WHO
 - » Drinking water: 0.001 mg/l
 - » Industrial waste: 0.01 mg/l
- Sources of Mercury Pollution
 - » An element in the earth's crust.
 - » Other Natural sources include volcanic eruptions and emissions from the ocean.
 - » Anthropogenic Sources include:
 - Coal burning power plants are the largest human caused source of mercury.
 - Use of Mercury to separate gold from ore bearing rock (another major source of mercury pollution)

- Other sources of mercury pollution includes.
 - Burning hazardous waste
 - Producing chlorine
 - Breaking mercury products and spilling mercury
 - Improper treatment and disposal of or wastes containing mercury (Kodaikanal Mercury Poisoning by Hindustan lever)
- **Exposure**
 - Most human exposure to mercury is from eating fish and shellfish contaminated with methylmercury
 - **Breathing mercury vapor:** When products that contain elemental mercury break and release mercury to the air, particularly in warm poorly ventilated indoor spaces.
- **Harmful effects:** Mercury is **poisonous in all forms** - inorganic, organic or elemental. It is a neurotoxin; it is particularly harmful in the early stages of development, it can impair motor skills and can adversely affect immune system
- **Airborne Mercury**
 - » Until recently species that do not eat fish were thought to be safe from the harmful effects of Mercury. However recently researchers have documented mercury in Bicknell's thrushes, terrestrial birds that inhabit mountain top in northeast Illinois, where habitat lie downwind of the coal burning epicenter of the Ohio.
- **Mercury Pollution in India**
 - Mercury contamination in India is reaching alarming levels largely due to the discharge of mercury-bearing industrial effluents ranging from 0.058 to 0.268 mg/liter.
 - **Centre for Science and Environment** have compiled data from various sources to identify critically polluted mercury regions in India:
 - High level of mercury in fish stocks have been found, mainly in coastal areas.
 - Mumbai, Kolkata, Karwar and North Koel (in Bihar) are some of the severely affected areas.
 - Koel river showed mercury concentration almost 600-700 times above the limits.
 - Mercury in ground water and Surface water was detected throughout the country
 - Further, near **industrial units** such as chlor-alkali, cement, chemical units and thermal powerplants, levels higher than the permissible limits were found.
- **Minamata Convention on Mercury**
 - It is an international treaty designed to protect human health and the environment from anthropogenic emissions and release of mercury and mercury compounds.
 - Convention was ratified by delegates from 140 countries in January 2013.
 - **Why is global response needed?**

- **Mercury pollution is global problem** that requires global action because it moves with air and water, transcends political boundaries, and can be transported thousands of miles in the atmosphere.
- **Major Highlights**
 - **Bans new mercury mines; phase out existing mines.**
 - **Control measures on air emissions** from power plants.
 - **Regulate informal sectors like small scale gold mining.**
 - **Phase out or reduce mercury use** in products like batteries switches etc.;
 - Addresses supply and trade, safer storage and disposal and strategies to address contaminated sites.
 - Technical assistance, information exchange, public awareness and research and monitoring
 - Parties to **report** on measures taken to implement certain provisions.
- **India ratified** the convention in 2018.
 - This allows India to get technological and financial assistance in the fight against mercury pollution.
 - The convention has given five year time to India to control and reduce emissions from new power plants and 10 years' time for already existing power plants.
- **Minamata COP-5 (Nov 2023)**
 - Held in Geneva
 - Parties decided new dates to phase out mercury-added products including cosmetics,
 - Strengthened ties with indigenous people.
 - Advanced the first effectiveness evaluation of the convention.
 - Reached an agreement on a threshold for mercury waste.

C) ARSENIC POLLUTION

- **Introduction**
 - » **Arsenic** is an odorless and tasteless metalloid which is widely distributed in the earth's crust.
 - | | |
|-----------------------|---|
| Periodic Table | Elemental arsenic is a member of Group VA of the periodic table, with nitrogen, phosphorus, antimony and bismuth. It has an atomic number of 33 and an atomic mass of 74.91 |
|-----------------------|---|
 - » **Arsenic contamination of the ground water is one of the most serious drinking water issue** being faced in India.
 - » **BIS** stimulates a permissible limit of 0.01 mg/L of arsenic in water. But, as per the latest CGWB study, **21 states** across the country have pockets of arsenic levels higher than this limit.
- **Key Areas impacted by Arsenic Pollution in India**
 - » The states in **Ganga-Brahmaputra-Meghna** river basin are the most affected. They include - UP, Bihar, Jharkhand, WB, and Assam.
 - » Other arsenic affected areas include Punjab, Haryana, Manipur, Chhattisgarh and Karnataka.
- **Sources of Arsenic Pollution**

- » Arsenic is introduced in soil and groundwater through weathering of rocks and minerals followed by subsequent leaching and runoff.
- » **Anthropogenic sources** - coal fired power plants, burning vegetation, and Volcanism.
- » **Ground water contaminated with Arsenic** is also entering food chain.
 - The chemical has found its way into rice, wheat and potato. A unique observation was that in several samples, arsenic content in food items was higher than that in drinking water.



- Impact

- Long-term intake of arsenic polluted water leads to **arsenic poisoning** or arsenicosis, with **cancer of skin, bladder, kidney or lung or diseases of skin, blood vessels of legs and feet**.
- **Key Recent steps:**
 - Under Jal Jivan Mission (Har Ghar Nal se Jal), since, planning, implementation, and commissioning of piped water supply scheme based on a safe water source may take time, purely as an interim measure, state and Uts have been advised to install community water purification plants (CWPP) especially in Arsenic and Fluoride affected habitations to provide potable water to every household at the rate of **8-10 litres per capita per day** to meet their drinking and cooking requirements.

D) RADIOACTIVE POLLUTION IN WATER

- Details

- » Radioactive pollution of water is a newly emerging, but grave concern of water pollution and human health.
- » Radioactive elements are naturally found in earth's crust. Percolation of naturally occurring radioactive materials (NORM) from the soil sediments to the aquifer causes groundwater contamination.
- » **Anthropogenic sources include:**
 - Nuclear weapon investigation.
 - nuclear calamities.
 - nuclear powerhouse;
 - dumping of radioactive waste are the major sources.
 - Use of radioisotopes in industries and scientific laboratories are the minor sources.
- » This pollution is more prevalent in groundwater as compared to surface water since it is much exposed to radioactive elements found in rocks. Sometimes magma also releases radioactive gases in environment.

- » A number of radionuclides are found in surface and sub-surface waters, among which 3H, 14C, 40K, 210Pb, 210Po, 222Rn, 226Ra, 228Ra, 232Th, and 234,235, 238 U are common.
 - **Uranium, thorium, and actinium** are three NORM series that contaminate water resources.
 - **Radium**, a descendent of NORM series, is one of the decidedly radiotoxic elements found in aquatic systems and can be penetrated into groundwater via (i) aquifer rock dissolution (ii) decaying of ^{238}U and ^{232}Th , or (iii) desorption process
- **How is radioactivity measured?**
 - » It is measured in **Becquerel** (SI unit) or in curies.
 - Energy absorbed per unit mass is measured by Gray, while the unit Sievert measures the quantity of radiation absorbed by human tissues.
- **A small amount** of radiation is found in all types of water, but the extended amount of radiation is harmful to human health.
- **Harmful Impacts of nuclear radiation:**
 - » Immediate: recoverable consequences distressing skin, lungs, genitals, and causing of hair fall.
 - » Long standing: permanent outcomes such as various infections like radiation damage, bone marrow fatality, cataract initiation, cancer stimulation, cholera, etc.
 - » Genetic effects: ionizing radiation induces mutations in germ cells
- **WHO guidelines:**
 - » Guidelines for drinking water quality and a permissible limit of reference dose level of 0.1 microsieverts per year.

E) THERMAL POLLUTION: WATER POLLUTION FROM THERMAL POWER PLANTS

- **Thermal Pollution** is the degradation of water quality by any process that changes ambient water temperature.
- **Heat** is considered a **water pollutant** if it is caused by human activities.
- **Major causes of thermal pollution include:**
 - **Coolant from thermal power plants**
 - **Industry effluents**
 - **Alteration of vegetation cover** - increases the heating of water.
- **Negative impact of Thermal Pollution**
 - **Oxygen** deficiency (reduced solubility and high metabolism)
 - **Temperature** sensitive aquatic organisms die.
 - **Decrease in decomposition of organic matter** (oxygen deficiency leads to aerobic decomposers not functioning effectively)
 - **Primary productivity and diversity** of aquatic plant species decline
- **Note:** Even unnatural lowering of temperature of a water body is harmful.
 - Aquatic biodiversity is very sensitive to temperature change.

9) MARINE POLLUTION

A) LISBON DECLARATION

- Why in news?
 - All 198 members of the UN have unanimously adopted the Lisbon Declaration on Ocean Conservation in July 2022 on the last day of the UN Ocean Conference 2022.
- Details
 - Participants agreed to work on preventing, reducing and controlling marine pollution. It includes:
 - Nutrient Pollution
 - Untreated Wastewater
 - Solid Waste Discharges
 - Hazardous Substances
 - Emissions from the marine sector, including shipping, shipwrecks
 - Anthropogenic underwater noise
 - The nations committed to follow science based and innovative action on an urgent basis.
 - They also agreed that developing countries (particularly small island developing states) and LDCs need assistance with capacity building.
 - Developing and promoting innovative financing solutions to help create sustainable ocean-based economies as well as expanding nature-based solutions to help conserve and preserve coastal communities.
 - Member nations also committed to empowering women and girls, recognizing their participation is crucial to building a sustainable ocean-based economy and achieving the UN-mandated SDG14.
- The conference has set the stage for the fifth session of the intergovernmental conference on an international legally binding instrument for the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction.

B) HIGH SEAS TREATY

- Why in news?
 - Negotiators from almost every country in the world finalized a new global treaty meant for conservation of sustainable use of biological resources in the high seas (March 2023)
- Background:
 - The High seas are open ocean areas that are outside the jurisdiction of any country. It consists of around 64% of the ocean surface and around 43% of earth. These are home to millions of marine species and trillions of micro-organisms.
 - Existing Legal Framework for High Seas:
 - UNCLOS
 - Antarctic Treaty System
 - Limitations:

- UNCLOS is not primarily focused on sustainability and environment protection. Though, it asks countries to protect the ocean ecology and conserve its resources, it doesn't provide the specific mechanisms or processes to do so.
- Technical Name of the Treaty: the 'Agreement under the UNCLOS on Conservation and Sustainable use of marine biodiversity in areas beyond national jurisdiction (BBNJ)'
- Key Highlights of the Treaty:
 - The nations of the world have agreed to a Framework for the Conservation and Sustainable Use of Resources in the open oceans.
 - The **High Seas Treaty** will work as an implementation agreement under UNCLOS, much like Paris Agreement under UNCLOS.
 - Key Provisions:
 - The treaty has **Four Main Objectives**:
 - Demarcation of **Marine Protected Areas** (MPAs), rather like there are protected forest and wildlife areas.
 - Under this, a state or group of states can submit a proposal for MPA along with relevant information. It also provides guidelines for implementation, monitoring, and review of MPAs established.
 - **Note:** As of now, only 1.44% of high seas are protected according to IUCN.
 - Sustainable use of marine genetic resources and equitable sharing of benefits arising from them.
 - Initiation of the process of Environmental Impact Assessments for all major activities in the oceans
 - The agreement includes an obligation to conduct EIAs for activities with potential impacts on the high seas that will apply to new activities such as geo-engineering.
 - It also includes a new impact threshold to trigger a screening process, which means more activities will now be subject to at least some assessment.
 - **Capacity building and Technology transfer.**

Marine Protected Areas	MPAs are where ocean systems, including biodiversity, are under stress, either due to human activities or climate change. These can be called the national parks or wildlife reserves of the oceans. Activities in these areas will be highly regulated, and conservation efforts similar to what happens in forest or wildlife zones, will be undertaken
Marine Genetic Resources	Oceans host very diverse life forms, many of which can be useful for human beings in areas like drug development. Genetic information from these organisms is already being extracted, and their benefits are being investigated. The treaty seeks to ensure that any benefits arising out of such efforts, including

	monetary gains, are free from strong intellectual property rights controls, and are equitably shared amongst all. The knowledge generated from such expeditions are also supposed to remain openly accessible to all
Environmental Impact Assessment	The high seas are international waters that are open for use by all countries. Under the provisions of the new treaty, commercial or other activities that can have significant impact on the marine ecosystem, or can cause large-scale pollution in the oceans, would require an environmental impact assessment to be done, and the results of this exercise have to be shared with the international community
Capacity Building and Technology Transfer	The treaty lays a lot of emphasis on this, mainly because a large number of countries, especially small island states and landlocked nations, do not have the resources or the expertise to meaningfully participate in the conservation efforts, or to take benefits from the useful exploitation of marine resources. At the same time, the obligations put on them by the Treaty, to carry out environmental impact assessments for example, can be an additional burden

- **COP**, which acts as the decision making body of the treaty, will take the work forward and will also act as a platform to work with existing authorities that regulate fishing, shipping and mining.
- **Difficult road ahead:**
 - The treaty is a result of 20 years of protracted negotiation. The details of all the major contentious provisions, including EIA, sharing of benefits from genetic resources, and mobilization of funds for conservation activities, are still to be worked upon. Many issues remain unaddressed, including mechanisms for policing the protected areas, the fate of the projects that are addressed to be heavily polluting, and resolution of disputes.
 - Process of ratification is also not going to be easy. (UNCLOS took 12 years to become international law and Kyoto Protocol took 8 years - because necessary number of ratifications were not achieved)
 - Treaty must be ratified by a minimum 60 countries for it to come into force

C) MARINE LITTER / MARINE PLASTIC POLLUTION

- **Introduction:**

- » **What is marine litter?**

- It's any man-made, long standing solid material that humans have incorrectly disposed of and that has ended up on the beach, in estuaries, rivers, seas and ocean.
- **Plastic** is the most common type of litter found at sea. Around 8 million tonnes of plastics end up in the world's ocean every year. It is estimated that more than 1 lakh of turtles and marine mammals die every year due to these plastic marine litter. It is estimated that around 18,000 plastic pieces are floating on every square kms of the world's ocean.

- » **Reasons for Increasing Marine Litter:**

- Very slow rate of degradation of litter items, mainly plastic
- Continuously growing quantity of the litter and debris disposed in oceans due to increased population, industrialization, single use plastics etc.
- **Harmful impacts**
 - Affects public health (plastics have now been found in human blood).
 - Threatens marine ecosystem
 - Animals get trapped in this litter. They also sometimes confuse marine litter with food.
 - Ghost Fishing: Nets, Fish Aggregation Devices (FAD) and other gears continue to fish for decades after getting discarded.
 - Impacts fishery and tourism sector

- **Key steps taken by India:**

- **Marine Plastics Survey Program of NCCR (National Centre for Coastal Research)**
 - This program studied the distribution of microplastics in coastal locations in the Bay of Bengal and Arabian Sea in particular along the International Shipping Routes.
 - It found that 50% composition of marine litter was by single use plastics from 2018 - 2021 at various beaches of India.
- **2021 Amendment to Plastic Waste Management Rules, 2016**
 - Ban on several single use plastic from July 2022;
 - Increase in thickness of plastic bags.
- **EPR guidelines related to Plastic packaging materials.**
- **Swatch Sagar Surakshit Sagar:**
 - Commemorating the 75th year of India's independence, a coastal cleanup drive was carried out at 75 beaches across the country across 75 days over 7500 km long coastline. This unique first ever national campaign culminated on "International Coastal Clean-Up Day" on 17th Sep 2022.
 - This drive was aimed at removing 1,500 tonnes of garbage from the sea coast which will be a huge relief to marine life and the people staying in coastal regions.
- At UN Ocean Conference in Lisbon, India has assured the world community that under PM Modi, it is committed to protecting at least 30% of our lands, waters and oceans, and thus adhere to its commitment of 30X30 by 2030 in a mission mode.
 - **Note:** India is part of the High Ambition Coalition for Nature and People, which was initiated at the "One Planet Summit" in Paris in January 2021, to promote an international agreement to protect at least 30 per cent of the world's land and ocean by 2030
- **International Cooperation:** Under the Commonwealth Litter Program (CLIP), the UK's Centre for Environmental Fisheries and Aquaculture Sciences (CEFAS) and India's National Centre for Coastal Research (NCCR) launched a pilot project to understand deteriorating sea water quality due to marine litter.

- **Key International Initiatives:**

- **London Dumping Regime** (of International Maritime Organization): it regulates deliberate dumping of plastic waste at sea from vessels and platforms.
- **International Convention for the Prevention of Pollution from Ships (MARPOL)**: It regulates both deliberate and accidental discharge of plastics from vessels.
- But, the **problem with both these rules is lack of enforcement**. It is hard to monitor and enforce the prohibition on plastic pollution from vessels on the high seas. Flag states often lack incentives to do so.

D) OCEAN DEOXYGENATION

- **Ocean Deoxygenation**
 - » It is the phenomenon of oxygen loss in ocean caused by excessive growth of algae due to nutrient pollution. The nutrient pollution may be caused by fertilizers, sewage, animal or aquaculture waste.
- **The IUCN Report 'Ocean deoxygenation: Everyone's problem'** is the largest peer reviewed study to date of the causes, impacts, and potential solutions to ocean deoxygenation.
- **Key Findings**
 - » **Ocean regions with low oxygen concentration** have expanded to all depths of the Ocean
 - » The **volume of area depleted with oxygen**, known as "**anoxic waters / dead zones**" have **quadrupled**.
 - » **What if the present situation continues?**
 - Under a business-as-usual scenario, the ocean is predicted to lose 3-4% of its global oxygen by 2100.
 - **Local changes** will be more severe.
 - Further, **most of the oxygen loss** will take place in the upper 1,000 meters, which is the richest part of the Ocean for biodiversity.
- **Reasons for Ocean Deoxygenation**
 - » **Climate Change and Nutrient Pollution** are the main drivers of the ocean oxygen loss.
 - » Ocean oxygen loss is also closely related to Ocean Warming and Acidification caused by anthropogenic carbon dioxide emissions and biogeochemical consequences related to anthropogenic fertilization of the ocean.
- **Adverse impact of low oxygen levels**
 - » **Balance of Marine Life**: The IUCN report has started impacting the balance of marine life, favoring species tolerant of low-oxygen conditions, like jellyfish, some squid and microbes, at the expense of species sensitive to low-oxygen, including most fish and many marine species.
 - » Negatively hamper **cycles of nitrogen and phosphorus**

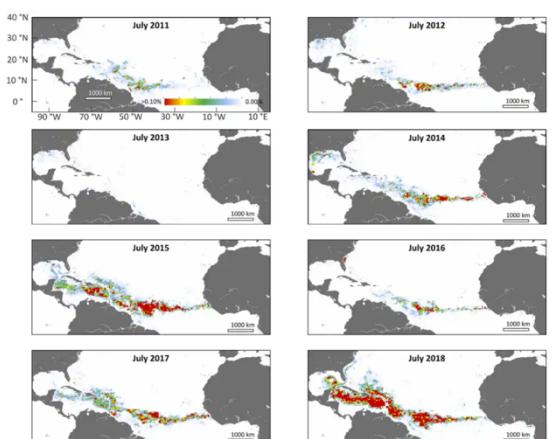
E) SARGASSO SEA WEED

- **About Sargasso Seaweed**
 - » **Between 2000-2010** there was little sea weed in the central Atlantic: most was found in the Gulf of Mexico and Saragossa Sea.

- » **Explosion** in Sargassum seaweed first materialized in 2011. It developed in subsequent years into a vast band - in 2018 this stretched for 5,500 miles.
 - The bloom peaks in the middle of the year and develop larger from small populations of the seaweed in the central Atlantic, with some contributions from west Africa.
 - A number of natural and man-made factors align together to make this happen.
- » **Problems caused by this explosion.**
 - Thick mats can block sunlight
 - Sometimes, when they die and sink, they may be deadly for fish and Corals.
 - They are also proving disastrous for humans. Increasingly huge quantities are washing up in tourist destination, creating stinking masses that threaten the tourism industry and pose a threat to health.
- » **Reasons:**
 - Alignment of circumstances like conducive sea-surface temperature and salinity combining with an increase in nutrients - in part from the upward movement of cool, nutrient rich water in the eastern Atlantic and an increase in discharge from the Amazon in the preceding years.

- About Sargasso Sea

- » Located entirely within the Atlantic Ocean, it is **the only sea without a land boundary**. While all **other seas in the world are defined at least in part by land boundaries**, the Sargasso Sea is **defined only by ocean currents**. It lies within the Northern Atlantic Subtropical Gyre. The Gulf Stream establishes the Sargasso Sea's western boundary, while the Sea is further defined to the north by the North Atlantic Current, to the east by the Canary Current, and to the south by the North Atlantic Equatorial Current. Since this area is defined by boundary currents, **its borders are dynamic**, correlating roughly with the Azores High Pressure Center for any particular season.
- » It has been named after genus of a free floating seaweed called Sargassum.
 - While there are many different types of algae found floating in the ocean all around world, the Sargasso Sea is unique in that it harbors species of sargassum that are 'holopelagic' - this means that the algae not only freely floats around the ocean, but it reproduces vegetatively on the high seas. Other seaweeds reproduce and begin life on the floor of the ocean.
 - Sargassum provides a home to an amazing variety of marine species.
 - Turtles use sargassum mats as nurseries where hatchlings have food and shelter. It also provides essential habitat for shrimp, crab, fish and other marine species.



F) DEAD ZONES

- Introduction

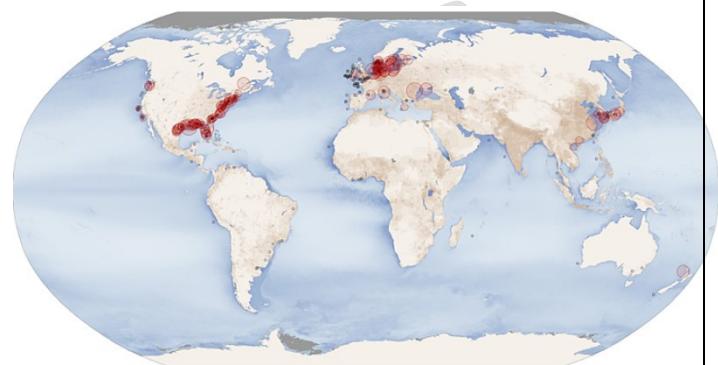
- » Excess nutrient pollution in oceans/lakes create a situation of **hypoxia** i.e. reduction in availability of oxygen in the water. This situation is often referred as **Dead zone** as most marine life either dies, or if they are mobile, leave the area. Because of creation of dead zones, habitats which are normally teeming with life become essentially **biological deserts**.

- Can Dead zone occur naturally?

- » Yes, dead zones may occur naturally. But, environmentalists are concerned about those which are created or enhanced by human activities.

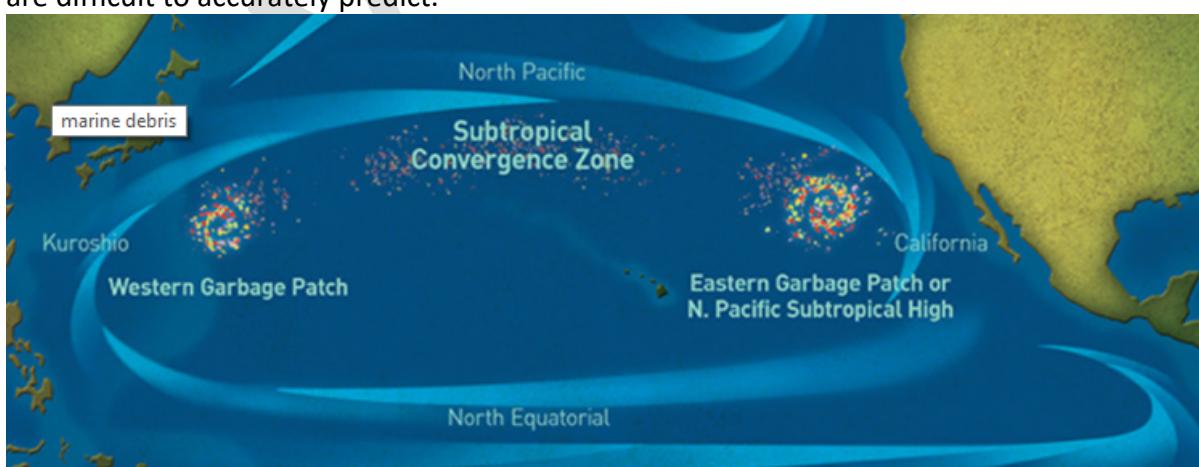
- Key factors responsible for creation of dead zones?

- » There are many physical, chemical and biological factors that combine together to create dead zones, but **nutrient pollution is the primary cause** of those zones created by human activities.
- » **Nutrients -> Algae -> Decomposition -> Oxygen Depletion.**
- » **Climate Change -> Rising temperatures ->** reduce the dissolved oxygen, increase metabolism rate and oxygen demand.



G) THE GREAT PACIFIC GARBAGE PATCH (GPGP)

- The Great Pacific Garbage patch is located about halfway between Hawaii and California. It is the largest accumulation zone of ocean plastic on earth.
- It consists of higher concentration of waste item, but much of the debris is actually small pieces of floating plastic that are not immediately evident to naked eyes.
- While great pacific patch is a term regularly used in the media, it doesn't paint the correct picture of the marine pollution problem in the North Pacific Ocean. Marine debris concentrates in various regions of the North-Pacific, not just in one area. The exact size, content, and location of the "garbage patches" are difficult to accurately predict.



• Why is it difficult to clean up the patches?

- i. Very large and shifting area
- ii. Uneven distribution of debris

- iii. Small pieces of plastic forms the largest chunk
- iv. Marine life doesn't allow simple skimming of these debris

10) PROTECTION OF COASTAL REGION

- **Introduction**
 - » Coastal zones are places of enormous ecological, cultural, social and economic significance. They contain unique and sensitive ecosystem of great natural and economic value and is home to numerous endangered species. The region also serves as home to 50% of the world's population and generated 40% of the global economic activities.
- **Key Problems Faced by Coastal Regions:** Recent decades have seen drastic increase in population, rapid industrialization, increased pollution and climate change. All these factors have negatively hampered the coastal region.
 - Along much of the earth's coast **a warming climate and sea level rise** are already negatively affecting natural ecosystems and human communities
 - **Coastal Erosion** has started hampering a number of coastal regions. E.g. Vishakhapatnam
 - **Rapid Industrialization and Deforestation**
 - **Pollution** due to mining, municipal waste disposal and industrial waste disposal are also leading to environmental problems in coastal regions.
 - **Invasive Species** -> Biodiversity loss
- **Efforts by India to Protect Coastal Regions**

A) COASTAL REGULATION ZONE

- » CRZ notification is issued under the **Environmental Protection Act, 1986** for regulation of activities in the coastal area by the MoEF&CC. The first CRZ was issued, in 1991 which was replaced by the 2003 and then by 2011 notification.
- » It classifies the coastal land upto 500 m from the HTL and a stage of 100 m along the banks of creeks, estuaries, backwater and river subject to tidal fluctuations as the **Coastal Regulation Zone (CRZ)**. The **CRZ** are further classified in **four categories**:

 - **CRZ-1** are ecologically sensitive areas.
 - **CRZ 1-A** constitute the ecologically sensitive area and the geomorphological features which play a role in maintaining the integrity of the coast viz: Mangroves, corals, sand dunes, salt marshes, national parks, WLS, Reserved forests, nesting grounds for turtles, birds etc.
 - **CRZ 1-B** consist of inter-tidal zones (between HTL and LTL)
 - **CRZ-2** are areas that have been developed upto or close to the shoreline. Unauthorized structures are not allowed in this zone.
 - **CRZ-3** are areas that are relatively undisturbed (both urban and rural)
 - **CRZ-4** are areas covered between Low Tide Line and 12 nautical miles seaward

- » **CRZ Notification, 2018: Easing of Norms for CRZ** approved by Cabinet (Dec 2018)
 - The comprehensive review was necessitated because of **demands of various stakeholders** to review the CRZ notification, 2011 as it was hindering developmental activities.
 - **Aimed at streamlining of CRZ clearances** and promoting economic growth while keeping in mind conservation principles of coastal regions.
 - The notification is based on the recommendations of the **Shailesh Nayak** (former secretary, Ministry of Earth Science) headed committee.
- » **Key Changes**
 - **Delegation of Project Clearance Power to State Governments.**
 - Only Projects in CRZ-1 and CRZ-IV will require permission from Union Ministry. The Powers to clear projects in CRZ-2 and CRZ-3 have been delegated to State Governments
 - **Defreezing of Floor Area Ratio (FAR)** in construction norms
 - Earlier, for CRZ-2, it was frozen to 1991 Development Control Regulation (DCR) levels, Now, it will be based on laws which are in vogue.
 - **Relaxation of No Development Zone (NDZ) criteria**
 - Densely populated (density > 2,161 per sq km) rural areas (under CRZ-III) referred as CRZ-III-A, now have a NDZ of 50 m from the High Tide Line (HTL) as against earlier 200 meters.
 - Further, for island close to the mainland coast and for all backwater islands the new NDZ is 20 m.
 - To **fight pollution**, treatment facilities have been made permissible activity in CRZ-I B area, subject to necessary safeguards.
 - **Steps to Facilitate Tourism:**
 - Permission of temporary tourism facilities such as shacks, toilet blocks, change rooms, drinking water facilities etc, in beaches even in the NDZ of the CRZ-III.

11) BLUE FLAG BEACHES

- **Why in news?**
 - » Two more Indian Beaches enter the coveted list of Blue Beaches (Oct 2022)
- The iconic blue flag is one of the world's most recognized voluntary eco-labels awarded to beaches, marinas, and sustainable boating tourism operators.
 - » The Blue flag program was started in France in 1985 and in areas out of Europe in 2001.
 - » The certification is provided by the **Foundation for Environmental Education (FEE)**.
 - » To get blue flag certification **33 stringent criteria** under **four major heads** should be met and maintained.
 - Environment Education and Information
 - Bathing Water Quality
 - Environment Management and Conservation
 - Safety and Services
- **Spain** with 620+ blue flag beaches have highest number of blue flag beaches in the world.

- **Blue Flag Beaches in India**
 - » As of Jan 2024, **12 Indian beaches** have blue flag certifications.
 - » **Two Beaches - Minicoy Thundi Beach and Kadmat Beach** - both in Lakshadweep were awarded the certification in Oct 2022.
 - The Thundi Beach is one of the most pristine and picturesque beaches in Lakshadweep archipelago where white sand is lined with turquoise blue water of the lagoon. It is a paradise for swimmers and tourists alike
 - The Kadmat beach is specially popular with cruise tourists.
 - Both these beaches comply with all 33 criteria mandated by the Foundation for Environment and Education.
 - » **Two beaches** - the Eden Beach in Puducherry and Kovalam Beach in Tamil Nadu were awarded Blue Flag certification in Sep 2021.
 - » **Eight Beaches** under blue flag certification earlier were: Kappad (Kerala), Shivrajpur (Gujarat), Ghoghla (Diu), Kasakod and Padubidri (Karnataka), Rushikonda (Andhra Pradesh), Golden (Odisha) and Radhanagar (Andaman and Nicobar Islands)

12) COASTAL EROSION

- **Introduction:**
 - Coastal erosion refers to wearing away of land and the removal of beach and dune sediments by wave action, tidal currents, drainage or high winds.
 - **Wave action** is the main cause of coastal erosion. Wave energy is a result of three factors: the speed of the wind blowing over the surface of the sea; the length of fetch; and the length of time the wind has been blowing.
- **Causes of Coastal Erosion** can be divided into two broad categories: **Natural or Manmade**:
 1. **Natural Causes:**
 - i. These include waves, winds, tides, near shore currents, sea level rise etc.
 - ii. Another major natural factor is phenomenon of subsidence. It is a regional phenomenon that lowers the surface area in a specific region.
 - iii. Catastrophic events like severe storms, tidal surges, and cyclones can cause severe erosion.
 2. **Manmade Factors:**
 - i. **Infrastructure creation in coastal regions**: For e.g., building houses via land reclamation or within sand dune areas.
 - ii. **Sand removal above replenishable quantities** from the coast upsets the longshore sand transport budget and can result in erosion.
 - iii. **Coral Mining and other means of damaging protective corals** may cause beach degradation.
 - iv. **Structures like seawalls, breakwaters** also have a side effect as it increases erosion of adjacent areas.
 - v. **Deforestation**: Damaging of mangroves and other coastal vegetation is a major factor.
 - vi. **Climate Change** which is mostly human induced is leading to sea level rise which is eroding more and more coastal regions.

vii. Unscientific Coastal Management

- Factors that influence Erosion Rates

» The ability of waves to cause erosion of the cliff face depends on many factors.

• Primary Factors

- **Erodibility of sea facing rock** is controlled by rock strength and the presence of fissures, fractures, and beds of non-cohesive materials such as silt and fine sand.
- Power of the waves
- Beaches (they dissipate wave energy on the foreshore and provide a measure of protection to adjoining land)
- The Adjacent bathymetry, or configuration of the sea floor, controls the way energy arriving at the coast, and can have an important influence on the rate of cliff erosion.

• Secondary Factors

- Weathering and transport slope processes.
- Slope Hydrology
- Vegetation
- Human Activity
- Resistance of cliff foot sediment to attrition and transport.

- Impact of Coastal Erosion

- Floods including worsening impact of high tide flooding.
 - Saltwater penetration into rivers, coastal agriculture plains

- Coastal Erosion Control Strategies: There are three coastal erosion control methods.

- Soft Erosion Controls/ Non-Structural Methods

- These methods are **temporary options of slowing the effects of erosion**.
 - **Artificial nourishment** of beaches
 - **Coastal Vegetation** such as mangrove and palm plantation
 - **Dune Reconstruction/rehabilitation**
 - Other options are **beach scraping** and **beach bulldozing** which allows for the creation of artificial dunes in front of building or as means of preserving building foundation.

- Most common method is the **Beach nourishment** projects.

- It involves placing **additional sand on a beach** to serve as a buffer against erosion or to enhance the recreational value of the beach.

- Because nourishment doesn't stop erosion, it has to be repeated to maintain the beach.

▫ **Advantages**

- Restores and widens recreational beach
- Beach nourishment doesn't leave hazards on the beach or on the surf zone.

▫ **Disadvantages**

- Erodes faster than natural sand so continuous refurbishing required.

- Number of Storms affecting the beach makes the life time of the nourishment vary.
 - Expensive, and must be repeated periodically.
 - Process of nourishment may damage, destroy or otherwise hurt marines and beach life by burying it, squishing it under bulldozers, changing the shape of the beach, or making the water near the beach too muddy.
 - Difference in "grain size" of the added sand affect the way waves interact with beach. This will affect surf conditions and bars on the submerged part of the beach.
- **Hard Erosion Controls/ Structural Measures**
 - More permanent solution than soft erosion methods.
 - **Seawalls and groynes (or groin)/breakwaters** serve as permanent infrastructure; Tetrapod-based seawall are also included in the category.
 - **Limitations**
 - » Not immune from normal wear and tear and will need **refurbishment or rebuilt**.
 - » Further, as the understanding of natural shoreline function improves, there is a growing acceptance that structural solution can cause more problems than they solve. It interferes with natural water currents, and prevent sand from shifting along coastline.
 - » They also cause erosion to adjacent beaches and dunes and lead to unintended diversion of stormwater and waves onto other properties.
- **Combination of the Structural and Non-Structural Methods** (i.e. combination of hard erosion control and soft erosion control)
 - This hybrid method reduces limitations of both the methods and provides better efficacy and efficiency.
 - Some of the common approaches of combination are:
 - a. **Combining Beach nourishment with artificial headlands/groynes**.
 - b. **Revegetation with temporary offshore breakwaters/ Artificial reefs** is commonly used.
 - Using a combination of beach nourishment and groynes/artificial headlands promotes the trapping of the downdrift movement of the sediments, thus reducing downdrift erosion. This also reduces the frequency of re-nourishment.
- **Relocation**
- **Situation of Coastal Erosion in India:** Ministry of Earth Sciences has informed the Lok Sabha that about 34% of coastal region in India is under varying degree of erosion.
 - Of the rest, 40% is stable and 26% is accreting in nature.

13) BIOLUMINESCENCE

- **Why in news?**

- Vishakhapatnam Beaches are glowing due to a phenomenon called **bioluminescence** (April 2023)
- **Details**
 - Bioluminescence, the glow of the waves, is caused by tiny marine organisms called **Phytoplankton**, which emit light on the ocean surface at night.
 - It is best experienced during a moonless night.
- **Bioluminescent** is widespread among deep sea animals in general. Many marine creatures like sponges, jellyfish, worms, species of fish, arthropods, echinoderms, and unicellular algae exhibit bioluminescence to either evade predators, attract prey or during mating.
- **Why did it happen in Vishakhapatnam?**
 - In Vishakhapatnam this phenomenon is most likely the result of algal bloom (Significant accumulation) of the **dinoflagellate species of noctiluca and ceratium**. These emit light when disturbed by breaking waters. This occurs when the luciferase enzyme reacts with luciferin compound in the presence of oxygen to produce a cold light.



- Some other beaches in India where this phenomenon is visible are - Havelock Island in the Andamans, Thiruvanmiyur beach in Chennai, Mattu beach in Karnataka and Bangaram Island in Lakshadweep.



TARGET PRELIMS 2024

BOOKLET-14; ENVIRONMENT-4

ENVIRONMENTAL POLLUTION-3

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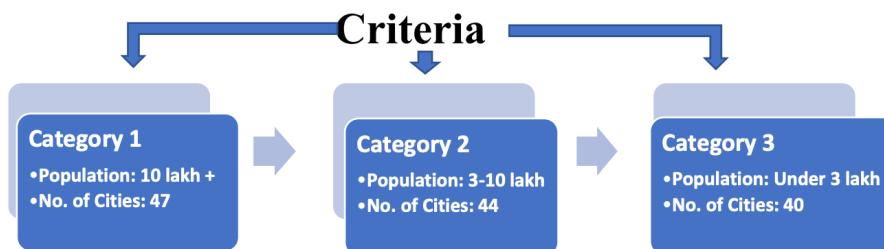
2. AIR RELATED CURRENT UPDATES

1) WORLD AIR QUALITY REPORT, 2023

- Published by a Swiss Air Purifier Company **IQAIR**.
- **Key Highlights** (March 2023)
 - » Delhi ranked 4th out of 50 of the world's most polluted cities in terms of PM 2.5 in 2022.
 - » India ranked 8th with a population weighted average of PM2.5 level of 53.3 micrograms/m³ in 2022.
 - » Chad, Iraq, Pakistan, Bahrain and Bangladesh are the most polluted countries in 2022.
- **Situation after Diwali 2023**
 - » The Day after Diwali (13th Nov 2023), Delhi was the most polluted city in the world with an AQI of 287.
- **Live Situation:** <https://www.iqair.com/in-en/world-air-quality-ranking>

2) SWATCH VAYU SURVEKSHAN, 2023

- "Swatch Vayu Survekshan" is an initiative by MoEF&CC to rank cities on the basis of implementation of activities approved under city action plan and air quality in 131 NCAP cities.
- **Objectives:**
 - Create Awareness; Inform citizens about the health impacts related due to exposure; comparing air quality conditions at different locations/cities; to achieve the goal of NCAP "Clean Air for All".



- All 131 cities covered under NCAP are assessed based on ranking framework submitted by cities/ULBs on PRANA portal (Dashboard to capture progress of NCAP program).
- **Air Quality** is improving on the basis of PM10 data.

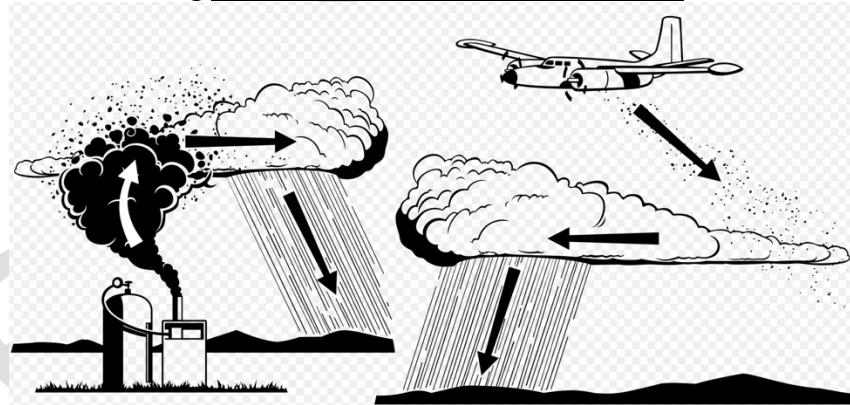
AIR QUALITY	2019-20	2020-21	2021-22	2022-23	2023-24
▫ Reduction in annual PM10 levels vis a vis base year 2017	Improvement in 85 cities	Improvement in 102 cities	Improvement in 95 cities	Improvement in 90 cities	Calculated on Financial Year basis so the data is awaited

3) CLOUD SEEDING

- **Understanding Cloud Seeding:**
 - » How clouds are formed naturally?

- Clouds are made up of tiny water droplets or ice crystals that form when water vapor in the atmosphere cools and condenses around a tiny particle of dust or salt floating in the atmosphere. Without these tiny particles raindrops or snow flakes can't form and precipitation will not occur.
- » **What is cloud seeding?**
 - It is a weather modification technique aimed at enhancing precipitation from clouds. The idea of cloud seeding was first conceived during WW-II and has since then become a much practiced activity in different dry regions of the world.
- » **How does it work?**
 - In cloud seeding, clouds are injected with salts like silver iodide, potassium iodide, or sodium chloride which act as seed. These salts provide additional nuclei around which more cloud droplets would form.
- » There are two principal cloud seeding techniques:
 - Hygroscopic Cloud Seeding:** It aims at speeding up droplet coalescence in liquid clouds, leading to production of large droplets that start to precipitate. Here seeding material is generally large salt particles.
 - Glaciogenic Cloud Seeding:** In this method the idea is to trigger ice production in supercooled clouds, leading to precipitation. It is usually done by dispersing efficient ice nuclei, such as silver iodide particles or dry ice (solid carbon dioxide) into the cloud, causing heterogeneous ice nucleation.

- » **How is cloud seeding done?**
 - It is done using ground based generators or aircraft.



- » **What are the conditions required for cloud seeding to be done?**
 - Moisture laden clouds:** Cloud seeding can only happen if there is sufficient cloud and sufficient depth of cloud.
 - Wind speed below a certain level**
 - Temperature** - cloud should be cold enough to contain supercooled liquid water

- Application/advantages

- » **Fighting water scarcity:** Rainfall in drought prone areas.
- » **Increasing winter snowfall** - which can supplement the natural water supply for communities in the surrounding area.

- » It can also be done to prevent hailstorm, dissipate fog etc.
 - » **Increasing hydro power generation** (for e.g. in Tasmania, Australia)
 - » **Fighting air pollution and Water pollution**
 - Rainfall can wash off pollution from air
 - More rainfall can also ensure ecological flow in rivers leading to reduced scope of pollution.
 - » **Controlling forest fires**
 - » **Atmospheric studies** - Studying cloud seeding can help scientists understand how normal cloud formation would occur.
- **Could cloud seeding be used to fight air pollution in Delhi?**
- » In India, cloud seeding hasn't been tried for fighting pollution.
 - **China** has tried this option.
 - » In winters, cloud from over Delhi due to Western Disturbances and thus some experts suggested cloud seeding for rainfall to occur.
- **Has Cloud seeding been done before in India, and has it been successful?**
- » It has been attempted in Monsoon, in places such as Karnataka, Maharashtra, and Tamil Nadu.
 - » A recent experiment, the fourth phase of the **Cloud Aerosol Interaction and Precipitation Enhancement Experiment (CAIPEEX-IV)** that took place in monsoon seasons of 2018 and 2019. It was conducted in drought-prone Solapur in Maharashtra. It pointed to relative enhancement of 18% in rainfall.
 - The approx. cost of producing water through this method was 18 paisa per litre, the cost will drop by more than 50% if we use indigenous seeding aircraft.

4) COAL FIRED POWER PLANTS

- **Why in news?**
- » Only 5% of India's coal-based thermal power capacity meets SO₂ emission norms: CSE report (June 2023)
- **Introduction:**
- » Coal is the most important and abundant fossil fuel in India. It accounts for 55% of India's energy needs. Infact, India's industrial heritage was built upon Indigenous coal.
- **Environmental Impacts of Coal Based Thermal Power Plants:**
- » **Air Pollution:** Burning of coal produces air pollutants like NO₂, SO₂, CO, PM, Mercury etc. which are primary air pollutants in the world.
 - » **Acid Rain:** Pollutants like NO₂, SO₂ etc. are primary contributor of Acid rain. It can harm forests, aquatic ecosystems, and buildings and it can also lead to soil and water acidification.
 - » **Climate Change due to global warming**
 - » **Excessive water Extraction:** Coal based thermal power plants require huge quantities of water which is often drawn from nearly rivers, lakes, or groundwater sources.
 - » **Water Pollution:** Leakage of heavy metals and acids from the exposed coal seams may cause water pollution. They can leach into the groundwater and nearby waterbodies, posing risks to

drinking water source and health of aquatic ecosystem. In addition, the release of warm water from the thermal power plant also causes thermal pollution.

» **Other issues created by mining of coals**

- **Emission Norms:**

- » The MoEF&CC had notified the emission norms for coal-based power plants in Dec 2015.
- » In 2021, **MoEF&CC divided the power plants on the basis of distance from polluted cities** to enforce deadlines and extended the **deadlines**.
 - i. **Category A** - coal based power plants within 10 kms radius of NCR and of cities with million+ population. (deadline changed from 31st Dec 2022 to 31st Dec 2024)
 - ii. **Category B** - power plants within 10 kms radius of critically polluted areas or non-attainment cities. (deadline changed from 31st Dec 2023 to 31st Dec 2025)
 - iii. **Category C** - remaining plants throughout the country. (deadline changed from 31st Dec 2024 to 31st Dec 2026)
 - This has the longest deadline and most of the country's coal based power plants fall in this category.
- » Even after multiple extension, only 5% of the coal fired power plants have installed FGD (Flue Gas Desulfurization) systems, which are air pollution control devices for SO2 emissions (June 2023 : CSE Analysis)
- » Similarly, another analysis by the Centre for Research on Energy and Clean Air (CREA) has found less than 8% of India's coal based power plants have installed the SO2 emission reduction technology recommended by MoEF&CC (Dec 2023)

- **Problems caused by Coal Based power plants**

- » **Older technology** -> Larger emissions of CO, NOx, SOx, Ozone etc.
- » **Lesser Fly ash Utilization** due to weak fly ash guidelines and poor implementations.
- » **Difficulty** in achieving the **Paris Agreement Targets**.

- **Why moving away from coal based power plants may be difficult?**

- » Very large dependency -> 75% of India's annual power output.
- » **Phasing in renewable energy sources and phasing out conventional sources rapidly** may lead to instability in the electricity grid which may potentially cause blackout.
- » **Political Economy Risk:** Aggressive early retirement of coal based capacity, without detailed analyses, could result in real or perceived electricity shortage in some states.

A) FLUE GAS DESULFURIZATION (FGD)

- FGD is a set of technologies that remove SO2 from exhaust flu gases of fossil fuel power plants, and from the emissions of other sulfur dioxide emitting processes such as waste incineration, petroleum refineries, cement and lime kilns.
- FGD systems use a scrubbing solution to absorb SO2.
 - » The most common type of FGD is wet scrubber which uses a limestone slurry or seawater to absorb SO2.
 - The SO2 reacts with the scrubbing solution to form sulfate particles which can then be removed.
 - The removal efficiency is upto 99%.

- » **Drug scrubbers** can also be used. It uses sorbent such as sodium bicarbonate or calcium oxide to absorb SO₂,
- » **Regenerative scrubbers**, use a chemical solvent to absorb SO₂ and then regenerate the solvent for reuse.

B) CIRCULATING FLUIDIZED BED COMBUSTION (CFBC)

- CFBC is a type of combustion technology used in thermal power plants to increase the efficiency of combustion and reduce emissions.
- It works by suspending a bed of inert particles (like sand or limestone) in a stream of air, creating a fluid like state. Fuel is injected in the bed and burned, with the heat transferred to the particles and then to a heat exchanger to produce steam or hot water.

C) CENTRE FOR RESEARCH ON ENERGY AND CLEAN AIR

- It is an independent organization focused on revealing trends, causes, and health impacts as well as the solutions to air pollution.
- It uses scientific data, research and evidence to support the efforts of government, companies and campaigning organizations worldwide in their efforts to move towards clean energy.
- It is registered in Finland with staff across Asia and Europe.
- It is funded by philanthropic grants and revenue from commissioned research

3. NITROGEN POLLUTION

- **Introduction**
 - » While nitrogen is the dominant gas in the atmosphere, it is inert and doesn't react. However, when it is released as part of compounds from agriculture, sewage and biological waste, nitrogen is considered 'reactive' and may be polluting and causing greenhouse effect.
 - » The release of these reactive nitrogen compounds in the atmosphere have increased over the years because of increased use of **fertilizers for agriculture** and increased **industrial pollution**. NO_x emissions grew at 52% from 1991 to 2001 and 69% from 2001-2011.
 - » In fact, a study in 2017 showed that we have **breached the planetary boundary of N (Nitrogen)**. This planetary boundary is set at 44 Tg (Tera-grams) per year globally. But currently we use 150 Tg N per year, primarily through fertilizer usage.

» Key Forms of Nitrogen

- N₂ - Un-reactive di-nitrogen; forms 78% of the air we breathe
N₂O - Reactive nitrogen; fixed in soil by microbes; reacts to form different compounds with various impacts
NH₃ - Ammonia; used for making fertilisers; can escape into the air as a pollutant
NH₄NO₃ - Ammonium nitrate, acts as fertiliser; when synthesised in

the atmosphere, contributes to particulate matter, water pollution and results in eutrophication

N₂O - Nitrous oxide, a greenhouse gas; depletes ozone layer

NO_x - Mixture of NO and NO₂; a major air pollutant

NO₃ - Nitrate; the form in which nitrogen gets fixed in soil; can pollute water sources; forms ozone, which adds to particulate matter load

- » **More Details about N₂O:** It is a greenhouse gas 300 times more potent than CO₂. It has the third highest concentration - after CO₂ and methane - in our atmosphere among greenhouse gases. It can live in our atmosphere for upto 125 years.

- **2020 Study about N₂O published in Nature:**
 - » **Human emission** of N₂O increased 30% in 36 years.
 - » 43% of the total emissions came from human sources.
 - » The increase means that climate burden from non-carbon sources is also increasing.
 - » Dichotomy between Climate Crisis and Food Security - Major proportion of the N₂O emissions in the last four decades came from the agricultural sector, mainly because of the use of nitrogen-based fertilizers.
 - » **Most of the emission** have come from **developing countries** like China, India and Brazil.
- **Key causes of Nitrogen Pollution**
 - » **Emission from chemical fertilizer** –
 - About 50% of the nitrogen used in global agri sector is released in environment (atmosphere, water bodies etc.).
 - Most important source.
 - Difficult to control (non-point source, food security concerns etc.)
 - » **Sewage and organic solid wastes** (second largest source):
 - » **Burning of fossil fuels**: Vehicular pollution, mostly from road transport is another major NOx producer.
 - » **Industries**
- **Key threats due to nitrogen pollution**
 - **Air Pollution**: Emissions of Ammonia, nitrogen oxide and nitrous oxide contribute to **particulate matter and acid rain**. These cause respiratory problems and cancers for people and damage to forests and buildings.
 - **Water Pollution - Eutrophication**
 - **Negatively hampers soil health** -> brings down the yield of agri-land.
 - **Climate Change**: Nitrous Oxide (N₂O) -> GWP: 300 times of CO₂; Also contributes to Ozone depletion.
 - **Negative impact on Health, economy and livelihood**
 - Deteriorating soil quality impacts Agri output and livelihood. Further, particulate matter and acid rains have adverse impact on health.

A) UNEP'S COLOMBO DECLARATION ON SUSTAINABLE NITROGEN MANAGEMENT (OCT 2019)

- Sri Lanka, with support from the UNEP, convened an event at which member states came together to adopt what is called the "**Colombo Declaration**".
- **Key Highlights**
 - Halve nitrogen waste by 2030.
 - The member countries also endorsed UN's plan for a sustainable nitrogen management called "**Nitrogen for Life**", which stems from the Sustainable Nitrogen Management Resolution which was adopted during the fourth session of the UN environment Assembly held from 11-15th March 2019, at the UNEP headquarter in Nairobi.
- **Analysis**

- This is the first-time governments have agreed to work together on a major quantitative global goal for improved nitrogen management.

4. SOLID WASTE

- **Introduction**
 - » Solid waste is the unwanted or useless solid materials generated from human activities in residential, industrial or commercial areas.
- Solid waste may be **categorized in three ways:**
 - » **Origin** (domestic, industrial, commercial, construction or institutional)
 - » **Contents** (organic material, glass, metal, plastic, paper, hazardous chemical)
 - » **Hazard Potential** (toxic, non-toxin, flammable, radioactive, infectious)
- As per **Indiawaterportal.org** the total MSW generated in urban India has been estimated at **68.8 million tons per year (TPY)**.
 - » This is expected to go to 165 million tonnes by 2030.
- But the Solid waste collection efficiency in India is around 70% at present, while it is 100% in many developed countries.
- Therefore, around 30% of MSW is not collected and thus lies littered around in Indian cities. Even the waste which is collected is not treated and thus is highly hazardous.
- **Problems of unscientific MSW disposal** -> Untreated, unprocessed and indiscriminately dumped waste causes air, water and soil pollution which have adverse impact on health situation. Further, this type of dumping goes against the **4Rs principle of environment Protection.**
- **Factors for increasing Solid Waste in India**
 - **Population, Urbanization, Increasing Per-Capita Income**
 - Increased Consumerism, Use and throw culture.
 - **Plastic waste** -> non availability of good alternative
 - **Technology change** -> Increasing electronic waste.
 - **COVID-19** also led to shooting up of domestic hazardous waste.
- **Proper Solid waste management**
 - SWM reduces or eliminates the adverse impact on the environment & human health. It includes a number of processes including segregation, collection and treatment and disposal in an environmentally sound manner.
 - The local authorities are responsible for the development of infrastructure for collection, storage, segregation, transportation, processing and disposal of MSW

5) TREATMENT AND DISPOSAL OF SOLID WASTE

A) OPEN DUMPING, LANDFILLS AND SANITARY LANDFILLS

- **Advantage:** Waste limited to well defined area; Reduces contact between waste and environment.
- **Disadvantages** - Open dumps get exposed to natural elements, stray animals and birds and may cause air pollution, water pollution and soil pollution.

B) THERMAL TREATMENT

- **Incineration plants (Waste to Energy Method)**
 - Incineration is combustion of waste in the presence of oxygen. Waste gets converted in CO₂, Water Vapor and Ash along with heat.
 - **Advantages** - reduction in volume; kills many diseases causing germs.
 - **Limitations** - Air pollution -> Health issues; Climate Change
- **Pyrolysis**
 - Here material is exposed to very high temperatures in an inert (oxygen less) environment. The material decomposes due to the limited thermal stability of chemical bonds of material, which disintegrates.
 - Pyrolysis is thus a thermo-chemical treatment, which can be applied to any organic (carbon-based) product. It produces volatile products and leaves a solid residue enriched in carbon, char.
- **Plasma Arc Gasification (PAG) process**
 - It is a waste treatment technology that uses a combination of electricity and high temperature to turn municipal waste (garbage or trash) into usable by-products without combustion.
 - » It shouldn't be confused with incineration. This technology doesn't combust the waste as happens in incinerators. It converts the organic waste into gas that contains all its chemical and heat energy and converts the inorganic waste into an inert vitrified glass called slag.
 - » This process reduces the volume of waste reaching the landfills and also generate electricity.

C) BIOLOGICAL TREATMENT METHODS - USE OF MICROORGANISMS

- **Bio-Gasification**
 - » It is a waste-to-Energy technique where biological decomposition of organic matter of biological origin under un-aerobic condition is done to produce methane and other secondary gases.
- **Composting**
 - » In this process, the organic waste is converted into compost through decomposition. Compost is rich in nutrients and can be used as soil conditioner, a fertilizer, addition of vital humus and humic acids and as a natural pesticide in soil.
 - » It can also be used for erosion control, land and sea reclamation, wetland construction, and as landfill cover.

- **Vermiculture/Vermicomposting:** It is the process of making compost through decomposition process. But here, decomposition is done by using various species of worms, usually red wiggler, white worms, and other earthworms.
- **Bioremediation**
 - » It involves use of bio-culture or microorganisms to degrade organic waste and contaminants that pose environmental and human risks. Here the environment is altered to stimulate the growth of micro-organisms and degrade pollutants. The organic waste is eventually converted into soil.
 - » **Various approaches** - Biostimulation; Bioaugmentation; a combination of both etc.

D) BIOMINING

- Biomining involves use of separator machines or large sieves to separate waste material of different sizes, thereby obtaining soil, plastic, wood and metal components in isolation for appropriate processing.

6) LANDFILLS IN DELHI AND KEY CONCERNS

- **Why in news?**
 - » Our target is to clear all three landfill sites in Delhi by December 2024: CM Kejriwal (March 2023)
- Chronic negligence of sustainable and scientific treatment has resulted in an ever-growing mass of municipal solid waste (MSW) making its way into dumpsites in India.
- There are **three main landfills** in Delhi - **Bhalswa** in north, **Gazipur** in east and **Okhla** in south with **total estimated waste of 20 million tonnes (as of Oct 2022)**
 - » Note: In 2019, the total legacy waste at these three sites totaled to **28 million tonnes**.
- **Present Situation of Landfills:**
 - » **Bhalswa** (36 acres): **8 million tonnes**.
 - » **Gazipur** (70 acres): **14 million tonnes**
 - » **Okhla** (46 acres): Currently the site contains around **4 million tonnes** of legacy waste. In last few years, around **2.5 lakh tonnes** have been removed from it. (at its peak it contained around 6.5 million tonnes of waste)
- **Harmful Impacts of landfills:**
 - » **Ground Water and River Water Pollution:** Leachate from these landfills are not only contaminating ground water but are also reaching Yamuna River.
 - » **Other concerns due to landfills** -> Air Pollution (methane); Odour Pollution; Wastage of Resources; breeding ground for diseases.
 - » **Prolonged exposure** to compounds such as **dioxins** which are carcinogenic.

Dioxin:

Dioxins are a group of chemically-related compounds that are persistent environmental pollutants. They are found throughout the world in environment and they accumulate in the food chain, mainly in the fatty tissue of animals.

More than 90% of human exposure is through food, mainly meat and dairy products, fish, and shellfish. Many national authorities have programs in place to monitor the food supply.

They are highly toxic and can cause reproductive and developmental problems, damage the immune system, interfere with hormones and also cause cancer.

Due to omnipresence of dioxins, all people have background exposure, which is not expected to affect human health. However, due to the highly toxic potential, efforts need to be undertaken to reduce current background exposure.

Prevention or reduction of human exposure is best done via source-directed measures, i.e., strict control of industrial processes to reduce the formation of dioxins.

- **Ecological Loss:** A study conducted by experts from the NEERI, CPCB and IIT Delhi assessed that ecological damage due to these three landfill sites is 450 crore rupees per annum.

7) LANDFILL FIRE – CAUSES

Methane Gas; Sabotage; collection of scrap metals; difficult to extinguish.

8) SOLID WASTE MANAGEMENT RULES, 2016

- In 2016, The Environment ministry had revised the solid waste management rules after 16 years.
- **Salient Features**
 - » **Extended Beyond Municipal Areas** - Covers urban agglomerations, census towns, notified townships, areas under control of railways, airports, airbases, port and harbour, SEZ etc.
 - » **Source Segregation** of waste has been mandated to channelize the waste to wealth by recovery, reuse, and recycle.
 - Waste generators have to segregate the waste in **three streams** - Wet (biodegradable; Dry (plastic, paper, glass, metal etc.) and Domestic Hazard wastes (diapers, napkins, empty containers etc.)
 - They should handover the waste to authorized rag pickers or waste collector or local bodies.
 - **Street vendors** to keep separate containers for separate wastes.
 - **Sanitary napkins and diapers** manufacturers or brand owners explore the possibility of using recyclable material in the product and shall provide a pouch or wrapper for disposal of each napkin or diapers along with packet of their sanitary products.
 - Educate masses in wrapping and disposal of their products.

- » The rules emphasized on integration of waste pickers/ rag pickers and waste dealers in the formal system by state governments, SHGs or any other group to be formed.
- » **Ban on open throwing burning or burying; Provisions for User Fee** for waste collectors and 'Spot Fine' for Littering and non-segregation.
- » **Provisions for Bulk and institutional generators** -> directly responsible for segregation and sorting the waste and manage in partnership with local bodies.
- » **The developers of SEZs, Industrial estate, industrial parks etc.** to earmark 5% of the total area of the plot or minimum 5 plots/sheds for recovery and recycling facility.
- » All manufacturers of disposable products such as tin, glass, plastics packaging etc. or brand owners who introduce such products in the market should provide necessary financial assistance to local authorities for the establishment of waste management system.
- » **The Biodegradable waste** -> processed through composting, bio-methanation etc.
- » **Promoting Waste to Energy**
 - Industrial units within 100 km of Solid waste RDF plants should get at least 5% of their fuel from them.
 - Non-recyclable waste with high calorific value (1500 K/cal/kg or more) should not be disposed of and should only be utilized for refuse-derived fuel or by giving away the feedstock for preparing refused derived fuel.
 - **High calorific wastes** shall be used for co-processing in cement or thermal power plants.

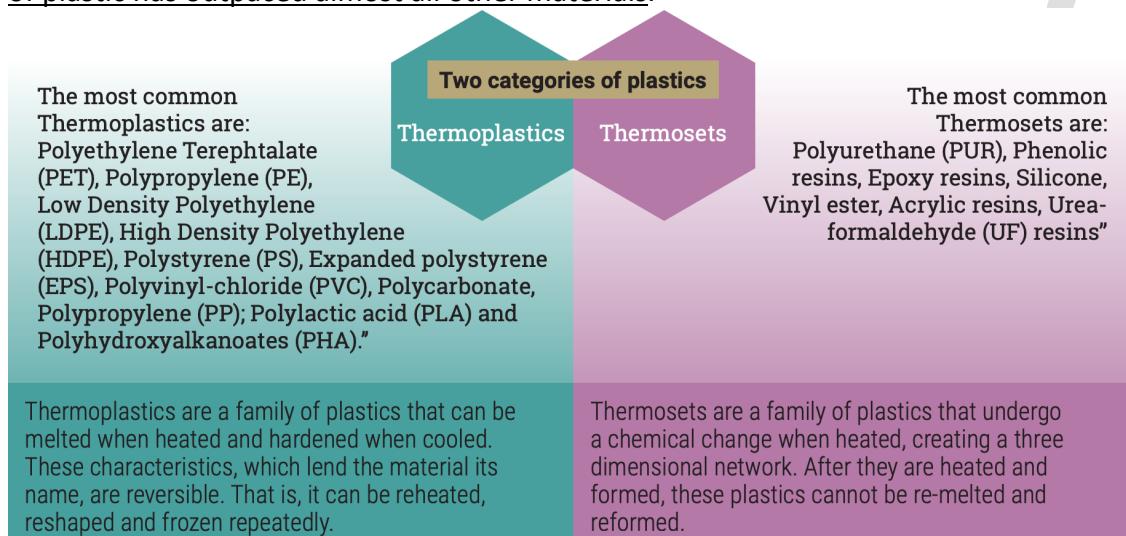
5. DOMESTIC HAZARDOUS WASTE

- **Details**
 - **A lot of harmful chemicals are used for domestic purposes**
 - » Chemicals to sanitize houses.
 - » Power bulbs, CFLs, Tube lights
 - » Medicines, ointments etc.
 - Caution is not applied while they are thrown in garbage.
 - **Current Concerns:**
 - » India hasn't estimated how much domestic hazardous waste do we generate.
 - » Traces of toxic waste can be found in most landfills.
 - » Absence of robust framework and infrastructure
 - » Segregation of domestic hazardous waste remains a distant dream for most cities.
- **Indore Municipal Corporation has shown the way:**
 - It has introduced a 3-way source segregation in 2018-19: **Wet, Dry and Domestic Hazardous**. Later, it has asked its residents to follow a five-way source segregation (wet, dry, hazardous, e-waste, and sanitary) to improve the purity levels of waste that can be recycled.
 - In Jan 2021, they added plastic waste as the sixth category.
 - The municipal corporation has taken an authorization of sending 1,000 tonnes of domestic hazardous waste to a treatment facility every year.

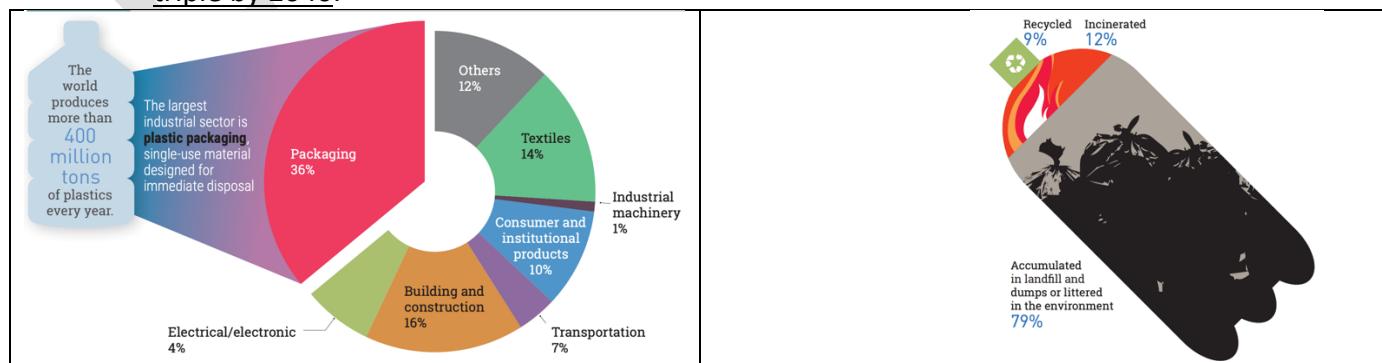
- **Bhopal has brought similar initiatives** and is making citizens segregate wastes into 4 categories (wet, dry, hazardous and sanitary)

6. PLASTIC POLLUTION

- Plastic is a lightweight, hygienic and resistant material which can be molded in wide range of applications and is cheaply manufactured. Because of these reasons, since the 1950s, the production of plastic has outpaced almost all other materials.



- **Negative Impact on Humans:** A study published by **World Wildlife Foundation** in 2019 estimates that **an average human may be ingesting as much as 5 gram of plastic every week**. This is because almost 1/3rd of the plastic waste that is getting generated ends up in nature, especially water, which is the largest source of plastic ingestion.
- **Extent of Plastic Pollution:**
 - » Globally, plastic production stands at about 400 million tonnes, and could double by 2040.
 - » **Global Plastic Production by Industrial Sector, 2015**
- **How is plastic disposed off?**
 - According to the UNEP, as of 2015, of the 9 billion tonnes of Plastic that the world has ever produced, only 9% has been recycled and 12% has been incinerated, the balance 79% has accumulated in landfills or in the natural environment. About 11 million tonnes of plastic is dumped into the ocean each year, and this figure is projected to double by 2030 and nearly triple by 2040.



- » India produces around **10 million tonnes of plastic** per year of which around 5 million tonnes is rendered waste every year. Therefore, it's crucial that this waste is properly managed.

A) GLOBAL PLASTIC OUTLOOK: POLICY SCENARIO TO 2060

- Recently released by OECD
- It is 2nd of the two reports, and provides a set of coherent projections on plastics to 2060, including plastic use and waste as well as the environmental impacts.
- **Key Projections:**
 - Tripling of the use of plastic and plastic waste by 2060
 - Largest increase will come from emerging economies in Africa and Asia
 - This is expected to double GHG emission, ozone depletion, acidification and human toxicity.

1) MICROPLASTICS

- Plastic never truly biodegrade, but simply breaks up into smaller and smaller pieces. These tiny fragments are called micro (1 micro meter - 5 micro meter) and nano (less than 1 micro meter) plastics.
- The world sea floor is littered with an estimated 14 million tonnes of microplastics. They contribute to about 80% of the ocean debris. As per the UNEP, in the last four decades, the concentration of microplastics is supposed to have increased drastically in the sea surface water.
- **Microplastics** are divided into **two categories**:
 - i. **Primary Microplastics**: They enter the environment directly as tiny particles. They may be tiny particles designed for industrial use or microfibers shed from clothing and other textiles like fishing nets. Example of microplastics include micro beads found in personal care products, plastic pellets used in industrial manufacturing, and plastic fibers used in synthetic textiles.
 - ii. **Secondary Microplastics** form from the breakdown of larger plastics such as water bottles. This happens when larger plastics undergo weathering through exposure to sea waves, UV rays of sun, wind abrasion etc.
- **Impact of Microplastics**
 - **Introduction in food chain**
 - They can also alter the functioning of important habitats, impact hatching, growth rates and food consumption of multiple different animals and cause mass death in coral species.
 - A study in March 2022, found micro-plastics in nearly 80% of the individual blood samples.
 - In June 2022, for the first time microplastics have been found in freshly fallen snow in Antarctica. Samples from 19 sites showed that all of them contained micro-plastics.
 - **Nano plastics** can cross over cellular membranes into the brain, where it can cause Behavioural and neurological problems.

2) SINGLE USE PLASTICS

- **What is Single use plastic?**

- » Single use plastics (SUP) are disposable plastics intended to be used only once before they are thrown away or recycled.
 - They include grocery bags, food packaging, bottles, straws, containers, cups and cutlery.
 - These are the waste products of a throwaway culture that treats plastic as disposable material rather than a valuable resource to be harnessed.
- Plastic Waste Management Amendment Rules 2021 defined SUP as "a plastic commodity intended to be used once for the same purpose before being disposed of or recycled".
 - » The rules also provides for phasing out of single use plastics.
- **Ban on several forms of Single Use Plastics from July 1, 2022:**
 - » As per the Plastic Waste Management Rules, 2016, there is a complete ban on sachets using plastic material used for storing, packing, or selling Gutkha, tobacco and Pan Masala.
 - » As per the PWM (Amended) Rules, 2021:
 - Carry bags made up of virgin or recycled materials and of less than 75 microns is banned wef 30th Sep 2021.
 - Import, stocking, manufacture, distribution, sale and use of the following identified SUP items, which have low utility and high littering potential is banned from 1st July 2022.
 - ear buds with plastic sticks, plastic sticks for balloons, plastic flags, candy sticks, ice- cream sticks, polystyrene [Thermocol] for decoration.
 - plates, cups, glasses, cutlery such as forks, spoons, knives, straw, trays, wrapping or packing films around sweet boxes, invitation cards, and cigarette packets, plastic or PVC banners less than 100 microns, stirrers.
 - » **Why ban these items?**
 - "difficulty of collection and therefore recycling".

3) HARMFUL IMPACT OF PLASTIC POLLUTION

- **Physical Pollution:** Pieces of plastics, the polymers themselves, interact with bodies and ecosystems.
- **Chemical Pollution:** Added chemicals escape plastics and interact with bodies and ecosystems;
 - A number of chemicals used in the plastic are toxic and problematic. These chemicals, in lab settings, have been shown to be associated with infertility, recurrent miscarriages, feminization of male foetuses, early onset of puberty, cancer etc.
- **Environmental Impacts:** Plastics take upto thousands of year to decompose and thus contaminate soil and water.
- **Plastisphere:** Sometimes called the 'Plastisphere', bacteria, viruses and other life colonize the surface of plastic waste, creating distinct communities and population structure.
 - They may also contribute in growth of invasive species. For e.g., more than 80% of invasive species in the Mediterranean may have arrived on floating plastic waste.
- **Health and Social Impact:** Health losses, welfare losses -> unusable parks, Sewage Blocking -> Malaria, Dengue etc.
- **Economic Impact**
 - Visual pollution negatively impacts the tourism sector.
 - Further, future cost of removing these plastics from nature is higher than the cost of preventing the littering today.
- **Exacerbate disasters like floods** - an important cause of urban floods.

- Even the biodegradable plastics have many unintended consequences.
- Exacerbates Climate Change: Plastics are 80% carbon and more than 99% of plastics use crude oil, fossil gas or coal as feedstock. Manufacturing also involves burning of large quantities of fossil fuels to provide high energy demands of the industrial processes.
 - By 2015, the total estimated lifecycle emissions from plastics were **1.78 billion tonnes** of CO₂ equivalent (GtCO₂e). For context, if the whole plastics lifecycle were a country, it would be fifth largest emitter of greenhouse gases in the world.

4) PLASTIC WASTE MANAGEMENT RULES 2016 (AND 2021 AMENDMENTS)

- Key Provisions of the 2016 Rules
 - Min thickness of plastic carry bags has been increased to 75 microns by 30th Sep 2021 and **120 microns by 31st Dec 2022** (after the 2021 amendment to the rules)
 - Expand the coverage to rural areas. The earlier regulations only covered urban municipal areas.
 - Phasing out of non-reusable Multi-layered Plastic.
 - Introduces Extended Producer Responsibility for producers and generators of Plastic Waste
 - Note: India first introduced EPR to manage electronic-waste in 2012.
 - EPR was extended to Plastic manufacturers after the notification PWMR, 2016.
 - Shopkeepers and Vendors can only use plastic carry bags which have been properly labelled and marked for use or else there will be imposition of fines.
 - ULB and Panchayats have been provided with the responsibility of establishing and operating waste management systems.
 - The Land Department (or any department with business allocation of land allotment with state governments) should allocate land for establishing waste management facilities.
 - Gainful usage of Plastic waste has also been promoted in road construction, waste to oil conversion etc

5) PLASTIC WASTE MANAGEMENT RULES, 2021 AND OTHER CHANGES

- Key provisions of 2021 amendment rules:
 - The min thickness of plastic carry bags has been increased from 50 microns **to 75 microns from 30th Sep 2021** and **to 120 microns with effect from the 31st Dec 2022**.
 - Note: Advantage of increased thickness - Higher cost -> more reuse; less mobile -> less pollution; less chances of being consumed by stray animals.
 - The manufacture, import stocking, distribution, sale and use of following single-use plastic, including polystyrene and expanded polystyrene, commodities shall be prohibited with effect from 1st July 2022.
 1. Ear buds with plastic sticks, plastic sticks for balloons, plastic flags, candy sticks, ice-cream sticks, polystyrene [Thermocol] for decoration;
 2. Plates, cups, glasses, cutlery such as forks, spoons, knives, straw, trays, wrapping or packing films around sweet boxes, invitation cards, and cigarette packets, plastic or PVC banners less than 100 micron, stirrers.

Note: It doesn't cover compostable plastic.

Note: The CPCB and the SPCBs have issued notification asking manufacturers, suppliers and consumers of single use plastic items to scrap and phase them out and switch to greener and sustainable alternatives.

- **Plastic Packaging Waste**, which is not covered under the phase out of identified single use plastic items, shall be collected and managed in an environmentally sustainable way through the EPR of producer, importer and Brand Owner (PIBO), as per the Plastic Waste Management Rules, 2016.
 - For effective implementation of EPR, the Guidelines for EPR being brought out have been given legal force through the Plastic Waste Management Rules, 2021.

A) THE MOEF&CC HAS NOTIFIED THE GUIDELINES ON EPR FOR PLASTIC PACKAGING UNDER PLASTIC WASTE MANAGEMENT RULES, 2016, IN THE GAZETTE OF INDIA ON 16TH FEB 2022.

- **Key Highlights of the guidelines:**
 - It promotes development of new alternatives to plastics and provide further next steps for moving towards sustainable plastic packaging by businesses.
- **Obligated entities that fall under the category of EPR (Producer of Plastic Packaging; Importer of all imported packaging, Brand Owners including online platforms, Plastic Waste Processors) have to get registered in the centralized portal developed by CPCB.**
- **The amendment categorizes SUPs in 4 categories:**
 - i. **Category 1:** Rigid plastic packaging.
 - ii. **Category 2:** Flexible plastic packaging with single layer or multilayer (more than 1 layer of plastic), plastic sheets, covers made of plastic sheets, carry bags, plastic sachets, or pouches.
 - iii. **Category 3:** Multi-layered plastic packaging where at least one layer is non-plastic, such as tetra pack cartons etc.
 - iv. **Category 4:** Plastic Sheet or like used for packaging as well as carry bags made of Compostable Plastics
- The targets for minimum level of recycling (excluding end of life disposal) as per Guidelines, are given below:

Plastic Packaging Category	2024-25	2025-26	2026-27	2027-28 onwards
Category I	50	60	70	80
Category II	30	40	50	60
Category III	30	40	50	60
Category IV	50	60	70	80

- **Environmental Compensation** shall be levied based upon polluter pay principle, with respect to non-fulfilment of EPR targets by Producers, Importers & Brand Owners, for the purpose of protecting and improving the quality of the environment and preventing, controlling, and abating environmental pollution.
- **Implementation of EPR** will be done through a Customized Online Platform which would act as the Digital backbone of the system.
 - It will allow tracking and monitoring of EPR obligations and will reduce the compliance burden for companies through online registration and filing of annual returns.

- Producers, Importers and brand-owners shall have to provide the details of recycling certificates only from registered recyclers along with detailed quantity sent for end-of-life disposal, by June 30, 2022 of next financial year while filing annual return on online portal.
- Sale and Purchase of surplus EPR certificates are allowed** -> this has thus set up market mechanisms for plastic waste management.
- Levy of environmental compensation** based upon polluter pay principle, with respect to non-fulfilment of EPR targets by the producers, importers & brand owners. The funds collected shall be utilized for collection, recycling, and end of life disposal of uncollected plastic waste in an environmentally sound manner.
 - CPCB shall charge compensation on default producers, importers & brand-owners that operate in more than two states.
 - SPCB shall levy compensation on the default producers operating within their jurisdiction.
- Producers, importers, & brand owners, may operate schemes such as deposit refund system or buy back or any other model.
- CPCB shall constitute a committee under chairpersonship of Chairman, CPCB that shall be responsible for recommending measures to MoEF&CC for the effective implementation of EPR that shall include amendments to the EPR guidelines.

6) OTHER STEPS BEING TAKEN

- Strengthening of waste management infrastructure through the **Swatch Bharat Mission**.
- **Promotion of Alternatives:**
 - CPCB has already issued one-time certificate to around 200 manufacturers of compostable plastics.
 - India Plastic Challenge - Hackathon 2021 is launched to develop innovative alternatives to SUP.
 - It calls upon start ups/ entrepreneurs and students of HEIs to develop innovative solutions to mitigate plastic pollution and develop alternative to single use plastic.
- **Strengthening of Institutional Framework at State/National level** to better implement 2016 rules:
 - States/Uts have been asked to develop a comprehensive action plan for elimination of SUP.
 - States have been requested to form a Special Task Force for elimination of SUP and effective implementation of 2016 rules.
 - A National Level Task force has been constituted by the ministry to take coordinated efforts to ban SUP and to implement 2016 rules.
- **Awareness Generation:**
 - Mascot 'Prakriti' has been launched to spread mass awareness about how adoption of small changes in our lifestyle can play a big role in environmental sustainability. It also teaches about various efforts and initiatives that the MoEF&CC and CPCB have taken in order to ensure effective Plastic Waste Management in the country (2022)
- **Promoting Alternative uses of plastic waste:**
 - For e.g. in 2021, MoRT&H issued guidelines for use of plastic waste in road construction.
 - Indian oil is also using technology to convert plastic waste into bitumen.

- **Promoting Reduce, Reuse and Recycling:**
 - World-Wide Fund for Nature - India (WWF India) and the Confederation of Indian Industry (CII) have **joined hands to develop a platform to promote a circular system for plastics**. The new platform is called, the '**India Plastic Pact**'

A) INTERNATIONAL EFFORTS

- a. **Steps towards Plastic Pollution Treaty:** In 2022, the UN member states agreed to start negotiating new global treaty to end plastic pollution. Now it is crucial that the treaty that is finalized is ambitious and effective enough to truly address the plastic crisis.
 - As of July 2023, 2 negotiation meetings, for the new treaty has taken place.
- b. **Awareness and Education:**
 - The theme of **World Environment Day, 2018** was "**Beat Plastic Pollution**" and it focused on increasing awareness related to plastic pollution across the world.
- c. **EU Parliament bans 10 single use Plastics** with effect from 3rd July 2021

B) GLOBAL PLASTIC TREATY NEGOTIATIONS:

- **Why in news?**
 - 2nd Session of Intergovernmental negotiation Committee (INC) on plastic pollution was held in Paris in June 2023.
- **Background:** In 2022, the UN member states agreed to start negotiating new global treaty to end plastic pollution. Now it is crucial that the treaty that is finalized is ambitious and effective enough to truly address the plastic crisis.
 - The Intergovernmental Negotiation Committee (INC) on Plastic Pollution is in the process of developing "an international legally binding instrument on plastic pollution, including in the marine environment"
 - As of July 2023, 2 negotiation meetings, for the new treaty has taken place.
- **Why is a global Treaty on Plastic Pollution required?**
 - i. **Plastic Pollution is a global problem** which requires global solution. Most of the plastic is being dumped into oceans. This is eventually converting into micro-plastics, entering food chain and affecting everyone.
 - ii. Plastic pollution is harmful to wildlife and biodiversity which is impacting everyone.
 - iii. **Increased International Cooperation** will be feasible through a global treaty.
 - iv. The treaty may set global target for reduction
 - v. A global treaty may make the fight against plastic pollution more fair -> by giving higher responsibility to developed economies and giving more time to under developed countries.

7) PROMOTING ALTERNATE USE OF PLASTICS

A) USE OF PLASTIC WASTE IN STEEL MANUFACTURING (DEC 2022: SOURCE: PIB)

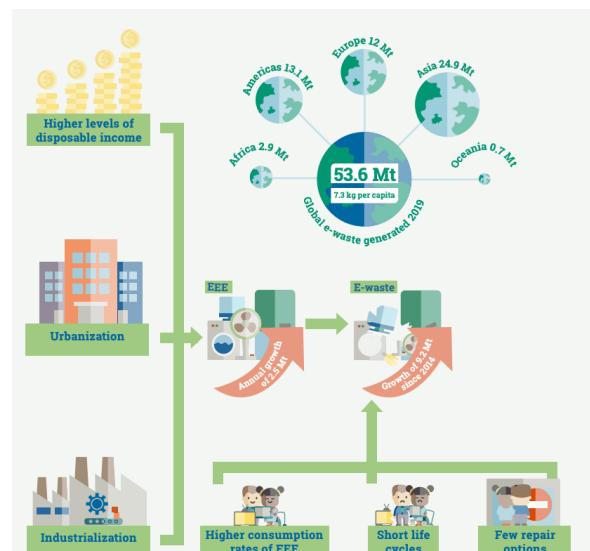
- Waste Plastic can be used as replacement of coking coal (by upto 1%) in coke making.
- Waste plastic can also be added in marginal quantities in Electric Arc Furnace (EAF) as replacement of pet coke.
- As per Plastic Waste Management Rules (PWM-2016) and subsequent amendment vide gazette notification G.S.R. 522(E) dated 06th July 2022, issued by the MOEF&CC, **only "End-of-Life Disposal" plastic is allowed for co-processing in the steel industry** and other waste plastic which can be recycled has been mandated for recycling only.
 - Presently, availability of "End-of-Life Disposal" waste plastic is a major constraint.
- Under the aforesaid Plastic Waste Management Rules, the municipalities/ local bodies are responsible for the creation and establishment of the plastic waste segregation, collection, storage, transportation, processing, and disposal system either on their own or by engaging agencies or manufacturers.

B) ROADS MADE UP OF PLASTIC WASTE

- **Why in news?**
 - MoRT&H has issued guidelines for use of plastic waste in Road construction (July 2021)
- **Details**
 - Mandatory use of waste plastic in periodic renewal coat of pavement on National Highways and also in wearing course of service road within 50 km periphery of urban areas having population of 5 lakhs or more.
 - Indian Roads Congress (IRC) has formulated guidelines for the use of waste plastic in hot bituminous mixes for wearing courses.

7. E-WASTE

- E-waste is a popular name for electrical and electronic equipment (EEE) discarded after their end of life'. Discarded laptops, desktops, cellphones, and their batteries, air conditioners and television sets, cables, and wires, tube-lights and CFLs which contain mercury, are some examples of e-waste.
- It is one of the fastest growing waste stream in the world.
- **Annual waste Output**
 - Global E-waste monitor (published by UN University) estimates that **53.6 million tonnes (7.3 kg per capita)** of e-waste was generated world over in 2019.
 - This is an increase of 21% in just five years.
 - This is expected to go to **74.7 Mt** by 2030.
 - **E-waste generation in India is expected to grow rapidly in the coming future** (income, urbanization, changing technology, import (legal or illegal), poor quality equipment, power surge issues etc.)
 - **India is already the third largest e-waste generator.**



- **Harmful effects of e-waste:**
 - Hazardous and toxic heavy metals - mercury, cadmium etc;
 - Ozone Depleting Substances;
 - High Global Warming Potential gases;
 - Unscientific extraction - Air Pollution, Water Pollution and Soil Pollution;
 - Severe negative health impacts - hampers central and peripheral nervous system, brain development, kidney, reproductive system etc.

1) E-WASTE MANAGEMENT RULES, 2022 NOTIFIED BY MOEF&CC IN NOV 2022

- It will replace E-Waste (Management) Rules, 2016 and will be effective from 1st April 2023. These rules will have new EPR regime for e-waste recycling.
- **Key Features:**
 - Applicable to every manufacturer, producer, refurbisher, dismantler and recycler.
 - All the manufacturer, producer, refurbisher and recycler are required to register on portal developed by CPCB.
 - No entity shall carry out any business without registration and also not deal with any unregistered entity.
 - Authorization has now been replaced by Registration through online portal and only manufacturer, producer, refurbisher and recycler require Registration.
 - Schedule I expanded and now 106 EEE (Electrical and Electronic Equipment) has been include under EPR regime.
 - Producers of notified EEE, have been given annual E-Waste Recycling targets based on the generation from the previously sold EEE or based on sales of EEE as the case may be.
 - Target may be made stable for 2 years and starting from 60% for the year 2023-2024 and 2024-25; 70% for the year 2025-26 and 2026-27 and 80% for the year 2027-28 and 2028-29 and onwards.
 - Management of solar PV modules /panels/ cells added in new rules.
 - The quantity recycled will be computed on the basis of end products, so as to avoid any false claim.
 - Provision for generation and transaction of EPR Certificate has been introduced.
 - Provisions for environment compensation and verification & audit has been introduced.
 - Provision for constitution of Steering Committee to oversee the overall implementation of these rules.
 - Provision for reduction of hazardous substances in manufacturing of Electrical and Electronic Equipment (EEE) has been provided.
 - It mandates that every producer of EEE and their components shall ensure that their products do not contain lead, mercury and other hazardous substances beyond the maximum prescribed concentration.
 - The E-Waste (Management) Rules also provide for .

A) MANAGEMENT OF SOLAR PV MODULES/CELLS HAS BEEN ADDED IN CHAPTER V OF THE SAID RULES.

- As per these rules, every manufacturer and producer of solar photo-voltaic modules or panels or cells shall:
 - i. Ensure registration on the portal;
 - ii. store solar photo-voltaic modules or panels or cells waste generated up to the year 2034-2035 as per the guidelines laid down by the Central Pollution Control Board in this regard.
 - iii. file annual returns in the laid down form on the portal on or before the end of the year to which the return relates up to year 2034-2035.
 - iv. ensure that the processing of the waste other than solar photo-voltaic modules or panels or cells shall be done as per the applicable rules or guidelines for the time being in force;
 - v. ensure that the inventory of solar photo-voltaic modules or panels or cells shall be put in place distinctly on portal; and
 - vi. comply with standard operating procedure and guidelines laid down by the Central Pollution Control Board in this regard.

8. BATTERY WASTE MANAGEMENT RULES, 2022

- MoEF&CC, Government of India published the Battery Waste Management Rules, 2022 on 24th August, 2022 to ensure environmentally sound management of waste batteries.
- New rules will replace Batteries (Management and Handling) Rules, 2001.
- The rules cover all types of batteries, viz. Electric Vehicle batteries, portable batteries, automotive batteries and industrial batteries.
- The rules function based on the concept of Extended Producer Responsibility (EPR) where the producers (including importers) of batteries are responsible for collection and recycling/refurbishment of waste batteries and use of recovered materials from wastes into new batteries
 - EPR mandates that all waste batteries to be collected and sent for recycling/refurbishment, and its prohibits disposal in landfills and incineration. To meet the EPR obligations, producers may engage themselves or authorize any other entity for collection, recycling or refurbishment of waste batteries
 - The rules will enable setting up a mechanism and centralized online portal for exchange of EPR certificates between producers and recyclers/refurbishers to fulfil the obligations of producers.
- The rules promote setting up of new industries and entrepreneurship in collection and recycling/refurbishment of waste batteries.
- Mandating the minimum percentage of recovery of materials from waste batteries under the rules will bring new technologies and investment in recycling and refurbishment industry and create new business opportunities.
- Prescribing the use of certain amount of recycled materials in making of new batteries will reduce the dependency on new raw materials and save natural resources.

9. RADIOACTIVE WASTE IN SCRAP

- **Radioactive materials or contaminated devices are entering into the booming scrap recycling chain,** posing a grave health hazard, according to the annual data on illicit trafficking of nuclear and other radioactive material released by IAEA
- **Details**
 - » The latest data has been extracted from the IAEA Incident and Trafficking Database (ITDB), where some 143 member states and international agencies report incidents of illicit trafficking of nuclear and other radioactive material under or out of regulatory control. This is part of IAEA's nuclear security plan.

10. CONSTRUCTION AND DEMOLITION WASTE

- In **2016**, government for the first time came up with **Construction and Demolition Waste Management Rules**, 2016. These rules are aimed at promoting recovering, recycling and reuse of the waste generated through C&D.
 - **Mandatory segregation** of C&D waste into four types - concrete, soil, steel and wood, plastics, bricks and mortars.
 - Deposit it at **collection centers** or hand it over to **processing facilities**.
 - It makes all stakeholders responsible for waste disposal (be it small scale generators, the municipal body or the government)
 - It makes debris recycling mandatory
 - **Illegalizes the dumping** of waste outside designated areas.
 - **Waste processing authorities** -> should have authorization from SPCB and should be located far away from habitation.
 - For **effective monitoring** of the rules, specific roles have been allocated to **CPCB**, the **Bureau of Indian Standards (BIS)**, the **Indian Road Congress (IRC)** and Central Ministries.
 - **Land Department** - Provide land for storage processing and recycling of C&D waste

11. BIOMEDICAL WASTE MANAGEMENT RULES, 2016

- The rules are applicable for wastes from vaccination camps, blood donation camps, surgical camps or other healthcare activity.
- **Main Provisions**
 - **Pretreatment** of laboratory waste, microbiological waste, blood samples and blood bags through disinfection or sterilization on site should be carried out as prescribed by WHO or NACO (National Aids Control Organization).
 - **Waste classification in four categories instead of 10** to improve the segregation of waste sources.
 - The BMW have to be collected by the health care facilities in colored bags - yellow, red, blue/white and black according to the category of biomedical waste.

Red Bin	Yellow Bin	Blue Bin	Black Bin
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Plastic Waste such as syringes bottles etc	Infectious waste - Bandages, Cotton, Placenta etc	Glass bottles, discarded medicines etc	Needles without syringes, metal articles etc.
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- **Phased discontinuation of chlorinated plastic bags**, gloves and blood bags
- **Bar-code system to classify disposal of bags of containers having BMW**
 - It can be used to track and identify bags better.
- **More Stringent standards** have been prescribed for incinerators to reduce the pollution to environment.
- **States to provide land** for setting up common biomedical waste treatment and disposal facility.
- **2018 Amendment** to the rules provided for:
 - **Extension of dates to** phase out chlorinated bags to March 27, 2019.
 - **Establishing of barcode system** by both generators and operators by March 27, 2019
 - **Institute GPS in vehicles of CBMWTF**

1) SEQUENTIAL PRODUCTION OF BIO-DIESEL, BIO-ETHANOL, BIO-HYDROGN, AND METHANE FROM LEATHER SOLID WASTES, AND EFFLUENT TREATMENT SLUDGES

- MoEF&CC had approved the lab-cum-demonstration project titled *Sequential production of Bio-Diesel, Bio-Ethanol, Bio-Hydrogen and Methane from leather solid wastes and effluent treatment sludges* in 2015.
 - The project was approved for Central Leather Research Institute, Chennai with the total project outlay of Rs 77.11 lakh.
- The Project envisaged delivery of environmental benefits like:
 - a. Effective solid waste management techniques for tanneries
 - b. Better pollution abatement techniques
 - c. Avoidance of groundwater contamination
 - d. Efficient greenhouse emission control techniques
- **CAG Report** for financial year 2020-21 (released in Dec 2022)
 - » Only one unit of a biodiesel recovery had been established in March 2018 against the expected physical output of four distinct fuel recovery units.
 - The unit produced 80 litres of bio-diesel and none of the other three units achieved fruition by May 2022.
 - » The deliverables of 10 international publications in high-impact factored journals and three PhD degrees had also not been achieved.
 - » Key deficiencies observed by CAG Report:
 - Inaction in processing the request of Central Leather Research Institute, Chennai (CLRI) to revise the number of project fellowships. Due to this, CLRI was unable to retain the project fellows who were engaged in the project.
 - Failure to obtain formal commitment from the industry partners, which resulted in limited participation by the industry partner;
 - A lack of regular monitoring of the progress of the project, which affected the timely implementation of the project.

12. SOME OTHER TECHNOLOGIES

1) HYDROTHERMAL CARBONIZATION

- The Hydrothermal Carbonization (HTC) is a (pre)treatment of lignocellulosic biomass in hot (180 degree - 280 degree) water at saturated pressure of 2-10 MPa and residence time varying from minutes to hours. It is carried out mainly to produce solid product similar to coal. The energy density is much higher for this solid product. They can be either combusted to produce energy or disposed for soil nourishment as fertilizer (also sequestration of carbon)

13. NOISE POLLUTION

- **Intro**
 - » Noise pollution refers the presence of such levels of noise or sound in the environment that are disturbing, irritating and annoying to living beings. It causes discomfort and harm to living being's mental and physical health. It is one of the major causes of deafness and other health hazards. Even animals suffer from excessive environmental noise.
- **Causes of Noise Pollution** - Vehicles, factories, industries, construction sites, fire crackers, loud speakers, domestic appliances; TV/Radio etc.
- **Effects of Noise Pollution**
 - Loud and prolonged noise can cause physiological and psychological damage.
 - a. **Loss of hearing and deafness** : Noise above the tolerable threshold is the leading cause for loss of hearing and deafness.
 - b. **Cardiac Disturbance** : Noise increase the risk of cardiac disturbance including coronary artery disease or ischemic heart disease
 - c. **Sleeplessness** : Noise may make people restless. It may keep people away from sound sleep
 - d. **Headache** : Human mind can tolerate sound only to a limited extent. Excess noise cause headache.
 - e. **Stress, tension and aggressiveness**
 - f. **Mental Imbalance and nervous debility**
 - g. **Psychological imbalance**
 - h. **Difficulty in talking**
 - i. **Diabetes and Hypertension:**
 - Two 15 year long studies for long-term resident of Toronto, Canada found that exposure to road traffic noise elevated risks of acute myocardial infarction and congestive heart failure, and increased incident of Type 2 diabetes by 8% and hypertension by 2%.
 - j. **Affects biodiversity:** For instance a recent study published in the Conservation Biology journal noted that chicks of the birds which were exposed to noise were smaller than the ones in quiet nests.

- **How sound is measured?**
 - » The faintest sound that our ears can detect is known as the Threshold of Hearing (TOH). The most intense sound that our ears can detect without suffering any physical damage is one billion times more intense than TOH. This large hearing range makes a linear scale of sound measurement inappropriate.
 - » Hence, we use **logarithmic scale** to measure the sound. The unit is a decibel (dB) and TOH is assigned zero dB.
 - So 10 dB means a sound that is 10 times more intense than TOH. 20 dB refers to an intensity of sound that is 100 times more than a TOH sound, 30 dB means an intensity that is 1000 times more than TOH, and so on.
 - $10 \cdot \log_{10} (P_1/P_0)$
 - » **What is dbA?**
 - Frequency and pitch of the noise also determines whether it is harmful or not. A modified scale called decibel-A (dbA) takes pitch into account.
 - A-weighted decibels, abbreviated dBA, or dba or dB(a), are an expression of the relative loudness of sounds in air as perceived by the human ear. In the A-weighted system, the decibel values of sounds at low frequencies are reduced, compared with the unweighted decibels, in which no correction is made for audio frequency.
- **What is the safe limit for noise?**
 - » The latest 2018 WHO guidelines established a health-protective recommendation for road traffic noise levels of 53 dB.
 - » Hearing loss begins if a person is exposed more than 8 hours a day to a noise level of 80-90 dbA.
 - » A level of 140 dbA is painful and 180 dbA could even kill a person.
 - Examples of noise levels
- **What is being done to curb the noise pollution?**
 - » The **CPCB** is mandated to track noise levels, set standards as well as ensure, via their State Units, that sources of excessive noise are controlled.
 - » In 1980s and 1990s there were several court judgements in India restricting the generation of noise by industries, fire crackers, electric horns etc.
 - » Finally in 2000, Indian government notified the **Noise Regulation Rules**, which were amended in 2010.
 - Noise Regulation Rules were notified under the Environment (Protection) Act of 1986.

- Two types of noise level standards are Prescribed
 - Ambient noise level standards
 - Noise levels for designated types of machinery, appliances, and fire crackers.
 - Ambient Noise Levels have been defined as follows:
- | Category of Area/Zone | Limits in dB(A) (Day) (6 am - 10 PM) | Limits in dB(A) (Night) |
|-----------------------|--------------------------------------|-------------------------|
| Industrial Area | 75 dbA | 70 dbA |
| Commercial Area | 65 dbA | 55 dbA |
| Residential Area | 55 dbA | 45 dbA |
| Silence zone | 50 dbA | 40 dbA |
- **Silence zone** - zones of silence (100 meters) near schools, courts, hospitals etc.
 - The rules specify that no permission could be granted by any authority for use of public address (PA) system in the open after 10.00 pm and before 6 am. Even after permission has been procured, the sound level must fall within the limits prescribed in the Noise rules.
- National Ambient Noise Monitoring Network (NANMN) was launched in 2011
- Central government set up a National Ambient Noise Monitoring Network (NANMN) through CPCB and the state pollution control boards (SPCBs) to monitor noise on a 24X7 basis in India's seven largest city.
 - Under NANMN, during Phase 1 and Phase 2, **70 monitoring stations** have been set up in seven cities - each in Delhi, Bengaluru, Kolkata, Chennai, Hyderabad, Lucknow, and Mumbai. - which are operated by SPCBs.
 - Phase 3 plan was to launch 90 stations in 80 other cities.

- **2015 Supreme Court Judgements:** In 2015, the Supreme Court, acting on a petition filed by four infants (all aged between six months and 14 months) seeking curbs on air and sound pollution, banned the bursting of sound-emitting crackers between 10 pm and 6 am during Diwali.
- In June 2020, the CPCB has proposed a new set of fines between Rs 1,000 to Rs 1,00,000 for those who violate norms restricting noise pollution under the **Noise Pollution (Regulation and Control) Rules, 2000**.

- This was submitted in a report filed with National Green Tribunal in response to a set of ongoing cases over noise pollution.
- **Under the new norms:**

▪ Violations related to norms over:	
Use of loudspeakers/PA systems etc.	Confiscation of system and a fine of upto Rs 10,000
Diesel generator sets	Sealing of the sets and a fine between Rs 10,000 to 1 lakh.
Sound Emitting Construction Equipment	Seizures, sealings and a fine of Rs 50,000

14. LIGHT POLLUTION

- Why in news?

- » International Dark Sky Week is an annual event hosted by International Dark Sky Association (IDA).
 - Astronomers and Sky enthusiasts marked the 2022 International Dark Sky Week from April 22-30. Hundreds of events were conducted across the globe where participants came together to learn astrophotography, take night walks, and observe the night sky without light pollution and learn how it negatively impacts our ecosystem.
- **Introduction**
 - » Light pollution, also known as photo-pollution or luminous pollution, is the **excessive, misdirected or invasive use of artificial outdoor lighting**.
 - » **Harmful Impact**
 - **Disturbs circadian rhythm** (the 24 hour cycle of many organisms) including humans and induces sleep disorder, and other health risks like obesity, depression, and diabetes.
 - **Unhealthy:**
 - Light pollution may cause damage to the retina in the eyes.
 - Some lights such as blue LED lights may be harmful for health.
 - **Impacts biodiversity:** It affects insects as they are drawn towards these lights. This affects their food chain and reduces pollinating activities. Other animals such as turtle are also affected as they get attracted towards these lights and thus are snapped by predators.
 - **Wastage of light** is also a reason for overuse of fuel and thus a factor behind climate change.
 - **Impacts astronomy:** Mismanaged lighting alters the color and contrast of the nighttime sky and eclipses natural starlight. It hinders study of the universe as proper study becomes difficult from areas where these artificial lights hinder celestial light. It makes stargazing difficult.



The city of Las Vegas dumps an enormous amount of light into its environment, turning the night sky above into a seemingly blank canvas.

- **Light Pollution and Satellites**
 - » A new study published in Monthly Notices of the Royal Astronomical Society: Letters shows that satellites that orbit the Earth can increase the overall brightness of the night sky by 10% above natural levels.
 - This additional light pollution has an impact over a larger part of the globe than ground-based sources

15. ENVIRONMENTAL IMPACT ASSESSMENT – EIA RULES AMENDED

- **Environmental Impact Assessment**
 - EIA can be defined as the study to predict the environmental, socio-economic, cultural and human-health impacts of proposed project/activity. The global environmental law for the EIA

is the "**precautionary principle**". Environmental harm is often irreparable so there should be a focus on prevention.

- It is a **decision making tool** which **compares various alternatives** for a project and chooses the one which ensures best combination of economic and environmental costs and benefits.
- **Advantages of EIA:** By considering the environmental effects of the project and their mitigation early in the project planning cycle, environmental assessment has many benefits:
 - Promotes environmentally safe and sustainable development.
 - Optimum utilization of resources
 - Saving of time and cost of the project
 - Properly conducted EIA also **lessens conflict** by promoting community participation, informing decision makers, and helping lay the base for environmentally sound project.
- **History of EIA in India**
 - » The Indian experience of EIA started in 1976-77 when the Planning Commission asked the Department of Science and Technology to examine the river valley project from an environmental angle.
 - » Till 1994, EIA was an administrative decision and lacked statutory backing.
 - » In 1994, the Ministry of Environment and Forest, under the EPA, 1986, promulgated an **EIA notification making environmental clearance mandatory** for expansion or modernization of any activity or for setting up new projects listed in Schedule 1 of the notification.
- **EIA Notification, 2006**
 - » Notified by MoEF&CC under the Environmental (Protection) Act, 1986.
 - » It makes it **mandatory for various projects** such as mining, thermal power plants, river valley, infrastructure (road, highway, ports, harbors and airports) and industries including very small electroplating or foundry units to get environmental clearance. This clearance is given only after the environmental requirements are fulfilled.
 - Unlike, the 1994 notification, it has put the **responsibility of clearing certain projects on the state government**:
 - **Category A** (National Level Appraisal): This category project mandatory require clearance and thus they don't undergo the screening process.
 - **Category B** (State level Appraisal) undergo screening process.
 - **Category B1** (mandatorily requires EIA)
 - **Category B2** (Don't require EIA)
- **Process of EIA**
 - » After 2006, EIA in India involves **four steps**:
 - Screening
 - Scoping
 - Public Hearing
 - Appraisal
 - » However, EIA process is cyclical with considerable interaction between various steps.

- The assessment is carried out by an Expert Appraisal Committee (EAC), which consists of scientists and project management experts.
 - The EAC frames the scope of EIA study and a preliminary report is prepared.
 - The report is published and a public consultation process takes place, where objections can be heard including from project-affected people.
 - The EAC then makes a final appraisal of the project and forward it to MoEF&CC. The Ministry is ordinarily obliged to accept the decision of the EAC.
- **Amendment to EIA Rules notified (July 2022)**
 - » It has exempted highway projects of strategic and defence importance, which are 100 km from the LoC, among other locations, from an environmental clearance before construction.
 - » Thermal power plants upto 15 MW based on biomass or non-hazardous municipal waste using auxiliary fuel such as coal, lignite or petroleum products up to 15% have also been exempted - as long as the fuel mix is eco-friendly.
 - » Increasing the threshold of ports which exclusively deal in fish handling and caters to small fisherman, which are exempted from environment clearance.
 - This is taking into account issues of livelihood security of fishermen involved at fish handling ports and harbors, and less pollution potential of these ports and harbors.
 - » **Toll plazas that need more width for installation of toll collection booths to cater to a large number of vehicles, and expansion activities in existing airport related to terminal building expansion without increase in airports existing area, rather than expansion of runways, etc., are two other exempted projects.**



TARGET PRELIMS 2024

BOOKLET-15; ENVIRONMENT-5

CA UPDATES ON POLLUTION

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2. AIR UPDATES

1) DUST SUPPRESSANTS AND AIR POLLUTION MITIGATION

- **What are Dust Suppressants?**
 - » These are salts of calcium or magnesium that can absorb moisture.
 - » **Delhi government used** Dust suppressants on roads to control pollution. Environment Minister Gopal Rai had said “the Dust Suppressant powder would be mixed with water and sprayed on roads to keep the dust down for longer.”
- In 2019, the CPCB told the NCR states that they may consider using dust suppressants on excavated earth surfaces, piles of construction and demolition waste, and access roads in construction areas.
 - » **One of the CPCB study** had found that dust suppressants along with water is relatively more effective in control of pollution than conventional methods of dust control i.e. water spraying.
- In 2019, the Delhi Pollution Control Committee had also issued directions that all construction agencies will use dust suppressants to control dust emissions and road-owning agencies with use it in dusty patches.

3. WATER UPDATES

1) ‘WATER TRADING MECHANISM TO PROMOTE THE REUSE OF TREATED WATER’: NITI AAYOG REPORT

- **What is water trading?**
 - » This is a water market mechanism that considers water as a commodity that can be traded among users according to their needs. Under this, water rights are allocated to each sector, and they use it according to their needs – Buy when they need more water and sell when they need less.
 - » In many countries water trading has promoted water use efficiency.
- **NITI Aayog Report:**
 - » Though it may not be advisable to introduce a full-fledged water trading in India for various socio-economic reasons, trading of treated wastewater among industrial users could be tried.
- **Advantages of trading:**
 - » Increased treatment (currently only 40% of India's wastewater is treated).

2) GROUNDWATER EXTRACTION HAS SHIFTED THE EARTH'S AXIS: A NEW STUDY (JUNE 2023: IE)

- **Background: Earth's Axis Keep Shifting:**
 - » Earth spins around an imaginary axis which passes through the north pole, its centre of mass and the south pole – just like a top spin around its spindle.
 - » The poles and axis keep shifting naturally as the mass distribution in and on the planet changes. The phenomenon is known as “Polar Motion”.
 - » For e.g., rocks slowly circulating inside Earth's mantle causes the Planet's mass to shift, leading to a change in the position of the rotational axis.

- The study – “**Drift of Earth’s Pole Confirms Groundwater Depletion as a Significant contributor to Global Sea Level Rise 1993-2010**”, was published in the journal **Geophysical Research Letters**.
- The study noted that humans pumped out around 2150 gigatons of ground water between 1993 and 2010. This has led to planet’s axis drifting at a rate of 4.36 cm per year towards the east. Although the shift isn’t significant enough to have real-life consequences, but the study shows shift in planet’s axis and rise in global sea level.

3) NIT WARANGAL FACULTY MEMBERS DEVELOP INNOVATIVE WASTEWATER TREATMENT SYSTEM FOR TEXTILE INDUSTRY EFFLUENTS

- **Textile Effluents:**
- A team of faculty members at **NIT-Warangal** has developed an environment friendly hybrid wastewater treatment system for textile industry effluents.
 - » **Traditional methods** use a lot of chemicals.
 - » However, in the new method, in order to reduce pollution levels to permissible limits of discharge, the team put forward a combination of coagulation, hydrodynamic cavitation (HC) – based oxidation system and ceramic membrane (CM) – based filtration process.
 - » In the coagulation process – turbidity of the effluents is removed.
 - » HC, a process involving generation and collapse of microbubbles in a liquid, is employed afterwards to initiate the breakdown/mineralization of complex organic compounds.
 - » In place of Polymeric membrane, the novel methodology uses ceramic membranes. After two years, polymeric membranes need to be discarded. It becomes a solid waste.
 - The surface modified ceramic membrane further improves filtration efficiency, ensuring the removal of even finer particles and impurities.
 - » This integrated method achieved an 80% reduction in organic pollutants.

4) COASTAL AQUACULTURE AUTHORITY

- Why in news?
 - » Coastal Aquaculture Authority (Amendment) Act, 2023 passed by both houses of the Parliament.
- **Background:**
 - » The Coastal Aquaculture Authority Act 2005 was enacted with an aim to protect coastal environment, while promoting orderly growth of coastal aquaculture farming in coastal areas.
 - » The act has established Coastal Aquaculture Authority which regulates activities connected with coastal aquaculture in the coastal areas.
 - » The act has also defined coastal aquaculture to include culturing under controlled conditions in ponds, pens, enclosures or otherwise, in coastal areas of shrimp, prawns, fish or any other aquatic life in saline or brackish water, but doesn't include freshwater aquaculture.
 - » The act also ensures continued operation of coastal aquaculture within **CRZ area** subject to restrictions imposed by the Authority.
 - » It also penalizes unregistered farms in prohibited areas.
- **Impact:**

- » **Facilitated millions of jobs, self employment opportunities, businesss and environment protection.**
 - » **Increased production of fishery sector.**
- **Need of Amendment:**
- » Some ambiguities related to the provisions of CRZ notifications - like that of "**No Development Zone**" has been misinterpreted to be applicable in the hatcheries as well. Hence, aquaculture farmers and stakeholders have been requesting to remove the ambiguities and amend some of the provision of the act to make this legislation progressive and decrease the regulatory burden.
- **2023 Amendment:**
- » **Broadens the definition** of Coastal aquaculture to include things like cage culture, sea-weed culture, bivalve culture, marine ornamental fish culture etc.
 - » **Registration given** under the Coastal Aquaculture Authority Act will be considered a valid permission under CRZ notification. This will enable lakhs of small marginal aquaculture farmers to avoid the possible need for obtaining CRZ clearances from multiple agencies.
 - » **Some Aquaculture activities** like hatcheries, nucleus breeding centres, and broodstock multiplication centres can be established in NDZ [200 m from HTL] of seas and buffer zones of creeks/rivers/backwaters.
 - » **Decriminalization** of cases of illegal coastal aquaculture and fixed penalties.
 - The original act provided for imprisonment for a period of 3 years for carrying out coastal aquaculture without registration. This was a very harsh punishment for an offence of purely civil nature.
 - » **Increase in role of the Authority:**
 - Fix standards of input and discharge of effluents from aquaculture units.
 - Prohibition of certain harmful inputs
 - Monitor and regulate various aquaculture units, inputs and outputs.
 - » The act also **prohibits the use of insecticides** and other pharmacologically active substances that can harm human health in coastal aquaculture.

4. PLASTIC UPDATES

1) PLASTIC OVERSHOOT DAY: BY EARTH ACTION (EA) (JULY 2023)

- On July 28, 2023, the Earth saw its first Plastic Overshoot Day: The point at which the amount of plastics exceed the global waste management capacity - As per Swiss based research consultancy Earth Action (EA).
 - » Nearly 68 million tonnes of additional plastic waste will end up in nature in 2023.
 - » India is among the 12 countries of the world including China, Brazil, Indonesia, Thailand, Russia, Mexico, USA, Saudi Arabia, the DRC, Iran and Kazakhstan, which are responsible for 52% of the world's mismanaged plastics.
 - » Under current scenario, despite pledges and increased waste management capacity, increased production of plastics will lead to global plastic pollution tripling by 2040.
- Plastic Overshoot Day is determined on the basis of country's Mismanaged Waste Index (MWI).

- » The imbalance between the volumes of plastic that are produced and used, as well as the world's ability to manage those volumes when they become waste, is the root cause of plastic pollution. The gap in waste management capacity and plastic consumption is called MWI.
- » India ranks fourth (after Mozambique, Nigeria, and Kenya) in terms of highest mismanaged waste with 98.55% of generated waste being mismanaged.

2) US STUDY FINDS HUNDREDS OF THOUSANDS OF NANOPLASTIC PARTICLES IN BOTTLED DRINKING WATER (JAN 2024)

- About the Study:

- » The research was published in journal - *Proceedings of the National Academy of Sciences*.
- » The study analysed micro and nanoplastics in three popular brands and daily consumed bottles of water using a technique called stimulated Raman scattering microscopy. The technique passes two lasers through the sample. It is particularly suitable for the identification of microplastics due to its ability to distinguish different types of plastics based on their molecular fingerprints.
 - The team looked for seven common types of plastics: Polyamide, polypropylene, polyethylene, polymethyl methacrylate, polyvinyl chloride, polystyrene, and polyethylene terephthalate.

- Key Findings:

- » Each litre of bottled water contains 110,000 to 370,000 plastic particles — and about 90 per cent of them are nanosized (less than 1 micrometer in size), a new study has found.
- » These nanoplastics are even smaller than microplastics and pose a greater risk to human health. Unlike microplastics, nanoplastics can move from the intestine and lungs directly into bloodstream before reaching the heart and brain.

3) PET46: NEWLY DISCOVERED DEEP-SEA ENZYME BREAKS DOWN PET PLASTIC (SEP 2023)

- A new study involving scientists from Professor Ruth Schmitz-Streit's research group at Kiel University has shown for the first time, using microorganisms from the deep sea, that polymers such as PET are continuously degraded by an enzyme called PET46.
 - » The results fundamentally expand the knowledge of PET degrading enzymes, the underlying mechanisms and the evolutionary understanding of the diversity of putative PET-degrading enzymes throughout the global ocean.



TARGET PRELIMS 2024

BOOKLET-16; EB&CC-6

CLIMATE CHANGE, OZONE LAYER, DESERTIFICATION

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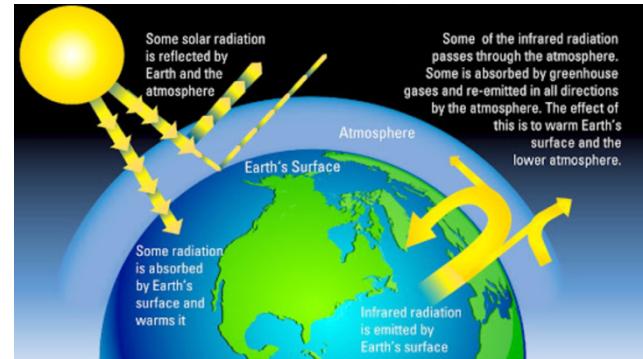
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2. CLIMATE CHANGE AND GREEN HOUSE GASES

- **Climate:** Long term pattern of weather in a particular area.

- **Climate Change:**

- The increasing temperature of earth due to greenhouse effect is known as climate change. It is leading to extreme weather events, melting of Polar ice, rising of sea levels etc.



- **Green House Effect:** Class discussion

- **Greenhouse Gases:** Gases in the earth's atmosphere that trap heat are known as Greenhouse gases. They let sunlight pass through the atmosphere, but they prevent the heat that the sunlight brings from leaving the atmosphere. Greenhouse gases are crucial for survival of life on earth. In the absence of Greenhouse gases, the average temperature on earth would have been -18 degree Celsius instead of the present 15 degree Celsius.

1) WATER VAPOR:

It is the most important Greenhouse gas and plays an important role in controlling earth's temperature.

- Water Vapors account for about 60% of the warming effect. The amount water in atmosphere rises with rising temperature and decreases with the fall in temperature. So, in a way it can be said that water vapors in atmosphere is controlled by the temperature.
- But it is the non-condensable gases (mainly CO₂ which is bringing the increase in the temperature after the first industrial revolution) which are really responsible for recent rise in global warming.

2) CARBON DIOXIDE (CO₂)

- It is produced by **burning of carbon containing substances**, mostly fuels (Coal, natural gas, oil), Solid waste, trees, other biological materials etc.

- CO₂ is removed from atmosphere when it is absorbed (sequestered) by plants during photosynthesis.

- **Concentration of CO₂ in atmosphere:**

- For the first time in history, the atmospheric CO₂ level reached 419 parts per million (PPM), as measured by the United States' National Oceanic and Atmospheric Administration's Mauna Loa Atmospheric Baseline Observatory in Hawaii.
 - » This is nearly 45% above the pre-industrial baseline of 278 PPM in 1750 accepted by IPCC.
- Our annual CO₂ emission have grown about 70 times since the pre-industrial era reaching nearly **36.4 Gt** in 2019.



3) METHANE

- As per UNEP, **Methane** is a GHG which is responsible for 30% of the warming since pre-industrial times. Its contribution is 2nd only to carbondioxide.
 - » Although the warming effect of methane is 30 times greater than CO₂, it is a shorter lived and lasts in the atmosphere for about 12 years. (CO₂ lingers for centuries)
- **Why special focus on methane is needed in our fight against climate change?**
 - » IPCC had said that the methane mitigation has the greatest potential to slow warming over the next 20 years.
 - A 0.3% reduction per year in methane is equivalent to net-zero for CO₂ - there would be no additional warming if this level of reduction is achieved.
- **Methane Emission: Biggest Source:**
 - **Natural Sources:** Wetlands, termites etc.
 - **Wetlands** are the largest source of methane.
 - **Agriculture** - Rice cultivation, animal husbandry etc. generate substantial amount of methane.
 - **Energy Production** (fossil fuel) - Among anthropogenic factors, after Agriculture, it is this sector which contributes to the highest methane production. It is released during the extraction, processing, and transport of fossil fuels, including coal, oil, and natural gas.
 - **Leakage:** For e.g. the ruptures in the underwater Nord stream in Sep 2022 caused the single largest such release of the greenhouse gas.
 - **Landfills** in recent times are also becoming a big source of methane emissions.
 - **Thawing of permafrost** in polar region is also releasing methane. In future, it may become a big source of methane emissions.
- **Current Emission levels:**
 - As per US NOAA, the atmospheric level of methane has jumped to 17 parts per billion in 2021, beating the previous record set in 2020.

A) INTERNATIONAL EFFORTS TO FIGHT METHANE POLLUTION

IMPROVING DETECTION:

- UNEP has launched International Methane Emissions observatory - the Methane Alert and Response System (MARS) at COP27. It is focused on scaling up global efforts to detect and act on major emissions sources in a transparent manner and accelerate implementation of the global methane pledge.

GLOBAL METHANE PLEDGE ANNOUNCED AT COP26

- By COP27, 150 countries have joined the initiative lead by USA and EU. They have promised to cut their methane emission by at least 30% from 2020 levels by 2030.
- **Significance:**
 - » Global warming would be reduced by at least 0.2 degree Celsius by 2050, if countries deliver according to the pledge.

- » **Health benefits:** Oxidation of methane is responsible for formation of ground-level ozone (smog), which is a harmful air pollutant.
- **Why has India not joined the pledge?**
 - » India's methane emissions are 'survival emissions' and not 'luxury' emissions.
 - The two prominent source of methane in India are enteric fermentation and 'paddy cultivation' and any restriction on them would harm small and marginal farmers.
 - » Other than harming farmers, it may also reduce agri production. Currently, India is one of the largest producers and exporters of rice.
 - » India also argues that 6th IPCC report has highlighted that CO₂ is the major global warming gas and this pledge is shifting focus to methane which has a lifetime of only 12 years, whereas CO₂ can survive for more than 100 years.
- **India has not joined the global methane pledge**, but it doesn't mean the India is not worried about methane emissions. There are several fronts on which India is working.
 - » **National Innovation in Climate Resilient Agriculture (NICRA)** project of ICAR has developed several technologies with the potential to mitigate methane emissions.
 - For instance, the 'System of Rice Intensification' has the potential to enhance rice yield from 36-49% with 22-35% less water than conventional transplanted rice. It also uses less seed, fertilizers, and pesticides.
 - » Key steps involve:
 1. Planting young seedlings (less than 15 days old) with only one or two leaves
 2. Planting them singly, spaced widely apart
 3. Maintaining soil moisture at a level that promotes aerobic soil conditions
 4. Controlling weeds by mechanical means, such as hand weeding or using a rotary hoe
 5. Using organic matter to improve soil fertility.
 6. Applying small amounts of fertilizer at specific stages of plant growth
 - Another technology, 'Direct Seeded Rice' reduces methane emissions as it does not involve raising nurseries, puddling, and transplanting. Unlike transplanted paddy cultivation, standing water is not maintained in this system.
 - **Harit Dhara:** It is an anti-methanogenic feed supplement developed by ICAR. It can cut down cattle methane emissions by 17-20% and can also result in higher milk production.
 - Under Crop Diversification Program, methane emission is being avoided due to diversion of paddy to alternate crops like pulses, oilseeds, maize, cotton, and agro-forestry.

B) REPORT: METHANE GLOBAL TRACKER REPORT BY IEA (FEB 2023)

- **Summary:**
 - » **Emissions from Energy Sector:** The energy sector accounts for around 40% of the total average methane emissions from human activity, as oil and natural gas companies are known to release methane into the atmosphere when natural gas is flared or vented. The greenhouse gas is also released through leaks from valves and other equipment during drilling, extraction and transportation process.
- **How can methane emission be reduced:** Although, it's impossible to completely eliminate all the emissions, **75% of the methane emissions from the energy sector** can be reduced with the help of cheap and readily available technology. However, **fossil fuel companies have failed to take any substantial action regarding the issue.**
- The effort will cost less than 3% of the net income received by the oil and gas industry in 2022.
- **Details:**
 - » Fossil fuel companies emitted 120 million metric tonnes of methane into the atmosphere in 2022, only slightly below the record high seen in 2019.
 - » The cheap and readily available technology can reduce 75% of the methane emissions from the energy sector.

C) BURP CONTROL: HOW CAN METHANE RELEASED IN LIVESTOCK BELCHED BE REDUCED? (DEC 2022: SOURCE - DTE)

- **Feed Supplements** - which can reduce a potent greenhouse gas belched out by stock animals like cattle, goat and sheep. A food supplement is considered ideal if it can **lower methane emissions by at least 20%**.
- In 2021, **EU approved a food supplement, Bovaer**, developed by Dutch bioscience company Royal DSM, saying it consistently reduces methane emissions from dairy cows by 30-80%.
 - **Bovaer**, is a fine granular powder containing **3-nitrooxypropanol**, which inhibits an essential enzyme responsible for the methane production.

D) TERMITES EMIT METHANE: BUT THE EXTENT OF THEIR RISK TO GLOBAL WARMING IS UNCERTAIN (SOURCE: DTE)

- As per the Global Carbon Project, in 2008-17, the world emitted 576 Tg of methane per year, of which termites contributed 9 Tg.
- **However**, scientists say that the real emissions may be greater or lesser than this. To establish certainty, there is a need to understand the relationship between termite colonies and methane.
- **How is methane produced by Termites?**
 - In natural ecosystems, they feed on and recycle the nutrients present in dead and decaying plant and animal matter.
 - It is this cellulose-rich diet that causes their emissions.
 - **Methanogenic microorganisms** that live in the gut of termites break down the cellulose entering the body and release methane.

4) NITROUS OXIDE (N₂O)

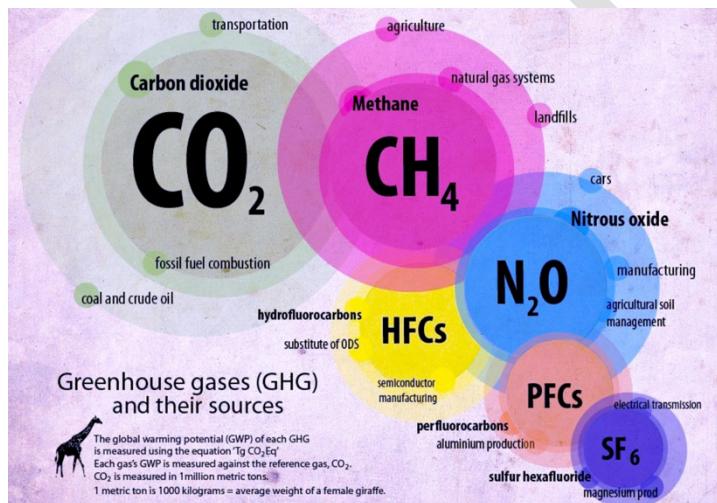
- It is the third most important GHG. It is long lived (average > 100 years), and also has ozone depleting properties.

- It is a natural part of the nitrogen cycle. Bacteria in soil and the ocean make it. It is also produced during agricultural and industrial activities, combustion of fossil fuels and solid waste, as well as during treatment of wastewater.
- **Reports: Global Nitrous Oxide Budget**
 - N₂O is accumulating in the atmosphere at an increasing rate, with **global emissions of 17 Tg N in 2016, 10% greater than in the 1980s**. **Net emission** (thus net addition) is **4.3 Tg**.
 - **Main Anthropogenic factors** is the agriculture.
 - Other factors include - fossil fuels, industry, waste and wastewater, and biomass burning.

5) OZONE (O₃) -> ALREADY COVERED WITH AIR POLLUTION

6) FLUORINATED GASES (HFCS, PFCS, SF₆, NITROGEN TRIFLUORIDE (NF3) ETC.)

- Not naturally found in atmosphere and are manmade.
- Fluorinated gases are used as substitute for ozone depleting substances like CFCs, HCFCs, and Halons.
- Though they are released in small quantities, but their global warming potential is very high.



7) BLACK CARBON

- **What is black carbon?**
 - » It is the sooty black material emitted from gas and diesel engines, coal-fired power plants, and other sources that burn fossil fuel. It comprises a significant portion of particulate matter or PM, which is an air pollutant. It consists of pure carbon in several linked forms.

- **Environment Pollutant** - It is a **short-lived** pollutant which is the key component of PM_{2.5}. It has negative implications for our health and may cause respiratory and cardio-vascular diseases, cancer, birth defects and premature mortality.
- **Climate Change:** It is also responsible for **climate change**.
 - » BC deposits can **accelerate the pace of glacier and snow melt** in the Himalayan region.
 - How?
 - » It is also responsible for affecting the cloud formation and thus affects rainfall.
 - » A recent study has shown that it may also be depleting ozone layer.
- **Main Sources: Incomplete burning of fuel** (i.e., inefficient burning environment) produces black carbon.
 - » **Solid Fuel burning** [coal, biomass etc.]
 - Industry (primary brick kilns) and residential burning of solid fuel together account for about 45-66% of anthropogenic BC deposition in Himalayan region.
 - » **Diesel exhausts** etc. contributes to 7-18% of BC deposits in the Himalayan region.
 - » Since, India has a large population depending on **bio-mass and solid fuel**, it contributes to around 25% of the world's Black Carbon emission.
 - According to a study published in the journal *Atmospheric Research* in April 2019, India is the 2nd largest contributor to Black carbon in the world.
- **Steps taken by Government to reduce black carbon:**
 - Enhancing **fuel efficiency standard of Vehicles**, phasing out diesel vehicles and promoting electric vehicles
 - Promotion of the use of **LPG** for cooking (**PM Ujjawala Yojana**)
 - Clean Cookstoves program
 - Upgrading brick kiln technologies
 - **Real time monitoring of black carbon aerosols in the Glaciated valley of northwestern Indian Himalayas.**
- However, with all existing measures, water from glacier melt is still projected to increase in absolute volume by 2040, with impact on downstream activities and communities.

8) BROWN CARBON

- **Brown carbon** is emitted mainly by **biomass combustion**. It is a **light absorbing** part of the **organic aerosol** (note: soot is also light absorbing in nature). In recent years it has come under a lot of research.
 - It absorbs strongly in the ultraviolet wavelength (high frequency) and less significantly into the visible (low frequency).
- **Sources of Brown Carbon**
 - » **Tar Material** from smoldering fires or coal combustion.
 - » **Breakdown products** from biomass burning, stubble burning.
 - » **A mixture of organic compounds** emitted from soil, and volatile organic compounds given off by vegetation.

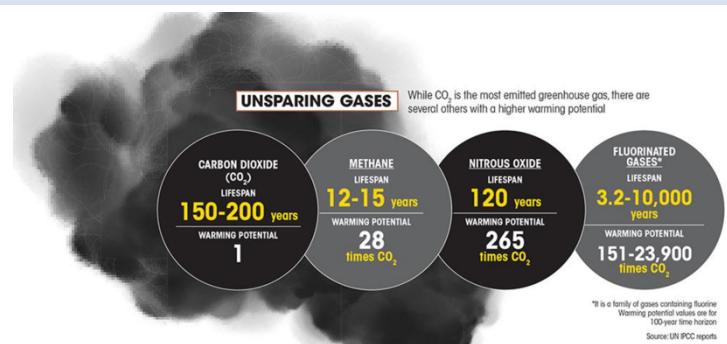
- **TAJ: The Pollutants causing discoloration identified**
 - » **Particulate carbon and fine dust particles** that are deposited on the marble are responsible for its browning.
 - » **Brown Carbon:** The group of carbon which absorbs light in the blue region of spectrum, and this is called brown carbon. Discoloration is because of what is happening to reflectance, reflectance in turn is influenced by these particles.
 - » **Presence of hematite in the dust** that is responsible for the **brown hue**. If hematite is not present in the dust then the dust would be only scattering in nature. Hematite is the ingredient that absorbs the blue wavelength of the spectrum.
- **Note: Brown Carbon vs Black Carbon**
 - » Black carbon is primarily produced by high temperature combustion and brown carbon is emitted mainly by biomass combustion.
 - » Of the total atmospheric absorption by aerosol, brown carbon contributes about 19%, while 72% is contributed by Black carbon. The remaining 9% is due to the coating effect of sulfate and organic aerosols on black carbon.
 - » Both of these are two most important light absorbing substances in the atmosphere.
- **Tarballs and its implications**
 - » Tarballs are formed from brown carbon. They are small light absorbing, carbonaceous particles formed due to burning of fossil fuels that deposit on snow and ice.
 - » Recent research has shown that tarballs from long-range transport can be an important factor in the climatic effect of glacier melting in Himalayas.
 - Nearly, 28% of particles collected from the air samples from a research station in Himalayan-Tibetan Plateau were tarballs.

Extra for Pre

Blue Carbon: It is the carbon that is stored and sequestered in the coastal ecosystem such as Mangroves, seagrass meadows and intertidal saltmarshes.

9) EFFECT OF A GAS ON CLIMATE CHANGE DEPENDS ON THREE MAIN FACTORS:

1. **Quantity** i.e., how much of the gas is present in the atmosphere.
 2. **Life** i.e., for what duration can the gas survive in atmosphere
 3. **Strength** i.e., how strongly they trap the heat
- For each gas a **Global Warming Potential (GWP)** is calculated by considering its duration of existence (i.e., life) and strength of its impact.



10) SDG AND CLIMATE CHANGE

- **Goal 13: Climate Action**
- **Targets**
 - Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
 - Integrate climate change measures into national policies, strategies and planning.
 - Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
 - Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly \$100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible
 - Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities.

3. IPCC AND ASSESSMENT REPORT 6 (AR-6)

- **Recent News:**
 - Scotsman **James Skea** elected new IPCC chair in Nairobi. He is a professor of sustainable development at Imperial College London and will lead IPCC through its seventh assessment report (July 2023: Source: DTE)
 - » The election was held at 59th session of IPCC which was held at UNEP headquarter in Nairobi, Kenya.
- The Intergovernmental Panel on Climate Change (IPCC) is the UN body for assessing the science related to climate change. Its job is **to assess already published scientific literature** to update our knowledge of climate change science.
 - IPCC's Assessment Reports (ARs), which are produced every few years, are the most comprehensive and widely accepted scientific evaluations of the state of Earth's climate.
 - They form the basis for government policies against climate change and provide scientific foundation for the global Climate Change negotiations.
 - So far, **Six Assessment Reports** have been produced.
- **IPCC was set up in 1988** by World Meteorological organization (WMO) and United Nations Environment Program (UNEP) to provide policy makers with regular assessment of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigations.
- Currently it has 195 members and relies on thousands of scientists who volunteer their time to support its work.
 - **India** is a member of IPCC

A) WHAT HAVE PREVIOUS REPORTS (AR-1 TO AR-5) SAID?

- The first **Assessment Report** (1990) noted that anthropogenic emissions are increasing atmospheric GHGs. In the business-as-usual scenario, temperature was likely to increase by 2 degree C compared to pre-industrial levels by 2025, and 4 degree C by 2100.
 - » The report formed the basis for the negotiation of the UNFCCC in 1992, known as the Rio Earth Summit.
- The **Second Assessment Report** (1995) revised the projected rise in global temperature to 3 degree C above pre-industrial level by 2100. It was the scientific underpinning for the Kyoto Protocol of 1997.
- The **third Assessment Report** (2001) projected the rise in global temperature to 1.4 to 5.8 degree C by 2100 compared to 1990.
- The **fourth Assessment Report** (2007) said that the GHG emissions increased by 40% between 1970 and 2004 and the atmospheric CO2 was the most in 650,000 years. In the worst-case scenario, the global temperature could rise by 4.5 degrees.
 - » The report won the 2007 Nobel Peace Prize for IPCC. It was also the scientific input for the 2009 Copenhagen Climate meeting.
- The **fifth Assessment Report** (2014) said that more than 50% of the temperature rise since 1950 is due to human activities. The rise in global temperature by 2100 could be as high as 4.8 degree C from pre-industrial times, and more frequent longer heatwaves were "virtually certain". It formed the scientific basis of the Paris Agreement in 2015.

1) IPCC SYNTHESIS REPORT

- **Why in news?**
 - » The IPCC has released its Synthesis report for the sixth assessment Cycle on 20th March in Interlaken, Switzerland
 - The report was signed by country representatives - an unusual step taken to ensure governments accept its findings (March 2023)
- **What is the report?**
 - » It is a compilation of the main findings of the IPCC's sixth assessment report, based on the results from three Working Groups (WGs).
 - **WG I evaluated the physical science basis of the climate change.**
 - **WG II evaluated the impacts, adaptation, and vulnerability,**
 - **WG III evaluated the mitigation.**
 - The synthesis report also drew from Special Report based on Global Warming of 1.5 degree C (Oct 2018), Climate Change and Land (August 2019), and the Ocean and Cryosphere in a Changing Climate (Sep 2019)
 - » The report was finally approved by nations after major economies like China, Brazil, Saudi Arabia, the US, and EU raised concerns about the working of the text.
 - » **Key Highlights:**

- The report highlights the urgency of drastically reducing the emission of greenhouse gases and so limit rising global temperature by 1.5 degree C from pre-industrial levels, set by the Paris Agreement.

2) AR-6

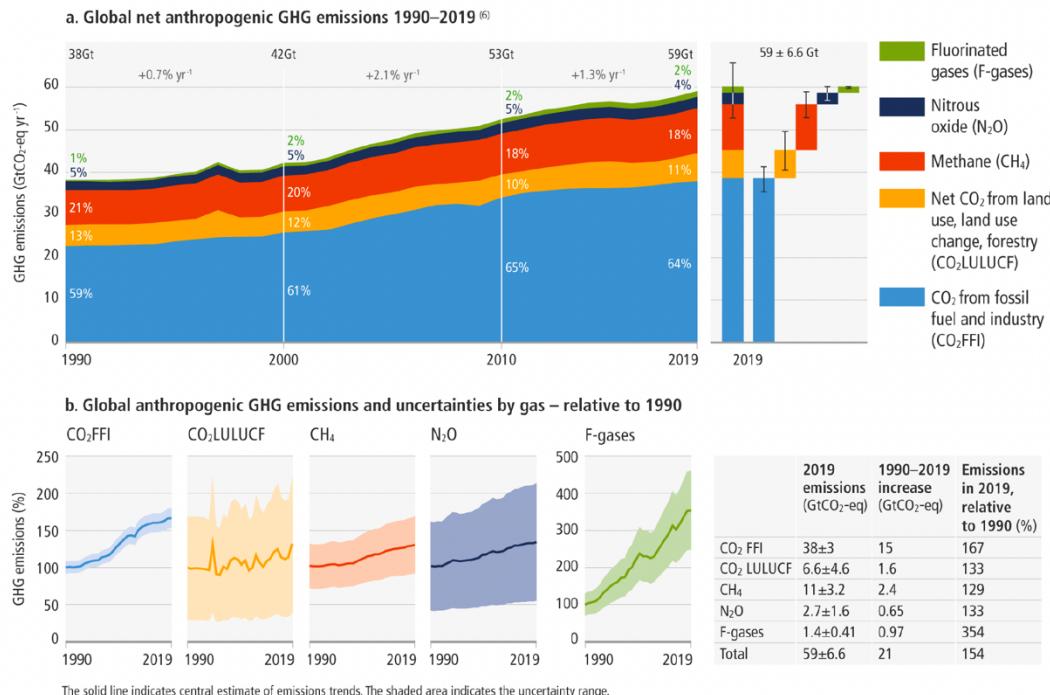
- The sixth report was published in **three parts**: - the first in Aug 2021, the second in Feb 2022, and the third in April 2022. These three parts were by **three working groups of scientists**:
 - **Working Group-1:** Deals with **scientific basis of climate change**
 - **Working Group-2:** Looks at **likely impacts, vulnerabilities, and adaptation issues**.
 - **Working Group-3:** Deals with **action that can be taken to combat climate change**.
- The first report "**Climate Change 2021: The Physical Science Basis**" highlighted the following:
 1. Climate was changing more rapidly than originally anticipated by climate scientists.
 2. Rise in **global temperature was direct result of human activities** and there is 'unequivocal evidence' about it.
 3. Temperature has already rise by 1.1 degrees from the pre-industrial 19th century.
 4. **Greenhouse gas Emissions:**
 - Emissions of Carbon dioxide, methane and nitrous oxide breached records in 2020.
 - CO₂ Concentration in the atmosphere - at around 416 parts per million - are the highest they have been in 2 million years.
 5. **Impact:**
 - A more intense and frequent heatwaves; increased incident of extreme rainfall; a dangerous rise in sea-levels; prolonged droughts; Melting of glaciers.
- The second report: **Climate Change 2022: Impacts, Adaptation and Vulnerability**
 - The report recognizes the interdependence of climate, ecosystem, and biodiversity, and human societies and integrates knowledge more strongly across the natural, ecological, social and economic sciences than earlier IPCC reports.

A) THE THIRD REPORT: CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE

- The report lays out actions that the world can take to stop global temperatures rising beyond certain levels by the end of the century.
- If countries stick to current NDC commitments, it will lead to breach of 1.5 degree C temperature rise.
 - Even the 2-degree Celsius target, in that case, would rely on "rapid acceleration" of climate actions after 2030.
 - **What should be the reduction to prevent temperature rise beyond 1.5 degree C?**
 - Global GHG emissions to peak before 2025 at the latest and be reduced by 43% by 2030; at the same time methane also needs to be reduced by 43% by 2030. Global use of coal, oil and gas in 2050 must decline by about 95%, 60% and 45% respectively, relative to 2019.
 - Even if all this happens, it is almost inevitable that this ceiling would be temporarily breached but, with appropriate action, it could again dip by the end of century.

- Global warming would stabilize if emissions reach net zero.
 - For 1.5 degree C target, this meant achieving net zero emissions globally in the early 2050s; for 2 degree C, it is in early 2070s.
 - Even limiting warming to 2 degree C would require greenhouse gas emissions to peak before 2025 at the latest and be reduced by a quarter by 2030.

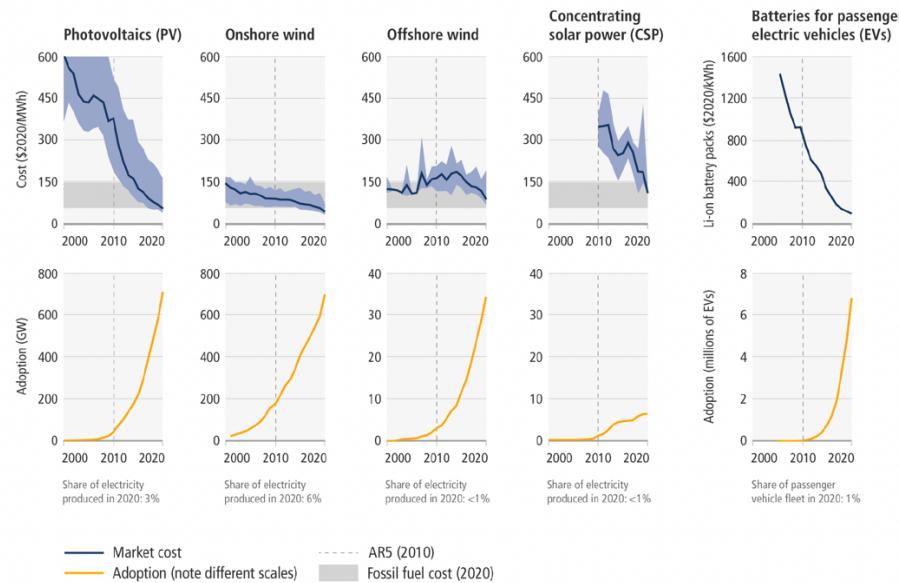
Global net anthropogenic emissions have continued to rise across all major groups of greenhouse gases.



- Carbon Inequality remains pervasive as ever with LDCs emitting only 3.3% of global emissions in 2019.
 - Their average per capita emissions in the period 1990-2019 were only 1.7 tonnes CO2e, compared to global average of 6.9 tCO2e.
- The Least Developed Countries (LDCs) emitted only 3.3% of global emissions in 2019.
- Abundant and Affordable Solutions exist across sectors including energy, buildings, and transport, as well as individual Behavioural changes.
 - The report has detailed 60 different options and pathways that can lead to 40-70% reduction in global emissions.
 - It states with high confidence that "several mitigation options, notably solar energy, wind energy, electrification of urban systems, urban green infrastructure, energy efficiency, **demand side management**, improved forests - and crop/grassland management and reduced food wastage and loss, are technically viable, are becoming increasingly cost effective and are generally supported by the public".

- The per-unit costs of several low emissions technologies have fallen continuously since 2010, however innovation has lagged in developing countries due to weak enabling conditions.
 - On a unit costs basis, solar energy has dropped 85%, wind by 55%, and lithium-ion by 85%.
 - Their deployment and usage has increased multifold since 2010 - 10 times for solar and 100 times for electric vehicles.
 - Factors:** Higher public spending in R&D; Funding for demonstration and pilot projects; and demand pull instruments such as deployment subsidies to attain scale.

The unit costs of some forms of renewable energy and of batteries for passenger EVs have fallen, and their use continues to rise.



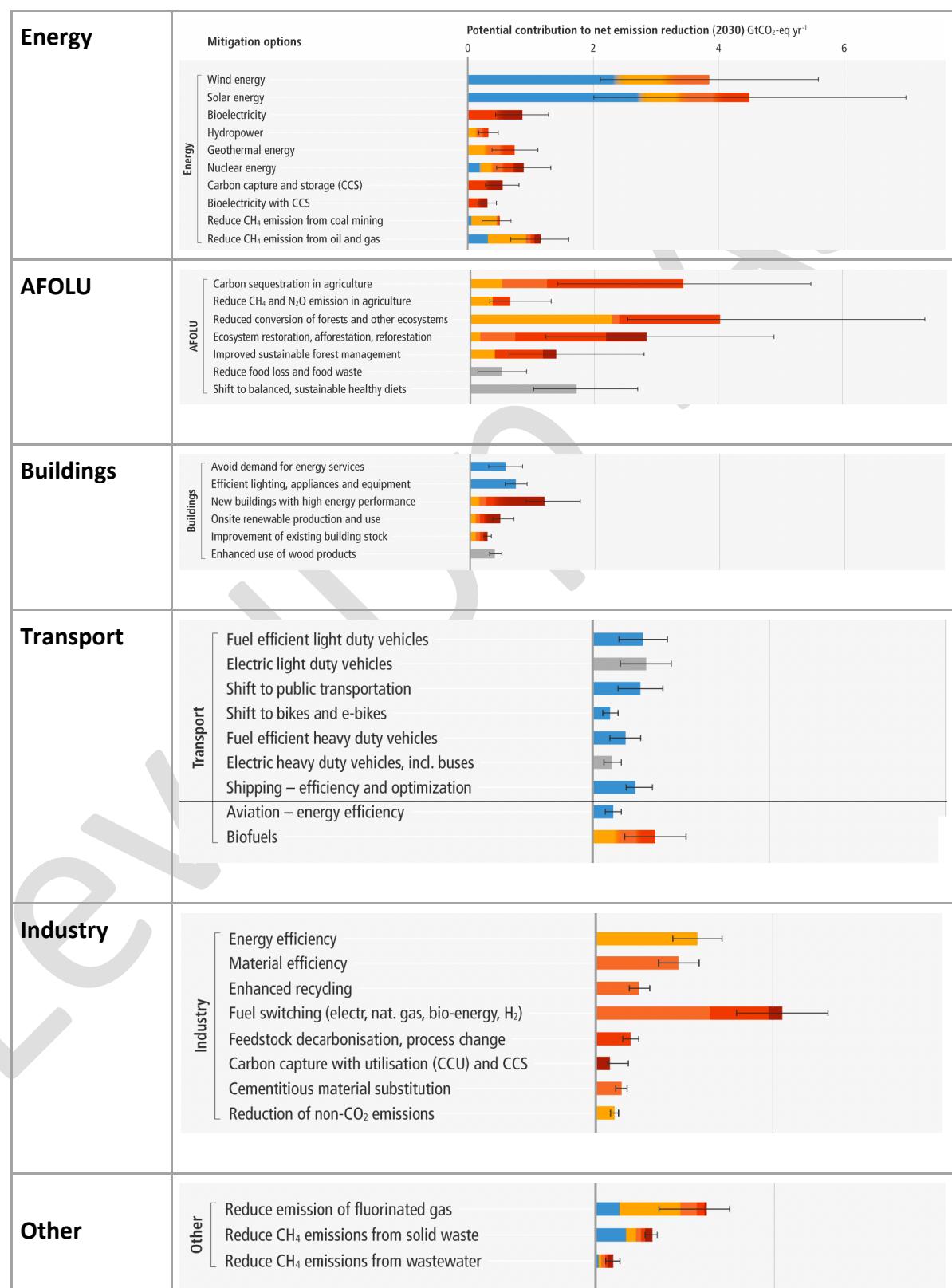
- The report covers **demand side mitigation** and states that it can help reduce emissions by 40-70% by 2050.
 - Demand Side Mitigation can be achieved through changes in socio-cultural factors, infrastructure design and use, and end-use technology adoption by 2050.

Food	Industry	Land transport
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<p>■ Socio-cultural factors</p> <p>Dietary shift (shifting to balanced, sustainable healthy diets), avoidance of food waste and over-consumption</p> <p>■ Infrastructure use</p> <p>Choice architecture¹ and information to guide dietary choices; financial incentives; waste management; recycling infrastructure</p> <p>■ End-use technology adoption</p> <p>Currently estimates are not available (for lab-based meat and similar options – no quantitative literature available, overall potential considered in socio-cultural factors)</p>	<p>Manufactured products</p> <p>■ Socio-cultural factors</p> <p>Shift in demand towards sustainable consumption, such as intensive use of longer-lived repairable products</p> <p>■ Infrastructure use</p> <p>Networks established for recycling, repurposing, remanufacturing and reuse of metals, plastics and glass; labelling low emissions materials and products</p> <p>■ End-use technology adoption</p> <p>Green procurement to access material-efficient products and services; access to energy-efficient and CO₂ neutral materials</p>	<p>Mobility</p> <p>Teleworking or telecommuting; active mobility through walking and cycling</p> <p>Public transport; shared mobility; compact cities; spatial planning</p> <p>Electric vehicles; shift to more efficient vehicles</p>
<p>Building</p> <p>Shelter</p> <p>Social practices resulting in energy saving; lifestyle and behavioural changes</p> <p>Compact cities; rationalisation of living floor space; architectural design; urban planning (e.g., green roof, cool roof, urban green spaces etc.)</p> <p>Energy efficient building envelopes and appliances; shift to renewables</p>	<p>Electricity</p> <p>■ Additional electrification (+60%)</p> <p>Additional emissions from increased electricity generation to enable the end-use sectors' substitution of electricity for fossil fuels, e.g. via heat pumps and electric cars {Table SM5.3; 6.6}</p> <p>■ Industry</p> <p>■ Land transport</p> <p>■ Buildings</p> <p>■ Load management²</p> <p>Demand-side measures -73%</p> <p>Reduced emissions through demand-side mitigation options (in end-use sectors: buildings, industry and land transport) which has potential to reduce electricity demand³</p>	

- **Individuals can also contribute in other ways:**
 - Putting political pressure on leaders.

- Many options available now in all sectors are estimated to offer substantial potential to reduce net emissions by 2030. Relative potential and cost will vary across countries in the longer term compared to 2030.



- **Implementing these mitigation strategies** would come at a substantial cost. The report estimates that taking the actions to keep temperature below 2 degree C could **reduce global GDP by 1.3% to 2.7% by 2050**, but not doing so has its own costs.
- **Climate Finance:**
 - Tracked financial flows were still **falling short** of the levels needed to achieve mitigation goals across all sectors and regions.
 - The **gaps are the widest** for the agriculture, forestry, and other land use (AFOLU) sector and for developing countries.
 - But the **global financial system is large enough** and "sufficient global capital and liquidity" exist to close these gaps.
- **Implications of the report for India**
 - The report warns against opening new coal plants.
 - The report says that Coal-fired power plants, without the technology to capture and store carbon (CCS), would need to be shuttered by 2050 if the world aspired to limit global temperature rise to 1.5-degree C.

B) OTHER IPCC REPORT

IPCC Report, 2018: The Special Report on Global Warming (1.5C Report)

IPCC Report: Special Report on Climate Change and Land

IPCC Special Report on the Ocean and Cryosphere (SROCC)

4. REPORTS ABOUT CLIMATE CHANGE

A) REPORT BY WORLD METEOROLOGICAL ORGANIZATION (WMO)

- **About WMO**
 - **WMO** is a specialized body of UN which is an authoritative voice on behaviour of earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distribution of water resources.
 - **Headquarter:** Geneva
 - It originated from the International Meteorological Organization, which was founded in 1873. It was established in 1950, and became the specialized agency of UN in 1951 for Meteorology (weather and climate), operational hydrology and related geophysical sciences.

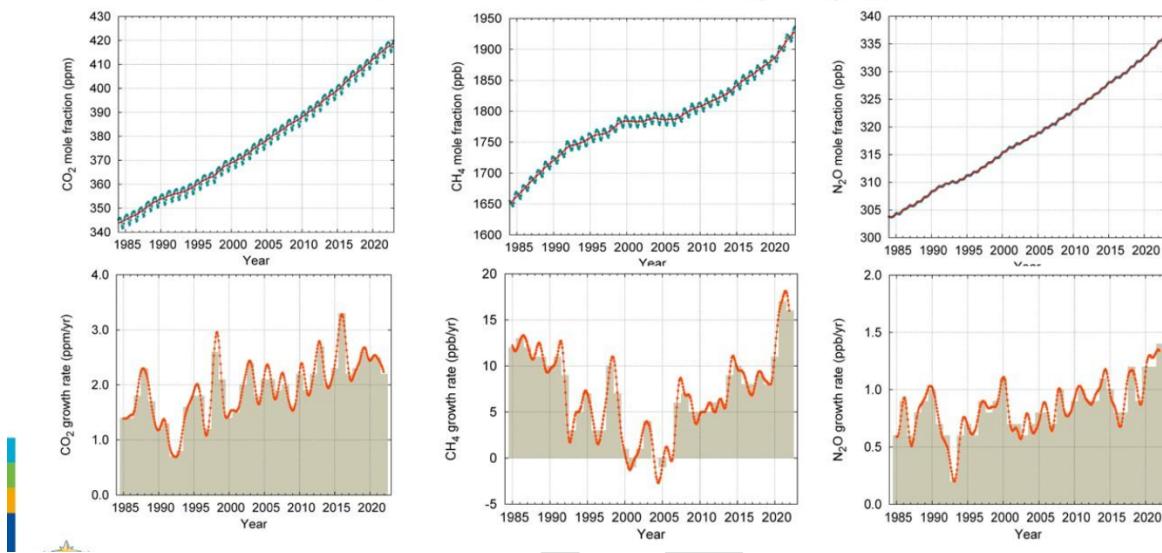
B) STATE OF GLOBAL CLIMATE REPORT, 2023

- Provisional data shows that 2023 is set to be the warmest year on record. Data until the end of Oct 2023 shows that the year was about 1.4 degree C (with a margin of uncertainty of +-0.12 degree C) above the pre-industrial levels.

C) GREENHOUSE GAS BULLETIN, 2023 BY WMO

The abundance of heat-trapping greenhouse gases in the atmosphere once again reached a new record last year (i.e. in 2022) and there is no end in sight to the rising trend, according to a new report from the World Meteorological Organization (WMO).

Main greenhouse gases (CO_2 , CH_4 , N_2O)



D) GLOBAL OCEAN OBSERVING SYSTEM (GOOS) REPORT CARD, 2022

It was prepared in collaboration with WMO, the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO) and other GOOS partners and experts, and produced by its operational centre OceanOP.

E) OTHER REPORTS BY WMO

- State of Climate in Asia, 2021
- State of Climate Service Report

3) REPORTS BY UNEP

F) THE EMISSION GAP REPORT, 2023

- About the Report

- The report provides the latest assessment of scientific studies on current and estimated future Green House Gases (GHG) emissions and compares these with the emission levels permissible for the world to progress on a least-cost pathway to achieve the goals of Paris agreement. The

difference between "where we are likely to be and where we need to be" has become known as the "**emission gap**".

- **Key Highlights of the 2023 Report:**

- There has been progress since the Paris Agreement was signed in 2015.
- GHG emissions in 2030, based on policies in place, were projected to increase by 16 per cent at the time of the agreement's adoption.
- Today, the projected increase is 3 per cent.
- However, predicted 2030 greenhouse gas emissions still must fall by 28 per cent for the Paris Agreement 2°C pathway and 42 per cent for the 1.5°C pathway.

G) THE ADAPTATION GAP REPORT

- **Introduction:**

- The report by UNEP looks at the progress in planning for, financing and implementing adaptation - with a focus on nature-based adaptation.
- Adaptation action is critical to enable both public and private sectors to prepare for and respond to the impacts of climate change.
- **Adaptation Gap Report 2023: Underfinanced. Underprepared – Inadequate investment and planning on climate adaptation leaves world exposed**
 - The report finds that progress on climate adaptation is slowing when it should be accelerating to catch up with these rising climate change impacts.

H) OTHER REPORTS BY UNEP

- Global Environment outlook report

4) REPORTS BY GLOBAL CARBON PROJECT

- Global Carbon Budget 2022 Report
- Global Methane Budget (GMB)
- Global Nitrous (N₂O) Budget

I) ABOUT GLOBAL CARBON PROJECT (GCP)

- » GCP is a global research project of Future Earth and a research partner of the World Climate Research Program.
- » It was formed to work with international science community to establish a common and mutually agreed knowledge base to help fight climate change.
- » It was established in 2001 by a shared partnership between the International Geo-Sphere-Biosphere Program (IGBP), the International Human Dimension Program on Global Environmental Change (IHDP), the World Climate Research Program (WCRP) and Diversitas. This partnership constituted the **Earth Systems Science Partnership** which subsequently evolved into future Earth.
- Goals

- » Develop complete picture of the global carbon cycle, including both in biophysical and human dimensions together with the interactions and feedbacks between them.

5) OTHER REPORTS

J) CLIMATE CHANGE PERFORMANCE INDEX (CCPI)

- Published since 2005, CCPI is an independent monitoring tool of countries' climate protection performance. It aims to enhance transparency in international climate politics and enables the comparability of climate protection efforts and progress made by individual countries.
- The CCPI assesses each country's performance in **four categories**:
 - **GHG emissions** (40% of the overall ranking)
 - **Renewable Energy** (20%)
 - **Energy Use** (20%)
 - **Climate Policy** (20%)
- **59 countries** (which together are responsible for 92% of the global emissions) are assessed under the ranking.
- The report is **jointly presented** by: **GermanWatch**, NewClimate Institute and Climate Action Network (CAN).

K) GLOBAL CLIMATE RISK INDEX – BY GERMANWATCH

L) OTHER REPORTS

- Climate and Development: An Agenda for Action: By the World Bank
- NDC Synthesis Report, 2022: UNFCCC
 - It is the annual summary of climate commitments made by countries and their impact on GHG emissions.
- Investing in Carbon Neutrality: Utopia or the new green wave
- State of Climate Action Report 2022 – By Climate action tracker (an independent analytic group comprising Climate Analytics and New Climate Institute), the United Nations High Level Climate Change Champions, World Resource Institute and Others
- The World Heritage Glaciers Report – Jointly released by UNESCO and IUCN
 - 1/3rd of the World Heritage Glaciers will disappear by 2050.
 - Note: So far, around 50 UNESCO Heritage sites have glaciers in them.

5. OTHER MISCELLANEOUS TOPICS

A) WET BULB TEMPERATURE

- **What is wet bulb temperature?**
 - Wet bulb temperature is the lowest temperature to which air can be cooled by the evaporation of water into the air at a constant pressure.

- It is therefore measured by wrapping a wet wick around the bulb of a thermometer and the measured temperature corresponds to the wet bulb temperature.
- In simpler terms, wet bulb temperature is the lowest temperatures that our bodies can reach when we are in hotter environments, by sweating. It tells us at what level our bodies will not be able to cool themselves down by sweating. In this case the threat of heat stroke rises dramatically.
- The **dry bulb temperature** is the ambient temperature.
- **The difference between** the two temperatures (dry bulb and wet bulb) is a measure of humidity of the air. The higher the difference in these temperatures, lower the humidity of the air.
- **Why is wet bulb temperature important?**
 - Dry temperature, or the temperature that we see in daily weather forecast - doesn't tell us the full story. Wet bulb temperature, especially in times of heat waves, tells us how habitable a place is for human body.
 - **A wet bulb temperature of 32 degree C** is the maximum that a human can endure and carryout normal outdoor activities. This is equivalent to dry temperature of 55-degree C. The theoretical maximum wet bulb temperature is 35 degree C - most humans, even with unlimited water supply, are likely to suffer heat strokes at this level, likely leading to death.
- **Climate Change and Wet Bulb temperature:**
 - IPCC study shows that with climate change, the wet bulb temperature in India is going up.
 - If emissions continue to increase Lucknow and Patna would be the cities which would reach wet bulb temperature of 35 degree C. Parts of Central India, including Vidarbha are at risk of exceeding wet bulb temperature of 32-34 degree C

6. IMPACT OF GLOBAL WARMING

GWG emissions is breaching all the records: As per the AR6, **Emissions of Carbon dioxide, methane and nitrous oxide breached records in 2020**. CO₂ Concentration in the atmosphere - at around 419 parts per million - are the highest they have been in 2 million years.

- **Three factors** make carbon budgeting complex:
 1. **The pollutants** - primarily GHGs like CO₂ and methane - have an extraordinary long life. Thus, historic emissions continue to warm up the planet just like current emissions.
 2. GHG emissions are linked to economic growth.
 3. **Sharing of burden** becomes difficult as the emissions are associated with economic growth.

1. Rising Temperatures

- » As per the AR6 of IPCC, the global temperature has already risen by 1.1 degree C since preindustrial 19th century. This could increase upto 1.5 degree Celsius in less than 20 years (before 2040).
 - **Further, the 2 degree C warming** is likely to get exceeded by the end of this century unless immediate and deep reductions in greenhouse gas emissions are initiated immediately.
 - **In business-as-usual approach**, or in **worst case scenario**, the temperature rise by the end of this century would exceed even 4 degree Celsius'

- The report is also 'unequivocal' (i.e. there is almost no doubt) that most of the observed warming of the planet since the late 1800s is caused by human activities.
 - » As per the WMO, the decade 2010-20 and the five years (2015-20) were the hottest in the earth's history
- 2. Melting of Glaciers and Sea Level Rise -> Submergence of coastal region**
- » AR6: Sea level rise has tripled compared with 1901-1971. The Antarctic sea ice is the lowest in last 1,00 years.
 - » The temperature of Antarctica rose above 20 degree Celsius for the first time on record.
- 3. Heating up of Oceans -> marine heat waves, intense cyclones etc.**
- 4. Increasing variability in weather patterns**
- » **Heat waves and floods** which used to be once-in-a century event are becoming more regular occurrence.
 - » **Weather Disasters** have displaced millions of people this year and **affected rainfall patterns** from India to northern Russia and the Central United States.
 - » **For instance: India saw 13 Deficit Monsoons in 18 years between 2001-18.**
- 5. Compounding extremes** (several climate change drivers operating together) are maximizing disaster in India and elsewhere.
- » E.g., heavy rainfall, landslides, snow avalanches, and flooding occurring together is an example of compounding event.
- 6. Thawing of Permafrost and Arctic Lakes Bubbling Methane**
- » **Reasons: Permafrost Thawing producing methane gas**
 - Organic matter in Artic generally remain frozen. But, with climate change thawing is taking place. This thawing is leading to organic matter decaying into carbon di oxide and methane which is leading to methane getting emitted in atmosphere.
 - » **Warmer temperature increases the thawing of permafrost and release methane to the atmosphere**
 - But this also means that growing season increases, more plant growth takes place and thus more CO₂ getting absorbed. But overall, the increase in release of GHGs would be much higher.
 - » **Presently Arctic is a net carbon sink**
 - But soon arctic could become a carbon source, if the earth continues to warm, and a lot of permafrost thaws out. This would start a cycle of releasing more carbon from permafrost thawing and less absorption where the extra carbon in the atmosphere results in increasing warming.
- 7. Sea Water is 26% more acidic** than at the start of the industrial era. This is leading to degradation of marine ecosystem.
- 8. Biodiversity Loss**
- » **At least 1 million species were at risk** because of the rising CO₂ concentration in the atmosphere and global warming.

- For instance, a recent study shows that seal pups (IUCN: LC) are finding it tough to survive in the Baltics in the absence of ice. 100s of grey seal pups are dying on the shores of the Baltic Sea in Estonia and Latvia as the Nordic coastline faced winter without ice in decades.

9. Negative Impact on Food Security, Agriculture and Economy

- » Variability in rainfall
- » Increased temperature and evaporation of water sources
- » Increased chances of Locust attacks
- » Extreme weather events triggered by climate change costs India \$87 billion annually : State of Climate in Asia, 2020 (report by WMO)

10. Climate Change has adversely affected both physical and mental health of people.

- » Impacts on health is mediated by both through natural and human systems, including economic and social conditions and disruptions.
- » Extreme heat events -> Mortality and morbidity
- » Climate related food borne and water borne diseases has increased. The incidence of vector borne diseases have also increased due to range expansion and/or increased reproduction of disease vectors.
- » Some mental health challenges are associated with increasing temperatures, trauma from weather and climate extreme events, and loss of livelihood and culture. Exposure to wildfire smoke, atmospheric dust, and aeroallergens have been associated with climate sensitive cardiovascular and respiratory distress.

11. Achievements of SDG targets have been negatively hindered.

12. Shrinking of Stratosphere:

According to a study published by NASA, the earth's energy imbalance doubled over the 14 year period between 2005 - 2019, doubling the pace at which the Earth retains heat from 2005. As a result of this we are already on the brink of losing stratosphere

7. UNFCCC – PARIS AGREEMENT TO COP27

1) UNFCCC

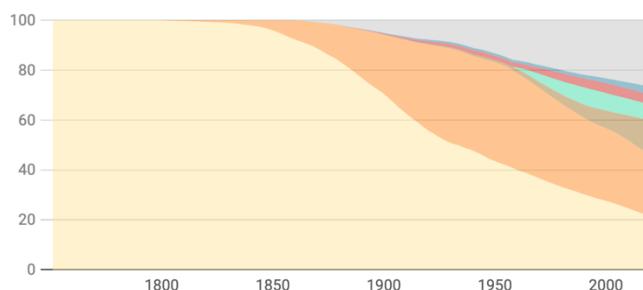
- It is one of the three conventions adopted at the Rio Earth Summit (UN summit Conference on Environment and Development (UNCED)) in 1992. Its sister Rio Conventions are the UN Convention on Biological Diversity and the Convention to Combat Desertification.
- This was the first multilateral legal instrument on climate change and came into force in 1994 after a sufficient number of countries had ratified it.
- **Ultimate Aim** of UNFCCC
 - Prevent dangerous human interference with the climate system by stabilizing greenhouse gas concentration in atmosphere.

- It sets on **non-binding limits** on greenhouse gas emission for individual countries and contain **no enforcement mechanism**.
- **Parties to Convention**
 - **197 parties**
 - All UN member states, Palestine (observer state), Niue and Cook Island (non-member states) and the European Union.
 - **Annex 1 Parties** -> Industrialized OECD countries, Economies in Transition (EIT), EU
 - **Annex 2 Parties** -> OECD members of Annex-1, NO EIT.
 - Provide financial and technical support to EITs and developing countries for mitigating Climate change.
 - **Non-Annex 1 Parties** -> Mostly developing
 - **Least Developed Countries (LDCs)**

Over the last 250 years, Europe and the US have contributed to most of the world's CO2 emissions

% share in cumulative global CO2 emissions

EU-28* United States China Russia Japan India ROW



*28 nations in the European Union

Source: Global Carbon Project; Our World in Data • [Get the data](#) • [Created with Datawrapper](#)

Key Significance of UNFCCC - 1) Recognition of the problem 2) Setting target of stabilizing GHGs 3) Onus on Developed countries 4) Funds and technology transfer to developing countries 5) Regular Reporting -> Keep a tap on the problem.

A) KYOTO PROTOCOL

- It was an international agreement to reduce greenhouse gas emissions. It was negotiated under the UNFCCC during a meeting held in Kyoto, Japan, in 1997 and came into force in 2005 (due to complex ratification process)
 - **The first commitment period** was 2008-2012
 - **The second commitment period** beginning 1 Jan 2013 to 2020.
 - Launched by Doha Amendment (2012)
- The **objectives of KP** included reducing greenhouse gas emissions through enforcement of compliance; promote sustainable development through tech-transfer and investment; and encourage developing countries and private sector to contribute to emission reduction.
- **Parties to Kyoto Protocol**
 - **Annex B:** Nearly identical to Annex - I of the UNFCCC; Agreed for emission reduction.
 - **Non-Annex B Parties:** Countries which are not listed in Annex B of KP.
- **Key Features**
 - The protocol 'operationalized' the UNFCCC. It commits industrialized countries to stabilize greenhouse gas emissions based on the principles of the Convention.
 - **Binding Emission targets for 38 industrialized countries and the European Community (Annex 1 Parties)** in its first commitment period.

▪ Only bound developed countries - **Common but Differentiated Responsibility**

- **Flexible Architecture of KP Regime to meet target**
 - **National Measures and Market Based Mechanisms**
 - This market based mechanism allows GHG abatement to start where it is most cost-effective - for e.g. in the developing world.
 - **3 Components - Carbon Trading, Clean Development Mechanisms and Joint Implementation**
- **Penalties for not meeting the targets**
- **What is the status of the Kyoto Protocol?**
 - The Protocol was ratified by 191 countries and EU. **Canada withdrew** from the Protocol in 2012.
 - The US was the only country that signed the protocol and never ratified it.
 - Internal country politics.
 - **Were targets met?**
 - Most countries didn't meet the targets for emission reduction assigned for the first period of commitment (2008-2012).
 - So protocols impact was very small.
- **Kyoto Beyond 2012**
 - At Doha in 2012, the amendments to Kyoto Protocol for the 2nd commitment period (the Doha Amendment) were successfully adopted for the period 2012-2020.
 - It entered into force on **31st Dec**, following an acceptance by the mandated minimum of at least 144 states, although the second commitment period ended on the same day.
 - **It entered into force in 2020** as the required number of countries didn't deposit their instrument of accession earlier.
 - But some developed countries started implementing their commitments under the '**opt-in**' provisions of the Doha Round.
 - **Note: India ratified** the second commitment period of Kyoto Protocol in Jan 2017

B) PARIS AGREEMENT

- The Paris Agreement and the accompanying COP decisions are focused on enhancing **efforts to mitigate and adapt to climate change beyond 2020.**
 - a. **Long Term Goal:**
 - » Reaffirm the goal of limiting global temperature increase well below 2 degree Celsius, while urging efforts to limit the increase to 1.5 degrees.
 - » **Two long term emission goals**
 - Peaking of emissions as soon as possible (with a recognition that it will take longer for developing countries)
 - A goal of Net Green House Gas Neutrality (expressed as "a balance between anthropogenic emissions by sources and removals by sinks") in the second half of this century.
 - b. **Ends the Strict Differentiation between developed and developing countries:** Provides for a framework that commits all countries to put forward their best efforts against climate change and keep strengthening these efforts.

- c. **Mitigation - Binding Procedural Commitments** -> Preparing, communicating and maintaining NDC; Communicate new progressive NDC every five years;
 - » The agreement commits parties to "pursue domestic measures with the aim of achieving the objectives" of its NDC.
 - » Doesn't make implementation or achievement of NDCs a binding obligation.
- d. **Carbon Markets** – the agreement recognized that the parties may use internationally transferred mitigation outcomes to implement its NDCs.
- e. **STOCKTAKE/SUCCESSIVE NDCs**
 - » To ensure successive improvement in efforts, the agreement provides for **two linked processes**, each on a five-year cycle.
 - **Global Stocktake** to assess collective progress towards the agreement's goals. The first global stocktake took place in 2023.
 - **New NDCs** every five years informed by the outcomes of the global stocktake. Signatories should ensure that the new NDCs are more ambitious than the previous ones.
- g. **Finance**
 - **Provisions for Support to poor developing countries by Developed countries.**
 - **Finance Mobilization goal.**
 - The COP decided to extend the \$100 billion-a-year goal through 2025, and beyond that, by 2025 COP will set a "new collective quantified goal from a floor of "\$100 billion a year".
- h. **Adaptation**

A major priority for many developing countries was strengthening adaptation efforts under the UNFCCC. The agreement does that by:

 - Establishing a global goal of "enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change"
 - Committing enhanced adaptation support for developing countries
 - Including a review of adaptation progress, and of the adequacy and effectiveness of adaptation support, in the global stocktake to be undertaken every five years.
- i. **Loss and Damage**
 - In a victory to small island countries and other countries highly vulnerable to climate impacts, the agreement includes a **free-standing provisions** extending the Warsaw International Mechanism for Loss and Damage
 - The mechanism, established at COP-19 is charged with developing approaches to help vulnerable countries cope with unavoidable impacts, including extreme weather events such as sea-level rise.
 - Potential approaches include early warning systems and Risk insurance.
 - Loss and Damage provision "did not involve or provide a basis for any liability or compensation.

C) WHEN DID PARIS AGREEMENT ENTER INTO FORCE?

- It required approval of atleast **55 countries accounting for atleast 55 percent of greenhouse gas emission.**
- It came into force on **Nov 4, 2016** (a month after required number of ratification)

D) INDIA'S UPDATED FIRST NDC UNDER PARIS AGREEMENT (AUG 2022)

- India submitted its INDC on 2nd Oct 2015.
- The NDC submitted in Aug 2022 is India's first NDC under the Paris Agreement. The Article 4, paragraph 9 of the Paris Agreement provides that each Party shall communicate a nationally determined contribution every five years in accordance with the decision of COP21.
- So, in Aug 2022, India communicated an update to its first NDC submitted earlier on Oct 2, 2015 for the period upto 2030, as under:
 - To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation, including through a mass movement for 'LIFE'–'Lifestyle for Environment' as a key to combating climate change [UPDATED].
 - To adopt a climate friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development.
 - To reduce Emissions Intensity of its GDP by 45 percent by 2030, from 2005 level [UPDATED].
 - To achieve about **50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030**, with the help of transfer of technology and low-cost international finance including from Green Climate Fund (GCF) [UPDATED].
 - To create an **additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent** through additional forest and tree cover by 2030.
 - To better **adapt to climate change by enhancing investments in development programmes** in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management.
 - To mobilize domestic and new & additional funds from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap.
 - To **build capacities, create domestic framework and international architecture for quick diffusion of cutting edge climate technology** in India and for joint collaborative R&D for such future technologies.

This update to India's existing NDC is a step towards our long term goal of reaching net-zero by 2070.

E) INDIA'S LONG TERM LOW EMISSION DEVELOPMENT STRATEGY (LT-LED STRATEGY) (NOV 2022)

- **Details**
 - LT-LED is a requirement emanating from the 2015 Paris Agreement whereby countries must explain how they will transition their economies beyond achieving near-term NDC targets, and work towards the larger climate objective of cutting emissions by 45% by 2030 and achieve net zero around 2050. This is what scientists say, offers the best chance of keeping temperature rise below 1.5 degree C. So far, no country is on track towards such a pathway.

- Very few countries (including India) have submitted their Long-Term Strategy. So far.
- **Highlight of India's Long-Term Strategy:**
 - i. **Nuclear Power Capacity** - It will be increased at least 3-fold in the next decade.
 - ii. India will focus on increasing the proportion of ethanol in petrol - with ethanol blending to reach 20% by 2025 and a strong shift to public transport for passenger and freight traffic.
 - iii. India would also become an international hub of producing green hydrogen.
 - iv. India will also focus on **energy efficiency** by the Perform, Achieve and Trade (PAT) scheme; increasing electrification; enhancing material efficiency; and recycling and ways to reduce emissions.
 - v. The country is also on track to achieve the NDC commitment of 2.5 to 3 billion tonnes of additional carbon sequestration in forest and tree cover by 2030.
 - vi. The emphasis is on ensuring energy security, energy access and employment, while keeping focus on our vision of Atmanirbhar Bharat.

2) THE CONTINUING UNFCCC NEGOTIATION

- **The Continuing UNFCC Negotiations:**
 - After the COP-21 - Paris Agreement, the negotiations have continued. COP-22 (Marrakech Summit, 2016), COP-23 (Bonn Summit, 2017), COP-24 (Katowice Summit, 2018), COP-25 (Madrid Summit, 2019), COP-26 (Glasgow, 2021);

B) COP 26 (GLASGOW PACT) - KEY OUTCOMES: 2021

- **Mitigation:**
 - » It asked countries to strengthen their 2030 climate action plan or NDCs by 2022.
 - » First clear recognition of the need to move away from fossil fuels -> it called for "phase down of coal" and "phase out of inefficient fossil fuel subsidies".
- **Adaptation:**
 - » Asked developed countries to atleast double the money being provided for adaption by 2025 from the 2019 levels.
 - » It created a two year work program to define a goal on adaptation.
- **Paris Rule Book has been finalized.**
 - » 'Transparency Framework' was completed - it included reporting rules and formats for emissions, progress on pledges and financial contributions.
 - » Carbon Market provisions have been finalized [a major achievement of COP26].
 - **Credit generated from earlier periods**, including through Clean Development Mechanism were transferred to the Paris Agreement but only since 2013. This will allow developing countries to meet its first NDC targets.
 - On the issue of double counting, it has been decided that a country that generates a credit will decide whether to authorize it for sale to other nations or

to count towards their climate targets. The emission cuts will be counted only once.

- Various Positive "Parallel Outcomes" (not part of the official COP26 negotiations)
 - » India's announcement of a Panchamitra
 - » Plurilateral Agreement on Methane Reduction among 100 countries is crucial. (Note: India is not a member)
 - » Plurilateral Agreement to reverse deforestation among another group of 100 countries. (Note: India didn't join the group due to concerns over a clause on possible trade measures related to forest products).
 - » COP26 Transport Declaration -> 100% transition to emission less (electric vehicles) cars by 2040.
 - This has also been signed by over 30 countries.
 - » Glasgow Financial Alliance for Net Zero (Gfanz): 450 of the world's banks and other financial institutions have pledged to report annually on the carbon emissions linked to the projects they lend to.
 - They also plan to lend trillions of dollars in green finance - while committing to net zero emission across the board by 2050.
- Problems that remained:
 - » Funding
 - » L&D
 - » Didn't specifically raise emission reduction targets.

C) COP-27 (SHARM EL SHEIKH, EGYPT)

- Quotes:
 - » The UN Secretary General had declared at the start of the conference, "We are on a highway to climate hell with foot still on the accelerator".
- Key Highlights:
 - » Nod for establishment of Loss and Damage Fund.
 - » Estimates of Financial Requirements -> COP27 agreement for the first time, quantified the financial needs for climate action. It said about US\$ 4 trillion had to be invested in the renewable energy sector every year till 2030 if the 2050 target of net zero was to be achieved.

D) COP28: DUBAI, UAE (30TH NOV 2023 – 12TH DEC 2023)

- The meeting reviewed the Progress of commitment made by 197 countries under the Paris Agreement to mitigate the razing global warming.
- Outcome: Dubai Consensus:
 - Negotiators adopt resolution titled "Dubai Consensus"; the text reflects a compromise between developed and developing countries on emissions.
- Highlights of Global Stocktake (GST):

- The GST text echoed the GST input findings that 1.5 degree target would require "deep, rapid and sustained" reduction in global emissions of 43% by 2030 and 60% by 2035 from the 2019 levels and eventually reaching net zero by 2050.
- **Fossil Fuel Phase-out:**
 - » Fossil fuels was the most hotly contested issue of the COP28; It was first time that fossil fuel was at the centre of discussion at UNFCCC COP.
 - » **Outcome:**
 - COP28 agreement has called upon countries to contribute towards "transitioning away" from fossil fuels and phase down of unabated coal power so as to achieve net zero by 2050.
 - » **Criticisms:**
 - No timelines
 - Not using the phrase "fossil fuel phase-out" and instead the use of "transitioning away".
 - While calling for phase down of "unabated coal power", the door was left open for "low-carbon fuels", "low emission" technologies, "low-carbon hydrogen" - all terms with very loose definitions.
- **Tripling global renewable energy capacity by 2030** (from 3400 GW today to 11000 GW) and doubling of global average rate of energy efficiency improvements by 2030.
 - COP28 calls the member countries to achieve these two targets which have the potential to avoid emissions of about 7 billion tonnes of carbondioxide equivalent between now and 2030.
 - **Tripling is a global target for renewables is not incumbent on every country** individually. It is not thus clear how this tripling will be achieved.
 - This is the only outcome that contribute to additional emission reduction between now and 2030.
- **Accelerating and substantially reducing non-carbon-dioxide emissions globally**, including in particular methane emissions by 2030.
 - **Criticisms:** No target mentioned
 - **Note:** A group of about 100 countries at Glasgow (in 2021) had made a voluntary commitment to reduce methane emissions by 30% by 2030.
- **Reduction of emission from road transport** on a range of pathways, including through development of infrastructure and rapid deployment of zero-and low-emission vehicles;
- **Phase down of inefficient fuel subsidies** that don't address energy poverty or just transition, as soon as possible.
- **Operationalization of L&D Fund:**
 - **Background:** A decision to set up a Loss and Damage Fund had been taken last year in Sharm el-Shaikh (COP27) but it had not been created, and no money had been promised.

- COP28 operationalized the fund and several countries have already made commitments worth around \$800 million by the end of the conference.
 - COP28 decided that the fund will be serviced by new, dedicated and independent secretariat. It will be supervised and governed by the Board.
 - The fund is accountable to and functions under the guidance of the CoP serving as the meeting of the Parties to Paris Agreement (CMA).
- This is the most significant outcome for vulnerable countries as L&D fund is meant to provide financial help to countries trying to recover from climate-induced disasters.
- Santiago network has also decided to avert, minimize, and address loss and damage to catalyze the technical assistance of relevant organizations, bodies, networks and experts for the implementation of relevant approaches associated with climate change impacts.

Santiago Network: At COP25, the parties to UNFCCC decided to set up a Santiago network as part of Warsaw International Mechanism (WIM) for loss and damages. It is aimed to organize the technical assistance of relevant organizations for the implementation of relevant approaches in developing countries that are particularly vulnerable to adverse impacts of climate change.
- Global Goal on Adaptation (GGA):
 - » Background: COP26 at Glasgow had decided to set up a two-year work program to define the contours of adaptation framework.
 - Adaptation hasn't received enough attention and the entire focus of various agreements have been on mitigation. But, developing countries have been arguing for a global framework for adaptation.
 - The two year work program resulted in identification of some common adaptation goals like reduction in climate-induced water scarcity, attaining climate-resilience in food and agricultural production, supplies and distribution and resilience against climate induced health impacts.
 - » The COP28 retains calls for a doubling in adaptation finance and plans for assessment and monitoring of adaptation needs in the coming year.
 - An explicit 2030 date has been integrated into the text for targets on water security, ecosystem restoration, health.
- Issue of Climate Finance Targets will be reviewed in next COP:
 - » Currently, the \$100 billion goal hasn't yet been met (although it appears on track this year) and is far short of what is needed.
 - » COP28 saw an agreement to draft a post 2025 finance target ahead of COP29. This is a step forward, but details will only be hammered next year.
- COP28 Declaration on Climate Change and Health
 - » This is the first ever move to commit action and finance to combat the health impact of climate change.
 - » The COP28 Presidency and the WHO together issued the 'COP28 UAE Declaration on Climate and Health'.

- It's signatories aim to accelerate action to protect public health and communities from negative and growing climate impacts and strengthen healthcare systems to cope with the effects of extreme heat, air pollution, infectious and zoonotic diseases and environmental risk factors.

- **Other Related Outcomes:**
 - » A group of **22 countries** signed a **declaration to triple nuclear energy capacity** between 2020 and 2050, in order to reduce dependence on oil, gas, and coal.
 - » **G7 countries** have announced to phase out coal by 2030 and have urged G20 countries to also agree on it.
 - » India and Sweden co-launched Phase II of the Leadership Group for Industry Transition (LeadIT 2.0) for the period 2024-26 at COP-28. They also launched the Industry Transition Platform, which will connect the governments, industries, technology providers, researchers, and think tanks of the two countries.
 - » **Green Industrialization Initiative**: African leaders came together on the third day of COP28 to launch the initiative. The GII is set to accelerate green growth of industries in Africa and attract finances and investment opportunities.

- **Limitations/Criticisms:**
 - » **Countries failed to adopt rules to set up global carbon market**: Civil society has hailed the move as parties didn't agree to adopt weak rules for carbon markets.
 - » **Climate Finance issue** is still pending and would be taken up in COP25.
 - » **No timelines for fossil fuel transitioning**: The text related to fossil fuel transitioning is weak, in-adequate and with loopholes.
 - » **NDCs** remain far away from achieving Net Zero by 2050.
 - » **Net Zero by 2050** target is expected to bring pressure on China and India whose net zero targets are for 2060 and 2070 respectively.
 - » **Major Decisions** have not been integrated with agendas like 'Common but differentiated responsibilities'.

3) NET ZERO

- **Details**
 - » Achieving a global balance between emissions and removal of greenhouse gases to and from the atmosphere is called **net zero** (or no net emissions). The Paris agreement targets this to be achieved somewhere in the second half of this century, but the earlier this happens, the greater the chances of keeping global warming below 2-degree C.
 - » Electricity and heat are responsible for 25% of global GHGs. The **International Energy Agency** envisages that in a net-zero world, almost 90% of electricity could come from renewable sources, mostly solar and wind, with nuclear power making up most of the rest.

- **Achieving Net Zero:**
 - » **Focus on 2030 goal first:**

- IPCC's AR6 emphasized that to keep temperature rise within 1.5 degree C, global emissions should be reduced by 45% from 2010 levels by 2030, on the way to net zero by 2050.
 - But the UN NDC report says that as per the current NDCs, the global emission is expected to increase by 16.3% in 2030 (compared to 2010 levels).
- » **Energy Conservation and Efficiency:** Global emissions show that energy is the biggest emitter (73.2%) including its use in transport, industry, and building. Therefore, energy efficiency can play a crucial role in achieving net zero.
 - Targeted consumer education and behavioral change would also be important here.
- » **Renewable Energy:** Gradually phasing out thermal energy (coal, petrol, gas etc.) and increase the capacity of renewables with improved grid infrastructure, smart grids, etc.
 - Insure against Renewable Droughts through other sources like **Nuclear Energy**.
- » **Transport Sector:** Accelerated transition to e-mobility and non-motorized transport is required.
- » **Create Offset:** Inspite of all the efforts, humans would still produce some billions of tonnes of emissions by mid-century. This will have to be balanced by removals to achieve net zero. Offset can be in the form of afforestation, increasing soil organic carbon, and advanced carbon sequestration techniques.
- » **Enhancement in Funding:** The Promised funding from developed to developing countries need to be delivered.
- » **More R&D in advanced technology** like low and zero emission technologies across all sectors. There is also a need of innovation for renewable integration, power to x-storage, and conversion and reconversion pathways. Moreover, carbon-removal technologies need to be focused upon.
- » **CBDR should not be ignored:** Developed countries should achieve net zero earlier and few extra decades should be available to developing countries.

4) INDIA'S DECISION TO ACHIEVE NET ZERO BY 2070: CRITICAL ANALYSIS

- At COP26, PM Modi has proposed a **fivefold strategy** for India to play its part in helping the world get closer to 1.5 degrees Celsius. India's 'Panchamrita' promises include:
 - » India will get its non-fossil energy capacity to 500 GW by 2030.
 - This is a 50 GW increase from its existing target.
 - » India will meet 50% of its energy requirements till 2030 with renewable energy.
 - » India will reduce its projected carbon emission by one billion tonnes by 2030.
 - » India will reduce the carbon intensity of its economy by 45% by 2030.
 - » India will achieve net zero by 2070.
- **India's demand from developed countries:**
 - » In the spirit of climate justice, the developed countries should be providing at least \$1 trillion in climate finance to assist the developing countries and those most vulnerable.
- **Analysis:**
 - This is a very positive move as India had resisted any net zero target in the run up to the COP26. This announcement is expected to put India on a firm path towards decarbonization.
 - This announcement also keeps in mind the Common but Differentiated Responsibilities and Respective Capabilities (CBDR-RC).

- India's net zero comes in 2070 and NDC is subject to funding from developed countries
- **India is contributing more than its share:** Despite a 2070 net zero year for India, India's cumulative emissions between 1900-2100 would be lower than the US, China or EU.
- **India continues to show international leadership** - It has launched the Infrastructure for Resilient Island States - an initiative under the coalition for Disaster Resilient Infrastructure to support vulnerable island countries. India has also launched Green Grids Initiative in partnership with UK to tap into renewable energy resources everywhere.

- **Critics of shifting to a Net Zero target**

- **Over-appropriation of global carbon budget** by a few.
 - Countries which have higher emissions presently are taking more advantages of the environment.
 - The campaign to achieve net zero by 2050 is designed to achieve Paris goals by the "lowest cost" methods, foregoing equity and climate justice.
- **Wasn't mandated by Paris Agreement.**
- **India is anyways a small contributor** - Our emissions are 4.37% of the world's share (with 18% population).

Critics of Sustainability of India's Net Zero Strategy

- India's plan to increase dependence on hydro projects and nuclear energy will create displacement, deforestation, hazardous radiation etc.
- Solar and Wind Energy is also focused on Mega energy parks which may cause displacements.

5) MECHANISMS AND ISSUES WITH CLIMATE FUNDING

- **Introduction**

- » Money has been central to many a fight at the Climate Change negotiations. UNFCCC as part of its CBDR principle requires developed countries to provide financial assistance to developing nations in their fight against the climate change.
- » **Globally**, there are two funding mechanisms - **The Green Climate Fund** and the **Global Environment Facility**.

- **Green Climate Fund (GCF)**

- » Established at COP-16 in 2010, it is the financial mechanism for UNFCCC under article 10. It is regarded as the chief instrument for the fulfillment of developed world's annual support of \$100 billion annually till 2025.
- » **COP-21 held at Paris** also decided that **GCF shall serve the Paris Agreement.**

- **Global Environment Facility (GEF)**

- » Created at Rio Earth Summit in 1992 to help tackle planet's most important environmental problems.

- **What has it done so far? / What does GEF do?**

- » GEF also serves as financial mechanism for the following conventions:
 - CBD
 - UNFCCC
 - UNCCD

- Stockholm Convention on Persistent Organic Pollutants (POPs)
- Minamata Convention on Mercury
- It also supports implementation of Montreal Protocol on substances that deplete the ozone layer in countries with economies in transition.

- **Current Funding Situation:**
 - **Requirement:** As per COP27 (Sharm el-Sheikh agreement), the global transition to a low-carbon economy would likely require about US\$ 4-6 trillion every year till 2050. This is 5% of the global GDP.
 - The cumulative requirement of developing countries, just for implementing their climate action plans, was about US\$ 6 trillion between now and 2030.
 - **Availability:**
 - The \$100 billion amount, that the developed countries have promised is the only money in play right now. And of this only around US\$50-80 billion per year is being mobilized. This indicates that the fund available in less than 10% of what is required.
- **Key Problems of current climate funding are:**
 - **Requisite finance** hasn't been mobilized.
 - **Funding bias in favour of climate change mitigation activities.** This bias is there because mitigation efforts are easily visible in short run and returns from adaptation efforts will be visible after long time.
 - For e.g., if we adapt by moving away from coasts, the benefit of this adaptation efforts would be visible much later.
 - **Developing world** in itself cannot fight the climate crisis as they are still struggling for finance for their development needs.
 - **A number of countries** are unable to access global finance. Present rules and regulations of global financial systems, make it difficult for many countries to access international finance, particularly those with political instabilities
 - **Lack of transparency** is leading to problems of double counting and green washing.
- **Way Forward:**
 - **Availability and Access** are two main dimensions to the problem of climate finance.
 - **Increasing Availability:**
 - **Developed countries** need to increase their contribution.
 - But, even if this happens, this won't be able to fulfill the requirement of around \$6 trillion needed annually.
 - **Mobilize resources from private sector:** Businesses and Corporations need to invest money into green projects.
 - In climate finance thus far, private investment have lagged behind public money. Barely 30% of current financial flows are coming from private sources.
 - **Creation of right environment for investments in green project** -> Private sector will not invest unless they are reasonably sure of healthy returns.
 - Here, international financial institutions should engage with governments, central banks, commercial banks etc. to incentivize climate friendly investments and discouraging, or even penalizing, dirty investments.

- **Carbon Tax** - Common citizens will have to contribute to the bulk of the additional financial resources.
- **Increasing Access:** There is a need to simply lending mechanisms and overhaul credit rating systems.
- **Increased Transparency:**
 - Climate finance flows through a maze of channel - bilateral, regional, multilateral. It is in the form of grants, concessionary loans, debt, equity, carbon credit, and more. As a result, there are widely different opinion on the quantum of climate finance currently being mobilized. This needs to be addressed.

8. OTHER EFFORTS TO FIGHT CLIMATE CHANGE

1) REDD+

- **Need of REDD+**
 - Deforestation and forest degradation account for 17% of carbon emissions, more than the entire global transportation sector and second only to energy sector. Therefore, conservation of forests can play a very crucial role in controlling climate change.
- **Introduction to REDD+**
 - **REDD+** is a climate change mitigation solution developed by parties to UNFCCC. It incentivizes developing countries to keep their forest standing by offering results-based payments for actions to reduce or remove forest carbon emissions.
 - » The idea is that developing nations should be able to financially benefit from the ecosystem services that their forests provide, such as carbon storage and as reservoirs of biodiversity.
 - The payment is targeted at five activities:
 - » **Reducing Emissions** from Deforestation
 - » **Reducing Emissions** from forest degradation.
 - » Conservation of carbon stocks
 - » Sustainable management of forests
 - » Enhancement of Carbon stocks.
 - **REDD+ goes beyond simply deforestation and forest degradation and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.**
 - **In 2019, Brazil** became one of the first countries to receive results-based aid.
 - **In 2020, Uganda** has become the first African country to submit the results for Reducing Emissions from Deforestation and forest degradation (REDD+) to the UNFCCC.
 - Uganda has now become eligible for results based payments.
 - In 2020, **Uganda became eligible** for REDD+ payments, the first African country to do so.

A) REDD+ IN UNFCCC

- First negotiated in UNFCCC 2005 (COP-11).
- Adopted at COP-13 in 2007 in Bali.
- In 2013, **COP-19** produced at least seven decisions on REDD+, which are jointly known as the "**Warsaw Framework on REDD-Plus**".
- And finally, the remaining decisions on REDD+ was **completed at COP21** in 2015 and the UNFCCC rulebook on REDD+ was completed. **All countries were also encouraged to implement and support REDD+ in Article 5 of the Paris Agreement**. This was part of the broader article that specified that all countries should take action to protect and enhance their greenhouse gas sinks and reservoirs (stores of sequestered carbon).
- UNFCCC requests All developing countries aiming to undertake REDD+ to develop the following elements:
 1. A **national strategy or action plan**;
 2. A **national forest reference emission level** and/or forest reference level.
 3. A **national forest monitoring system** for monitoring and reporting on REDD+ with if possible subnational monitoring

Elements of UNFCCC Warsaw Framework for REDD+



B) REDD AND REDD+

- REDD originally referred to "reducing emissions from deforestation in developing countries" the title of the original document on REDD. It was superseded in the negotiation by REDD+.
- REDD+ refers to "reducing emissions from deforestation, and forest degradation in developing countries, and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries". This is the most recent elaborated terminology used by COP.

C) INDIA'S REDD+ STRATEGY (RELEASED IN AUG 2018)

- The strategy has been **prepared by Indian Council for Forestry Research & Education (ICFRE)**, Dehradun.
- The strategy builds upon existing national circumstances which have been updated in line with India's National Action Plan on Climate Change, Green India Mission, and India's NDC to UNFCCC.
- **Key focus**
 - Cooperation and involvement of the tribals, other forest dwelling communities and the society as a whole
- **Significance**
 - Reiterates India's commitment to Paris Agreement on CC
 - It will help in conservation of forests and enhance productivity of forest ecosystem.
 - REDD+ strategy will help India fulfill its NDC commitment and contribute to the livelihood of the forest dependent population.

2) THE UN REDD PROGRAM (THE UN COLLABORATIVE PROGRAM ON REDUCING EMISSIONS FROM DEFORESTATION AND DEGRADATION IN A DEVELOPING COUNTRIES)

- It is a multilateral body which partners with developing countries by assisting them to develop the capacities needed to meet the UNFCCC REDD+ requirements.
 - It does so through a country based approach that provides advisory and technical support services tailored to national circumstances and needs.
- It is a collaborative initiative of FAO, UNDP, and UNEP. It also harnesses technical expertise of other UN agencies.

3) CENTRAL AFRICAN FOREST INITIATIVE (CAFI)

- CAFI was founded in 2015 as a collaborative agreement between six Central African Countries - the Central African Republic, the Democratic Republic of Congo, the Republic of Congo, Gabon, Equatorial Guinea and Cameroon - and six financial partners: the European Union, France, Norway, Germany, South Korea and the Netherlands.
 - It is **based around the REDD+ mechanism** developed by the parties to the UNFCCC.

9. MITIGATION STRATEGIES

Key issues covered – Carbon Sequestration, Carbon Sink, Carbon Credit, Carbon Offset, Carbon Tax, and Geo-Engineering

1) CARBON SEQUESTRATION

- It is the process of capturing and storing atmospheric carbon dioxide. It is one of the methods of reducing the amount of carbon dioxide in the atmosphere with the aim of fighting climate change.
- **There can be two major types of carbon sequestration:**
 - » **Biological:**
 - Biological Carbon Sequestration is the storage of carbon dioxide in **vegetation** such as grasslands, or forests, as well as in **soils and oceans**.
 - **Plant rich landscapes** like forests, grasslands etc. capture 25% of the global carbon emissions.



- **Soil** can store carbon in the form of Soil Organic Carbon.
 - Soil can also store carbon as carbonates.
- **Colder and nutrient rich part of ocean** can absorb more carbon dioxide than warmer parts. Therefore, polar regions generally serve as carbon sink.

» **Geological Carbon Sequestration**

- It is the process of storing carbon dioxide in underground geologic formations, or rocks.
- **Naturally, Carbonates** are created over thousands of years when carbon dioxide dissolved in water and percolates in soil, combining with calcium and magnesium minerals, forming '**caliche**' in desert and arid soil.
- **Artificially**, CO₂ captured from industrial, or any other sources may be injected into porous rocks for long-term storage.
 - **Hydrodynamic Trapping**: It refers to a time-dependent hydrogeological process where injected CO₂ is effectively trapped by the existence of very long travel times to the surface.
 - **Solubility Trap**: CO₂ dissolved in liquid like water or oil.
 - **Mineral Carbonation**: CO₂ can be made to react to naturally occurring minerals to form stable compound which can stay like that for years (e.g. Calcium carbonate)

» **Technological Carbon Sequestration**

- These are the new ways being explored by scientists to capture and store carbon using innovative technologies and to make useful products out of it.
- **Graphene Production**
- **Direct Air Capture** - Capturing carbon directly from air using advanced technology plants.
 - For now the technology is highly expensive and energy intensive. But with more advancement in technologies, this may become a viable option.
- **Engineered Molecules** - These molecules can change shape by creating new kinds of compounds capable of singling out and capturing carbon dioxide from the air.

2) CARBON SINK (GREEN AND BLUE CARBON)

- **Green Carbon**: It is the carbon which is stored by vegetation (forests, grasslands, etc.). It is basically **biological carbon sequestration**. Reforestation and Afforestation are mechanisms to enhance Green Carbon
- **Blue Carbon**: Carbon stored by coastal, aquatic or marine ecosystems. These include mangroves, seagrasses etc.
 - Coastal ecosystems are more efficient carbon sinks when compared to tropical rain forests.

1) CARBON CREDIT AND CARBON OFFSETTING (ALREADY DISCUSSED WITH MARKET BASED MECHANISM)

2) CARBON PRICING INCLUDING CARBON TAX

- **Carbon Pricing** is a method which captures the external cost of green house emissions - i.e. the losses to different sectors like agriculture, health, property etc. due to addition of Greenhouse gas in atmosphere. There are **two major types** of Carbon Pricing - **Emission Trading System** (or Cap and Trade System) and **Carbon Tax**.
- **Advantages of Carbon Pricing:**
 - » Shifts the cost on polluters -> internalize the external cost of pollution
- **Carbon tax** is a potential alternative to the 'cap and trade' method currently used by the Kyoto protocol to reduce the carbon emission.
 - » A carbon tax aims to internalize the externality of climate change by setting a price on the carbon content of energy consumed or greenhouse gas emitted in the production of consumption of goods.
- **Advantages of carbon taxes over 'Quantitative limits' or 'Cap and trade' system**
 1. **Avoids the problem of choosing a baseline** : In a price approach, the natural baseline is a zero carbon tax.
 2. **Better adaptation to element of uncertainty** which pervades the science of climate change.
 - Quantitative limits are related to the stocks of greenhouse gas emissions, while the price limits are related to the flow of emissions.
 3. **Less volatility and more predictability** : From uncertainty (point 2) arises volatility. Carbon tax regime is likely to cause less volatility in the prices of carbon emission
 4. **Less administrative arbitrariness - easier implementation - lack of manipulation**
 - Quantity limiting policies are often accompanied by administrative arbitrariness and corruption through rent seeking. This sends of wrong signals to investors.
 - In a price based system, the investors has an assured long-term regulation to adapt to and can weigh in the costs involved.
 5. **Addresses the problem of equity**
 - Equity is the most contentious issue in any international negotiation on climate change mitigation either at the level of WTO or UNFCCC.
 - The price based approach in the form of carbon tax makes it easier to implement the equity based international adjustments than the quantity based approach.
 6. **Carbon tax will essentially be a Pigovian tax** which balances the marginal costs and benefits of additional emissions, thereby internalizing the cost of environmental damage.
 7. **Better understandability**: the carbon tax is simpler to understand and therefore may be braced by more people
- **Limitations of Global Carbon Tax**
 - **No CBDR**: It penalizes incremental carbon emissions rather than those who have **already spewed into the atmosphere** since the Industrial revolution.
 - **Taxes are part of national social contracts** that emerge out of very specific conditions that can't necessarily be replicated on a global scale.
- **Has India imposed any carbon tax yet?**
 - A carbon tax increases the price that consumers pay for energy. Increase in **fuel taxes** as well as **quadrupling of the coal cess** is sometimes interpreted as a variant of a carbon tax.

- Similarly, not decreasing the petrol/diesel prices according to the decrease in crude oil prices can also be seen as a method of imposition of carbon tax.

3) GEO-ENGINEERING

- Introduction:**
 - Definition:** Geo-engineering is a theoretical concept which aims to modify and cool environment to defeat the global warming. It may involve reduction of Sunlight reaching earth or absorption of CO₂ to reduce global warming (Carbon Capture Technologies).
 - Since the global community is looking for a Net Zero target by 2050, the Geo-engineering technologies are expected to play a key role in this.
- Reduction of sunlight reaching Earth:**
 - Stratospheric Aerosol Injection:** Injecting the atmosphere with Sulphur/ Hydrogen Sulphide (copies volcanic effect and scatters sunlight).
 - Putting Large Mirrors in Space** - reduce the amount of sunlight reaching earth.
 - Using Wind-Powered Motors to **whiten the cloud** -> by spraying water into the sky -> reflect solar radiation.
- Carbon Capture and Storage (CCS)** (Or Carbon Capture Utilization and Storage (CCUS)) refers to technologies that can capture CO₂, at a source of emissions before it is released into atmosphere.
 - The process starts with capture of CO₂ which undergoes a compression process to from a dense fluid. This eases the transport and storage of the captured CO₂.
 - This dense fluid is transported via pipelines and then injected into the underground storage facilities. It can also be used as a raw material in other industrial processes such as bicarbonates.
- CDR** takes the form of both natural means like afforestation or reforestation, and technologies like direct air capture where machines mimic trees by absorbing CO₂ from their surrounding and storing it underground.
 - E.g. Fake Trees containing compounds which can react with CO₂ to absorb it and store it in solid from.
- Other Carbon Capture Technologies**
 - Ocean Iron Fertilization:** Seeding the Sea with Iron
 - Phytoplankton prefer iron and flourish in its presence, thus absorbing a lot of CO₂.
- How significant is the role of CCS and CDR in achieving net-zero by 2050?**
 - In IPCC AR6, there is no pathway to 1.5 degrees C that doesn't use CDR.
- Limitations/Problems with these CCS and Geoengineering method:**
 - CCS and CDR** are still technologies under development without demonstrated feasibility at large scale despite decades of development.
 - It also suffers from other challenges like high energy requirements; high cost; challenges in the transport and long-term storage of carbon.
 - CDR** methods like afforestation, reforestation, Bioenergy with Carbon Capture and Storage (BECCS) are constrained by their need of land. It may also hamper food and water security.

- » **Ocean Iron Fertilization:** The Convention of Biological Diversity has already imposed a de facto moratorium based on precautionary principle. It could result in eutrophication, which may adversely affect the ocean ecosystem.
- » **Stratospheric Aerosol Injection** is also highly controversial as this could have unintended effects on global and regional climates.
- » Further, there are concerns related to **fairness, equity, and justice** in the adoption of geo-engineering technologies as most of the R&D is dominated by North American and Western Euro.

- So far, there has been very little progress on these technologies and most of the R&D is dominated by North American and Western European Nations. Emerging economies like China and India have also begun to look into these options more seriously.
 - CCS is **absent from INDCs of most of the countries**, indicating that most of the countries have not yet accepted it as promising technology.
 -
- **Why very little progress?** - Lack of policy support and spending on R&D.

4) OCEAN CARBON DIOXIDE REMOVAL

- **Introduction:**
 - » Ocean stores about 50 times more carbon than the atmosphere. So, for taking carbon out of atmosphere and storing it someplace where it won't continue to warm the planet, the ocean is the single biggest place it can go.
 - » **Ocean Carbon dioxide Removal (Ocean CDR)** uses the ocean's natural ability to take up carbon on a large scale and amplifies it.
 - **Carbon gets into ocean from atmosphere in two ways:**
 1. Air dissolves in the ocean surface. Because sea water is slightly alkaline, the CO₂ is absorbed into the ocean.
 2. The second involves **biologic pump**.
 - Ocean is a living medium and has algae, crustaceans, fish, whales etc. When organic material is eaten or dies, it gets recycled. It rains down through the ocean and makes its way to the ocean twilight zone, a level around 200 to 1,000 meters deep.
 - This twilight zone sustains the biological activities of the ocean. It is the soil of the ocean where organic carbon and nutrients accumulate and are recycled by microbes.
 - It is also home to the largest animal migration on the planet. Each day, trillions of fish and other organisms migrate from the depths to the surface to feed on the phytoplankton and one another and go back down, acting like a large carbon pump that captures carbon from the surface and shunts it down into the ocean where it is stored away from the atmosphere.
- **Why is OCEAN CDR drawing so much attention right now?**
 - » Some experts feel that because of its volume and carbon storage potential, the ocean is really the only arrow in our quiver that has the ability to take up and store at the scale and urgency required.

- » A 2022 report by the national academies outlined a research strategy for ocean carbon dioxide removal. The **three most promising methods** highlighted are:
 - **Ocean Alkalinity enhancement:** Oceans are naturally alkaline, with a pH of about **8.1**. Increasing alkalinity by dissolving certain powder rocks and minerals makes the ocean a chemical sponge for atmospheric CO₂.
 - **Add micro-nutrients to ocean surface**, particularly soluble iron.
 - Very small amount of soluble iron can stimulate great productivity (algal growth), which drives a more vigorous biological pump.
 - Over a dozen of these experiments have been done, so the scientists know that it works.
 - **Grow Kelp in the Ocean:** It captures carbon at the surface through photosynthesis, then bale it and sink it to the deep ocean.
- » But, **all these methods** have drawbacks for large scale use, including cost and unanticipated consequences

10. EFFORTS BY AVIATION AND SHIPPING SECTOR

1) ICAO – CORSIA

- **Introduction**
 - » The International Civil Aviation Organization (ICAO) is a specialized agency of UN which deals with administration and governance of the Convention on International Civil Aviation (Chicago Convention).
 - » It was established in **1944** and is headquartered at **Montreal Canada**.
 - » It works with 192 Member states of convention and other industry groups to come to a consensus on **International Civil Aviation Standards and Recommendation Practices (SARPs)** and **Policies** to ensure safe, efficient, secure, economically sustainable and environmentally responsible civil aviation.
 - » It also assists member states in capacity building towards various aviation development objectives.
- **Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)**
 - » In **2016**, ICAO finally (after years of negotiations) sealed the first deal for limiting green-house gases from international aviation. The decision was taken during 39th ICAO general assembly meeting attended by 191 countries.
 - » **Details of the Offsetting Scheme:** From **2021**, any increase in airline CO₂ emission will be offset by activities like tree planting, which soak up CO₂.
 - CO₂ will be allowed to grow to 2020 but after that, emissions will need to be offset.
 - Three Phases:
 - **Pilot Phase:** 2021-2023 (Voluntary)
 - **First Phase:** 2024-2026 (Voluntary)
 - **Second Phase:** 2027-2035 (Mandatory for all member states)
 - The deal will be voluntary till 2026 but most major nations are expected to take part.
 - Review period every three years and it rules out "double counting" of offsets to ensure that forest protection efforts elsewhere aren't used to negate aircraft emissions.

- » Applicable to Civilian passenger and cargo flights.
- » **Exceptions:** Humanitarian, Medical, Firefighting flights etc.
- **Developing countries** like India, China, Brazil etc had opposed the provisions. Why? ?
- **CORSIA** is part of the effort from ICAO to halve the carbon emissions by 2050 compared to 2005 levels.
 - » **Other efforts** include adoption of new technology - including deployment of sustainable alternative fuels, more efficient aircraft operations, infrastructure improvements including modernized air-traffic management systems.
- **DGCA Guidelines to airlines operators** (Oct 2018)
 - » Under these guidelines, all operators engaged in international operations have to capture their fuel consumptions and carbon emissions data annually, starting from Jan 1, 2019.
 - » Further, beginning 2021, the operators will have to meet offsetting requirements by purchasing and cancelling "emission units".

2) INTERNATIONAL MARITIME ORGANIZATION (IMO) REACHES A DEAL TO CUT EMISSIONS

- **Key Highlights of the deal:**
 - » More than 170 countries under the aegis of IMO have agreed to a target to reduce greenhouse gas emissions from shipping by at least 50% of 2008 levels by 2050. This is being called as "initial strategy".
 - » The strategy also proposes to reduce carbon intensity from shipping - the amount of CO₂ emitted from each unit of transport - by at least 40% by 2030, and 70% by 2050.
 - » The final IMO Plan is not expected by 2023.
 - » **Some possible medium term measures** discussed include:
 1. Low carbon and zero carbon fuels
 2. Improved energy efficiency of new and existing ships
 3. Possible market based mechanism to encourage shift to lower carbon fuels.
- **Analysis**
 - » Experts feel that IMO should and could have gone much further in their contribution. Opposition from some countries especially USA, Saudi Arabia and Panama had limited what could be achieved at the IMO session.
 1. To align with Paris goals, the reduction target should be 70-100%.
 - » **Developing countries** like India are worried that a target to reduce emission from shipping sector will negatively hamper their yet to fully develop sector.
- **Note:** Shipping and Aviation sector avoided specific emission-cutting targets in a global climate pact agreed in Paris in 2015.

11. EFFORTS BY INDIA TO FIGHT CLIMATE CHANGE

1) NATIONAL ACTION PLAN ON CLIMATE CHANGE (NAPCC)

- **Introduction**
 - » Challenges emerging from climate change are complex and multi-sectoral, and therefore these have to be dealt with a multi-dimensional approach.

- » Keeping this in mind, **GoI in 2008, adopted NAPCC** which is aimed at promoting development objectives and at the same time tackling climate change effectively.
 - » There are 8 missions which form the core of NAPCC. These missions represent the multipronged and integrated approach required to deal with climate change.
- **How NAPCC was supposed to deal with Climate Change**
- Development and use of **new technologies**.
 - **Involving multiple ministries** which will focus on different mission objectives
 - **Involving private sector** through PPP projects and civil society actions.
 - **Promoting awareness** about climate change, adaptation, energy efficiency etc.
- **Understanding Achievements and Limitations of Individual Missions**
- i. **National Solar Mission** is aimed at increasing the solar energy capacity in the country and thus reducing the emission of GHGs.
 - Governed by Ministry of New and Renewable energy.
 - The target of JNNSM was enhanced to 100 GW by 2022 which includes 60 GW through large and medium scale grid connected solar power projects and 40 GW through rooftop solar.
 - ii. **National Mission for Enhanced Energy Efficiency (NMEEE)** is aimed at improving energy efficiency and thus meeting energy demands of the country.
 - **Ministry:** Ministry of Power
 - The mission commenced in 2010 with a target to achieve the following:
 - GHG reduction of 98.55 million tonnes/ year at full implementation stage.
 - Annual fuel savings of 23 million tons.
 - iii. **National Mission for Sustainable Habitat**
 - **Ministry of Housing and Urban Affairs**
 - The mission commenced in 2010 with an aim to reduce emission in cities.
 - It focuses on GHG reduction opportunities by increasing energy efficiency of the building, improving municipal solid waste management, and encouraging people to use public transport.
 - Some specific initiatives to achieve these objectives are Adaptation of the existing Energy Conservation Building Code and promoting investments in development of high capacity public transport system.
 - iv. **National Water Mission**
 - Ministry of Jal Shakti.
 - The mission commenced in 2011 with an aim to ensure water security and improve access to water resources. It aims to achieve this by promoting water conservation and water use efficiency.
 - It covers the entire sweep of water management to fight climate change impacts: from water conservation to water use efficiency.
 - v. **National Mission for Sustaining Himalayan Ecosystem**

- Governed by **Department of Science and Technology**
 - Commencement in 2011
 - Aimed at developing capacity to assess the health status of Himalayan Ecosystem and helping Himalayan states in policy formulation and implementation.
- vi. **The National Mission on Strategic Knowledge for Climate Change**
- Governed by **Department of Science and Technology**
 - Commencement in 2014
 - Aimed at establishment of knowledge network among the existing knowledge institutions engaged in R&D related to climate change.
 - The two missions (NMSHE and NMSKCC) operated under **DST** and aims to generate new information, building scientific and technical capacity, and produce new channel of collaboration between scientists, policy makers and law makers to ensure that climate action is based on sound knowledge and science.
- vii. **National Mission for Green India**
- **MoEF&CC**
 - Commencement: 2014
 - Aims: To increase forest and tree cover.
 - Under this the focus is on reviving degraded forests with a focus on increasing forest cover & density and conserving biodiversity.
- viii. **National Mission for Sustainable Agriculture**
- Commenced in 2012 with aim to climate-proof agriculture and reduce emission from the sector.
 - There are **four components** under NMSA
 1. **Soil Health Management** aims at nutrient management through judicious use of chemical fertilizers for improving soil health and productivity.
 2. **Rainfed Area Development** to develop or bring agri-land under integrated farming system.
 3. **Sub-Mission on agro-forestry** to promote plantation along with crops.
 4. **Climate Change and Sustainable Agriculture: Monitoring Modeling and Networking** (CCSAMMN) for creating models on adaptation and dissemination of information about climate change.

3) MISSION LIFE

- **Why in news?**
 - » PM Modi launched Mission LiFE (Lifestyle for Environment), in the presence of UN Secretary General Antonio Guterres (Oct 2022)
- **Details about Mission LiFE**
 - » It was first proposed by PM Modi at COP 26 of UNFCCC in Nov 2021. It is envisioned as an India led global mass movement that will nudge individual and collective action to protect and preserve the environment.
 - PM Modi has underlined that Mission LiFE makes the fight against climate change democratic, in which everyone can contribute with their respective capacities.

- It emboldens the spirit of the P3 Model: Pro Planet People.
- It functions on the basic principles of 'Lifestyle of the planet, for the planet and by the planet'.
- » At the launch, PM Modi also highlighted that the concept of 'Reduce, Reuse and Recycle' and circular economy; and mentioned that it has been part of the Indian Lifestyle for thousands of years.
- » LIFE also resonates with **climate justice** -> it highlights enhanced obligations for those in developed countries and supports climate adaptation and mitigation for those most affected and yet least responsible.
- **NITI Aayog and MoEF&CC**, in collaboration with Government of Gujarat, organized the global launch of Mission Life.
 - » NITI aayog will curate and incubate Mission Life in the first year, and it will subsequently be implemented by MoEF&CC.
 - » It is a five year program.
- **Significance:**
 - » According to UNEP, more than 2/3rd of the GHG emissions can be attributed to household consumption and lifestyles -> therefore the urgent cuts to global emissions we need can only be achieved through widespread adoption of greener consumption habits.
 - » Life recognizes that small individual actions can tip the balance in the planet's favor.
 - Actions such as saving energy at home; cycling and using public transport instead of driving; eating more plant-based foods and wasting less; and leveraging our position as customers and employees to demand climate-based friendly choices.
 - » Many of the goals of LiFE can be achieved by deploying 'nudges', gentle persuasion technique to encourage positive Behaviour.
 - The UNEP employs proven nudging techniques:
 - Discouraging Food waste by offering smaller plates in cafeterias;
 - encouraging recycling by making bin lids eye-catching;
 - and encouraging cycling by creating cycle paths
- **Note: Other Recent global initiatives launched/initiated by India:**
 - Panchamrita Targets announced by Mr Modi at COP26
 - International Solar Alliance
 - The Coalition for Disaster Resilient Infrastructure

4) GREEN BONDS: MOBILIZING FUNDS

- Though the Paris Agreement provides for mobilization of resources from developed countries, the process has been very slow.
- Thus, India has scaled up its efforts towards greater mobilization of private capital to meet its ambitious climate action goals.
- Green Bonds are financial instruments that generate proceeds for investment in environmentally sustainable and climate suitable projects.
 - Developed countries such as UK, France, Germany etc have been using Green bonds to raise billions of dollars of sovereign green debts.

- In India, as per SEBI's data between 2017 and Sep 2022, 15 Indian corporates have issued green bonds of value of Rs 4,539 crores. Most of this is related to renewable energy generation.
- Union Budget 2022-23 announced the issuance of Sovereign Green Bonds.
 - The final sovereign Green bond framework of India has been issued.
 - The Green Financing working committee has also been set up to oversee and validate key decisions on the issuance of Sovereign green bonds.
 - The committee has the mandate to select the projects for allocation of proceeds, do a time-bound review of the allocation and carry out annual reporting along with an impact assessment of the proceeds from sovereign green bonds issued

A) REGULATORY FRAMEWORK FOR ISSUANCE OF GREEN DEBT SECURITIES

- Reserve Bank of India:
 - In Nov 2021, the RBI published its 'Statement of Commitment to Support Greening India's Financial System' - **NGFS**. Here, the Reserve Bank of India (RBI) laid out, keeping in view its national commitments, priorities, and complexity of our financial system, committed to, among others, exploring how climate scenario exercises can be used to identify vulnerabilities in RBI-supervised entities' balance sheets, business models and gaps in their capabilities for measuring and managing climate-related financial risks.
 - **Also, in 2007, the RB advised banks to put in place an appropriate action plan for making a meaningful contribution** to sustainable development.
 - Over time, RBI has incentivised bank lending towards greener industries and projects.
 - For example, renewable energy projects have been included under Priority Sector Lending (PSL).

B) SECURITIES AND EXCHANGE BOARD OF INDIA (SEBI)

- SEBI introduced the regulatory framework for issuance of green debt securities as a mode of sustainable finance under the erstwhile SEBI (Issue and Listing of Debt Securities) Regulations, 2008, (ILDS Regulations), in 2017.
- At the time of review of the ILDS Regulations, the provisions of the erstwhile circular were subsumed, and the definition of "green debt security" was incorporated as Regulation 2(1)(q) in the SEBI (Issue and Listing of Non-Convertible Securities) Regulations, 2021 ('NCS Regulations'). The disclosure requirements were prescribed vide Operational Circular dated August 10, 2021.
- In Nov 2022, SEBI has allowed an issuer under the SEBI (Issue and Listing of Municipal Debt Securities) Regulations, 2015 ('ILMDS Regulations') to issue a green debt security if it falls within the definition of "green debt security" as per Regulation 2(1)(q) of the NCS Regulations. Such an issuer has to comply with both ILMDS Regulation and NCS Regulation
- In the backdrop of increasing interest in sustainable finance in India as well as around the globe, and with a view to aligning the extant framework for green debt securities with the updated Green Bond Principles recognised by International Organisation of Securities Commission (IOSCO), SEBI undertook a review of the regulatory framework for green debt securities. Based on the review, it has been decided in the SEBI board meeting dated December 20, 2022, to:

- Enhance the scope of the definition of green debt security by including new modes of sustainable finance in relation to pollution prevention and control, eco-efficient products, etc.;
- Introduce the concept of blue bonds (related to water management and marine sector), yellow bonds (related to solar energy) and transition bonds as subcategories of green debt securities.

12. DESERTIFICATION AND LAND DEGRADATION

- **Introduction**
 - Desertification is a type of land degradation in which relatively dry land region becomes increasingly arid, typically losing its bodies of water as well as vegetation and wildlife.
 - Currently, 41% of the landmass worldwide is prone to desertification and more than 2 billion people are affected by desertification and land degradation.
- **Key causes**
 - i. **Deforestation**
 - ii. **Overgrazing and unsustainable agri practices** are other major factors leading to desertification.
 - iii. **Increasing Pollution** also negatively hampers biodiversity (including biodiversity), causes infertility of soil and promotes desertification
 - iv. **Climate Change and higher probability of droughts** have made more areas vulnerable to desertification
 - v. **Salination** caused by overuse of water, degrades soil and promotes desertification.
 - vi. **Unsustainable Mining practices** also degrades the geographic region and promotes desertification.
 - vii. **Invasive species** of plants such as **Proposis Juliflora** have also resulted in the decline of natural vegetation and expansion of deserts.
 - This can be specifically seen in case of **Banni Grassland**, of Kutch Gujarat.
 - viii. **Forest fires** are the other major drivers of desertification.
 - ix. **Lack of Resources** to fight desertification
 - The issue was also raised recently in the 14th COP on UNCCD. Only \$6.4 billion have been spent in last 2 years to combat desertification, the real cost should be as much as \$450 billion annually.
- **Impact**
 - i. **Threatens socio-economic development** by threatening food security, increasing poverty and unemployment due to land degradation.
 - ii. **Increases vulnerability of already vulnerable groups**
 - iii. **Promotes the vicious cycle of degradation**
 - Poverty force people to go for unsustainable agri practices, further promoting desertification.
 - iv. **Desertification adds to and worsens the impact of climate change**
 - It reduces forest cover and thus reduces the sinks for CO₂.

1) UNITED NATION CONVENTION ON COMBATING DESERTIFICATION (UNCCD)

- UNCCD is one of three important conventions finalized in 1992 Earth Summit (the other being CBD and UNFCCC)

- It was **established in 1994** and is the **sole legally binding international agreement linking environment and development to sustainable land management**.
 - The convention addresses specifically the arid, semi-arid and dry sub-humid areas, known as drylands, where some of the most vulnerable ecosystems and peoples can be found.
- The convention has **197 members** who work together to:
 - Improve the living condition of people** in drylands
 - Maintain and restore soil productivity**
 - Mitigate the effect of drought**

2) THE NEW UNCCD 2018-30 STRATEGIC FRAMEWORK

- It is the most comprehensive global commitment to achieve **Land Degradation Neutrality (LDN)** to achieve a land degradation-neutral world consistent with the 2030 Agenda for Sustainable Development.
- **Land Degradation Neutrality**
 - A state whereby the amount and quality of land resources, necessary to support ecosystem functions and services and enhance food security, remains stable or increases within specified temporal and spatial scales and ecosystems.
- **The LDN Target Setting Program**
 - Through this, the Global Mechanism (GM) and Secretariat on UNCCD, in collaboration with multiple international partners, are supporting interested countries in their national LDN target setting process.
- **The LDN Fund**
 - It is an impact investment fund, blending resources from the public, private and philanthropic sectors to support achieving LDN through sustainable land management and land restoration **projects implemented in private sector**.
 - It is the first of its kind investment vehicle leveraging public money to raise private capital for sustainable land projects.
 - It was officially launched at COP 13 in Ordos, China.

3) WORLD DAY TO COMBAT DESERTIFICATION AND DROUGHT: 17TH JUNE

- **Background**

- In 1994, General Assembly established the United Nations Convention to Combat Desertification (UNCCD), the sole legally binding international agreement linking environment and development to sustainable land management, and declared 17th June "World Day to Combat Desertification and Drought".
- Later, in 2007, UNGA declared the decade 2010-2020 as the **UN Decade for Deserts and Fight Against Desertification to mobilize global action to fight land degradation.**
- The 2021 Desertification and Drought day focused on turning degraded land into healthy land.

Desertification & Drought Day

17 JUNE
2021



Restoration. Land. Recovery.

We build back better with healthy land

4) THE BONN CHALLENGE

- It is a global goal to bring 150 million hectares of degraded and deforested landscapes into restoration by 2020 and 350 million hectares by 2030.

5) GREAT GREEN WALL INITIATIVE

- This initiative was launched in 2007 by African Union and is aimed at restoring Africa's degraded landscapes and transform millions of lives in one of the world's poorest regions, the Sahel.
- It will be covering the Sahel region, from Senegal in the west to Djibouti in the East of Africa.
- Once, complete the wall will be the largest living structure on the planet - an 8,000 km natural wonder of the world stretching across the entire width of the continent.
- The initiative has brought together African Countries and International Partners, under the leadership of African Union Commission and Pan-African Agency of the Great Green Wall.
- **Objectives:**
 - By 2030, restore 100 million ha of currently degraded land; sequester 250 million tons of carbon; and create 10 million green jobs.



6) UN HIGH LEVEL DIALOGUE ON DESERTIFICATION, LAND DEGRADATION, AND DROUGHT

- **Why in news?**
 - PM Modi gave a keynote address at the UN 'High-Level Dialogue on Desertification, Land Degradation and Drought' (June 2021)
- **Details**

- The President of General Assembly convened a High-Level Dialogue to assess the progress made in the fight against DLDD during the UN Decade for Deserts and the Fight Against Desertification (2011-2020) and map the way forward. This dialogue took place in May 2021.

- **Key Purpose**

- Bring attention to how COVID-19 recovery process can be aligned to address DLDD through job creation project in land restoration, regenerative agriculture, renewable energy and energy efficiency, and investments in sustainable land management.
- Elevate the discourse on DLDD issues' global significance for the entire SDG agenda and for climate, biodiversity and disaster risk reduction.
- Build upon the commitments made by member states during CBD summit, UNFCCC summit and so on.
- Encourage all UN members to adopt and implement Land degradation Neutrality targets and National Drought Plans as part of their NDCs to Paris Agreement.
- Call member countries to support the Land Degradation Neutrality Fund and other funding mechanisms to scale up land restoration by all sectors of society
- Share experiences, best practices, cutting edge technologies and innovative business models that advance green, resilient and inclusive recovery strategy.

- **Key Highlights of PM Modi's Address**

- In India, we have **always given importance to land and considered the sacred Earth as our mother.**
- **Key steps by India:**
 - » **Afforestation:** Over last 10 years, India has added 3 million hectares of forest cover.
 - » India is on track to achieve our national commitment of Land Degradation Neutrality [SDG target 15.3].
 - » India is also working towards restoring 26 million hectares of degraded land by 2030.
 - This would also contribute to India's NDC commitment of an additional 2.5 to 3 billion tonnes of carbon dioxide equivalent.
 - » In the spirit of south-south cooperation, India is also helping fellow developing countries to develop land restoration strategies.
 - » A centre of excellence is being set up in India to promote scientific approach towards land degradation strategy.
- **Restoration of land** can start the virtuous cycle of good soil health, increased land productivity, food security and improved livelihood.

7) DESERTIFICATION AND LAND DEGRADATION ATLAS OF INDIA

- It has been published by Space Application Centre, ISRO Ahmedabad (June 2021)
- The Atlas provides state wise area of degraded lands for the time frame 2018-19. It also provides change analysis for the duration of 15 years, from 2003-05 to 2018-19.
- **Key Highlights**
 - 29.7% of India's land is degraded.
 - i.e. 97.8 million hectares of India's total geographical area (TGA) of 328.72 mha underwent land degradation

- Area under **desertification** have also increased to 83.69 million hectares in 2018-19 from 82.64 mha in 2011-13.
 - Note: Land degradation within dry land regions (arid, semi-arid, and dry sub-humid regions) is termed as desertification.
- **Statewise breakup**
 - **Increase in level of desertification** have been seen in 28 out of 31 states and UTs between 2011-13 and 2018-19.
 - Even in **Goa and Odisha** where desertification had earlier declined (between 2003-05 and 2011-13), it has increased now.
 - Land degradation and desertification was **declining** in UP, Rajasthan and Telangana in 2018-19.

Around 23.79% of the area undergoing desertification with respect to the TGA of the country was contributed by Rajasthan, Maharashtra, Gujarat, Karnataka, Ladakh, Jharkhand, Odisha, Madhya Pradesh, and Telangana.

13. OZONE LAYER

- Ozone is a natural gas, it is an allotrope of oxygen consisting of three atoms of oxygen bound together in a non-linear fashion. The chemical symbol for ozone is O₃.
- It's a pale blue gas with distinctive pungent smell.
- **Pollutant at ground level** - discussed with air pollution
- **Ozone Layer**
 - » The ozone layer or ozone shield is a region of Earth's stratosphere that absorbs most of the sun's ultraviolet (UV) radiation. It contains high concentration of Ozone (O₃) in relation to other parts of the atmosphere, although still small in relation to other gases in the stratosphere.
 - » Ozone layer is mainly found in lower stratosphere (approx. 20-30 km above earth)
- **Usefulness of ozone layer:** Prevents damaging Ultraviolet from reaching earth thus benefitting both plants and animals; Protects oxygen of lower layer which would break up by the action of ultraviolet rays otherwise.

1) OZONE LAYER DEPLETION

- **What caused Ozone Layer depletion?**
 - » In 1970s scientists discovered that Chlorofluorocarbons (CFCs), broke apart in the atmosphere and released **chlorine atoms**. This caused the ozone depletion. The same effect resulted when bromine atoms were released by halons. Thus, **CFCs and halons** are examples of Ozone depleting substances.
- **What are the uses of Ozone depleting substances/ when and why they are produced?**
 - » **Chlorofluorocarbons (CFCs):** Used as refrigerants and aerosol propellants, for making plastic foam, cleaning of electronic equipment.

- Lifetime and removal of CFCs: Unlike other chemicals, CFCs cannot be eliminated from atmosphere by the usual scavenging processes like photo dissociation, rain-out and oxidation.
 - Escape of CFCs: The CFC enter into atmosphere by gradual evaporation from their source (discarded refrigerators etc.) Since the CFCs are thermally stable, they can survive in the troposphere. But in the stratosphere, they are exposed to UV radiation.
- **Bromine containing compounds:** Bromine containing compounds called halons and HBFCs, i.e., hydro Bromo fluorocarbons [both used in fire extinguishers] and methyl bromide (a widely used pesticide).
- **Carbon Tetrachloride:** It is a cheap, highly toxic solvent. Used in manufacture of synthetic rubber, the production of pesticides and pharmaceuticals.
- **Methyl Chloroform:** Used as cleaning solvent for clothes and metals, and a propellant in a wide range of consumer products, such as correction fluid, dry cleaning sprays, spray adhesives) and other aerosols.
- **Trichloroethane:** A versatile, all-purpose solvent.
- **Hydrochlorofluorocarbons (HCFCs):** Developed as an interim replacement for CFCs. Much less harmful than CFCs. But have high global warming potentials.
- **Nitrous Oxide (N₂O):** It can gradually reach the middle of the stratosphere, where it is photolytically destroyed to yield nitric oxide which in turn destroys ozone.
- **Sulphuric Acid Particles:**
 - The most prominent acid used in various industries
 - These particles free chlorine from the molecular reservoirs, and convert reactive nitrogen into inert forms thus preventing the formation of chlorine reservoirs.

2) SCIENCE OF OZONE DESTRUCTION

- **Through Chlorine atoms**
 - The molecules of CFCs when exposed to UV radiation break up, thus freeing chlorine atoms. A free chlorine atom reacts with an ozone molecule to form chlorine monoxide (ClO).
 - The depletion of ozone is catalytic ((ClO) further combine with an atom of oxygen to form O₂ and Cl. This Cl can further react with O₃ and the cycle continues. Thus, a single chlorine atom can destroy thousands of ozone molecules)
- **Bromine atoms**
 - Each bromine atom destroys hundred times of more ozone molecules than what a chlorine atom does.
 - » Bromine + Ozone ---> Bromine monoxide + Oxygen
 - » Bromine monoxide + Chlorine Monoxide ---> Oxygen + Bromine + Chlorine
- **Nitric Oxide (NO)**
 - Nitric oxide also catalytically destroys ozone
 - » Nitric Oxide (NO) + Ozone (O₃) -> Nitrogen dioxide (NO₂) + Oxygen (O₂)

» Nitrogen dioxide (NO_2) + monoxide (O) \rightarrow Nitric Oxide (NO) + oxygen (O_2)

3) EXTENT OF MAXIMUM DAMAGE OF OZONE LAYER

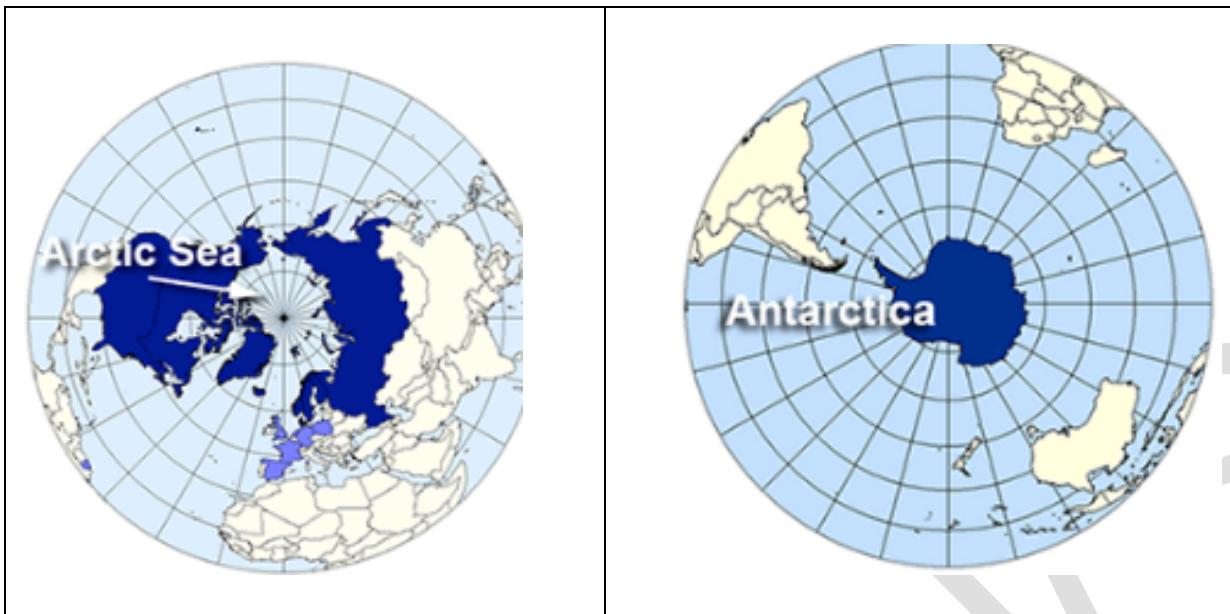
In 2000, the areas of Antarctic Ozone hole reached a record **of 29 million sq km**

4) POLAR STRATOSPHERIC CLOUDS AND OZONE DEPLETION

- What is Polar Stratospheric Cloud?
 - PSCs, also known as nacreous clouds (or mother of pearl, due to its iridescence), are clouds in the winter polar stratosphere at altitude of 15 - 25 kms. They contain water, nitric acid and/or sulfuric acid.
- Role in ozone depletion
 - Situation without PSCs
 - » **Chlorine** released by the breakdown of CFCs exists initially as pure chlorine or as chlorine monoxide but these two react further to form compounds Chlorine nitrate and HCl that are stable (inactive chlorine)
 - » The stable compounds HCl and ClONO_2 reservoirs of chlorine, and therefore for chlorine to take part in reactions of any sort, it has to be freed.
- Role of PSCs: Activating chlorine and absorbing nitrogen
 - Ice particles of the PSC provides substrates for chemical reaction which frees chlorine from its reservoirs. Usually, the reaction between HCl and ClONO_2 (Chlorine Nitrate) is very slow, but this reaction occurs at a faster rate in the presence of suitable substrate which is provided by the stratospheric clouds at the poles.
 - $\text{HCl} + \text{Chlorine Nitrate} \rightarrow \text{Cl}_2$ (Molecular chlorine) + HNO_3 (Nitric Acid)
 - PSCs not only activate chlorine, but they also absorb reactive nitrogen. If nitrogen oxides were present they would combine with chlorine monoxides to form a reservoir of chlorine nitrate (ClONO_2).

5) WHY IS OZONE DEPLETION PREDOMINANT OVER ANTARCTIC (AND NOT ARCTIC) AND OTHER AREAS WHICH PRODUCE MORE OZONE?

1. Antarctic is more cold than arctic: The Antarctic stratosphere is **much colder**. The low temperature enables the formation of PSCs, below 20 km.
 - Why Antarctic is colder than Arctic?



2. Stability of Vortex is longer here

- The vortex is a ring of rapidly circulating air that confines the ozone depletion in the Antarctic region.
- The longevity of the Antarctic vortex is another factor, enhancing favorable conditions for the depletion of ozone.
- The vortex in Antarctic remains, in fact, throughout the polar winter, well into midspring whereas the vortex in the Arctic disintegrate by the time of polar spring (March-April)

6) ENVIRONMENTAL IMPACT OF OZONE DEPLETION: IMPACT OF UV-B RADIATION ON LIVING AND NON-LIVING THINGS ON EARTH

- Decrease in the quantity of total-column ozone tend to cause increased penetration of solar UV-B radiation (290-315 nm) to the earth's surface. It has profound effect on human health, animal plants, microorganisms, material, and air quality.
 - i. **Effect on Human and Animal Health**
 - Eye disease, skin cancer and infectious morbidity
 - In susceptible (light skinned colored) population UV-B radiations is the key risk factor for development of non-melanoma skin cancer (NMSC).
 - ii. **Effects on terrestrial plants and Aquatic Ecosystem**
 - Physiological and developmental process are affected
 - iii. **Effects on biogeochemical cycles**
 - Alternates both source and sinks of greenhouse and chemically important trace gases
 - iv. **Effects on air quality**
 - **Higher photo dissociation rates of key trace gases** that controls the chemical reactivity of the troposphere.
 - Increase both production and destruction of ozone (O_3) and related oxidants such as hydrogen peroxide (H_2O_2), which are known to have adverse effect on human health, terrestrial plants, and outdoor materials.

- Can lead to increased production of particulates such as cloud condensation nuclei.
- v. **Effects on Materials**
 - Synthetically occurring polymers and naturally occurring bio-polymers as well as other materials are adversely affected by solar UV radiation.
 - It increases photodegradation of these materials, limiting their life outdoors.

7) VARIOUS INITIATIVES TO CONTAIN OZONE DEPLETION

A) VIENNA CONVENTION

- **Background:** Signed in 1985 and came into force in 1988
- **Convention**
 - The objective of the convention was for countries to promote cooperation by means of systematic observations, research and information exchange on the effects of human activities on the ozone layer and to adopt legislative and administrative measures.
 - Did not contain legally binding controls and targets.
 - However, it set an important precedent. For the first time, nations agreed in principle to tackle a global environmental problem before its effects were felt or conclusively proven by science.
 - In 2009, the Vienna Convention became the first convention of any kind to achieve universal ratification.

B) MONTREAL PROTOCOL

- Once the scientific observation confirmed the ozone hole, governments recognized the need for stronger measures to reduce production and consumption of several CFCs and halons.
- Thus the Montreal protocol was signed in Sep 1987. It is an international treaty designed to protect the ozone layer through reduction of production and consumption of ODS. It came into force in 1989.
- **Key features**
 1. It required all parties to eliminate the production and import of nearly 100 substances that deplete the ozone layer, in accordance with agreed timelines.
 2. Special provisions for developing countries -> grace period of 10-15 years.
 3. Multilateral funds - a financial mechanism to help qualifying developing countries to phase out their consumption of ozone depleting substances.
 4. It required parties to report annually on production, import and export of ODSS.
 5. Precludes parties from trading ozone-depleting substances with non-parties.
 6. Requires regular assessments to enable parties to make informed decisions with the most up to date information.
- **Chemicals covered**
 - The Montreal protocol controls nearly 100 chemicals, grouped in the following categories:
 - CFCs
 - Halons
 - Carbon tetrachloride (CTC)
 - HCFC
 - Methyl Chloroform
 - Methyl Bromide

- It has been ratified by 197 parties making it first and only universally ratified protocol in UN history.
- **Impact of Montreal Protocol**
 - It has also been a highly successful international arrangement, as it has phased-out more than 98% of the ODS which was part of its main mandate by 2021. The remaining ODS are HCFCs which are in the process of being phased out.
- **What has India done under the Montreal Protocol**
 - India has already phased out CFCs, and CTC.
 - In Jan 2020, India also achieved complete phaseout of Hydrochlorofluorocarbon (HCFC)-141 b, which is a chemical used by foam manufacturing enterprise and is one of the most potent ODS after CFCs.
 - It is mainly used as a blowing agent in the production of rigid polyurethane (PU) foams.
 - Currently India is engaged in the phase-out of production and consumption of other Hydrochlorofluorocarbons (HCFCs) with an accelerated phase out schedule as per the Montreal Protocol.
 - India's current plan will result in 60 percent phase out of HCFCs by Jan 1, 2023.

C) KIGALI AMENDMENT TO MONTREAL PROTOCOL

- **About Kigali Agreement to Montreal Protocol.**
 - During the 28th Meeting of Parties (MoP) of the Montreal Protocol in 2016, Kigali Agreement was finalized.
 - Kigali agreement refers to an amendment to the 1989 Montreal Protocol to eliminate planet-warming HFC gases.
 - » It calls for phasing-out of HFCs, a set of 19 gases in Hydrofluorocarbon family that are used extensively in air-conditioning and refrigerant industry.
 - These gases are not ozone depleting but are thousands of times more dangerous than carbon dioxide in causing global warming.
 - Currently, they may have a small contribution in global warming, but with increase in the use of Air-Conditioning and Refrigeration, its contribution will be huge. Some estimates show that if the growth in the use of HFCs continue at the current rate, their contribution to global warming may reach 19% by 2050.
 - » **Why put the target in Montreal Protocol and not UNFCCC?**
 - Montreal Protocol is much more successful than the UNFCCC and have fairly good track record in controlling various kinds of emissions.
 - **Legally binding commitments**
 - » Rich and industrialized countries bring down their HFC production and consumption by at least 85 percent by 2036 compared to their annual average values in the period 2011-13 starting from 2019.
 - » A group of developing countries (more than 100) including China, Brazil and South Africa are mandated to reduce their HFC use by 80 percent of their average value in 2020-22 by the year 2045 starting from 2024.

- » India and some other developing countries - Iran, Iraq, Pakistan, and some oil economies like Saudi Arabia and Kuwait - will cut down their HFCs by 85 percent of their values in 2024-26 by the year 2047 starting from 2028.

- **The Parties to the amendment agreed to provide financing for HFCs reduction**
- **Significance:**
 - Fight Climate Change; CBDR to ensure developmental needs of countries like India; Target approach to better monitor progress
- **India's decision to ratify the Kigali Amendment (Aug 2021)**
 - Union Cabinet has decided to ratify the Kigali agreement. It comes close on the heels of similar decisions by the USA, and China - the world's largest producers and consumers of HFCs.
 - India has also announced that it will draw up a national strategy for phase-down of HFCs by the year 2023 in "consultation with all industry stakeholders". India will also amend the existing domestic laws that govern the implementation of the Montreal Protocol by the middle of 2024 to facilitate the HFC phase-down.
 - **Note-1:** India's reductions have to begin only after 2028
 - **Note-2:** By July 2021, **122 countries have ratified** the Kigali Agreement.



TARGET PRELIMS 2024

BOOKLET-17; EB&CC-7

BIODIVERSITY-BASICS; IMPORTANT MAMMALS

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2. BIODIVERSITY-BASICS

1) DEFINITION

- Biodiversity is the term popularized by the socio-biologist **Edward Wilson** to describe the **combined diversity at all levels of biological organization**.
- Biodiversity is defined as '**the variability among living organisms from all sources**, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; **this include diversity within species, between species and of ecosystems**'. (UN Earth Summit).

2) HOW IS BIODIVERSITY DISTRIBUTED ON EARTH?

- The **vast majority** of all species are found in the **tropics, and subtropics**, where most of the developing countries are also located. Infact, **50-75%** of all species are found in **tropical rainforests** that account for just **6% of the land areas**.
 - The **genetic diversity needed to maintain the world's agricultural system** is found **mainly in tropics, and sub-tropics**. These areas also contain **most of the important medicinal plants from which new pharmaceutical products are extracted**.
 - In the **northern regions, the recurrent ice ages did not permit the flowering of many life forms**.
- **Variation with altitude:** In general biodiversity **increases with altitude until a certain threshold** and **then decreases**. This is due to environmental factors such as temperature, air pressure, and precipitation.
 - **Many mountain ecosystems show greater biodiversity and higher levels of endemism than adjacent lowlands.**
 - **Mountain at lower altitudes can support exceptional biodiversity, due to compression of a wide range of ecosystems into a relatively short distance.** Mountains also often provide **islands of suitable habitat**, isolated from unfavourable surrounding lowlands.
 - **Humboldt's Enigma:**
 - » **Background:** Conventionally, it was understood that **biodiversity will be highest around the equator, in tropics, as this region has higher primary productivity as it receives the highest sunlight (energy)**. As one moves away from equator biodiversity decreases. **Tropical rainforests** thus hold the crown for species richness.
 - **Humboldt's Observation:** Alexander von Humboldt, a German naturalist, during his extensive travels through South America in the early 19th century, noticed something intriguing. **Mountain ranges**, despite occupying relatively small areas compared to vast tropical forests, displayed exceptionally diverse plants and animal life. This stood in stark **contrast to the predicted decrease in higher latitudes**.
 - » Two centuries later, **group of bio-geographers** - scientists who explore the relationship of diversity with geography - used modern tools to take another look at the drivers of

biodiversity. Based on their findings, they proposed their own version of the link between biodiversity and mountains and called it **Humboldt's enigma**.

» **Examples of Humboldt's enigma in India:**

- **Eastern Himalayas:** These are the second-most diverse area of perching birds in the world. For river birds, the eastern Himalayas may be the most diverse.

▫ **Reasons for the Enigma:**

- » **Compression of a wide range of ecosystem into relative short distance:** Mountains boast diverse landscapes with varied terrain, elevation, and microclimates. This creates a mosaic of distinct habitats, fostering speciation and niche adaptation among organisms.
- » **Geological Process like Uplifts,** result in new habitats where new species arise, so the habitats are 'cradles'.
- » **Climatic Stability:** Some climatologically stable mountains persist there for a long time, so these spots are 'museum' that accumulate many such species over time.
 - This provides refuge and protection to species during changing environment and thus aids biodiversity.
- » **Unique Resources:** Mountains have resources like nutrient rich volcanic soils and unique water regimes which gives sustenance for specialized species.

▫ **E.g.:**

- » **Coastal Tropical Sky Islands** (mountain surrounded by lowlands), like the Shola Sky Islands in the Western Ghats, are good examples of 'museum'. Here old lineage has persisted on the mountains tops as climates and habitats fluctuated around them in lower elevations. This is the reason, some of the oldest bird species in the western ghats, such as the **Sholicola**, and the **Montecincla**, are housed on the Shola Skey Islands.
- » The **Northern Andes Range** - including **Chimborazo** - is considered the most biodiverse place in the world. If we start from the foothills of the Andes and climb, we're going to counter different temperature and rainfall levels that support everything from **tropical evergreen biomes in the lower elevation to the alpine and tundra biomes near the top**. Such a large variation over short distances supports the immense biodiversity found in mountain regions - and worldwide.

3) MEGA DIVERSE COUNTRIES

- The megadiverse country is a term used to refer to the world's top biodiversity-rich countries. These were identified in 1988 by **Conservation International (CI)**, to promote the awareness for biodiversity conservation among world nations. According to CI, there are 17 of these nations, which are mostly located in the tropical and subtropical region.
- **Criteria**
 - The principle criterion is **endemism**, first at the species level and then at higher taxonomic levels such as genus and family. To qualify as a Megadiverse Country, a country must:
 - i. Have at least 5,000 of the world's plants as endemics (native restricted to a certain place)
 - ii. Have marine ecosystem within its border.

- Purpose of this classification [Raises awareness about biodiversity conservation; complements biodiversity hotspots and HBWA in protection of biodiversity; Demonstrates how a few countries hold a large portion of global biodiversity and therefore have disproportionate political responsibility]

List of 17 megadiverse countries according the conservation international:

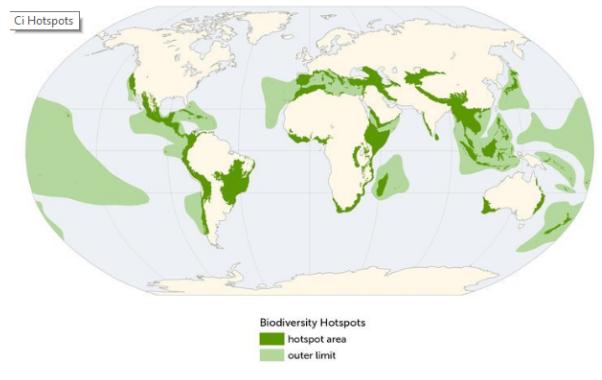
- USA
- Mexico
- Brazil
- Venezuela
- Colombia
- Ecuador
- Peru
- Democratic Republic of Congo
- South Africa
- Madagascar
- India
- China
- Malaysia
- Indonesia
- Philippines
- Papua New Guinea
- Australia



LevelUpIAS

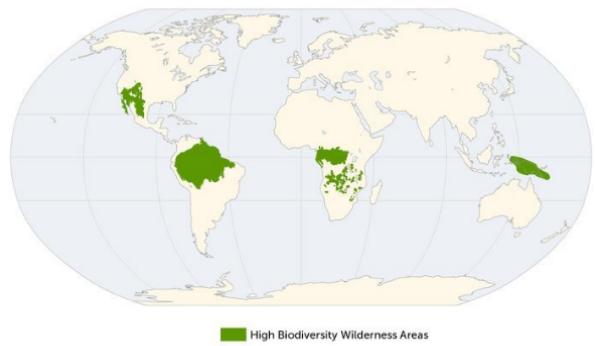
4) BIODIVERSITY HOTSPOTS

- Biodiversity hotspots are **regions containing exceptional concentrations of plant endemism and experiencing high rates of habitat loss.**
- Of the total 35/36 globally identified biodiversity hotspots India has 4 of them i.e. **Eastern Himalayas**, Nepal, India; **Indo-Burma**, India and Myanmar, **Western Ghats**, India; **Sundaland**s: include Nicobar group of islands (and Indonesia, Malaysia, Singapore, Brunei and Philippines)
- Norman Meyers wrote about the concept in two articles in "The Environmentalist" (1988) & (1990)
- **Description:** Biodiversity hotspots are a method to identify those regions of the world where attention is needed to address biodiversity loss and to guide investment in conservation.
- To qualify as a biodiversity hotspot on Meyers 2000 edition of the hotspot-map, a region must meet **two strict criteria**
 - i. **Plant Endemism:** It must contain at least 0.5% of the world's total or 1500 species of vascular plants as endemics.
 - ii. **Serious Habitat Loss :** It has to have lost at least 70% of its primary vegetation.
- Around the world 36 areas qualify under this definition, with some other possible candidates.
- Supported by Conservation International



5) HIGH BIODIVERSITY WILDERNESS AREA

- The large intact ecosystems of the world that hold significant levels of global biodiversity.
- Approach developed by **Conservation International**.
- HBWAs consist of 5 of the 24 major wilderness areas that hold globally significant levels of biodiversity.
- The 5 HBWAs are Amazonia, the Congo forest of Central Africa, New Guinea, the Miombo-Mopane woodlands of Southern Africa (including the Okvango delta), Northern American desert complex of northern Mexico and South Western part of USA.
- In the **past**, the HBWAs were mostly considered to have 'low vulnerability' because of their low level of past habitat loss. However, recent analysis suggests that the high cultivation potential of many HBWAs makes them a target for future agri-expansion.



6) THREE LEVELS OF BIODIVERSITY

a. Genetic diversity

- Genetic diversity refers to variety at the level of genes. It consists of variation of genes in a particular species.
- Significance of genetic diversity
 - High Genetic Diversity -> Higher Adaptability -> Higher chance of survival
- **E.g.**
 - India has more than 50,000 genetically different strains of rice, and 1,000 varieties of mangoes.
- **E.g. of low genetic diversity :**
 - Only one species of Asiatic Cheetah survives in the world today and due to **inbreeding**, this species has lost genetic diversity.
 - Hence Cheetahs are prone to genetic disorders and low reproductive success.
 - Koalas in Europe

b. Species diversity

- Diversity at the species level.
- Species diversity refers to variety of plants and animals' species present in a community or ecosystem.
- Species differ from one another, markedly in their **genetic makeup, do-not interbreed in nature**.
- Closely-related species however have in common much of their hereditary characteristics. For instance, about 98.4% of the genes of humans and chimpanzees are the same.
- It is the **ratio of one species population over total number of organisms across all species in the given biome**.
 - 'Zero' would be infinite diversity, and 'one' represents only one species present.
- For e.g.
 - Western Ghats have greater amphibian species diversity than the Eastern Ghats.

- **Species diversity is high in:**
 - Tropical rain forests
 - Coastal zones

- **Species diversity is low in:**
 - Small isolated islands
 - Polar regions

c. Ecosystem Community Diversity (Ecological Diversity)

- Ecosystem diversity refers to **variety of ecosystems** found in a given area or region.
- This refers to the **different type of habitats**. A habitat is the cumulative factor of the climate, vegetation and geography of a region.
- There are several kinds of habitats around the world. **Corals, grasslands, wetlands, desert, mangrove and tropical rain forests are example of ecosystems.**
- As the environment changes, species best adapted to that environment becomes predominant. **Thus, the variety of diversity of species in the ecosystem is influenced by the nature of the ecosystem.**
- E.g.
 - **India** with its deserts, rain forests, mangroves, coral reefs, wetlands, estuaries, and alpine meadows has **a greater ecosystem diversity than a Scandinavian country like Norway.**

7) FACTORS WHICH DETERMINE THE DEGREE OF DIVERSITY

- **Habitat stress:** Diversity is low in habitats under any stress like **harsh climate or pollution**
- **Geographical isolation:** Diversity is **less in isolated regions** like an island. If a species in an island disappears, it can't be easily replaced.
- **Dominance by one species:** The dominant species **consumes a disproportionate share of the resources**. This does not allow many species to evolve and flourish.
- **Availability of ecological niches:** A **complex community offers a greater variety of niches** than a simple community and promotes greater diversity.
- **Edge Effect:** Always **greater diversity at ecotones** or transition areas between ecosystem.
- **Geological history:** **Old and stable ecosystems like rain forests** that have not experienced many changes have high diversity. **An ecosystem like the Arctic has undergone many changes and this does not allow species to establish themselves.**

8) SIGNIFICANCE OF BIODIVERSITY

A) BIODIVERSITY AND FOOD SECURITY

- Biodiversity is the **cornerstone of healthy and sustainable food system**.
 - » It plays a role in **protecting pollinators; improving soil fertility; and building resilience of food system to the effects of climate change**. It is thus **crucial for fighting global hunger**.

B) BIODIVERSITY PROVIDES A NUMBER OF NATURAL SERVICES FOR HUMANS

- a. **Ecosystem Services**
 - Protection of water resources

- Soil formation and protection
- Nutrient storage and recycling
- Pollution breakdown and absorption
- Contribution to climate stability
- Maintenance of ecosystem
- Recovery from Unpredictable events

b. Biodiversity Services

- Food
- Wood Products
- Ornamental Plants
- Medicinal resources and pharmaceutical drugs
- Breeding stocks, population reservoirs
- Future resources
- Diversity in genes, species and ecosystems

c. Social Services

- Research, education and monitoring
- Recreation and tourism
- Cultural values

9) ENDEMIC SPECIES

- An endemic species is found only in a specific geographical location, and not found anywhere else. A species may be native to an area, but is not endemic to that area, if it is found elsewhere too.
 - For e.g., the **Lion-tailed macaque** (*Macaca silenus*), and the **Nilgiri Langur** are endemic to the **western Ghats of India**.

10) KEYSTONE SPECIES

- Keystone species are those species which have disproportionately large effect on the communities in which it occurs. It plays an essential role in the structure, functioning in fact, it determines the ability of a large number of species in the community to survive.
- When a keystone species disappears, it could result in a series of extinction of other species.
 - **E.g. 1:** An example is the **wild durian**, a tree endemic to the western Ghats.
 - Its fruits attract insects and birds come in to eat insects. Reptiles consume both insects and birds. The tree is also the habitat of monkeys, which eat the fruits, leaves and insects. Even tigers may come to eat the animals that are attracted by all the food in the tree ecosystem.
 - **If the wild durian tree is removed from the ecosystem, many of the species will be adversely affected and some may disappear.**
 - **E.g. 2: Wolves**

- If wolves go extinct in an ecosystem, the population of deer and other herbivores will increase exponentially. Due to excessive grazing by the herbivores, many plants may go extinct. Then, the small animals and insects that feed on the plants may disappear.

11) INDICATOR SPECIES

- Indicator species is one whose presence, absence, or abundance reflects a specific environmental condition. They are very **sensitive indicators of environmental problems**. They give early warning of problems that could potentially affect other species. They are also called sentinel species.
 - E.g. **Lichen**, which is sensitive to the presence of heavy metals or acids in rain. Its behaviour may indicate that acid rain is falling in the area.
 - Lichens are mutualistic association of fungus and algae or cyanobacterium and occurs as a crusty patch or bushy growths on trees, rocks and bare grounds.
 - Lichens are very sensitive to SO₂ pollution and since industrial revolution a number of their population have become extinct. **So, if air is badly polluted by SO₂, no lichens may be present.**
- Top predators like tigers and snow leopards** are also indicator species. Their presence indicates that entire ecosystem is healthy.
- Frogs and other amphibians** may also be indicator species

12) FLAGSHIP SPECIES

- A flagship species is a species selected to act as an ambassador, icon or symbol for a defined habitat, issue, campaign or environmental cause. It is chosen to raise support for biodiversity conservation in a chosen place or context. These species have the ability to capture the imagination of public and induce people to support conservation action and/or to donate funds.
- By focusing on, and achieving conservation of that species, the status of many other species which share its habitat - or are vulnerable to the same threats - may be improved.
- They are usually relatively large and considered to be **charismatic** in western countries.
- They may or may not be keystone species and may or may not be good indicators of biological process.
- E.g.
 - Bengal Tiger**
 - Jerdon's Courser (a CR bird found only in Andhra Pradesh)
- Some limitations**
 - May skew the management and conservation priorities in their favour and to detriment of more threatened species.
 - The disappearance of the flagship can have negative impact on the attitude of conservation stakeholders.

13) PRIORITY SPECIES

- It is a **WWF** term which is solely for the purpose of planning and simple communication.

- For WWF, a priority species may be either a **flagship specie** or a **keystone specie** and is chosen to represent an ecoregion or region.
- A priority species is **reflective of a key threat** across that eco-region - such that **conservation of the species will contribute significantly to a broader threat mitigation outcome**. It is often crucial to the economic and/or spiritual well-being of people within that eco-region.
 - **Note:** World Wide Fund for Nature was originally called World Wildlife Fund (WWF), a term which is still used in Canada and USA. It is an international NGO founded in 1961 working in the field of biodiversity preservation and the reduction of human impact on environment.
- **WWF Priority species of India**
 - Asian Elephant (EN)
 - Bengal Tiger (EN)
 - One-horned Rhino (VU)
 - Ganges River Dolphin
 - Snow Leopard
 - Red Panda

14) INVASIVE SPECIES

- **Introduction:**
 - **An alien** plant/animal also referred to as exotic, introduced, foreign etc. is one that has been introduced by humans intentionally or otherwise through human agency or accidentally from one region to another.
 - An alien plant/animal that has escaped from its original ecosystem and is reproducing at its own in the regional flora is considered a **naturalized species**.
 - Those naturalized aliens that become **so successful as to spread in the flora/fauna and displace native biota or threaten valued environmental, agricultural or personal resources** by the damage it causes are considered **invasive**.
 - **To be called invasive, it should also be a threat** to the native species of the area by rapidly growing in population. This happens when the invasive species has no predator in the area.

A) ASSESSMENT REPORT ON INVASIVE ALIEN SPECIES AND THEIR CONTROL: BY INTERGOVERNMENTAL PLATFORM ON BIODIVERSITY AND ECOSYSTEM SERVICES (IPBES)

- Human beings have introduced 37,000 alien species, including plants and animals. Of these 3,500 are invasive alien species that have played a key role in 60% of global plant and animal extinction recorded.
- The report has noted that the number of alien species (species introduced to new regions through human activities) has been rising continuously for centuries. But now, they are rising at unprecedented rate, with increased human travel, trade and expansion of global economy.
- **E.g.:**
 - » **Water Hyacinth** is the world's most widespread invasive alien species on land.
 - » **Lantana**, a flowering shrub, and the **black rat** are the second and third most widespread globally.
- Invasive alien species are one of the five major direct drivers of biodiversity loss globally, alongside land and sea use change, direct exploitation of organisms, climate change, and pollution.

B) EXAMPLE OF INVASIVE SPECIES

DOMESTICATED CATS (*FELIS CATUS*):

- The State of Indian Birds, 2023 have highlighted that cats are a silent bird killer lurking in India's urban areas. SO along with other threats like industrialization, forest degradation, and climate change, climate change is also a threat for birds in India.
- **But**, detailed studies are lacking in India. In the USA, where detailed studies have been done, it is estimated that free ranging domestic cats kill billions of birds every year.
 - One study says that cats may be the single greatest source of anthropogenic mortality for the birds and mammals in the USA.
- **Worldwide**, free ranging domestic cats have caused or contributed to dozens of extinctions of birds species recorded in the IUCN red list.
- **Cats are more dangerous than free ranging dogs:**
 - As they can climb easily and thus reach the bird habitat.
 - Cat saliva is also more likely to contain bacteria (*Pasteurella multocida*) that are lethal to birds. So, if the cat attack doesn't kill the bird, the bacteria does.
 - Cats also maintain a landscape of fear making birds avoid or nesting in these regions.
- **Origin of Domestic Cats:**
 - **Domestic Cats (*Felis catus*)** are the only domesticated species in the family **Felidae**.
 - Studies show that Wild Cats (*Felis sylvestris*) were probably first domesticated in West Asia around 10,000 years ago and since then they have spread to different parts of the world.
 - Today, they are one of the world's 100 worst invasive alien species.
- **Handling Domestic Cats:**
 - A popular method in the West has been **Trap-Neuter-Return (TNR) policy**, whereby stray dogs and cats are trapped, sterilized and returned in the hope that this will reduce their population. But this hasn't been very successful.

RABBITS IN AUSTRALIA

AFRICAN CATFISH:

- The fish species is not native to India and is originally found in Africa and the middle east.
- It is known to be aggressive feeder, eating even the chicks of waterfowl. It poses a **major threat to native fauna**.
- The female matures in about 3 years and can bear 10s of thousands of eggs.
- The species has now spread to subcontinent and is found in Cauvery, Ganga, Yamuna and even the streams of western Ghats.
- This was introduced by businessmen for commercial fish cultivation in the National Park as it could adapt to poor quality of water, raised in high densities, and reproduce well in captivity, making it ideal for those looking to sell the fish for food. Though, **the cultivation of this specie was banned by Agriculture Ministry in 2000 itself**.

RED EARED SLIDER TURTLE IN NORTH-EAST INDIA

» This is a cute American turtle popular as a pet. But it is threatening to invade the natural water bodies across the northeast, home to 21 of the 29 vulnerable native Indian species of freshwater turtles and tortoises.

CARIBBEAN FALSE MUSSEL (*MYTILOPSIS SALlei*):

Origin: The Caribbean false mussel is originally from the Atlantic and Pacific coast of South and Central America. They may have travelled to Indian subcontinent via ships (ballast water) and then using small vessels spread to estuaries.

Damage: It is damaging locally important fishery in Kerala, by wiping out native clams and oysters.



ACHATINA FULICA (AFRICAN APPLE SNAIL)

The snail (a mollusk) is native to coastal areas and islands of east Africa.

It is invasive species across the world. It has a broad diet preference and cause heavy loss to farmers.

In India, it is **most invasive of all faunas**.

Most invasive of all fauna

It was first reported in A&N island but today it is found all across the country and is threatening habitats of several native species.



C) IN 2017, ZOOLOGICAL SURVEY OF INDIA (ZSI) HAS FOR THE FIRST TIME COME UP WITH LIST OF 157 ALIEN INVASIVE SPECIES IN INDIA

- While invasive plant species have been studied in the past, the **animal species was analysed in detail for the first time**. Invasive animal species like the plant species pose threat to biodiversity.
- **Key Highlights**
 - i. Of the **157 species** 58 are found on land and the remaining 99 in Marine ecosystem.
 - ii. Of the 58 invasive species on land, 38 are arthropods, 19 of fish, three of Mollusks and birds, one reptile and two mammals.
- **Examples of Alien species found on Land** (including rivers)
 - i. **Paracoccus Marginatus (Papaya Mealy Bug)**
 - Destroyed crops of Papaya in Assam, WB and TN.

- Originally from Mexico and Central America
- ii. **Phenacoccus Solenopsis (Cotton Mealybug)**
 - Severely affected cotton crops of deccan
 - Native to North America.
- iii. **Invasive Fish Species**
 - **Pterygoplichthys pardalis** (Amaxon sailfin Catfish)
 - Destroying fish population in wetlands of Kolkata.
- **Examples of Alien Species found in Marine Ecosystem**
 - i. **Tubastrea Coccinea** (Orange Cup- Coral)
 - Originated in Indo-east-pacific but has now been reported in the A&N Islands, the Gulf of Kutch, Kerala, and Lakshadweep.

15) SPECIATION

- Speciation refers to formation of new species due to genetic changes in an existing species. Speciation occurs when a group within a species separates from other members of its species and develops its own characteristics. In the process of a species adapting itself to changing environmental conditions, a new species may emerge.
- **There are five types of speciation:**
 - **Allopatric Speciation:** It occurs when a species separates into two separate groups which are isolated from one another. A Physical barrier, such as mountain ranges or a waterway, makes it impossible to breed with one another. Each species develops differently, based on the demand of their unique habitat or the genetic characteristics of the group that are passed to the offsprings.
 - **For e.g.:**
 - Four distinct sub-species of the Asian elephant probably emerged due to allopatric speciation.
 - Squirrels and other small mammals on the two sides of Grand Canyons
 - **Peripatric Speciation:** When small group of individuals break off from the larger group and form a new species. This is called peripatric speciation. Like allopatric speciation, here also, physical barriers make it impossible for members of the group to interbreed with one another.
 - **Main difference** between Allopatric Speciation and peripatric Speciation is that in peripatric speciation, one group is much smaller than the other.
 - **Parapatric Speciation:** In this method, a species is spread over large geographical area. Although, it is possible for any member of the species to mate with another member, individual only mate with those in their own geographical region. Like allopatric and peripatric speciation, different habitats influence the development of different species in parapatric speciation. **Instead of being separated by a physical barrier**, the species are **separated by differences in the same environment**.
 - **Sympatric Speciation:** It is controversial. Some scientists don't believe that it exists. It occurs when there are no physical barriers preventing any members of species from mating with

another, and all the members are in close proximity to one another. A new species, perhaps based on a different food source or characteristic, seems to develop spontaneously. The theory is that some individuals become dependent on certain aspects of environment - such as shelter or food source, while others don't.

- For e.g., the parasitic great spotted cuckoo, and its magpie host, both native to southern Europe, are considered to be sympatric species.
- **Artificial Speciation:** It is creation of new species by people. This is achieved through lab experiments, where scientists mostly research insects like fruit flies.

16) MEASUREMENT OF BIODIVERSITY

- **Diversity is a single statistic** in which the number of species richness and evenness are compounded. Biodiversity is measured in two components:
 - Species Richness
 - Species Evenness
- **Species Richness**
 - It is the measure of number of species found in a community
 - **Alpha Diversity**
 - The diversity within a particular area or ecosystem and is usually expressed by the number of species (i.e., species richness) in that system.
 - **Beta Diversity**
 - It represents **differences in species composition among sites (ecosystem)**.
 - It is something of a bridge from local (alpha) to the regional (gamma) scale.
 - It can be considered a metric of dissimilarities between sites.
 - It can also be interpreted as rate of accumulation of diversity with an increasing number of sites sampled.
 - In simple terms it is ratio between gamma (regional) and alpha(local) diversities.
 - **Gamma Diversity**
 - It is the measure of **diversity of the entire landscape** (regional species pool).
- **Species Evenness**
 - It measures the proportion of species at a given site, e.g. low evenness indicates that only few species dominate the site.

17) CLASSIFICATION OF LIFE FORMS

- **Kingdom** (Monera, Protista, Fungi, Plantae, Animalia)
- **Phylum** (For animals) / **Division** (for plants)
 - **Class**
 - **Order**
 - **Family**
 - **Genus**
 - **Species**

E.g. For tiger

Kingdom: Animalia
Phylum: Chordata
Class: Mammalia
Order: Carnivora
Family: Felidae
Genus: Panthera
Species: P. Tigris

E.g. For Humans

Kingdom: Animalia
Phylum: Chordata
Class: Mammalia
Order: Primates
Family: Hominidae

- Members of this family are known as great apes or hominids. Currently it consist of four genera.
 - **Pongo** (Bornean, Sumtran, and Tapanuli Orangutan); **Gorilla** (the eastern and western Gorilla); **Pan** (the Chimpanzee and the bonobo); and **Homo** (of which only Homo Sapiens remain)

Genus: Homo

Species: H. sapiens

3. IUCN CLASSIFICATION

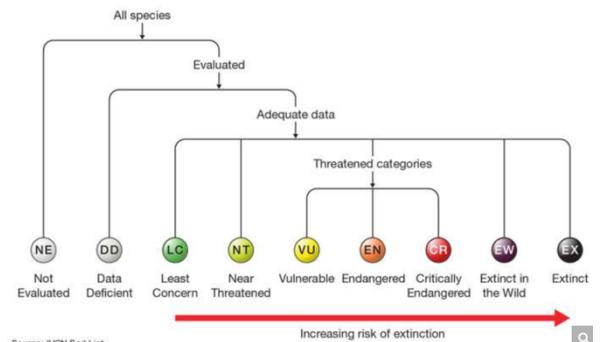
1) THE RED DATA BOOK

- Species judged as threatened are listed by various agencies as well as by some private organizations. The most cited of these lists is the Red Data Book.
- It's a loose-leaf volume of information on the status of many kinds of species. This volume is continuously updated and is issued by International Union for Conservation of Nature (IUCN) located in Merges, Switzerland.
- The red data book was **first issued in 1966** by the IUCN's special Survival Commission as a guide for information, preservation and management of species listed. In this book, information for endangered mammals and birds are more extensive than for other groups of animals and plants, coverage is also given to less prominent organisms facing extinction.
- "Red" of course is symbolic of danger that species both plants and animals presently experience throughout the globe.
 - **The Pink page** in this publication include the critically endangered species. As the status of the species change, new pages are sent to the subscribers.

- **Green pages** are used for those species that were formerly endangered, but have now recovered to a point where they are no longer threatened. With passing time the number of pink pages continue to increase. There are pitifully few green pages.

2) DETAILS ABOUT IUCN

- IUCN is a membership union composed of both government and civil society organizations.
 - It harnesses the experience, resources, and reach of its more than 1,400 member organizations.
 - It is a **democratic union** that brings together the world's most influential organizations and top experts in a combined effort to conserve nature and accelerate the transition to sustainable development.



- The **Red Databook** of IUCN is the most cited list of threatened species.
 - It classifies the **conservation status** of individual species based on their probability of extinction.

3) IUCN DATABASE OF CONSERVATION PRIORITY

1. **Extinct (EX):** A taxon is extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual.
 2. **Extinct in Wild (EW):** A taxon is extinct in wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed extinct in wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual.
 3. **Critically Endangered (CR):** A taxon is critically endangered when the best available evidence indicates that it meets any of the criteria for critically endangered.

- Criteria

A. Reduction in population size

- (>=90% over the last 10 years or three generations, whichever is longer), where the causes of reduction is clearly reversible AND understood AND ceased.
 - (>= 80% over the last 10 years of three generations, whichever is longer), where the causes of reduction may not have ceased to exist OR may not be understood OR may not be reversible
 - (>=80%, projected or suspected to be met within the next 10 years or three generations, whichever is longer (upto a maximum of 100 years)
 - An observed **estimated inferred**, projected or suspected population size reduction of >= 80% over any 10 year or three generation period, whichever is longer (upto a maximum of 100 years in future), where the time period must include **both the past and the future**, and where the reduction and its causes may not have ceased OR may not be understood OR may not be reversible.

B. Geographical Range in the form of either B1 (**extent of occurrence**) OR B2 (**area of occupancy**) OR both:

- **Extent of occurrence** estimated to be less than 100 Km², and estimate indicating atleast two of the following
 - Severely fragmented or known to exist only at a single location
 - Continuing decline
 - Extent of occurrence
 - Area of occupancy
 - Area, extent and/or quality of habitat
 - Number of locations and subpopulations
 - Number of mature individuals
 - Extreme fluctuation in any of the following
 - Extent of occurrence
 - Area of occupancy
 - Number of locations or subpopulations
 - Number of mature individuals
- **Area of Occupancy** estimated to be less than 10 Km², and at least 2 of the following
 - Same three criteria as above (extent of occurrence)

C. Population size estimated to number fewer than 250 mature individuals and either

- An estimated continuing decline of 25% within three years or one generation, whichever is longer,(upto a maximum of 100 years in future)
- A continuing decline, of mature individuals AND atleast one of the following
 - Population structure in the form of one of the following
 - No subpopulation estimated to contain more than 50 mature individuals, OR
 - Atleast 90% of mature individuals in one subpopulation
 - Extreme fluctuation in number of mature individuals

D. Population size (number less than 50 mature individuals)

E. Quantitative analysis showing the **probability of extinction** in wild at least 50% in their 10 years or three generations, whichever is longer(upto maximum 100 years)

4. **Endangered**

5. **Vulnerable (VU)**

6. **Near Threatened (NT)**

- A taxon is near threatened when it has been evaluated against the criteria but does not qualify for CR, EN, VU now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

7. **Least Concern (LC)**

- A taxon is least concern when it has been evaluated against the criteria and does not qualify for CR, EN, VU, or NT. Widespread and abundant taxa are included in this category.

8. **Data Deficient (DD)**

- A taxon is DD when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution or population status. Appropriate data on abundance and/or distribution is lacking. Not a category of threat.
- Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate.

9. Not Evaluated (NE)

- When it has not yet been evaluated against the criteria.

4) IUCN HAS RELEASED THEIR NEW RED LIST OF THREATENED SPECIES DURING UNFCCC COP28 IN DEC 2023

- Over 44,000 species are threatened with extinction (around 2,000 more than last year) of the total 157,190 species in the IUCN Red List.
- The update includes the First Broad Assessment of the health of freshwater fish species. Around 25% of the species (around 3,000) are facing risk of extinction.
 - » Climate change, pollution, overfishing and invasive species are the major challenge.
- Atlantic Salmon (a ray-finned species) found in northern Atlantic Ocean Basin has declined by 23% (2006-2020) thus moving it to Near Threatened (from LC)
- Green Turtles (of Central South Pacific and East Pacific) populations are respectively Endangered and Vulnerable.
- Mahogany Tree (*Swietenia macrophylla*), also known as Honduran Mahogany or big leaf mahogany, has become Endangered.
 - » It is one of the species that yields genuine mahogany timber.
 - » It is native to South America, Central America and Mexico. It is also naturalized in Phillipines, Singapore, Malaysia and Hawaii and is cultivated in plantations and windbreak elsewhere.
 - » Note: *Swietenia mahogani*, is another species which is also found in India and is NT
- Some Success Stories:

Scimitar-horned oryx: It has moved from EW to EN showcasing the reintroduction efforts the republic of Chad.



Saiga Antelope improves from CR to NT due to conservation measures. In past it inhabited a vast area of Eurasian Steppe. Today, it is only found in Russia, Mongolia, Kazakhstan, Turkmenistan, Uzbekistan etc. **Key Feature:** Unusual hanging nose.



A male at the Steppnoi Nature Sanctuary of Astrakhan Oblast, Russia



A female at the Askania-Nova Biosphere Reserve of Kakhovka Raion, Ukraine

5) NATIONAL ENDANGERED SPECIES DAY

- The National Endangered Species Day is celebrated on the **third Friday of May every year** across the USA. It was established by the US Senate, in 2006.
- **2023 Theme:** "Celebrating 50th anniversary of endangered species act".
Note: In USA, the Endangered Species Act was enacted in 1973.

4. MAMMALS – EXTINCT

1) ASIATIC CHEETAH (EXTINCT IN INDIA)

- **IUCN Status of Asiatic Cheetah**
 - **CR** in Iran (Iran has a subspecies of Asiatic Cheetah, but has refused to share it with India)
 - **EX** in India.
 - It is the only large carnivore that got wiped out of India, mainly due to over-hunting and habitat loss.
 - The last **physical evidence** of Asiatic Cheetah in India was from Madhya Pradesh in 1947 when it was hunted by Maharaja Ramanuja Pratap Deo of Surguja State. A female is also said to have been sighted in **Koriya District** of Chhattisgarh, in 1951.
- **Why extinct?**
 - » Hunting (excessive from Mughal Era to British Period)
 - » Two key characteristics:
 - The Cat was very easy to tame. Therefore, it was regularly caught for sports.
 - It was nearly impossible to breed in captivity.
 - There is only 1 formally recorded instance of captive breeding in Emperor Jahangir's Tuzuk-i-Jahangiri.
 - » **Classification as Vermin** by Britishers in 19th century was the last nail in the coffin.

A) ACTION PLAN FOR INTRODUCTION OF CHEETAH IN INDIA: PROJECT CHEETAH

- Project Cheetah is the world's first inter-continental large wild carnivore translocation project. Under this there is a plan to introduce 50 African Cheetahs in various protected areas of India under 'Action Plan for Introduction of Cheetah in India'.
- **Goals of Reintroduction:**
 - » **Establish viable Cheetah metapopulation** in India that allows the Cheetahs to perform its functional role as a top predator and provide space for the expansion of the Cheetah within its historical range thereby contributing to its conservation efforts.
- **Reintroduction:**

- » **20 African Cheetah** have been imported so far.
 - **The first batch** of 8 Cheetah arrived in Sep 2022 from **Namibia**.
 - **Another batch** of 12 Cheetah arrived in Feb 2023 from South Africa.

- Now, Cheetah is the **sixth in the list of Big cats found in India** after **Royal Bengal Tiger (Panthera Tigris tigris)**, **Asiatic Lion (Panthera leo leo)**, **Indian Leopard (Panthera pardus fusca)**, **Snow Leopard (Panthera uncia)**, and **Clouded Leopard (Neofelis nebulosa)**.

- **Cheetahs were not directly released into wild:**
 - They were first kept in **quarantine for a month**. Then they are released into **large electronically fenced area** to get acclimatized. Finally, they were released into wild.

- **One Year of Project Cheetah (Sep 2023)**
 - **The Project** has achieved success on **four fronts**:
 - » **50% survival** of the introduced Cheetahs
 - » **Establishment of home ranges**
 - » **Birth of cubs in Kuno**
 - » **Increased tourism and revenue for local communities.**
 - **Yet**, as of Jan 2024, the **project lost 45% of its functional adult population**. Of the 20 Cheetahs that arrived in India, **7 died** (Dhatri, Shasha and Shaurya from Namibia and Suraj, Uday, Daksha, and Tejas from South Africa); 2 (Jwala and Nabha from Namibia) were deemed unfit for wild.
 - **Four cubs** were born in India March 2023, **three of which died** due to heatwaves, and the fourth is being raised in captivity.
 - **3 more cubs** were born in Jan 2024 to Namibian Cheetah **Aasha**. This was also born in captivity.
 - **3 more cubs were born** in Jan 2024 to **Namibian Cheetah Jwala**.
 - As of **16th Feb 2024**, there are **20 Cheetahs at Kuno Palpur** (13 adults (7 females, 6 males), 7 cubs)

- **Why so many deaths?**
 - **Different weather pattern** between home and host countries.
 - » The cheetahs introduced to India, were from **countries in southern hemisphere**, where the weather cycle is opposite.
 - » **Namibia and South Africa had much drier conditions** when compared to India. Namibian and south African Cheetah had **never experienced heavy rains** which they had to face in Kuno.
 - » **Collars** also became a problem. The Cheetahs were **unable to lick and clean their wounds** as the collars posed an obstruction which then gave rise to bacteria and maggots.
 - » For e.g. Dhatri died on 12th Aug 2023, because of **infection due to maggot infestation due to humidity**. Earlier, two male cheetahs had died of the same cause.
 - **Negligence** by authorities.

- **Steps being taken:**
 - Cheetahs **were brought back to enclosures** and were properly being monitored. Their collar has also been removed.
 - Experts suggest that **India may need to bring Cheetah from northern hemisphere** from countries like Somalia.
 - There is a **suggestion for developing much bigger habitats before bringing in more Cheetahs.**

- **Where are Cheetahs being reintroduced?**
 - They are being brought to Kuno Palpur National Park (KNP) in MP. This site was rated the highest among the 10 surveyed sites.
 - KNP is 748 sq km in area, devoid of human settlements.
 - It is probably the only wildlife site in the country where there has been a complete relocation of villages from inside the park. It forms part of Sheopur-Shivpuri deciduous open forest landscape and is estimated to have a capacity to sustain 21 cheetahs.
 - It also has good population of Chinkara, spotted deer, and blackbuck, on which Cheetahs can prey and grow in the wild.
 - Here facilities for the big cats have been developed, staff have been trained, and larger predators, such as leopards, have been moved away.
 - The **Other Sites** recommended for holding and conservation breeding of Cheetahs in India, in controlled conditions are:
 - i. Nauradehi Wildlife Sanctuary (1,197 sq. km, habitat 5,500 sq.km), Madhya Pradesh
 - ii. Gandhi Sagar Wildlife Sanctuary – Bhainsrorgarh Wildlife Sanctuary complex (~2500 sq.km), Madhya Pradesh
 - iii. Shahgarh bulge in Jaisalmer, Rajasthan (4,220 sq.km)
 - iv. Mukundara Tiger Reserve as fenced enclosure (~80 sq.km), Rajasthan
- **Where are Cheetahs coming from?**
 - Since, it is not possible to source the CR Asiatic Cheetah from IRAN without affecting this subspecies, India has sourced Cheetahs from Namibia and South Africa.
 - **African Cheetahs have other advantages** (why they are suitable for introduction in India)
 - They have maximum observed genetic diversity among extant cheetahs, an important attribute for a founding population stock.
 - They are also ancestral to all the other cheetah lineage including those found in Iran.
 - **Note:** Cheetahs being introduced are African Cheetah and Cheetahs which had gone extinct from India were Asiatic Cheetah and they are today found in small numbers only in Iran.
- **Background: Genesis of the Plan**
 - Cheetah reintroduction project was first conceived in 2009 and an expert panel formed in 2010 recommended KunoPalpur (MP), Velvadar National Park (Gujarat) and Tal Chappar Sanctuary (Rajasthan) for reintroducing Cheetah.
 - But the plans were quashed by the SC as it may have conflicted with reintroduction of Lions here.
 - After many hurdles, in Jan 2020, the SC had given the green signal to introduction of African Cheetah on pilot basis to a suitable habitat in India.

5. BIODIVERSITY IN INDIA: MAMMALS – CRITICALLY ENDANGERED

1) ANDAMAN WHITE TOOTHED SHREW (CROCIDURA ANDAMANENSIS), JENKIN'S ANDAMAN SPINY SHREW (CROCIDURA JENKINSI) AND NICOBAR WHITE TAILED SHREW

- Distribution

- Andaman White toothed shrew is found on Mount Harriet in the South Andaman Islands. It is endemic to South Andaman Island.
- Jenkin's Andaman Spiny Shrew is found on Wright Myo and Mount Harriet in the South Andaman Islands
- Nicobar White Tailed Shrew is found in the southern tip of Greater Nicobar Island and is also recorded in the area extending from the Campbell Bay National Park to the Galathea River in the Andaman and Nicobar Islands.



Andaman shrew



Extinct Threatened Least Concern
EX EW CR EN VU NT LC

Critically Endangered (IUCN 3.1)^[1]

- All three of them are endemic to India.

- They are usually active by twilight or in the night and have specialized habitat requirements.



Jenkin's shrew



Extinct Threatened Least Concern
EX EW CR EN VU NT LC

Critically Endangered (IUCN 3.1)^[1]

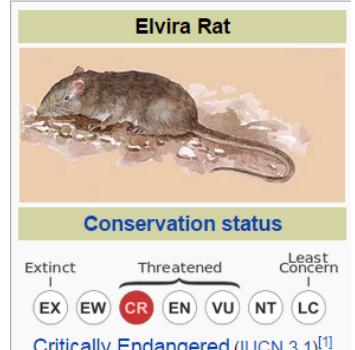
- Habitat: Leaf litter and rock crevices

- Threats : Habitat loss due to selective logging, natural disasters such as the tsunami and drastic weather changes.

- WPA: Schedule-2 (as amended in 2022)

2) THE LARGE ROCK RAT (ELVIRA RAT) (CREMNOMYS ELVIRA)

- It is a medium size, nocturnal and burrowing rodent, endemic to India.
- Habitat:** Tropical dry deciduous shrubland forest, seen in rocky areas.
Distribution: Known only from eastern Ghats of Tamil Nadu, India.
- Threats:** Major threats are habitat loss, conversion of forests and fuel wood collection.



Elvira Rat



Extinct Threatened Least Concern
EX EW CR EN VU NT LC

Critically Endangered (IUCN 3.1)^[1]

3) THE NAMDAPHA FLYING SQUIRREL (BISWAMOYOPTERUS BISWASI)

The Namdapha flying squirrel is an arboreal, nocturnal flying squirrel endemic to India.

It was sole in the genus Biswamoyopterus until the description of the Laotian giant flying squirrel (*Biswamoyopterus laoensis*) in 2013.

It was first recorded in 1981 where a single individual was found in Namdapha Tiger Reserve. After that it wasn't seen till 2022.

Updates: Missing for 42 years, Namdapha flying squirrel resurfaces in Arunachal (Dec 2023)

IUCN: CR

WPA: Schedule-1 (after 2022 amendment)



Habitat: Tropical forests

Distribution : It is now restricted to as single valley in the Namdapha N.P. (or) W.L.S. in Arunachal Pradesh.

Namdapha National park is the **largest protected area in the Eastern Himalayan Biodiversity hotspot** and is located in Arunachal Pradesh. It is also **one of the largest National Park in India in terms of area** (after hemis, desert, Simlipal and Gangotri)

Threats: It is CR due to habitat loss. In addition it is **hunted for food, and skins/fur.**



Note: Namdapha is home to another flying squirrel (Red Giant Flying Squirrel) (*Petaurista petaurista*), whose IUCN status is LC. Like other flying squirrels, Red Giant Flying Squirrel is also mostly nocturnal and is able to glide long distance between trees.

4) MALABAR CIVET (VIVERRA CIVETTINA) ALSO KNOWN AS MALABAR LARGE SPOTTED CIVET

- It is considered one of the world's rarest mammals. It is endemic to India and was first reported from Travancore, Kerala.
- Nocturnal in nature
- **Distribution:** Found exclusively in western Ghats.
- **Habitat :** Wooded plains and hill slopes of evergreen forests.
- **Threats :** Deforestation and commercial plantations are major threats.
- WPA (as amended in 2022): Schedule-1



5) HIMALYAN BROWN BEAR/ RED BEAR (URSUS ARCTOS ISABELLINUS)

- **Why in news?**
 - » A Himalayan brown bear (*Ursus arctos isabellinus*) as captured by J&K Wildlife Department on May 13, 2023, at Rajwara in the North Kashmir district of Handwara, days after it was found wrecking graveyards, reportedly in search of human cadavers to eat (June 2023: Source - DTE)

It is the largest animal in Himalayas and is usually reddish brown in color. They inhabit altitudes ranging from 2,000 to 2,500 metres, predominantly above the tree line.

It also shows sexual dimorphism (Males (1.5 - 2.2m), Females (1.37 - 1.83m)).

Distribution: Nepal, Pakistan, and Northern India. In Hemis National Park, Great Himalayan National Park, Nanda Devi Park -> this may be seen as the giant mammal walking upright.

IUCN Status: CR

Please note that IUCN status of Brown bear is LC (due to its wide distribution). But the Himalayan subspecies is CR.

Updates:

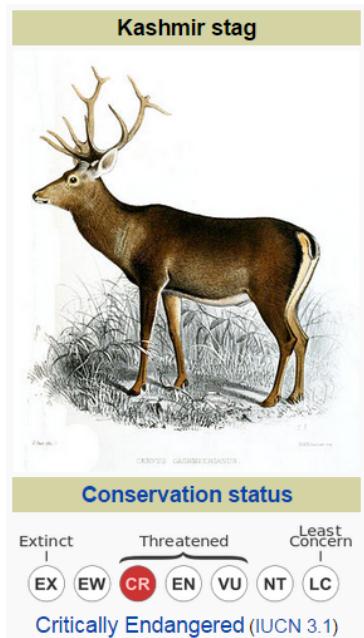
Human encroachment in wildlife has led to bears straying more often into human-dominated areas. Several incidents from various villages of J&K such as Behnipora, Budshungi, and Shatiam have been reported, where more than one bear may have entered.

Key reasons: Insufficient food in their habitats;



6) HANGUL/KASHMIR RED STAG (CERVUS ELAPHUS HANGUL)

- A sub species of red deer which is native to India.
- Hangul has red-brownish coat bringing them in the fold of red deer. The **color, however, changes with season and age**.
- **Note:** Earlier it was believed to be a subspecies of red deer. But Mitochondria DNA genetic studies have revealed that is part of the Asian Clade of elk.
- It is native to Jammu and Kashmir, where it is the **state animal**.
- Known for its giant antlers bearing 11 to 16 points. Hangul has been hunted over centuries and its habitat destroyed.
- **Habitat/Distribution:** In dense riverine forests, high valleys, and mountains of the Kashmir valley and northern Chamba in Himachal Pradesh.
- **Threat:**
 1. habitat destruction
 2. Over-grazing by domestic livestock
 3. Poaching.
- **In 2016, Hangul was classified as CR by IUCN**



- Once found in thousands in the mountains of Kashmir Valley, the population of the famed Kashmir red deer, has dwindled to less than 150, according to senior wildlife scientists.
- Its **last bastion** is **Dachigam National Park** located on foothills of **Zabarwan range** on the outskirts of Srinagar, J&K.

7) CHINESE PANGOLIN

The Chinese Pangolin is a pangolin found in Northern India, Nepal, Bhutan, Bangladesh and Myanmar, northern Indo China, through most of Taiwan, and Southern China.



7) SUMATRAN RHINO AND JAVAN RHINO – EXTINCT IN INDIA

More About Sumatran Rhino

- It is the smallest hairiest and most endangered of the five rhinoceros species.
- It is now thought to be regionally extinct in India, though its ones occurred in foothills of Himalayas and north east India.
- They are now critically endangered, with only five substantial populations in the wild: four on Sumatra, and one in Borneo (Indonesian Borneo).
- In total **only 80 Sumatran Rhino** are thought to exist in the wild now. All are found in Indonesia.

Key threats

- Isolation** is the biggest threat this species face. This is because the females of this species can develop cysts and fibroids in their reproductive tracts if they go too long without mating.
 - It is because of this, in 2018, the world's leading conservation non-profits, including the National Geographic society, announced an unprecedented collaboration called the Sumatran Rhino Rescue. The aim was to find and safely capture as many Sumatran Rhino as possible so that they can be brought together for captive breeding.
- Habitat destruction** have remained a major concern for long.

Sumatran rhinoceros^[1]



Conservation status



Critically Endangered (IUCN 3.1)^[2]

The Javan Rhinoceros (*Rhinoceros sondaicus*) is also believed to be extinct in India and only a small number survive in Java and Vietnam

Other Important Rhino species (not found in India)

1. Northern White Rhino (*Ceratotherium simum cottoni*)

Introduction:

- The northern white rhinoceros, or northern square-lipped rhinoceros, was one of the two subspecies of the white rhinoceros.
- Formerly, found in several countries in East and Central Africa of the Sahara, it is listed as **Critically Endangered**.
- Other subspecies of white Rhino, the Southern White Rhino has the conservation status of **Least Concerned**.

Northern white rhinoceros



Angalifu, a male northern white rhinoceros at the San Diego Zoo Safari Park. Angalifu died 14 December 2014^[1]

Conservation status



Main Reasons for decreased population

- **Poaching:** Demand for northern white Rhino Horns which can be sold at \$50,000 per kg making them more valuable than gold. The demand was fueled by belief in Asia of it treating various ailments.
- **Habitat Loss**

There are only **2 rhinos of this subspecies** left.

- Both belong to the Dvur Kralove Zoo in the Czech Republic but live in the **Ol Pejeta Conservancy in Kenya** and are protected round the clock with armed guards.
- These two rhinos are
 - Two females (mother-daughter) Najin and Fatu.
- Existence of no males makes the species **functionally extinct**.
 - It is "possibly extinct in the wild".

In March 2018, Sudan the last male white Rhino Died

Future Prospects

- Developing **in-vitro-fertilization techniques** using eggs from the last two remaining females, stored northern-white rhino semen from males and surrogate southern white rhino females.
- There is a chance that females of Northern white rhino can mate with males of Southern white Rhino a subspecies. Offspring will not be a 100% northern white Rhino; it would be better than nothing.

Note: there are **five Rhino species in the world**: White Rhino (Southern White Rhino (LC) and Northern White Rhino (EW) are two subspecies of this); Black Rhino (CR); Greater One Horned Rhino (VU); Sumatran Rhino (CR); and Javan Rhino (CR).

LevelupIAS

6. BIODIVERSITY IN INDIA: MAMMALS – ENDANGERED

1) TIGER – COVERED

2) PIGMY HOG

- **Geographical Range**
 - » It is only known from India.
 - » Its presence is uncertain in Bhutan and is extinct from Nepal and Bangladesh.
- **More Details about Pigmy Hog**
 - » World's smallest wild pig, with adults weighing only 8 kg.
 - » **Habitat:** Grassland - Found in relatively undistributed tall Tarai grasslands
 - » **Distribution:** Formerly, the species was more widely distributed along the southern Himalayan foothills but now is restricted to only a single remnant population in Manas wildlife sanctuary and its **buffer reserves**.
 - » **Threats:** The main threats are the loss and degradation of grasslands, dry season burning, livestock grazing and afforestation of grasslands. Hunting is also a threat to the remnant population.
 - » It is one of the most useful indicators of the management status of the grass land habitats. The grassland where the pigmy hog resides are crucial for the survival of another endangered species such as Indian Rhinoceros, Swamp Deer, Wild Buffalo, Hispid Hare, Bengal Florican and Swamp Francolin.
 - » In 1996, a captive breeding program was initiated in Assam, and some hogs were reintroduced in Sonai Rupai area in 2009.
- **Conservation Status**
 - » IUCN - EN
 - » WPA (as amended in 2022) - Schedule-1
- **Pygmy Hog Sucking Louse**, a parasite that feeds only on Pygmy Hogs will also fall in the same risk category of EN as its survival is linked to that of the host species.



3) ASIATIC LION

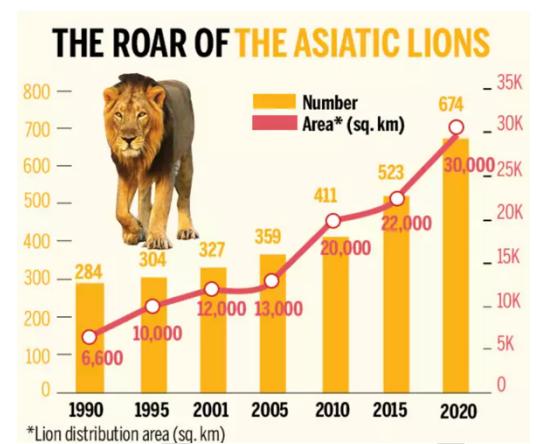
- Asiatic lions once ranged from Persia to Eastern India, but were almost drawn to extinction by indiscriminate hunting and habitat loss.
- **By 1890s, a single population of about 50 Lions** remained in the Gir Forests of Gujarat.
- **With timely and stringent protection offered** by the state government and the central government, they have increased to over 674 now.
 - » Of this around 50% are found outside protected areas.

- » Note: The Gir Protected Area Network includes **Gir National Park, Gir Sanctuary, Pania Sanctuary, Mitiyala Sanctuary adjoining forest reserves, protected forests and unclassed forests.**
- » Lions has been recorded in a total area of about 30,000 sq kms of which, only about 1,650 sq km is in five Protected areas. The protected areas carrying capacity seems to be exceeded.

- Over last several years, the lion population in Gujarat has been steadily rising.
- Male female ratio: 161:260

- **Asiatic Lions and African Lions**

- » They are both distinct subspecies of Lion. They are the second largest cats in the world after tigers. Male Lions are characterized by thick mane of hairs around their head which is absent in females.



Characteristics	Asiatic Lion	African Lion
Distribution:	Only in Gujarat, India	Several countries across Africa, from the Savannah in east Africa to dry grasslands of South Africa
Physical Appearance	Slightly smaller than African Lion, with <u>a shorter mane and fold of skin on their bellies</u>	African Lions have <u>larger manes</u> .
Genetics	The two subspecies have <u>distinct genetic profile</u> . They diverged from the same ancestor around 1,00,000 years ago	
Behaviour	Asiatic Lions are <u>more solitary</u> and <u>live in pairs or small groups</u> of related females and their cubs.	The African Lions are known for their social behaviour and live in large groups called Prides , consisting of <u>several females, their cubs, and one or more males</u> .
IUCN Status	EN	VU

B) WORLD LION DAY: AUG 10

- » Celebrated on Aug 10 of every year to raise awareness about lions and to mobilize support for their protection and conservation.
- » World Lion Day is the brainchild of co-founders Dereck and Beverly Joubert, a husband-and-wife team with a passion for big cats. They began the initiative in 2013, bringing together both **National Geographic** and the **Big Cat Initiative under a single banner** to protect the remaining big cats living in the wild.

C) CONSERVATION STATUS:

- » IUCN: Endangered
- » WPA (as amended in 2022): Scheduled 1
- » CITES: Appendix 1

D) 8 ASIATIC LIONS TESTING POSITIVE FOR COVID-19 (MAY 2021)

- » Where? Nehru Zoological Park, Hyderabad
- » This was the first case of the human infecting the feline and making them sick in India.

E) PROJECT LION

- » It was announced by PM on Aug 15, 2020. It will be on the lines of Project Tiger and Project Elephant.
- » The project has been launched for the conservation of Asiatic Lion and will focus on habitat development by engaging modern technologies in management as well as in addressing the issue of disease in lion.
- » The **Wildlife Institute of India** with the Gujarat Forest Department have created a Project Lion Proposal and set it to the Union MoEF&CC.
- » **Six new sites** apart from the Kuno-Palpur WLS have been identified under Project Lion for possible lion relocation.
 - Madhav National Park, Madhya Pradesh
 - Sitamata Wildlife Sanctuary, Rajasthan
 - Mukundra Hills Tiger Reserve, Rajasthan
 - Gandhi Sagar WLS, Madhya Pradesh
 - Kumbhalgarh WLS, Rajasthan
 - Jessor-Belaram Ambaji WLS and adjoining landscape, Gujarat.
- » In Dec 2022, Minister of State for EF&CC, Shri Ashwini Choubey, informed that the Project Lion document titled "Lion@ 47: Vision for Amrit Kal" has been prepared with the following objectives to secure and restore lions' habitats for managing and growing population; scale up livelihood generation, and participation of local communities; become global hub of knowledge on big cat disease diagnostics and treatment and create inclusive biodiversity conservation through project lion initiative.

F) ISSUE OF RELOCATION OF LIONS

- IUCN has raised concerns here "The Asiatic Lion currently exists as a single subpopulation, and is thus vulnerable to extinction from unpredictable events, such as an endemic or large forest fire."
- **Other Reasons to support translocation:** A large number of lions are outside the PA. These places are human dominated and have very little prey population. Thus, they depend on livestock which they kill or livestock carcass which are dumped outside the villages.
- **The Project Lion document of 2020** have also mentioned that babesiosis and CDV in Gir and that it has resulted the death of at least more than 60 lions in 2018-19.
 - It cautions that "the CDV can also spread very fast within the entire lion population of Gir, especially when containment is not possible due to feral animal vectors in a landscape that remains connected for disease transmission.

- Therefore, IUCN has recommended "establishment of at least one other wild population for population safety, for maximizing genetic diversity and in terms of ecology (re-establishing of the lion as a component of the fauna in its former range).
- **Wildlife activists** have been demanding transfer of lion to a second home **since 1990s**.
- **Studies** of three potential sites with the historical range of the Asiatic Lion **identified Kuno-Palpur sanctuary** in MP to be the most suitable for introducing the species.
 - In 2004, the Center had written to Gujarat for the first time for this relocation, but Gujarat kept dragging the issue and the matter reached Supreme Court.
- **Supreme Court of India** in April 2013, after several recommendations by various expert groups had ordered translocation of Gujarat Lions to Madhya Pradesh. This was done to ensure a second home for the endangered species and to save it from extinction, due to catastrophe like extinction.
 - The review and curative petitions by Gujarat were rejected by the court in 2014.
- **But the transfer hasn't happened yet**. In 2022, government officials have stated that there are no plans to translocate lions outside Gujarat and they will facilitate natural dispersal of lions within Gujarat.
 - These statements completely disregard 2013 SC verdicts and doesn't make any ecological sense.
- **Reason for non-removal** - it has more to do with **politics** than the effectiveness of translocation.

G) ISSUE OF DEATHS OF LION - CANINE DISTEMPER VIRUS (CDV)

- **More than two dozen** lions died in 2018 due to outbreak of canine distemper virus (CDV) and babesiosis.
 - **Canine Distemper Virus**
 - » Canine distemper is a contagious and serious disease caused by virus that attacks the respiratory, gastrointestinal, and nervous system of puppies and dogs. The virus has also been reported in Lions, tigers and other wild animals.
 - **Babesiosis:**
 - » It is caused by microscopic parasites that infect red blood cells and are spread by certain ticks.
- **Incidence of death due to disease in past**
 - In 2007, there were evidence of the Peste Des Petits Ruminants virus (PPRV) which had caused some death. PPRV (also known as Goat Plague) is highly contagious and can be deadlier than even CDV that wiped out a third of Africa's lion.

4) ELEPHANT

- **Introduction**
 - Elephant (Elephas maximum) is the **largest terrestrial mammal of India**.
 - **In past centuries**, forests of India literally teemed with elephants. Mughal emperors are known to have more than 1,00,000 elephants in their services giving us an idea about huge population of elephant in our country then.

- Today's population is obviously a fraction of the population of that time, but large numbers of sustainable herd exist - particularly in south and northeast.
- India has also declared elephant as 'National Heritage Animal'.

- **Conservation Status:**

- IUCN: Endangered
- WPA: Schedule 1
- CITES: Appendix 1

A) POPULATION OF ELEPHANTS (ELEPHANT CENSUS, 2017 REPORT ("SYNCHRONIZED ELEPHANT POPULATION ESTIMATION INDIA, 2017"))

- The census pegs India's total Asian Elephant population at 27312 across 23 states (a decrease over 2012 numbers of around 30,000 - but previous counts were not synchronized and may have had duplications. Therefore, experts say that comparisons should not be drawn). This was the first all India synchronized census which avoided many errors in estimation due to movement of elephants across different states.
- State wise:** Karnataka has the highest number of elephants, followed by Assam and Kerala
 - » Karnataka (6,049)
 - » Assam (5,719)
 - » Kerala (3,054)
- Region wise:** Highest in Southern (11, 960), followed by northeast (10,139), east central (3,128) and northern region (2,085)
 - » Further another survey in 2000 found that there are around 3,400 domesticated animal in the country.

B) INITIATIVES: PROJECT ELEPHANT

- Launched by GoI in 1992 as a centrally sponsored scheme.
- Objectives**
 - » To assist states having free ranging population of wild elephants.
 - » To protect elephants, their habitat & corridors.
 - » Addressing the human-elephant conflict issues
 - » Improving the welfare of captive animals.
- 16 states/UT in focus**
 - » The projected is being mainly implemented in 16 states
 - » Andhra, Arunachal, Assam, Chhattisgarh, Jharkhand, Karnataka, Kerala, Maharashtra, Meghalaya, Nagaland, Orissa, TN, Tripura, Uttaranchal, UP and WB.
- Steps taken**
 - » **Elephant Reserves:**
 - » Establishment of 33 elephant reserves throughout the elephant's traditional range and covering a total area of more than 30,000 km².
 - » Tamil Nadu and Assam have the highest number of elephant reserves (five each), followed by Kerala (4), Odisha (3), UP (2), Arunachal (2), Chhattisgarh (2), Karnataka (2), Nagaland (2), and West Bengal (2), Andhra (1), Jharkhand (1), Meghalaya (1), and Uttarakhand (1).

- In 2022, on the 30th anniversary of Project Elephant, government announced formation of three Elephant Reserves (LEMRU ER (Chhattisgarh), Agasthyamalai ER (TN) and Terai ER (UP)).

TERAI ELEPHANT RESERVE: INDIA'S 33RD ELEPHANT RESERVE IN UTTAR PRADESH (OCT 2022)

- The Centre has approved setting up of Terai Elephant Reserve (TER) at Dudhwa-Pilibhit in Uttar Pradesh.
 - The TER will be developed in joint forest area of Pilibhit tiger reserves and Dudhwa TR, covering conservation of four wild species such as Tiger, Asian Elephant, Swamp Deer, and One-horned Rhinoceros in the entire landscape that also includes Kishanpur and Katarnighat WLS.
 - It is situated on India-Nepal border.
- The TER will also implement human-elephant conflict mitigation strategy and protect villagers living in the Indo-Nepal border areas of Uttar Pradesh.

LEMRU ELEPHANT RESERVE – CHHATTISGARH

AGASTHYAMALAI ELEPHANT RESERVE

- Central government has accepted the proposal of the TN government to establish one more elephant reserve in the state in Agasthyamalai.
- Its total area would by 1,197 sq km.
- It is TN's 5th Elephant Reserve

C) INITIATIVE: MIKE

- MIKE (Monitoring of Illegal killing of Elephants) program of CITES.
- Discovered a significant increase in the poaching of bull tuskers, which has damaged population dynamics by disturbing the sex ratio.
 - In some areas the normal level of 1:12 ratio has been so distorted that 1:100 has been known.
 - This abnormality seriously affects the genetic viability of what on the surface can look like healthy sustainable population.

D) ODISHA TURNS TO SEED BOMBS TO FIGHT ELEPHANT PROBLEM

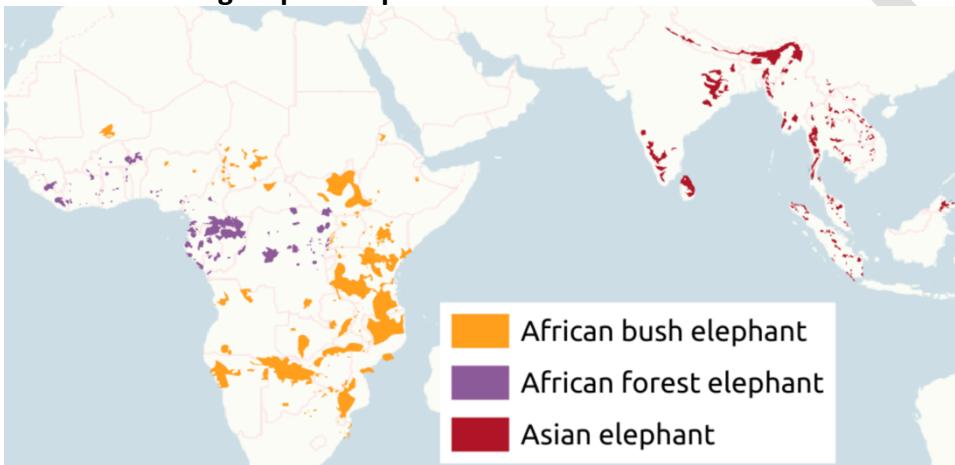
E) WORLD ELEPHANT DAY: 12TH AUG

- It was launched on 12th of August 2012 globally to mobilize attention and support for conservation of Asian and African Elephants.
- As per the available population estimates there are 4,00,000 African Elephants and 40,000 Asian elephants on earth.
- **India adopted the World Elephant Day in Aug 2016** to conserve and protect elephant in India and improve their welfare.
- **Nationwide Campaign "Gaj Yatra"**
 - Was first launched on Aug 12, 2017, by WTI (Wildlife Trust of India).

- **Aims to** protect elephant population.
- **Runs campaign** in 12 elephant range states

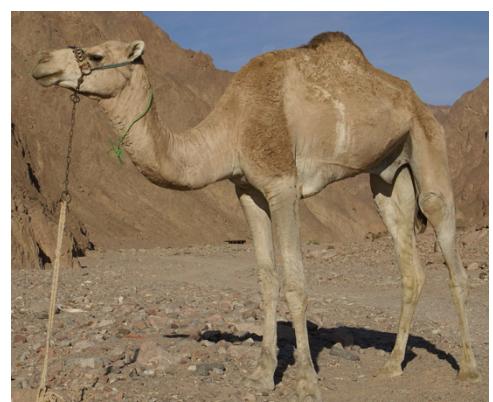
F) SOME GYAN ABOUT AFRICAN ELEPHANT

- African elephants are the largest elephant walking the earth. Their herd wander through 37 countries.
 - There are **two species of African Elephants**.
 - » The Savanna (or bush) elephant
 - » The Forest Elephant
 - **Savanna elephant** are larger than the forest elephants and their tusk curve outwards. They are the largest species of elephants and the biggest terrestrial animal on earth.
 - » IUCN: EN
- **Forest elephants** are smaller and darker; their tusks are straighter and point downwards. There are also difference in the size and the shape of the skull and skeleton between the two species.
 - » IUCN: CR
- **Distribution of Living Elephant Species**

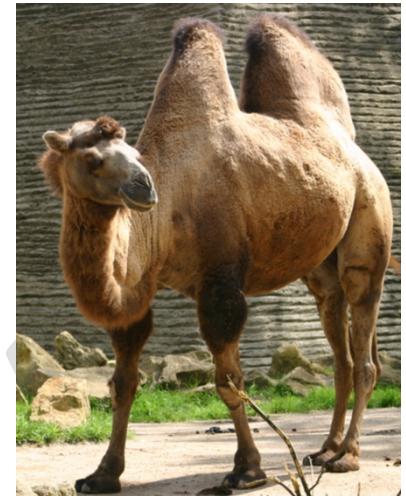


5) CAMELS IN RAJASTHAN

- **Different Types of Camels in India:**
 - The National Bureau of Animal Genetic Resources (NBAGR) lists **nine dromedary (*Camelus dromedarius*) breeds** of camel in India.
 - » **Five** (Bikaneri, Jaisalmeri, Jalori, Marwari, and Mewari) originated in Rajasthan
 - » **One - Mewati** can be seen in both Rajasthan and Haryana.
 - » **Two** (Kutchi and Khrai) are Gujarati
 - » **One** (Malvi) belongs to Madhya Pradesh.



- India also has **a small population of the double-humped Bactrian Camel (*Camelus bactrianus*), found mostly in the Nubra valley in Ladakh.**
- India's total camel population - all of them **descendants of wild dromedary, or Arabian, Camels** - decreased by 37% between 2012 and 2019.
 - Current estimates suggest that **there are fewer than 200,000 camels left among the nine breeds**, and **80% of these animals live in Rajasthan**, where they are bred to provide **transport, wool, and milk**, as well as plough field.
 - **Why decrease in Camel population?**
 - **Development in Western India** -> new roads, vehicles etc. -> reduces the need of camel transportation.
 - **Irrigation projects; Solar and Wind Farms** etc. have **reduced the land available for grazing of camels**.
 - **Collapsing tourism** (COVID-19 pandemic)
 - **Ban on export and sale of male camels** including blanket ban on the sale of camel meat.



- **Can Camel milk bring a solution?**
 - Camel milk is **touted as the next superfood**. It has **low amounts of sugar**, is **rich in vitamins and minerals**, such as **Vitamin C and potassium**, and is **alternative for lactose intolerance**.
 - Some studies have also shown that **Camel milk may reduce a person's need for Insulin (in case of Type-1 diabetes)**.
 - **Hurdles in promotion of use of Camel Milk?**
 - Supply and **potential demand centres** are very far away.
 - To transport raw camel milk to cities, it must be **pasteurized and refrigerated**, a **costly process**.
 - Learn from Gujarat model where **camel milk dairies have proven profitable**. Camel herders from Kutch region have **partnered with Amul**, which launched camel milk in 2019.

A) KHARAI CAMEL

- **Details**
 - » Kharai Camel are a **unique breed of camels** found **only in Kutch**. They are known for their **ability to swim in water**. They have **webbed feet** like that of a frog.
 - » The name is **derived from the local word Kharai** which means Saline. They are also known as **dariyataru** (meaning sea-swimmer).
 - » During the rainy season, they **swim along the Gulf Of Kutch**, an inlet of the Arabian sea, to **small forest islands and graze on mangroves and other saline-loving plants**.
 - » **IUCN: EN**
 - » **WPA: Schedule-1**
 - » **Key threats:**
 - **Habitat destruction** (mangrove forests they feed on are being destroyed)

- Salt pans have increased in the area, and they have destroyed habitat and blocked to path of travel for the camels.
- **Recognition as separate Breed:**
 - » The Kharai camels were recognized as a separate breed only in 2015.
- **Declining numbers**
 - » In 2010, there were about 10,000 camels in the region, which has now (2020) declined to around 5,000.
- **Key recent efforts**
 - » Amul have started making camel milk products to support camel herders.
- **Altercations between Kharai Camel Owners (Of Jamnagar and Devbhumi Dwarka) and Forest Department (Sep 2021) -> Grazing in Marine National Park**

6) KONDANA SOFT FURRED RAT (ALSO KNOWN AS KONDANA RAT OR LARGE METAD)

- Nocturnal burrowing rodent that is found only in India. It is sometimes known to build nests.
- **Habitat:** Its natural habitat are subtropical and tropical dry forests, subtropical or tropical dry lowland grassland, and urban areas.
- **Distribution:** Known only from the small Sinhagharh Plateau (about 1 km²), near Pune in Maharashtra.
- **Threats:** Major threats are habitat loss, overgrazing of vegetation, and disturbance from tourism.

7) Dhole/ ASIATIC WILD DOG OR INDIAN WILD DOG (CUON ALPINUS)

- **Other Names:** Indian wild dog, whistling dog, Chennai dog, Asiatic Wild Dog, red wolf etc.
- **Distribution:** Native to central Asia, South-East Asia.
 - » In India there are few remaining adults in the wild. They can be seen in protected areas of Karnataka, Maharashtra, and Kerala.
- **Population:** With less than 2,500 individuals surviving in the wild globally, the dhole is already extinct in about 10 Asian countries.
- **Very efficient predators:** They are so efficient as predators that there have been reports of them even attacking tigers.
- **Threat**
 - » Habitat loss
 - » Loss of prey



- » Competition with other species
- » Persecution
- » Possibly diseases transfer from other dogs (domestic and feral dogs).

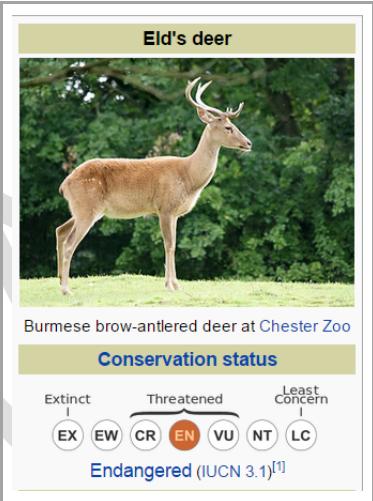
8) BROW-ANTLERED DEER/SANGAI DEER (PANOLIA ELDII)

Specific Habitat requirements: They inhabit the floating biomass in Loktak Lake Manipur.

Key threats: Hunted for their bow-shaped antlers.

Note: Sangai Deer (EN) is an endemic and endangered subspecies of brow-antlered deer found only in Manipur, India.

- It's original habitat is the floating marshy grasslands of the Keibul Lamjao National Park, located in the southern part of the Loktak lake, which is the largest freshwater lake in eastern India.
- State animal of Manipur.
- They are also known as **dancing deer**. This is because while walking on the floating island it often balances itself and appear to be dancing.



A) SANGAI FESTIVAL

- It is a **10-day annual cultural festival** organized by Manipur Tourism department every year from Nov 21 to 30.
- It was first celebrated in 2010. It was earlier called tourism festival which has been renamed to Sangai festival to promote the uniqueness of brow-antler deer.
- The festival also promotes Manipur's unique art, handicraft, sports, cuisine.
- Some **folk dances** of Manipur like **Kabui Naga Dance, Bamboo Dance, Maibi Dance, Lai Haraoba Dance, Khamba Thoibi Dance** etc could be seen here.
- **Manipur's martial art** form **Thang Ta** can also be seen here.
- **Some games** include:
 - **Yubi-Lakpi**, which is a game played like a rugby with greased coconut;
 - **Mukna Kangjei**, a game combining hockey and wrestling.
 - **Sangol Kangjei**, or Polo - It is believed that modern polo came from Manipur Polo, Sagol Kangjei.
- **Manipur cuisines** such as **Nga-thongba** (fish curry), and the popular **Eromba** (a mixture of boiled veggies with fermented fish) are also available at the festival.

B) LOKTAK LAKE

About the Lake

- It is one of the largest freshwater lakes in India. It is pulsating lake with surface area varying from 250 sq km to 500 sq km during the rainy season with a typical area of 287 sq km.
- It is lake in Manipur, which is located 40 kms south of Imphal.
- The town of Moirang, on its bank, was the headquarter of the Indian National Army where they established a provisional independent government after defeating the British.
- The lake covers 61% of the total identified wetlands of the state. It plays a significant role in socio-economic and cultural life of Manipuris.
- It is famous for Phumdis (soil and organic matter at various stages of decomposition) floating over it. The largest of all the phumdis covers an area of 40 km² and is situated on the southeastern shore of the lake. Located, on this Phumdi, Keibul Lamjao National Park is the only floating national park in the world. The park is the last natural refuge of the endangered Sangai (state animal).
- Once considered extinct, the population of brow-antlered deer found only on Keibul Lamjao National Park.
- Loktak lake is also one of the Ramsar sites in India.
 - It is also in Montreux Record and government is taking a lot of steps to get it delisted.



Key threats:

- Human Pressure - Floating houses and fishing structures.
- Ithai Barrage - brought about drastic changes in the characteristics of the wetlands.
- Pollution: Moreover, River Nambul that flows from Imphal into the lake, dumps in the untreated sewage of the entire city.

About Ithai Barrage

In 1983, NHPC constructed a barrage at the confluence of the Manipur and Khuga river - two of the five major rivers that drain into Loktak lake. This barrage has provided electricity and irrigation water to the region, but has created a number of problems for Loktak lake.

- Now even during dry season water level is high in Loktak lake and the Phumdis are not able to reach ground and absorb nutrition from there.
- Further, the dead biomass remains in the Lake only as the outflow has been blocked due to the barrage.
- The barrage has also blocked the route of migratory fish coming into the lake from Myanmar and so Loktak can no longer meet the demand of the entire state.

9) GEE'S GOLDEN LANGUR (TRACHYPITHECUS GEEI)

- **Distribution:** Golden langur is an old-world monkey, found in small regions of **western Assam, India and neighboring foothills of the Black Mountains of Bhutan.**
 - Manas National Park provides good sighting of this animal.
- **Status:** Endangered. One of the most endangered primate species of India.
- They have been named for their luscious coats and are considered sacred by Himalayan people.



10) HIMALAYAN WHITE BELLIED MUSK DEER

- **Habitat/Distribution:** Kashmir, Kumaon, Sikkim in India. Himalayas of Nepal and China.
- **Threats**
 - **Poaching and illegal trade for its musk**
 - **Musk:** is a substance with a persistent odor obtained from a gland of the male musk deer (only male produces the musk). The substance has been used as perfume fixative, incense material and medicine.



11) ALPINE MUSK DEER (MOSCHUS CHRYOSOGASTER)

- Alpine musk deer is a musk deer species native to the eastern Himalayas in Nepal, Bhutan and India to the highlands of Tibet.
 - It is now considered a separate species, to Himalayan Musk Deer. It is the state Animal of Uttarakhand.
 - IUCN Status: EN



12) KASHMIR MUSK DEER (MOSCHUS CUPREUS)

- It is an endangered species of musk deer native to Afghanistan, India, Pakistan and Nepal.
- In the past, the species was described as a subspecies to the alpine musk deer, but is now classified as a separate species.
- **IUCN:** EN

13) HISPID HARE

- **Details:** The Hispid hare, also called Assam rabbit, is a leporid, native to South Asia.
- **Habitat/Distribution:**
 - Historically it had wider range in southern Himalayan foothills, now distributed only patchily in India, Bangladesh, Nepal and Possibly Bhutan.
 - A significant population is found in Shuklaphanta National Park in Nepal, elsewhere it only occurs sporadically.
 - Habitat is highly fragmented due to increasing agriculture, flood control, and human development.



14) HOG DEER

Habitat/Distribution: Habitat ranges from Pakistan, through northern India, to mainland southeast Asia.

- But it has lost ground in most of its range.
- **Two sub species** of hog deer have been reported from its range
 - The western race is distributed from Pakistan and Terai Grassland (along the Himalayan foothills), from Punjab to Arunachal Pradesh.
 - The Eastern Race of hog deer is found in Thailand, Indo-China, Laos, Cambodia, and Vietnam.

Name: The hog deer runs through the forests with its head hung low (hog-like manner) so that it ducks under obstacles instead of leaping over them like most other deer do.



Eastern Hog Deer (*Axis Porcinus annamiticus*) - A rare subspecies of hog deer found in Keibul Lamjao National Park (2018)

- The sub-species was earlier believed to be confined to the eastern part of Thailand.
- **Genetic Study** by researchers at WII, Dehradun have reported presence of small population of Hog Deer at Keibul Lamjao National Park in Manipur.

15) LION TAILED MACAQUE / WANDEROO (*MACACA SILENUS*)

- **Details:** It's an old-world monkey, endemic to the Western Ghats of South India. They avoid human presence and they do not live, feed or travel through plantations.
- **Habitat:**
 - They live in Southwest India in pockets of evergreen forests, called **Sholas**, in the Western Ghats range. Today, they only live in mountain forests scattered across three Indian states: Karnataka, Kerala and Tamil Nadu.
- **Threat**
 - **Habit Fragmentation:** Due to spread of agriculture and tea, coffee, teak, and Cinchona, construction of water reservoirs and human settlements to support such activities.
- **Conservation Efforts**



- **Captive Breeding:** Aringnar Anna Zoological Park, Chennai and in Mysore Zoo.

16) NILGIRI TAHR

It is the only mountain ungulate in southern India amongst the 12 species present in India. It is also the state animal of Tamil Nadu. It is a sure-footed ungulate that inhabits the open montane grasslands habitats at elevations from 1200 m to 2600 m of the Southwestern ghats.

Distribution:

- Earlier, it was found throughout western ghats.
- But, today, it is distributed along a narrow stretch of 400 km between Nilgiris in the north and Kanyakumari in South. It has become locally extinct in around 14% of its traditional shola forests -grassland habitats.
- There are smaller populations found in the Palani Hills, Srivilliputtur, and the Meghamalai and Agasthiyar ranges, only two well protected large population is documented - one from the Nilgiris and the other from the Anamalais, including the high range of Kerala.
 - The Eravikulam National Park in Anamalai hills, Kerala, is home to the largest population of Nilgiri Tahr, with more than 700 individuals.
 - **Mukurthi National Park (TN)**, was created to protect this endangered species

Conservation Status

- IUCN/WPA/CITES: EN/Schedule-1/Appendix 1

Threats

- Habitat loss, overgrazing, illegal hunting.

Historical references:

- Referred in Tamil Sangam literature 2,000 years back.
- Late Mesolithic paintings (10000-4000 BCE) also highlight significance of Tahr in the folklore, culture and life.



A) NILGIRI TAHR CONSERVATION PROJECT (DEC 2022)

- It is an initiative launched by TN government, at a cost of Rs 24.14 crores.
- Under this, the government wants to:
 - » Develop a better understanding of the Nilgiri Tahr Population through surveys and radio telemetry studies.
 - » Reintroduce the Tahrs to their historical habitats
 - » Address Proximate threats
 - » Increase public awareness of species.
- The funds, for the project is provided by the TN Pollution Control Board (TNPCB).
- Further, Oct 7, will be celebrated as 'Nilgiri Tahr Day' in honour of E.R.C. Davidar, who was responsible for pioneering one of the first studies of the species in 1975.

17) INDIAN PANGOLIN

- About Indian Pangolin

- The Indian Pangolin, thick tailed pangolin, or scaly pangolin is a pangolin found in the **plains and hills of India, Sri Lanka, Nepal, and Bhutan.**
- It is an **insectivore** that feeds on ants and termites, digging them out of mounds and logs using its long claws, which are as long as its fore limbs. It is a **solitary, shy, slow moving, nocturnal mammal.**



- Main Threats

- **Hunting for its meat and scale**
- Various body parts used in traditional medicines

- Conservation Status

- IUCN: Endangered
- WPA: Scheduled 1
- CITES: Appendix 1 (reclassified in 2016 from Appendix 2 to Appendix 1)

- Pangolins and India

- Among **8 species of Pangolin** found globally, four each are found in Asia and Africa. **India is home to two species - the Chinese Pangolin and the Indian Pangolin.**

- Recently, CITES COP19 has urged member countries to **remove references to Pangolins from Pharmacopoeia** – an official collection of approved pharmaceutical standards.

18) RED PANDA (AILURUS FULGENS) (LESSER PANDA, RED BEAR-CAT, AND RED CAT-BEAR

It is a **small arboreal mammal** native to **eastern Himalayas and south-western China.**

Habitat/ Distribution: **Sikkim, Assam, Meghalaya, Northern Arunachal Pradesh and Darjeeling.** Almost **50% of the Red Pandas** inhabit eastern Himalayas.



Physical features: It has **reddish brown fur** and a long shaggy tail.

Diet: Omnivorous (mainly on bamboo)

Conservation Status

- IUCN/WPA/CITES: EN/Schedule 1/ Appendix 1

Threats: Habitat loss and fragmentation; Poaching for Furs; Inbreeding Individuals;



A) THE PADMAJA NAIDU HIMALAYAN ZOOLOGICAL PARK (PNHZP) (DARJEELING ZOO) HAS STARTED AN INITIATIVE TO **RELEASE 20 RED PANDAS** IN FORESTS IN THE NEXT FIVE YEARS.

- **About the Zoo:**

- It is a zoological park located in Darjeeling. It is named after Padmaja Naidu, the former Governor of West Bengal, India. She is also the daughter of Indian Independence leader Sarojini Naidu.
 - It is a park situated 2,000 meters above the sea level. It was established in 1958 and is the largest high-altitude zoo in India.
 - It has been quite successful in captive breeding of the Red Panda. As of July 2022, there are 27 Red Pandas in the zoo.
- **Release of Red Pandas in Wild:**
- In the first re-wilding program of red Pandas in India, the PNHZP has started an ambitious program to release 20 of these mammals in about five years to the forests. They will be released in Singalila National Park.
 - In the past, two pairs of Red Pandas were released in 2021. Two animals managed to survive.

B) A RECENT PUBLICATION BY SCIENTISTS OF ZOOLOGICAL SURVEY OF INDIA (ZSI) HAVE RESOLVED THE MYSTERY AROUND DEMOGRAPHY AND SPECIATION OF RED PANDA.

- India is home to both the (sub) species - Himalayan Red Panda (*Ailurus fulgens*) and the Chinese red Panda (*Ailurus Styani*) and the Sang River in Arunachal Pradesh splits the two phylogenetic species.

19) ASIAN WILD BUFFALOE

- It is the large bovine native to the Indian subcontinent and Southeast Asia.
- It has been listed as endangered since 1986 and remaining population totals less than 4,000. More than 90% of its population is found in India, mostly in Assam.



7. TIGER (IUCN: EN, WPA – SCHEDULE-1; CITES – APPENDIX-1)

- **Introduction**
- The tiger can be called a keystone species because it has a strong influence on other animals and plants in the ecosystem, especially deer and boar. From the conservation perspective it is also called Umbrella Species because when its ecological needs are met, so are those of myriad other living things that share its landscapes.
 - It is estimated that India had 40,000 tigers in 1900, and the number declined to 1800 in 1972. Similarly, world had around 1,00,000 tigers in 1900's, to less than 4,000 in the 1970's.
 - Tigers have the species name **Panthera Tigris**. There are nine sub-species of tigers, three of which are extinct.

- Tiger Sub-Species

Species (non-extinct)	Other details
Bengal (Panthera tigris tigris)	India, Nepal, Bhutan and Bangladesh; most numerous, about 4,000
Indo-Chinese	Thailand, Cambodia, Vietnam, Laos, Myanmar, China etc fewer than 300 remain
Malayan	Malay peninsula and in the southern tip of Thailand; 500
Siberian or Amur	Russian Far East; 300
South China	China; probably extinct in the wild
Sumatran	Sumatra, Indonesia; 500-600
Species (Extinct)	
Bali	
Caspian	
Javan	



- IUCN has recently (2022) confirmed that tigers have gone extinct in Cambodia, Laos, and Vietnam. Poaching and habitat loss are the key reasons.

- Major Threats faced by Tigers.

1. **Poaching** driven by illegal international demand for tiger parts and products.
 - For e.g. Bangladesh has also emerged as a major hub in the illicit poaching and trafficking of tigers.
2. **Depletion of prey** caused by illegal bush meat consumption
3. **Habitat loss** due to ever increasing demand of forest lands
4. **Inbreeding**
5. **Human-Animal Conflicts**

1) INTERNATIONAL TIGER CONSERVATION EFFORTS

A) GLOBAL TIGER INITIATIVE, 2008

Global Tiger Initiative (GTI), 2008 is a global alliance of governments, international organizations, civil society, the conservation and scientific community, and the private sector committed to working together towards a common agenda to save wild tigers from extinction.

- » It was launched in 2008 by founding partners the World Bank, Global Environmental Facility, Smithsonian Institution, Save the Tiger Fund and International Tiger Coalition (representing more than 40 NGOs).
- » It is led by 13 tiger range countries (TRCs).
 - Russia, China, India, Nepal, Bhutan, Bangladesh, Myanmar, Thailand, Laos, Cambodia, Vietnam, Indonesia and Malaysia.
- » GTI secretariat, based at the World Bank in Washington, DC, assists 13 tiger range countries to carry out their conservation strategies and drive the global tiger conservation agenda, through planning, coordination and continuous communication.
- » The TRCs came together in an unprecedented pledge to double the world's tiger population by 2022 (which is the year of the Tiger on the Asian lunar Calendar), with a goal of achieving at least 6,000 tigers.
- » GTI is contributing through protection of habitat, fighting wildlife crime, building capacity, reducing demand, engaging community, and innovation.

B) GLOBAL TIGER RECOVERY PROGRAM 2.0 (GTRP 2.0)

- » Why in news?
 - Countries submit population numbers from 2010-2022 to Global Tiger Recovery Program, CITES (Jan 2024)
- » About GTRP:
 - GTRP (2010-22) was launched in 2010 under the GTI by the World Bank to save wild tigers. Tiger Range countries committed to doubling the tiger population by 2022.
 - How effective was it?
 - Successes in South Asia and Russia.
 - Failures (decline) in Southeast Asia.
- » GTRP 2.0:
 - On 29th July 2023, marking Global Tiger Day, the Global Tiger Initiative (GTI) introduced the latest iteration of the **Global Tiger Recovery Program (GTRP 2.0) For the Year 2022 to 2034**. It aligns with Post-2020 Global Biodiversity Framework (GBF), providing an opportunity for TRCs to integrate tiger conservation with global goals.
 - The following outcomes are expected from the GTRP 2.0:
 - Cross Sectoral Conservation
 - Increased Investment
 - Habitat protection
 - Conflict Management
 - Reduced Wildlife Trade
- » Submission of Numbers by Countries:
 - The submissions were made under GTRP 2.0 and CITES.
 - There has been overall increase in tiger population by 60%, taking the number to 5,870.
 - However, Bhutan, Myanmar, Cambodia, Lao-PDR, and Vietnam showed decline in tiger population. It makes the situation grim in the Tiger Range Countries (TRC) of southeast Asia.

C) TX2

GTI adopted St Petersburg declaration on Tiger Conservation and endorsed TX2 in 2010.

- Goal of TX2 is to double the number of tigers across their geographical areas.

D) TX2 TIGER CONSERVATION AWARD (TTCA)

- The Awards celebrate the 10-year anniversary of all 13 Tiger Range countries committing to double the global population of wild tigers by 2022 - a goal called TX2.
- It is given in two categories.
 - » **TX2 Conservation Excellence Award**
 - The award recognizes a site that has achieved excellence in two or more of five themes:
 - » Tiger and prey population monitoring and research (tiger translocation/prey augmentation);
 - » Effective site management.
 - » Enhanced law enforcement, protection and ranger welfare improvement;
 - » Community-based conservation, benefits and human-wildlife conflict mitigation and.
 - » Habitat and prey management.
 - » **TX2 Award** - It is given for efforts to increase tiger population and includes a financial grant to assist the ongoing conservation efforts.
 - These awards are supported by Conservation Assured | Tiger Standards (CA|TS), Fauna & Flora International, Global Tiger Forum (GTF), IUCN Panthera, UNDP, WildLife Conservation Society (WCS), and WWF.
- In 2023, Pench Tiger Reserve (PTR), Maharashtra, is among the three tiger reserves to win the TX2 Award for a fivefold increase in its tiger population from 9 individual in 2006 to 44 in 2021.
 - » The other two tiger reserves include Pench (Madhya Pradesh) and Satpura Tiger Reserve. While Pench (MP) increased its tiger population from 33 (2006) to 87 (2018), STR increased its numbers from 13 in 2010 to 48 in 2021.

E) INTEGRATED TIGER HABITATION CONSERVATION PROGRAM (ITHCP)

- **Why in news?**
 - IUCN Tiger Program launches phase-IV (Aug 2023)
- It is a strategic funding mechanism which aims to save tiger in the wild, their habitats and to support human populations in key locations throughout Asia. It was launched in 2014.
- **IUCN** is the program implementing agency.
 - » It is supported by German Government and the German Development Bank (KfW) and was launched in late 2014.
 - » The program contributed to the international goal set up during the 2010 St Petersburg Summit to double wild tiger population by 2022.
- **In India**, it was launched in Karnataka in 2016.
 - » In 2018, it was extended for further five years.

- **Updates:** Launch of Phase IV (Aug 2023)
 - » ITHCP has launched a call for Concept Notes for Phase IV of the Tiger Program.
 - It aims to allocate a total of Euro 10.7 million and, for the first time, the program will extend eligibility to other species that significantly contribute to the intricate tapestry of tiger conservation.
 - Projects can target one of the following species: Tigers (Panthera tigris), leopard (Panthera Pardus), and Clouded leopards (both mainland and Sunda)
 - Countries eligible under this call for concept notes include Nepal, Bhutan, India, Bangladesh, Myanmar, Thailand, Cambodia and Indonesia.
 - It should be noted that funding will exclusively be channeled towards specific Designated Program Areas, ensuring a focused and targeted approach to conservation efforts.
 - » By embracing a comprehensive and diversified strategy that encompasses a wider array of species, the program will continue to secure a viable future for these Species, their Habitats and the people that live in and around them.

F) CONSERVATION ASSURED TIGER STANDARDS (CATS)

- **CATS** is a conservation tool that specifies best practices and standards to manage target species and encourages assessments to benchmark progress.
 - It is a partnership of 13 Tiger range governments, inter-government agencies, NGOs, and conservation organizations.
 - WWF is helping the Tiger range countries to implement CATS.
 - It was launched in 2013 and Tigers are the first species selected for the initiative.
- **In July 2020:**
 - NTCA has decided to adopt the Conservation Assured Tiger Standards (CATS) across all fifty tiger reserve across the country.
 - » The Global Tiger Forum (GTF) and World Wildlife Fund India are the two implementing partners of the NTCA for CATS assessment.
 - This makes India the first among 13 Tiger range countries to nationally adopt CATS, which are a set of minimum standard setting benchmark for managing conservation sites.
 - » This will bring India's total number of registered sites to 94 including sites outside tiger reserves.

G) WORLD TIGER DAY/ INTERNATIONAL TIGER DAY: 29TH JULY

- **Why 29th July?**
 - It was a reminder of agreement signed by countries at St Petersburg Tiger Summit in Russia, 2010, to raise awareness about decline of global tiger population.
 - It was established in 2010 to raise awareness about the decline of wild tiger numbers.
- Tadoba Tiger Reserve, Maharashtra plays host for National Global Tiger Day Celebrations 2022

2) NATIONAL EFFORTS FOR TIGER CONSERVATION

A) PROJECT TIGER

- **News:** Project Tiger completes 50 years in 2023.
- It is a centrally sponsored tiger conservation programme launched in 1973 by the MoEF&CC, GoI.
- **Objectives / Aims**
 - » Ensuring a viable population of Bengal Tigers in their natural habitats and also to protect them from extinction.
 - » Preserving areas of biological importance as a national heritage for the benefit education and enjoyment of people.
 - » Harmonizing the rights of tribal people living in and around tiger reserves.
- **Tiger Reserves**
 - Tiger reserves are the areas that are notified for the protection of the tiger and its prey, and are governed by Project Tiger and administered by the National Tiger Conservation Authority.
- Tiger reserves are constituted on a **core/buffer strategy**:
 - The **Core Area** have the legal status of a national park or a sanctuary with an **exclusive tiger agenda**.
 - These areas are required to be kept inviolate for the purposes of tiger conservation, without affecting the rights of Scheduled Tribes or such other forest dwellers.
- The **Buffer or peripheral areas** are a mix of forest and non-forest land, managed as a multiple use area with an inclusive people-oriented agenda.
 - » It aims to promote coexistence between wildlife and human activity with due recognition of the livelihood, developmental, social and cultural rights of the local people.
 - » Limits of such area are determined on the basis of scientific and objective criteria in consultation with the concerned Gram Sabha and an Expert Committee constituted for the purpose.
- **Corridor Habitat**
 - » 2010 tiger census showed a decline in tiger occupied area. This decline in tiger occupancy area was recorded in areas outside the tiger reserves, indicating loss of habitat quality and extent - a crucial element essential for maintaining genetic connectivity between individual tiger population.
 - » To address this vital conservation concern, the **NTCA in collaboration with the WII delineated the minimal tiger habitat corridors connecting tiger reserves** for implementing landscape scale tiger conservation.
 - » Now all tiger reserves manage their tiger populations based on a Tiger Conservation Plan (TCP), which addresses specific prescriptions for core, buffer, and corridor habitats.
- Currently, there are 54 tiger reserves spread across 75,796 km², effectively covering 2.3% of India's total land area.

B) NATIONAL TIGER CONSERVATION AUTHORITY (NTCA)

- Wildlife Protection Act of 1972 was amended in 2006 to provide for the formation of National Tiger Conservation Authority to aid in the implementation of measures for the conservation of tiger. It comes under MoEFCC.
- **What does it do?**
 - » Providing central assistance to states under the ongoing Project Tiger, for activities based on Tiger Conservation Plan.
 - » **Conducting countrywide tiger census every four years.** It does assessment of the status of tiger, co-predators, prey, and habitat using the refined methodology approved by the Tiger Task Force.
 - » Taking steps for protection and act against poaching
 - Alert states as and when required; Transmit backward/forward linkages of information relating to poachers.
 - Use IT for improved surveillance (e-Eye system) using thermal cameras.
 - Launch tiger reserve level monitoring using camera trap to keep a photo ID database of individual tigers.
 - Prepare a national database (Tiger Net) of individual tiger photo captures to establish linkage with body parts seized or dead tigers.
 - Assist states to refine protection oriented monitoring through Monitoring System for tiger's intensive protection and ecological status (M-STIPES).
 - It is an android app which was launched in 2010.
 - Support states for raising, arming and deploying the Special Tiger Protection Force.
 - Address issues such as the movement of tigers out of their habitats into human settlements.

C) MANAGEMENT EFFECTIVE EVALUATION (MEE) OF TIGER RESERVES IN INDIA

- MEE is a globally accepted framework for measuring the conservation efforts of tiger reserves. It has been adopted from the framework of the IUCN World Commission on Protected Areas and has emerged as the most important tool to assist and improve management perspectives of Tiger Reserves and their associated landscape connectivity.
- In India MEE is being jointly conducted by the NTCA and WII and has paved the way for a successful evaluation of national tiger conservation effort.
- **India is the only country in the world to have institutionalized and effectively completed five cycles of MEE of Tiger Reserves in the country.**
- **Key Highlights of the fifth cycle of Evaluation:**
 - A total of 51/53 tiger reserves have been independently evaluated through the MEE process in the fifth cycle in 2022.
 - 10 independent regional expert committees (RECs) were constituted and deputed in 10 different clusters of five tiger landscapes to evaluate the 51 tiger reserves of the country.
 - Each team consisted of a chairperson and 2-3 members (retired IFS officers having experience in wildlife management, especially in the field of tiger reserves).

- **33 criteria/Indicators** were used for evaluation of six elements of MEE framework.
- **The results** were classified in four categories based on the percentage of maximum possible score: (50-59% rated as '**Fair**'; 60-74% rated as '**Good**'; 75-89% rated as '**very good**' and >=90% rated as **excellent**).

- **Results:**

- Overall average score of 78.01% for 51 Tiger Reserves.
- **12 tiger reserves got excellent category (score >=90%).**
 - These include - Periyar (KER), Satpura (MP), Bandipur, Nagarhole, Kanha, Biligiri Ranganatha Swamy Temple (KAR), Annamalai (TN), Pench (MHA), Bhadra (KAR), Kali (Dandeli-Anshi) (KAR), Simlipal (Odisha), Mudumalai (TN).
- **21 tiger reserves got very good category; 13 'Good' category and 5 Tiger Reserves in 'Fair Category;**
 - "**Very Good**" tiger reserves include - Pench (MP), Tadoba-Andhari (MHA), Manas (Assam), Melghat (MHA), Sathyamangalam (TN), Parambikulam (Kerala), Kaziranga (Assam), Navegaon-Nagzira (MHA), Bandhavgarh (MP), Panna (MP), Kalakad-Mundanthurai (TN), NSTR (AP), Dudhwa (UP), Corbett (UK), Sahyadri (MHA), Amrabad (Telangana), Bor (MHA), Pakke (Arunachal), Valimiki (Bihar), Sundarbans (WB) and Satkosia Odisha)
 - "**Good**" tiger reserve includes Kawal (Telangana), Ranthambore (Raj), Kamlang (Arunachal), Sanjay-Dubri (MP), Pilibhit (UP), Achanakmar (Chhattisgarh), Rajaji (UK), Orang (Assam), Palamu (Jharkhand), Sariska (Raj), Buxa (WB), Srivilluputhur Megamalai (TN), Mukundra (Raj)
 - "**Fair**" tiger reserves include Namdapha (Arunahcal), Udanti-Sitanadi (Chhattisgarh), Nameri (Assam), Indravati (Chhattisgarh) and Dampa (Mizoram).

D) CENTER MERGES PROJECT TIGER AND PROJECT ELEPHANT (JULY 2023)

- **The MoEF&CC** announced the merger in April and notified Project Tiger (PT) as Project Tiger and Elephant (PTE).
 - » **The Project Tiger Division** has been merged with **Project Elephant** and a new division with the name 'Project Tiger and Elephant Division' has been created under the MoEF&CC.
 - » After the merger, the staff and divisional heads of Project Elephant (PE) will now report to the additional director general of forests (ADGF), Project Tiger (PT), who has now been designated as ADGF (PT&E).
- **Criticism:**
 - » **Decision without any discussion:**
 - » **May hamper Project Tiger** as it may get bogged down in the bureaucratic quagmire of MoEF&CC.
 - NTCA has a single-minded focused attention on conserving tiger and is disconnected from the tentacles of the vast bureaucracy.
 - » A similar proposal of planning commission was rejected by NBWL in the past.

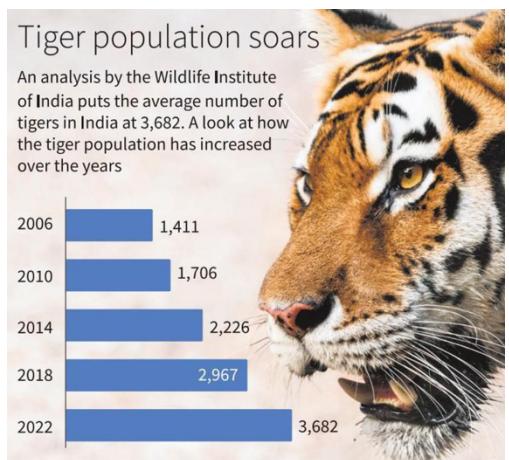
E) TIGER REVIVAL PROGRAM OF NTCA: TRANSLOCATION OF BIG CATS TO MADHAV NATIONAL PARK IN MP TO BEGIN ON MARCH 10, 2023

- In March 2023, the Madhya Pradesh Forest department has released tigers in Madhav National Park as part of the tiger reintroduction project.
 - » It will be first time in two decades that the park will have tigers.
- This is the **third time** the MP forest department has reintroduced a tiger in a wildlife sanctuary, which is devoid of majestic beasts.
 - » Earlier, the tigers have been successfully rehabilitated in the Panna Tiger Reserve and the Nauradehi WLS in Sagar

F) INTER-STATE TIGER TRANSLOCATION PROJECT – CLASS DISCUSSION

3) TIGER ESTIMATES IN THE COUNTRY

- NTCA has been conducting a survey of tiger population every four years since 2006.
- NTCA's census of tigers conducted in 2006, 2010, 2014, 2018 and 2022 show an increasing trend.
- India currently harbors 75% of the world's wild tiger population.
- **Key Highlights of All India Tiger Estimates - 2022:** Release of detailed report (July 2023)
 - » **Total Tiger Population** - 3682 (as per detailed report released in 2023)
 - Note: In April 2022, PM Modi declared the minimum tiger population of 3167, which is the population estimate from the camera trapped area.
 - Now (2023), further analysis of data done by Wildlife Institute of India (WII), from both camera-trapped and non-camera trapped tiger presence areas, the upper limit of tiger population is estimated to be 3925 and the average number is 3682 tigers, reflecting a commendable annual growth rate of 6.1% per annum.
 - » **States with Highest Tiger Population:** MP (785); Karnataka (563); Uttarakhand (560) and Maharashtra (444)
 - **Some states**, including Mizoram (0), Nagaland (0), Jharkhand (1), Goa (5), Chhattisgarh, and Arunachal Pradesh (9), have reported disquieting trends with smaller tiger population.
 - » **Tiger reserves with highest number of tigers:** Corbett (260), Bandipur (150), Nagarhole (141), Bandhavgarh (135), Dudhwa (135) etc.
 - **Corbett** also has the highest density of wild tigers in the world.



- » **Reserves with no tigers** (Dampa (Mizoram); Kamlang (Arunachal Pradesh); Kawal (Telangana), Satkosia (Odisha), Sahyadri (MHA);
- » **Tiger Reserves with less than 10 big cats:** These are Ranipur in Uttar Pradesh; Achanakmar, Indravati and Udanti Sitanadi in Chhattisgarh; Palamau in Jharkhand; Bor in Maharashtra; Mukundara and Ramgarh Vishdhari in Rajasthan; Kalakad Mundanthurai in Tamil Nadu; Nameri in Assam; Pakke and Namdapha in Arunachal Pradesh and Buxa in West Bengal.
- » **Landscape wide distribution:**
 - i. **Central India landscape** has seen an increase in tiger population to **1161** (from 1033 in 2018).
 - ii. **Western Ghats** showed a decline of tiger population (**824**)
 - iii. **Shivalik Hills and Gangetic Plains** landscape had **804** tigers and have witnessed an increase from 648 population in 2018.
 - iv. **Northeastern Hills and Brahmaputra Plains landscape** - have shown evidence of **194 tigers**.
 - v. **Sundarbans** (100) also saw an increase from 88 in 2018.
- » **Techniques used for estimation:**
 - **M-STrIPES** (Monitoring System for Tiger-Intensive Protection and Ecological Status): It uses a GPS and remote sensing to collect information from the field.
 - **Camera-Trap based capture**
 - **Extracting DNA from SCATs** in area where camera traps were not possible.

G) ODISHA WANTS ITS OWN CENSUS (SEP 2023)

- **Why?**
 - » It disagrees with NTCA findings.
 - All India Tiger Estimate (AITE) had said that more than half the tigers of Odisha had in 2016, have vanished, with one of its two notified tiger reserves Satkosia has none.
 - Odisha says that this is an inaccurate representation as the sampling intensity was very low.
 - They said though the AITE protocol mandates that the phase-I survey be carried out in all forest beats (in tiger reserves, protected areas, reserve forests, protected forests, revenue forests in all wildlife and territorial divisions) and phase-III in all potential tiger-bearing forest blocks, in Odisha, it was carried out only in limited areas. The state claimed a total of 733 camera traps were deployed in Odisha, as against 6,894 and 4,872 in Madhya Pradesh and Maharashtra respectively.
- **How will Odisha do Census?**
 - » While the AITE since 2006 has replaced the pugmark method with new technologies, Odisha's survey will rely on the camera trap method along with pugmark and other approaches.
 - » **Where?**
 - All districts (except coastal districts)

H) INAUGURATION OF INTERNATIONAL BIG CAT ALLIANCE

- PM Modi inaugurated the International Big Cat Alliance (IBCA) in Karnataka's Mysuru (April 2023)
 - » India has proposed to launch a mega global alliance to protect big cats and assured support over five years with guaranteed funding of \$100 million (over Rs 800 crores).
 - » The IBCA will focus upon conserving 7 major big cats of the world - Tiger, Lion, Leopard, Snow Leopard, Puma, Jaguar, and Cheetah
 - » The alliance aims to reach out to 97 range countries covering the natural habitats of Tiger, Lions, Snow Leopard, Leopard, Puma, Jaguar, and Cheetah.
 - » It will further strengthen global cooperation and efforts to conserve wild denizens, especially big cats.
 - » **Governance:** General Assembly, Council and Secretariat

I) PROTECTION OF BLACK TIGER (MELANISTIC TIGER)

- **Melanistic tigers** have been recorded only in Similipal Tiger Reserve in Odisha. As per the 2022 census, there are total 16 individual tigers in Similipal out of which **10 are melanistic**.
- **A standard operating Procedure (SOP)** has been issued by the NTCA for active management towards rehabilitation of tigers from source areas at the landscape level.
 - Based on genetic composition, the Similipal Tiger Reserve has been identified as a distinct genetic cluster for conservation. **Funding assistance is provided** under the ongoing Centrally sponsored scheme of Integrated Development of Wildlife Habitats (CSS-IDWH) to the Similipal Tiger Reserve for conservation of tigers, raising awareness on tiger & other wildlife conservation, habitat management, protection, eco-development, human resource and infrastructure development, voluntary village relocation, as per the sanctioned Annual Plan of Operation of the Tiger Reserve which emanates from a statutory Tiger Conservation Plan (TCP).

8. VULNERABLE MAMMALS OF INDIA

4) GREAT INDIAN ONE HORNED RHINO

Details: Fifth largest land animal.

Threats:

- Poaching - rhino horn great demand in China and other Asian countries for traditional medicines.
- Habitat loss
- Fragmentation of Habitat

Habitat and Distribution

- **Past:** Once ranged throughout the entire stretch of Indo-Gangetic Plain.
 - Population went down to a mere 200 in the early 1990s, and was declared to be endangered.
- **Present:** Found only in the tall grasslands and forests in the foothills of the Himalayas. Today more than 3,000 Rhino live in wild, most of them confined in Assam (2500+). They range from few pockets in Southern Nepal, northern Bengal, and Brahmaputra Valley.
 - Today, they are mostly found in 7 protected areas:
 - In Assam: Kaziranga National Park, Pobitora WLS, Orang NP, Manas NP
 - In WB: Jaldapara NP and Gorumara NP
 - In UP: Dudhwa NP
 - Protected Areas for Rhino (all three in Assam)
 - Kaziranga National Park
 - Pabitora Wildlife Sanctuary
 - Manas National Park



Indian rhinoceros (^[1]*Rhinoceros unicornis*)

in the Kaziranga National Park



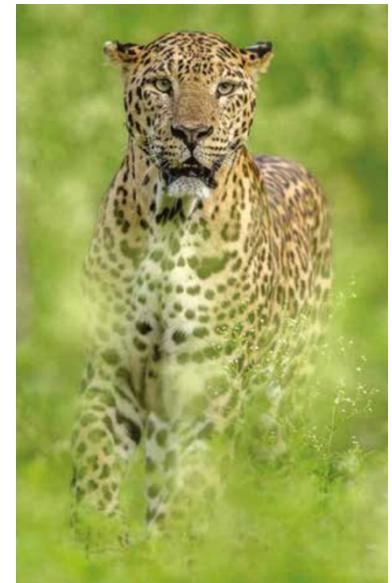
A) INDIAN RHINO VISION 2020 COMES TO AN END

- It was a partnership among the government of Assam, the International Rhino foundation, WWF, the Bodoland Territorial Council, and the US Fish and Wildlife Service that aims to increase the number of Rhino population and provide long term viability in seven of Assam's protected areas by 2020.
- Need of such mission
 - Rhino population had been confined to 2-3 protected areas of Assam.
- The main feature of the vision was the translocation of rhinos from Kaziranga, Orang and Pobitora to other protected areas.
 - Other activities involved anti-poaching, monitoring, community conservation efforts etc.

- The ambitious program came to a **close in April 2021** with the release of two Rhinos in Assam's Manas National Park transported from Pobitora WLS about 185 km to the east.
 - There were total eight rounds of rhino translocation under IRV2020.
 - Manas NP has received a total of 22 Rhinos from other protected areas.
- **Has the target been achieved:**
 - It is believed to have achieved its target of attaining a population of 3,000 Rhinos in Assam. (2018 Census had 2650 Rhinos)
 - But, the plan to spread the Rhinoceros unicornis across 7 Protected Areas of Assam didn't materialize completely.

2) INDIAN LEOPARD (PANTHERA PARDUS FUSCA)

- **Details about Leopard**
 - They are found in **widely distributed and adaptable habitats**. It is absent only in arid deserts and above timber line in the Himalayas and are found throughout the country. In Himalayas, they are sympatric with snow leopard (Panthera uncia).
 - Among all sub-species, the Indian leopard retains the largest population size and range outside Africa.
 - In areas devoid of any other large carnivore, the leopards can act as an **umbrella species for biodiversity conservation**.
- **Protection Status**
 - IUCN: VU
 - WPA: Schedule - 1
 - CITES: Appendix-1
- **Status of Leopard in India, 2018** (published in 2020)
 - During the **All-India tiger estimation** of 2018, leopard population was also estimated within the forested habitats in tiger occupied states.
 - » Note: Non-forested areas like coffee and tea plantation, higher reaches of Himalayas, arid landscape and majority of north-eastern landscapes were not sampled, and therefore this population estimate should be considered as minimum number of leopards in each of the landscapes.
- **Key highlights**
 - **Total Population:** 12,852
 - **60% increase in population** in 2018 when compared to 2014.
 - » **But North-eastern region** see the population facing major threat due to land use changes triggered by agriculture, tea gardens and linear infrastructure projects.
 - **Regional Distribution** (MP > KAR > MHA > TN > Chhattisgarh > UK)



- » **Shivalik Hills and Gangetic Plains:** 1,253 leopards
 - Uttarakhand > UP > Bihar
- » **North-eastern Landscape:** 141 leopards
 - WB > Assam > Arunachal
- » **Central India and Eastern Ghats:** 8071 leopards
 - MP > MHA > Chhattisgarh
- » **Western Ghats:** 3,386 leopards
 - Karnataka > TN > Kerala

3) SNOW LEOPARD

Distribution:

- Native to mountain ranges of central and South Asia, it is found along the upper reaches of Himalayas at elevations between 3000-4000 m.
 - It is known as the "**ghost of mountain**" and is the top predator of the region. It is a flagship species for high altitude Himalayas. It is also an indicator species and its presence gives an indication about the whole mountain ecosystem.
 - Reclusive nature of Snow Leopard and difficult terrain have made population estimation difficult.
- In India it is found in **Ladakh, Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh**.
 - **Hemis** (Ladakh) is also known as the snow leopard capital of the world.
 - India has identified **three landscapes** namely:
 1. **Hemis-Spiti** across Ladakh and Himachal Pradesh;
 2. **Nanda Devi - Gangotri** in Uttarakhand
 3. **Khangchendzonga - Tawang** across Sikkim and Arunachal Pradesh.
- Globally, it is found in **12 countries** of South Asia and Central Asia - India, Nepal, Bhutan, China, Mongolia, Russia, Pakistan, Afghanistan, Kyrgyzstan, Kazakhstan, Tajikistan, and Uzbekistan.

Conservation Status

- IUCN: VU
 - Note: IUCN moved it from endangered to vulnerable in 2017
- WPA: Schedule 1 (Part 1)
- CITES: Appendix 1
- Convention on Migratory Species (Appendix - 1)

Snow leopard



Snow leopard in Wakhan District, Afghanistan



At Hemis National Park, India

Conservation status



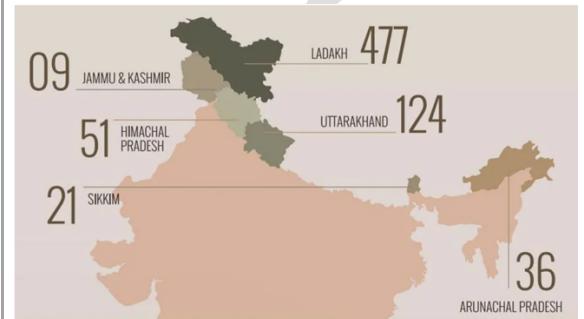
National Heritage Animal: Snow leopard is national heritage animal of Afghanistan and Pakistan.

Key threats

- Habitat loss, fragmentation, human-animal conflict, hostile habitat -> traditionally lower population

Status Report of Snow leopard in India (Jan 2024)

- The report was released by the Union Minister of EF&CC during the National Board of Wildlife Meeting in Delhi.
- The Snow Leopard Population Assessment in India (SPA) Program is the first ever scientific exercise** about snow leopard population in India.
- The Wildlife Institute of India (WII)** is the National Coordinator for this exercise that was carried out with the support of all snow leopard range states and two conservation partners, the Nature Conservation Foundation, Mysuru and WWF-India.
- The SPAI systematically covered over 70% of the potential snow leopard range in the country of around 1,20,000 sq km. It covered the UT of Ladakh, UT of J&K, and states such as Himachal Pradesh, Uttarakhand, Sikkim, and Arunachal Pradesh.
- The exercise was carried out between 2019-2023 using a meticulous two step framework:
 - The first step** involved evaluating snow leopard spatial distribution.
 - The second step** snow leopard abundance was estimated using the camera traps in each identified stratified region.



Key Highlights of the report:

Total Population: 718

Ladakh (477), UK (124), Himachal (51), Arunachal (36), Sikkim (21), and Jammu and Kashmir (9)

The report also mentions the need for establishing a dedicated Snow Leopard Cell at WII under MoEF&CC with primary focus on long-term population monitoring, supported by well-structured study designs and consistent field surveys.

Programs by GoI to protect Snow Leopard

A) SECURE HIMALAYAS

- It is a GEF-UNDP funded project which is focused on conservation of high altitude biodiversity and reducing the dependence on local communities on the natural ecosystem.
 - It is currently operational in four snow leopard ranges - J&K, Himachal, UK and Sikkim.

B) PROJECT SNOW LEOPARD (LAUNCHED BY GOI IN 2009)

- It is an initiative for strengthening wildlife conservation in the Himalayan High altitudes, covering Jammu and Kashmir, Himachal Pradesh, UK, Sikkim and Arunachal Pradesh.
- It aims at promoting knowledge-based and adaptive conservation framework that fully involves local communities, who share snow-leopard's range, in conservation efforts.

- » The project facilitates a landscape level approach to wildlife conservation by developing scientific frameworks for comprehensive surveys, rationalizing the existing protected area network and improving protected area management.

C) "HIMAL SANRAKSHAK" - COMMUNITY VOLUNTEER PROGRAM

- Launched in Oct 2020

D) THE UT OF LADAKH HAS ADOPTED SNOW LEOPARD AND BLACK NECKED CRANE, AS THE STATE ANIMAL AND STATE BIRD (SEP 2021)

E) SNOW LEOPARD CONSERVATION BREEDING PROGRAM

- It is being carried out at Padmaja Naidu Himalayan Zoological Park.

International Efforts

A) INTERNATIONAL SNOW LEOPARD DAY: 23RD OCTOBER

- It marks the adoption of Bishkek Declaration by 12 countries on the conservation of snow leopard in 2013.
- The Global Snow Leopard & Ecosystem Protection Program (GSLEP) was also launched on the same day.

B) GLOBAL SNOW LEOPARD & ECOSYSTEM PROTECTION PROGRAM (GSLEP)

- The GSLEP is a first-of-its kind intergovernmental alliance for the conservation of the snow leopard and its unique system. It was created in 2013 when officials, and conservationists arrived at a common conservation strategy enshrined in the Bishkek Declaration (2013) to cooperate in the conservation of this species and its habitat.
- It is a range wide effort and unites range country government, NGOs, local communities, and private sector to conserve snow leopard and their ecosystem.
- It is led by environment ministers of 12 countries in Asia which form the home range of snow leopards.
- The GSLEP secretariat is in Bishkek.
- India is a member of GSLEP since 2013.
 - Gol also hosted 4th Steering Committee of the GSLEP in 2019 which also resulted in the "New Delhi Statement" of strengthening the resolve of the snow leopard range countries towards conservation of the mountain ecosystem of Central and South Asia.

4) CLOUDED LEOPARD (NEOFELIS NEBULOSA)

- Why in news?
 - » A new study reveal that clouded leopard doesn't follow any specific pattern of operating in a certain space, unlike other carnivores (Aug 2023)
- About Clouded Leopard

The clouded leopard has been named so after the cloud-shaped pattern on its skin. They are considered evolutionary link between big cats and small cats.

Habitations

They are typically rainforest dwellers, but can also be found in drier forest of South East Asia.

Distribution: Himalayan foot hills to Southeast Asia and China. In India, they are distributed in Northern West Bengal, Sikkim, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura.

Study: A new study revealed that clouded leopard doesn't follow any specific pattern of operating in a certain space, unlike other carnivores. They seemed to go wherever they pleased without worrying about other predators, primarily because of their ability to climb trees, even hang upside down from large branches.



IUCN Status: VU

It is also the **state animal of Meghalaya**

5) BLACK PANTHERS

- It is a melanistic color variant of any big cat species.
 - o In Asia and Africa, they are leopards.
 - o In Americas they are jaguars.
- **Conservation Status**
 - o IUCN/WPA/CITES: VU/Schedule 1/ Appendix 1
- **Distribution in India**
 - o Odisha to Kerala



6) FISHING CAT

Fishing cats are generally twice the size of the household cats. They are generally found on the Marshy wetlands of northern and eastern India, and on the mangroves of the east coast.

- They are found in Sundarbans of India and Bangladesh, Chilika Lake and surrounding wetlands in Odisha, Coringa and Krishna Mangroves in Andhra Pradesh.
- The fishing cat has also been document in Ranthambore Tiger Reserve, Pilibhit, Dudhwa, Valmiki Tiger Reserve, and Sur Sarovar Bird Sanctuary.



Protection Status

» IUCN: VU

- They are generally observed while hunting along the edges of water bodies grabbing prey from the water or diving in to catch prey farther from the banks.

» **CITES:** APPENDIX-II

» **WPA:** Schedule-1

Other features

- They are mostly active at night and adults are solitary in nature

World's First Fishing Cat Census done in Chilika (June 2022)

- » The Chilika Lake, Asia's largest brackish water lagoon, has 176 fishing cats: As per the census done by Chilika Development Authority in collaboration with the Fishing Cat Conservation Alliance (FCCA), a non-profit.
- » **About Fishing Cat Conservation Alliance (FCCA)**
 - It is an NGO which consists of team of conservationists, researchers, and enthusiasts across the world working to achieve a single dream - a world with functioning floodplains and coastal ecosystems that ensure survival of the fishing cat and all species with which it shares a home.
- **Fishing Cat Project** launched by Chilika Development Authority in collaboration with FCCA in 2010
 - » As part of the project awareness will be created among local people and fishermen for the animal's conservation.

- In 2012, **WB government** declared fishing cat as the **state animal** and the Calcutta Zoo has two big enclosures dedicated to them.

Major threats

- » **Habitat Loss** (wetland degradation, and conversion of aquaculture, and other commercial projects), **Sandmining along riverbanks, agriculture intensification** etc.
- » Killed by people under assumption that it is a juvenile tiger and thus dangerous.

7) BINTURONG (ARCTICTIS BINTURONG) (BEARCAT)

It is also known as **bearcat** and is an arboreal mammal. It is native to south and Southeast Asia.



Distribution: It is found in India, Nepal, Bangladesh, Bhutan, Myanmar, Thailand, Laos, Cambodia, Vietnam, Malaysia, Indonesia, Philippines and Yunnan in China.

In India, it is confined in tall forests of the foothills and hills with good tree cover. It is known from Manas National Park, Karbi Anglong and other regions.

IUCN: VU

WPA: Schedule-1

Recent Development (Jan 2024): Kaziranga National Park adds two new Mammal Species - Binturong (Arctictis binturong), and the Small Clawed otter (Aonyx cinera).

8) HIMALAYAN SEROW (**CAPRICORNIS SUMATRAENSIS THAR**)

- There are several species of serows, and all are found in Asia. The **Himalayan serow is restricted to Himalayan region** and are typically found at altitudes between 2,000 meters and 4,000 meters. They are found in eastern, central and Western Himalayas but not in trans-Himalayan region.
- Taxonomically it is a subspecies of the mainland serow (*Capricornis Sumatrensis*).



9) GAUR/ INDIAN BISON (BAUS GAURUS)

It is also known as Indian Bison and is a bovine native to South Asia and Southeast Asia. It is the biggest among wild cattles.

IUCN: VU

Habitat: Largely confined to evergreen forests or semi-evergreen and moist deciduous forests.

Historical Distribution: It occurred throughout mainland south and southeast Asia.

Present Distribution:

- But today the population is fragmented, with it being extinct from Sri Lanka and Malaysian Peninsula.
- They are largely confined to evergreen forests or semi-evergreen and moist deciduous forests, but also inhabits deciduous forest areas at the periphery.

Note: The domesticated form of the gaur is called gayal (*Bos frontalis*) or mithun.



Distribution in India:

- Western Ghats** in particular Wayanad - Nagarhole - Mudumalai - Bandipur complex constitute one of the most extensive extant strongholds of gaur. Nilgiri forest division is estimated to have a population of more than 2,000.
- Eastern Ghats** also has some population of gaurs in Odisha and Andhra Pradesh.

Interesting Fact: The famous drink "Red Bull" is based on a Thai drink 'Gratin Daang', meaning "red gaur".

Bos frontalis (Mithun) - Domesticated form of Gaur:

Recent News: The Food Safety and Standards Authority of India (FSSAI) has recognized the mithun as a '**food animal**' with effect from 1st Sep. With this, the mithun can be commercially farmed and its meat processed for pickles, soups, wafers nd biryani.

Work is on to help farmers and tribal village communities benefit commercially from the sale and processing of Mithun.

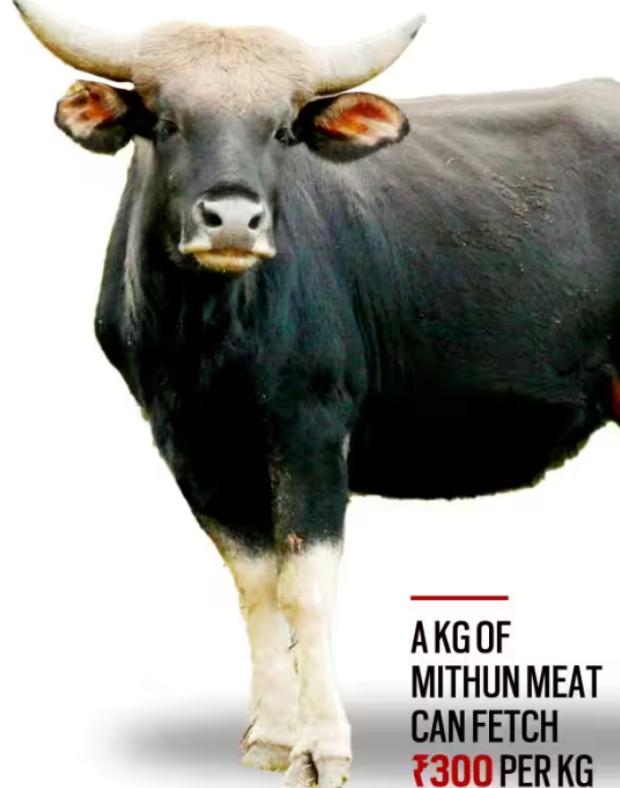
The **Animal** is endemic to Arunachal Pradesh, Nagaland, Manipur and Mizoram. It is semi-domesticated and is reared in free range forest ecosystem. The only **supplementary feed** that it needs is salt.

It is the **state animal** of both Arunachal Pradesh, and Nagaland.

The slaughter of the mithun is traditionally reserved for special occasions such as festivals or weddings (and now a days - elections)

Biodiversity Significance: The "food animal" status can increase the commercial value and may increase the population of Mithun.

Mithuns: From farms to the table



A KG OF
MITHUN MEAT
CAN FETCH
₹300 PER KG

10) FOUR HORNED ANTELOPES (*TETRACERUS QUADRICORNIS*)

Details: Species of small antelope found in **open forests of India and Nepal**.

It is the only species currently classified in genus Tetracerus. It is the smallest of Asian bovids.

Males are unique among extant animals as they possess four permanent horns.

Threats: Loss of natural habitat to agriculture land.

It should drink water regularly to survive.



Conservation status					
Extinct	EW	CR	EN	VU	Least Concern
EX	EW	CR	EN	VU	NT LC

11) NILGIRI MARTEN

Details: The Nilgiri Marten is the only species of Marten found in South India. Only species of marten which is considered Vulnerable to extinction.



Habitat: Hills of Nilgiris and parts of Western Ghats. Endemic to western Ghats, inhibit areas that are far from human disturbance.

Threat: Habitat loss and fragmentation; Hunting for fur

12) NILGIRI LANGUR / NILGIRI LEAF MONKEY (TRACHYPITHECUS JOHNII)

- **Endemic to** Southern India. Distributed in southern western ghats - Karnataka, TN and Kerala.
 - It prefers higher altitude and is a canopy dweller. It forages on fruits and vegetables.
- **Threats**
 - **Habitat Destruction:** Deforestation
 - **Poaching:** For fur and Flesh (which is believed to have aphrodisiac properties)



13) BARASINGHA OR SWAMP DEER

- **Habitat/Distribution**
 - » It has a very patchy distribution.
 - » There are **three subspecies of the swamp deer**:
 - **Southern Swamp Deer/Hard Ground Barasingha** are found in Central and North India. They have hard hooves and is adapted to the flooded tall grassland habitat in the Indo-Gangetic plain.
 - They are restricted to Kanha National Park and Satpura Tiger Reserve.
 - **Eastern Swamp Deer** are found in Kaziranga (Assam).
 - **Western Swamp Deer** has splayed hooves and is adapted to the flooded tall grassland habitat in the Indo-Gangetic plains.
 - » **IUCN:** VU



14) ORIENTAL SMALL CLAWED OTTER AND SMOOTH COATED OTTER

A) ORIENTAL SMALL CLAWED OTTER / ASIAN SMALL CLAWED OTTER

Smallest otter species in the world, weighing less than 5 Kg. It posses partially webbed feet with short claws, enhancing their hunting skills in aquatic environments. They predominantly inhabit freshwater habitats, sustaining themselves on a fish, crustaceans and mollusk diet.



Habitat: Live on mangrove swamp or fresh water wetlands of Bangladesh, Burma, India, South China and South East Asia.

In India, its presence is noted in WB, Assam, Arunachal, Karnataka, TN and some parts of Kerala.

Threat : Habitat loss, pollution, trade and hunting.

- Trade is rampant as the pups of both these otters are high in demand in Asian market and can fetch upto \$10,000.

IUCN: VU

CITES: Appendix-1

WPA: Schedule-1 (2022 amendment)

Recent Development (Jan 2024): Kaziranga National Park adds two new Mammal Species - Binturong (*Arctictis binturong*), and the Small Clawed otter (*Aonyx cinera*).

B) SMOOTH COATED OTTER (LUTROGALE PERSPICILLATE)

- It is a species of otter, the only extant representative of the genus Lutrogale.
- The species is found in **most of the subcontinent and eastward in South East Asia**, with a disjunct population in Iraq.
- As its name suggest the fur of the species is smoother and shorter than that of other otters.
- The otter lives in rivers, lakes, peat swamp forests, mangroves and estuaries.
 - It uses swamps as natal den sites and nursery during the breeding season in early winter.
- CITES:** Appendix-1
- WPA:** Schdeule-1



THE EURASIAN OTTER (IUCN: NT)

Other than oriental small, clawed otter and smooth coated otter, India also has Eurasian Otter.

About Eurasian Otter: It is classified as NT on the IUCN red list. It is regarded as a flagship species and indicators of high-quality aquatic habitat.



Distribution: it has one of the widest distributions of all palaearctic mammals. Its range covers parts of Europe, Africa and Asia.

In India, it occurs in northern, northeastern and southern India.

Recently, a team of scientists have camera trapped **three Eurasian Otters** - two adults and one sub-adult in the NEERU stream of the Chenab catchment (March 2023)

Neeru river is a tributary of the **Chenab river** and the finding shows that upper stretch of its remain unpolluted.



15) ASIAN BLACK BEAR/ MOON BEAR OR WHITE CHESTED BEAR

- **Details:** Medium size bear, largely adapted for arboreal life.
- **Habitat:** Asian Black Bear has wide distribution in the higher elevation of N and NE India and other Southeast Asia.
 - > Out of the **7 subspecies**, 'Himalayan Black Bear, Indo Chinese Black Bear, and Tibetan Black Bear are distributed within the Indian boundaries of its global distribution.
 - > **Himalayan subspecies** is found in Kashmir Himalayan and Sikkim.
 - > **Indochinese subspecies** is distributed in Himalayas along the China Border
 - > **Tibetan subspecies** is found in Nepal and Assam.
 - > Threats: Deforestation and hunting for its body parts.
- **Threats:** Deforestation and hunting for its body parts.
- **WPA:** Schedule-1 (2022 amendment)



16) INDIAN SLOTH BEAR (MELURSUS UR SINUS UR SINUS) – SUBSPECIES OF SLOTH BEAR

- It is one of the eight bear species found in India. It is endemic to Indian sub-continent. They have evolved from ancestor brown bear during the Pleistocene and shares features found in insect-eating mammals.
- **They are unique bears** -> they carry their young on their backs for six-nine months and 50% of their diet is made up of termites and ants. They also feed on honeybee colony and fruits.
- **Population Decline:** In last 3 decades, the population has fallen by 40%-50%.

- **Key threats:**
 - Habitat loss and Fragmentation
 - Poaching
 - Increasing Human Animal conflict:
 - The sloth bear is more inclined to attack man unprovoked than almost any other animal, and casualties inflicted by it are unfortunately very common.
 - In the past, the ethnic group of Kalandars captured these bears and tortured them to perform.
- **Conservation Status**
 - **IUCN:** Vulnerable
 - **WPA:** Schedule 1
 - **CITES:** Appendix II
- **Where are they found in India?**
 - It is the most widespread bear species in India, where it mostly occurs in areas with forest cover, low hills bordering outer ranges of Himalayas from Punjab to Arunachal Pradesh.
 - It is absent in high mountains of Himachal and Jammu and Kashmir, the northwestern deserts of Rajasthan, and a broad unforested swath in south, where Mount Abu WLS is located.
- **Global Distribution:** Sloth bear's geographical range includes **India**, the **Southern lowlands of Nepal**, and **Sri Lanka**. It is regionally extinct in Bangladesh.
 - In Nepal, only a tiny scattering of this species is found.
 - In Sri Lanka a subspecies is found.
 - Thus, **India is the main home** of this species and 90% of the global sloth bear population is found in India.
 - It occurs in wide range of habitats including wet and dry tropical forests, Savannahs, Scrublands, and grassland below 1500 m on the Indian sub-continent

17) HIMALAYAN YAK

Categorization as Food Animal:

- **Background:** The request was submitted by National Research Centre on Yak (NRC-Y) based in Arunachal Pradesh's Dirang in 2021.

FSSAI's Approval came in Nov 2022.

Significance:

- The categorization is expected to help check the decline in the population by making it part of the conventional milk and meat industry.
- It will also contribute to development of local entrepreneurship.
- Yak Milk and Meat are nutrient loaded:



Yaks are traditionally reared under a transhumance system which is primitive, unorganized and full of hardship. But the Yak Population in the country had been decreasing at alarming rate (It has dropped by 25% to 58,000 in 2019 from the 2012 numbers).

The mains reason is the less remuneration from the bovid. It is mainly because Yak milk and meat are not a part of

- Yak Milk has 78-82% of water; 7.5-8.5% of fat; 4.9 - 5.3% protein, 4.5-5.0% lactose and 12-13% of solids-not fat.
- Yak Meat is also lean with 21.7% protein and 1.5% crude fat.

the conventional dairy and meat industry. Thus, there sale is limited to local consumers.

IUCN: VU

CITES: Appendix-1

WPA: Schedule-1

9. NEAR THREATENED MAMMALS

1) ASIAN WILD ASS / KHUR (EQUUS HEMIONUS KHUR)

- Locally known as **GHUDKHAR**
- **Past Distribution:** Once extended from western India, southern Pakistan, Afghanistan, Southeastern Iran etc.
- **Today, Distribution:**
 - Last refuge lies in the **Indian Wild Ass Sanctuary, Little Rann of Kutch.**
- **Conservation Status**
 - IUCN: NT (was moved from EN to NT in 2016)
 - WPA: Schedule 1 (2022 amendment)
- **Threat**
 - **Diseases**
 - In 1958-60, surra disease, caused by Trypanosoma evansi (a Protozoa) and transmitted by horse flies.
 - In 1961, outbreak of south African horse sickness.
 - **Other Threats**
 - Habitat degradation due to salt activities
 - Invasion of Prosopis juliflora shrub
 - Encroachment and grazing by the **Maldhari**
 - Uninformed release of water from Sardar Sarovar dam impacting short grasslands on which it depends.
 - **Human wild-life conflict increasing** (now 1/3rd of the Wild Ass Population lives outside the protected area)



A) BANNI GRASSLAND

- The grassland consists of an area of 2,500 sq km in the Kutch district. It is the largest natural grassland in the Indian subcontinent.
- **In the past** it was among Asia's finest grasslands, with nearly 200 varieties of vegetation.
- The grassland has degraded over the years, owing largely to an invasion of an alien woody species - **Prosopis Juliflora**, known locally as **Gando baval**.

B) CHARI DHAND WETLAND CONSERVATION

This is a seasonal reserve wetland and only gets swampy during a good monsoon, receiving water from north flowing rivers as well as the huge catchment areas of many surrounding hills.

2) CHIRU/ TIBETAN ANTELOPE

- **Details:** The Tibetan antelope is a medium sized bovid native to the Tibetan Plateau.
- **Habitat:** Tibet Cold desert.
 - In India, it is found in the Ladakh region besides some places in Himachal Pradesh bordering Tibet, Sikkim and Nepal.
- **Threat**
 - Hunting
 - » Soft and warm wool known as **shahtoosh** (usually obtained after death).
 - » Magnificent horns
 - » Meat
- **Protection**
 - Included under Schedule-I of Wildlife (Protection) Act, 1972.
 - It gets highest degree of protection.
 - Hunting of these species, and trade of its parts and products, including shawls made of Chiru wool are prohibited under the Act.
 - CITES
 - Selling or owning Shahtoosh was made illegal in all countries that signed the CITES in 1975.
- **In 2017, Parliamentary Panel on Environment and Climate Change headed by Congress leader Renuka Chowdhury has recommended lifting ban, allowing weaving and trading in the world's most expensive fabric, shahtoosh, made from the fine fur undercoat of the endangered Tibetan Antelope known as "Chiru".**
 - It recommended that MoEF&CC should conserve and breed the Chiru goat and vast tract of land should be utilized for conserving the Chiru goat.
 - These goats can be given to shawl makers for collecting hair. This would not only increase the number of goats but would also help in sustainable livelihood opportunities of the people of Jammu and Kashmir.
 - China and Mongolia are already doing captive breeding of these animals.
 - **Currently, Shawl's sale or possession is banned in India and in many countries**
- **But in 2018, MoEF&CC refused to allow captive breeding** as this species have poor survival rate in captivity.



3) MARKHOR

- **Distribution:** Northeastern Afghanistan, Northern Khyber Pakhtunkhwa, Jammu and Kashmir, South Tajikistan, and Uzbekistan.
- **National Animal:** The markhor is also **national animal of Pakistan.**
- **Status:** Till 2015, IUCN classified it as endangered, but now it has been down listed to Near Threatened, as their numbers have increased in recent years by an estimated 20% for last decade.
- **Threats**
 - **Hunting:** For meat and for its twisted horns.
 - **Armed Conflict**
 - **Habitat loss**



4) SLENDER LORIS (GREY SLENDER LORIS)

- **Details**
 - » Slender Loris are small nocturnal animals. They are arboreal in nature as they spend most of their lives on trees.
 - » **IUCN status:** NT
 - » WPA: Schedule-1
- **Benefits for farmers:**
 - The species act as a biological predator of pests (insects) in agricultural crops and benefits farmers.
- **Least Known behaviour:** The behavior of the gray slender loris is amongst the least known of the primates, despite the relatively large number of studies undertaken since 2000s.
- **Four Subspecies:**
 - Malabar Slender Loris
 - Mysore Slender Loris
 - Northern Ceylonese Slender Loris
 - Highland Slender Loris
- **TN notifies India's first slender loris sanctuary (Oct 2022)**
 - The state government notified 'Kadavur Slender Loris Sanctuary' under section 26(A)(1)(b) of Wildlife (Protection) Act, 1972.
 - **The Kadavur Slender Loris Sanctuary** is to cover 11,086 hectares in Karur and Dindigul districts.
- **Note:** Red Slender Loris are native to Sri Lankan rain forests and are EN in the IUCN red list.
- **Note:** In recent times, TN government has also notified India's first Dugong Conservation Reserve in Palk Bay, the Kazhuvedi Bird Sanctuary in Villupuram, the Nanjarayan Tank Bird Sanctuary in Tiruppur, and a fifth elephant reserve at Agasthyamalai in the Tirunelveli district.



10. OTHER MAMMALS IN NEWS

1) NILGAI (BOSELAPHUS TRAGOCAMELUS)

Nilgai is the largest Asian Antelope. It is the sole member of genus Boselaphus.

It shows sexual diamorphism - Females and juveniles are orange to tawny, adult males have a bluish grey coat. Only males possess horn.

It is a diurnal animal (i.e., it is active mainly during daytime).

Distribution and habitat: Nilgai prefer areas with short bushes and scattered trees in scrub forests and grassy plains. Major population occur in the Indian and Nepali Terai. Pakistan and Bangladesh also have some population.

Other than **Terai region of India**, it is also found in Haryana, Rajasthan, Madhya Pradesh, Chhattisgarh, Maharashtra, Andhra Pradesh etc.

It is also common in agricultural land, but rarely in dense forests. It is a **herbivore** and prefers grasses and herbs; woody plants are commonly eaten in the dry tropical forests of India.

The nilgai can survive for long periods without water and doesn't drink regularly even in summers.



IUCN: LC

WPA: Schedule-II (2022 amendment)

2) BLACK BUCK (ANTILOPE CERVICAPRA)

- Details:

- Black Buck, also known as Indian Antelope, is an antelope found only on Indian subcontinent in Nepal, Pakistan and India.
- In India it is found in Punjab Haryana in North to TN in south, and Rajasthan-Gujarat in the west to Odisha in the east. But it is **not found in very vast herds** anywhere.
- **Details:** Only living species of genus antelope. It shows sexual dimorphism.
- **Protection**
 - IUCN: LC
 - WPA: Schedule -1 (i.e., highest protection)
- **Habitat:** Grassland
- **Distribution:** Today, Black buck population is confined to area of MHA, Orissa, Punjab, Rajasthan, Haryana, Gujarat, Andhra Pradesh, Karnataka, and Tamil Nadu.
 - They occur in protected areas of India.



- **Blackbuck National Park, Velavadar** in Bhavnagar, Gujarat.
 - Highest numbers here
 - **Point Calimere Wildlife and Bird Sanctuary**, Nagapattinam TN.
 - **Tal Chhappar Sanctuary**, Churu District, Rajasthan.
 - **National Chambal Sanctuary**, near the Tripoint of Rajasthan, MP and Uttar Pradesh.
 - **Keoladeo National Park**, Bharatpur, Rajasthan. Formerly known as the Bharatpur Bird Sanctuary.
 - **Rehekuri Blackbuck Sanctuary** in Ahmednagar district Maharashtra.
 - **Ranibennur Blackbuck Sanctuary**, Haveri District Karnataka.
 - **Guindy National Park**, Chennai, TN
- In Rajasthan, there are many areas such as Guda Vishnoiyan, Dhawa Doli and Kankania (where actor Salman Khan allegedly hunted in 1998), that are **protected by the Bishnoi Community** who consider blackbuck sacred. Similarly in parts of Haryana and Punjab a few thousand black bucks are surviving in Bishnoi dominated areas.
- **Threat:**
- Poaching, habitat destruction, habitat fragmentation, urbanization, and neglect are the major causes for disappearance of Blackbuck.
 - A new menace is the free ranging village dogs which now roam all over India killing Blackbuck, Chinkara, Nilgai etc.
 - Excessive hunting for meat and sporting trophies, as well as habitat loss.

3) PASHMINA GOAT/ CHANGTHANGI GOAT

Changthangi or Pashmina Goat is a special breed of goat indigenous to the high altitude regions of Ladakh. They are raised for ultra-fine Kashmere wool, known as Pashmina, once woven. The textile is home spun and were first woven in Kashmir.

These goats are generally domesticated and reared by nomadic communities called the Changpa in the Changthang region of Great Ladakh. They live in tough and hostile terrain of **Changthang** and are solely dependent on Pashmina for livelihood. At present there are around 2,400 families rearing around 2.5 lakh goats.

Ladakh produces around 50 MT of the finest grade Pashmina in the world (12-15 microns).

IUCN: LC

In 2019, PASHMINA products have received BIS Certifications.

BIS has published an Indian standard for identification, marking and labelling of Pashmina products to certify its purity.



Significance of BIS Certification

- It will discourage counterfeit or substandard products presently mislabeled and sold as genuine Pashmina in the market.
- It will also ensure better prices for the goat herding community in Ladakh as well as Local handloom artisans producing genuine Pashmina products. They are till now disadvantaged due to rampant marketing malpractices.

11. MARINE MAMMALS

1) FRESH WATER DOLPHINS

- Fresh Water Dolphins of India: Ganga River Dolphin ('Susu')
 - » Habitat/ Distribution: India, Bangladesh, Nepal.
- At present World has 7 Fresh Water Dolphins
 - » Amazon River Dolphin (*Inia geoffrensis*) (VU)
 - » Bolivian River Dolphin (*Inia boliviensis*) (VU)
 - » Ganges River Dolphin (*Platanista gangetica*) (EN)
 - » Indus River Dolphin (*Platanista gangetica minor*) (EN)
 - » Irrawaddy River Dolphin (*Orcaella brevirostris*) (EN) (not a true freshwater dolphin can be found in brackish water also)
 - It traverses three rivers in South and Southeast Asia: the Irrawaddy, the Mahakam, and the Mekong.
 - » The Yangtze Finless Porpoise (*Neophocaena asiaeorientalis*) (CR)
 - Note: The difference between a dolphin and a porpoise has to do with their appearance: dolphins have longer snouts, bigger mouths, more curved dorsal fins, and longer, leaner bodies than porpoises
 - » Tucuxi from Amazon and Orinco river basin (*Sotalia fluviatilis*) (EN)
 - With the latest update it was moved from DD to EN, which has effectively led to all the world's freshwater dolphin species being listed as threatened.
- Species in the subcontinent: Species in Indian Subcontinent are divided into two subspecies. (Recent studies have shown that they are two separate species)
 - » Ganges River Dolphin (*Platanista gangetica gangetica*) ~ 3000 individuals
 - Assam: 962 (based on the Jan-March 2018 assessment)
 - UP: 1,272 (assessment in 201
 - » Indus River Dolphin (*Platanista gangetica minor*) ~ 1500 individuals.
- Note: Both sub-species are effectively blind.

2) PROJECT DOLPHIN

- Details

- The plans about the project were announced by PM Modi during his Independence Day speech in Aug 2020.
- It will be aimed at saving both river and ocean dolphins.
- The project will be on lines of Project Tiger which has helped in increasing tiger population. Such an initiative got in-principal approval in December 2019 itself, at the first meet of the National Ganga Council headed by the PM.
- The proposed project is aimed at saving both river and marine dolphin.

A) GANGES RIVER DOLPHIN

- **Conservation Status:**
 - » IUCN: Endangered
 - » WPA: Scheduled 1 (even after the 2022 amendment)
 - » CITES: Appendix 1
 - » CMS: Appendix 1
- **Habitat/Distribution:** Ganges and Brahmaputra River, and their tributaries in India, Bangladesh and Nepal.
 - » In India, distributed in Uttar Pradesh, Bihar, Jharkhand, WB, Rajasthan, Madhya Pradesh and Assam.
 - » Note: Various examples of the dolphin found in rivers of Odisha.
- **National Aquatic Animal of India.**
- **WB** got India's first river dolphin reserve on Hoogly river.
- **Key threats**
 - » Loss of habitat due to increased development work on the river.
 - National Waterway Project is threatening Gangetic Dolphins: Conservationist
 - » Rising salinity in Sundarbans is also causing a decrease in population of Gangetic Dolphin.
 - » **Biological Resource Use**
 - Fishing & harvesting aquatic resources.
 - Depletion of prey base
 - Accidental mortality in fishing net



Ganges river dolphin leaping out of the water



Size compared to an average human



Important Steps for Protection:

- » **Project Dolphin:** In his Independence Day speech on 15th Aug 2020, PM Modi announced Project Dolphin on lines of the Project Tiger and Project Elephant. It was officially launched in 2021.
 - The project will focus on both river dolphins and sea dolphins and strengthen biodiversity, create employment, and attract tourism.
- » **National Ganga River Dolphin Day** - 5th Oct

<ul style="list-style-type: none"> » Accidental deaths due to vessel propellers » Invasive & other problematic species » Pollution <ul style="list-style-type: none"> ▪ Domestic, industrial and agricultural pollution <p>- Other features: Essentially Blind - Hunt by ultrasonic sound</p> <p>- Why its crucial to save Gangetic Dolphin?</p> <ul style="list-style-type: none"> » Aquatic life is an <u>indicator</u> of the <u>health of the river ecosystems</u>. Since the Gangetic Dolphin is at the <u>top of the food chain</u>, protecting the species and its habitat will ensure <u>conservation of aquatic lives of the river</u>. 	<ul style="list-style-type: none"> • It was on this day, the then PM Dr. Manmohan Singh, while presiding over the meeting of NGRBA, <u>declared Ganga Dolphin as the National Aquatic Animal</u>. <p>» Declared National Aquatic Animal</p> <p>» Protected Areas:</p> <ul style="list-style-type: none"> • Vikramshila Sanctuary (Bihar) - 1991 • Hastinapur Sanctuary (UP) - Proposed
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RESCUE OF GANGETIC RIVER DOLPHIN FROM ODISHA (JAN 2024)

- A fisherman in Odisha's Balasore district captured a rare and endangered Gangetic dolphin in the Jalaka river on 18th Jan 2024. Forest authorities then rescued the dolphin from a pond locals put it in and are planning to release it into Budhabalang river soon.

REPORT: 'RESCUING GANGES RIVER DOLPHINS FROM IRRIGATION CANALS IN UTTAR PRADESH, NORTH INDIA, 2013-2020 (OCT 2023)

- The publication says that dams and barrages have severely affected river habitat and dolphins have moved into irrigation canals where they were at risk of injury or death due to multiple factors, such as rapidly receding waters, heat stroke and human interference.

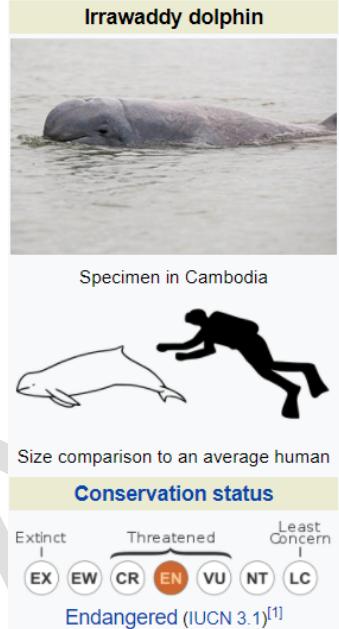
B) INDUS RIVER DOLPHIN (EN)

- Habitat/Distribution: Indus River in Pakistan and its Beas and Sutlej tributaries.
- Also called **Bhulan**

3) OCEANIC DOLPHINS

A) IRRAWADY RIVER DOLPHIN

- It is an eutrophic species of oceanic dolphin found in discontinuous sub-populations near sea coasts and estuaries and rivers in parts of Bay of Bengal. It is also found in South-east Asia.
- **Protection Status**
 - IUCN: EN
 - WPA: Schedule 1
 - CITES: Appendix 2



B) VAQUITA PORPOISE

- **Why in news?**
 - » The plight of the vaquita forces International Whaling Commission to issue first extinction alert (Aug 2023)

Drastic Decline in Population: The Species global population is down to only 10. The species has seen a 98% decline in population in 2 decades.

- » It is the world's smallest cetacean and the most endangered marine mammal.
- » IUCN: CR

Where is it found?

- » They are all found in northern part of the Gulf of California or Sea of Cortez.
- » It has smallest range of any whale, dolphin or porpoise and live in small 1500 square mile area in Mexico's upper Gulf of California, near the town of San Felipe.



Extinction Alert: The first extinction alert by IWC was released on 7th Aug 2023. it is to encourage wider recognition of the warning signs of impending extinctions, and to generate support and encouragement at every level for the actions needed now to save the vaquita.

The vaquita is caught as bycatch in gillnets meant for totoaba, a fish the swimbladders of which are priced in Chinese cuisines.

4) HERBIVOROUS MARINE MAMMALS

F) DUGONG (DUGONG DUGON)

- **Why in news?**

- World Dugong Day - 28th May

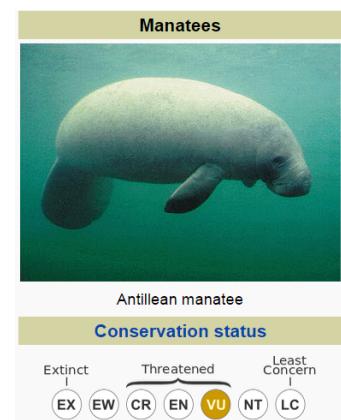
- **About Dugong**

- Dugong is commonly known as **sea-cow** as it is a herbivorous marine mammal. It is a medium sized marine mammal which is fighting for its survival in Indian waters.
- **IUCN: VU, WPA (Schedule - 1), CITES (Appendix - 1)**
- **Habitat:** Swamps, rivers, estuaries, marine wetlands, and coastal marine waters.
- **Threats:** Hunting (meat and oil), habitat degradation, and fishing related fatalities.
- **Distribution in India** - According to a study by Zoological Survey of India (ZSI), there are only 250 Dugongs left in India.
 - Marine National Park in Gulf of Kutch, Jamnagar, Gujarat.
 - First Marine National Park of India.
 - Only remaining population of Dugong in Western India.
 - Gulf of Mannar Marine National Park and Palk Strait
 - Here population is seriously depleted.
 - Andaman and Nicobar Islands
 - **State Animal** of the territory.



G) MANATEES (VU) - ALSO KNOWN AS SEA COWS

- **Habitat/Distribution:** Caribbean Sea, Gulf of Mexico, the Amazon Basin, and West Africa
- **Threat:** Coastal development, red tide, hunting.
- Also known as **West Indian Manatees** (referring to West Indies)



5) NOTE: WHALES, DOLPHINS, AND PROPOISES ARE ALL MAMMALS

- In fact Whales, Dolphins and Porpoises belong to the Cetacean family and share several physiological traits with one another including blowholes, breathing oxygen, maintaining constant awareness of their breathing and being able to dispose of additional salt that are taken in by their body when they consume food.
- As marine mammals they are also warm-blooded animals that give birth to their young and produce milk to feed their babies.

12. FEW UNIQUE MAMMALS

1) FLYING MAMMAL

- **Note:** Bats are the only flying mammal.
- **Bats in India**
 - i. India is home to 130 known bat species
- **Important Species:**

Indian Flying Fox (Pteropus medius)

It is one of the world's largest bat species. It is also known as the fruit bat or great Indian Fruit Bat.

The bat is named so due to its fox like appearance, distinguishable long snout, and large eyes.

Important Disease vector: It is capable of transmitting several viruses to humans.

IUCN: LC



2) EGG LAYING MAMMALS (MONOTREMES)

- The unique feature of monotremes a subdivision of mammal, is that monotremes lay eggs rather than giving birth to the young ones.
- **Only 5 living monotremes**
 - Duck Billed Platypus
 - 4 species of Spiny Anteaters (also known as echidna)
- **Habitat**
 - Australia and New Guinea Region

A) PLATYPUS

- A semi aquatic animal - endemic to **eastern Australia including Tasmania**.
- The female retires to a burrow in the bank of a river or pond. The burrow is lined with dry vegetation, and there the eggs are laid.
- The male is poisonous - its venom can kill a small dog or cause excruciating pain among humans.



Conservation status



Least Concern (IUCN 3.1)^[2]

B) ECHIDNAS (SPINY ANT EATERS)

- **Habitat / Distribution:** Australia and New Guinea
- In Echidnas eggs are carried in a pouch on the female's belly until the young hatches, at which point the barely developed young must find a mammary gland and latch onto it for nourishment.



Western long-beaked echidna

Note: Organisms which roll up to protect vulnerable parts

- Hedgehog
- Pangolin

OTHER SPINY MAMMALS

Hedgehog - they are small, spiny mammals that roll themselves up into a tight ball when threatened



Armadillos - they are small armored mammals that can roll themselves up into a ball to protect themselves



- Echidnas
- Pangolins

6) MARSUPIALS

- Group of mammals commonly thought of as pouched mammals (like the **wallaby and Kangaroo**). They give live birth, but they don't have long gestation times like placental mammals. Instead, they give birth very early and the young animal, essentially a helpless embryo, climbs from the mother's birth canal to the nipples. There it grabs on with its mouth and continues to develop, often for weeks or months depending on the species.
- Like other mammals, the marsupials are covered with hair. Mother nurse their young - a young Kangaroo may nurse even when it has grown almost to the mother's size.
- **E.g. of Marsupials**

A) KANGAROO (LC)

B) KOALAS

- The Koala is an arboreal, herbivorous marsupial native to Australia.
- It is found in coastal areas of mainland's eastern and southern regions, inhabiting Queensland, New South Wales, Victoria, and South Australia. It is a major attraction for tourists in Australia.
- **Physical features:** It is easily recognizable by its stout, tailless body, and large head with round, fluffy ears and large spoon - shaped nose.
- **Conservation Status:**
 - IUCN: VU
- **Key threats faced:**
 - Habitat destruction due to agriculture, urbanization and forest fires.



C) THYLACINE (TASMANIAN TIGER, TASMANIAN WOLF)

- Tasmanian government has recently released a document, reporting eight sightings of a Tasmanian tiger from across the continent in past three years (Nov 2019)



D) TASMANIAN DEVIL

- Details

▫ Current distribution:

- Till recently, it was only found in Island state of Tasmania, but it has now been reintroduced to New South Wales in mainland Australia, with a small breeding population.
- They had become extinct from Australian mainland thousands of years ago most probably by Wild Australian Dogs known as dingoes.
- The birth of these babies is a baby step towards bringing Tasmanian devil back in Australia's wilderness.
- It remains unclear how the animals would fare outside the fenced 1,000 acre wildlife preserve where they were born.

Other Examples of Marsupials: Wallabies, possums, opossums, wombats etc.

